UNIVERSITY RESEARCH

DOT-TST-77-78

ALTERNATIVE SCENARIOS FOR FEDERAL TRANSPORTATION POLICY

VOLUME I

SUMMARY

DEPARTMENT OF TRANSPORTATION ★ UNITED STATES OF AMERICA ★

FIRST YEAR FINAL REPORT

JANUARY 1977

UNDER CONTRACT: DOT-OS-50239

Document is available to the U. S. Public through
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Springfield, Virginia 22161

Prepared For:

U. S. DEPARTMENT OF TRANSPORTATION
Research and Special Programs Directorate
Transportation Programs Bureau
Washington, D.C. 20590

Technical Report Documentation Page

1. Report No.: DOT-TST-77-78

2. Government Accession No.:

3. Recipient's Catalog No.:

4. Title and Subtitle: ALTERNATIVE SCENARIOS FOR FEDERAL TRANSPORTATION POLICY - Summary First Year Report - VOLUME I

5. Report Date: January 1977

6. Performing Organization Code:

7. Author(s): Ann Friedlaender and Robert Simpson

8. Performing Organization Report No.:

9. Performing Organization Name and Address:
Massachusetts Institute of Technology
Center for Transportation Studies
Cambridge, Massachusetts 02139

10. Work Unit No. (TRAIS):

11. Contract or Grant No.: DOT-OS-50239

12. Sponsoring Agency Name and Address:
Office of University Research
Research and Special Programs Directorate
U. S. Department of Transportation
Washington, D. C. 20590

13. Type of Report and Period Covered: First Year Final Report

14. Sponsoring Agency Code: DPB-50

15. Supplementary Notes:

Technical Monitor: Byron Nupp, TPI-11.1

16. Abstract

The research evaluates the economic effects of existing and prospective federal policies governing intercity and international freight and passenger transportation enterprises in the economy of the United States. The analysis encompasses all modes of transportation, including rail, motor, water, air and intermodal coordinative institutions, and focuses upon the impact of alternative regulatory policies. However, other federal policies including subsidy, taxation, procurement, government ownership and investment, special programs for particular transportation industry problems and impacts of general national policies on transportation will be included when relevant.

Economic evaluation includes the study of efficient resource allocation and distributional effects of alternative policies together with consideration of both partial and general equilibrium effects. The research is interdisciplinary in scope, drawing upon engineering, economics, statistics, law and administration.

There are four volumes included in this report:

- Volume I - Summary of First Year Report
- Volume II - Policy Review and Scenario Development
- Volume III - An Integrated Policy Model for the Transportation Industries
- Volume IV - Network Models for Transportation Policy Analysis

17. Key Words:
transportation policy
regulatory policy
interdisciplinary approach
federal policy
passenger & freight transportation

18. Distribution Statement:
Document is available to the U. S. Public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report): UNCLASSIFIED

20. Security Classif. (of this page): UNCLASSIFIED

21. No. of Pages:

22. Price:

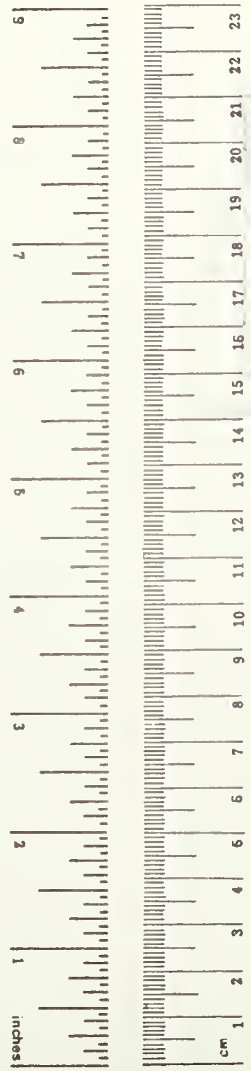
Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

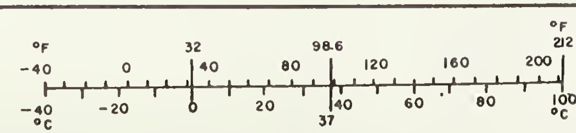
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Executive Summary

Alternative Scenarios for Federal Transportation Policy

Introduction

The purpose of this research is to develop and implement a number of linked models that can be used by policy makers to aid them in evaluating alternative scenarios for federal transportation policy. To this end, the research has analyzed existing transportation policies to determine a number of specific variables that are of particular interest to policy makers. It has then developed a number of linked models incorporating these variables that can be used to simulate the behavior of the transportation industries, regional incomes, and interindustry relationships under alternative scenarios of federal transportation policy.

Problem Studied

Federal transportation policies have wide ranging impacts upon the transportation industries and through them upon the regional and the national economies. Federal regulatory policies directly affect rates, routes, entry and mergers in the rail, trucking, air and inland waterway industries. Federal investment and user charge policies directly affect the infrastructure and costs of using highways, waterways, and airports while railroad abandonment policies affect the infrastructure and costs of using the railroad roadbeds. Policies dealing with safety, energy, the environment, and agriculture affect the costs and utilization of the various intercity modes.

Since transportation services are used as an input in virtually all industries in all regions, changes in any one of these policies that affect the equilibrium in the various modes will affect inter-industry flows, regional incomes, producer prices, employment, and so forth, which will in turn affect the costs and/or demand function in the transportation industries. Thus changes in transportation policies can have wide ranging impacts throughout the entire economy.

It is the purpose of this research to develop and implement a number of simulation models that can be used to quantify the impact of changes in transportation policies upon relatively broad aggregates concerning the transportation industries, other industries in the national economy, and upon the level of economic activity among the various regions in the nation as well as upon the level of service provided by the different modes to different types of communities. To this end, the research has developed a number of of linked models that can be used to quantify the impact of federal policies concerning intercity freight and passenger transportation upon a wide range of variables relevant to the transportation industries, the regional economies, and interindustry relationships.

Results Achieved

Policy Evaluation

Our research has indicated that policy makers have generally been more concerned with issues of fairness, support of rural and agricultural interests, and industry stability than with economic efficiency per se. Consequently variables that measure regional or locational price discrimination the general freight rate structure; modal profitability, employment, and wage payments and regional incomes and employment are incorporated into the analysis.

Freight Policy Models

Our research has developed the following linked models that can be used to evaluate the impact of federal transportation policy upon relatively broad transportation, regional, and industry aggregates such as output employment, incomes, profits etc.

- A regional transportation model that estimates cost and demand functions for the various modes that can be used to evaluate the impact of alternative transportation policies upon modal and firm equilibrium with respect to rates, costs, traffic allocations, factor utilization, shipment characteristics, etc.
- A regional income model that can be used to evaluate the impact of alternative transportation policies upon interregional commodity flows, regional incomes and employment by broad industry type.

- An interindustry model that can be used to evaluate the impact of alternative transportation policies upon inter-industry firms and factor employment by industry group.

<u>Air Policy Models</u>

While data limitations have prevented consideration of the network effects associated with freight transportation policy, the air models have focussed upon these effects. These air models have analyzed the distribution of flights among the various city pairs of the air network and analyzed how freqeuncy, load factor, and costs could be expected to react to changes in transportation policies.

<u>Utilization of Results</u>

The focus of the first year's research has been upon policy analysis and the development of models and methodologies that can be used to evaluate alternative transportation policies. Nevertheless, the following should prove useful to transportation analysts:

- A detailed evaluation of federal policy with respect to intercity transportation (rail, truck, air, water, and pipeline) considering cross modal policies with respect to rates, entry, and mergers, and documenting the implicit and explicit tradeoffs that have been made among fairness, support of rural and agricultural interests, industry stability, and economic efficiency.

- A general methodology that can be used to estimate short run and long run cost functions in the transportation industries that encompass multiple outputs and service attributes. These cost functions can also be used to determine short run and long run marginal costs by commodity, economies of scale, and the underlying production function.
- An analysis of trucking costs that indicates an absence of technological economies of scale when output is standardized for service attributes.
- An interindustry analysis that can assess the impact of changes in the costs and/or technology of the transportation industries upon resource utilization in the rest of the economy.
- An analysis of airline behavior in the major market areas, which assesses the impact of changes in rate or entry policy upon levels of service in these major markets.
- An analysis of the Continental airline system to see how a typical hub-spoke network would respond to changes in policies with respect to rates, entry, fuel costs etc.

Conclusions

Most analyses of federal transportation policy have concentrated upon global measures of economic efficiency and have thus had an excessively narrow focus. Since policy makers either implicitly or explicitly make trade-offs between economic efficiency and other goals associated with fairness, income maintenance, and industry stability, it is important to quantify the impact of changes in transportation policy upon these various goals. By developing a number of linked models that encompass variables reflecting distributional as well as efficiency goals, this research should provide the policy maker with tools to enhance rational decision-making.

ALTERNATIVE SCENARIOS FOR FEDERAL TRANSPORTATION POLICY

Volume I

Summary First Year Report

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Chapter One

Introduction and Overview

Although intercity transportation is provided by the private sector of the economy, virtually all aspects of the transportation industry are affected by federal transportation policies. The regulatory policies of the CAB and the ICC directly affect rates, routes, entry, and mergers in the rail, truck, air, water, and pipeline industries. The federal government provides funding for the bulk of the infrastructure used in the inland water, highway, and air industries. Although the federal government has not yet provided much support for rail infrastructure, with the formation of Conrail, there are signs that it may begin to offer substantial support for the rail roadbed. Federal policies with respect to user charges, subsidies, safety, energy, loan guarantees, environmental impacts and so forth all have a direct affect upon the behavior of the various transportation industries. Thus federal transportation policies have a wide ranging impact upon the transportation industries, and through them, upon the allocation of economic activity among industries and regions throughout the nation.

Clearly a change in any given federal transportation policy with respect to any given mode will have a direct impact upon the costs and/or demands facing the firms in that mode, and thus upon the equilibrium configuration of rates, traffic allocations, service levels, etc. within that mode. But, because it will change the relative prices and service levels among modes, it will also affect the rates, traffic allocations and service levels of the competing modes. However, the impact of changes in federal transportation policy does not stop with the transportation industries alone. Since transportation is used as an intermediate good in virtually all industries in all regions of the country, changes in transportation costs will alter the allocation of economic activity among industries and regions, and thus will lead to changes in the levels of income and employment among regions, among industries, among different kinds of labor and capital, and among cities of different sizes.

Consequently, it is the purpose of this research to analyze a wide range of alternative scenarios for federal transportation policy by evaluating the full general-equilibrium impacts of that change upon the transportation industries, the national economy, and the regional economies. To this end, this research will provide a number of integrated models that can be used to quantify the impact of changes in various transportation policies upon a wide range of variables that not only provide measures of aggregate economic efficiency, but also provide measures of level of service and the allocation of economic activity among regions, industries, and localities.

Most studies of transport policy have had an excessively narrow focus and thus failed to have much impact on policy. Economic studies have tended to look at the question from the viewpoint of economic efficiency alone, and have concentrated upon providing global measure of user savings, resource saving, or welfare losses. While informative, these studies have tended to ignore questions of the income distribution as well as broader questions of efficiency concerned with full employment and transfer costs. Thus what happens to employment and wages in a given transportation industry; what happens to regional income levels and the regional allocation of economic activity; what happens to the level of service to given communities have been questions that economists have generally not raised, much less answered.

Clearly, however, if one looks at legislative or regulatory proceedings, issues of the income distribution have tended to dominate the discussion. Whether service will be curtailed to a given city or class of cities; whether labor income and/or employment will fall within a given transportation industry or a given region; whether industry incomes and outputs will rise or fall; are all questions that the policy maker has tended to weigh more heavily than questions of aggregative economic efficiency. Thus, if economic analysis is to be used to help evaluate changes in transportation policy, it must not only provide answers concerning aggregative efficiency impacts, but also provide answers relative to a whole host of distributional questions. Consequently, one of the major goals of this research is to provide analytical models that can be used to quantify the magnitude of the various distributional effects as well as to quantify the magnitude of the efficiency effect of a change in transportation policy.

To approach this problem, we have undertaken the following activities:

- A review of federal policy with respect to the rail, truck, water, air, and pipeline modes.
- Development of alternative policy scenarios with respect to the various modes.

- Development of integrated models to assess the impact of federal transportation policy upon the surface freight industries, interindustry flows, the regional economies, and the national economy.
- Development of models of the air industry that analyze the impact of alternative air policies upon carrier profitability, fares, and the distribution of service over the network.

Thus this report takes the following form:

Chapter Two undertakes a review of existing federal transportation policies. If it is to be useful for policy evaluation, any modeling effort must include variables that concern the relevant policy makers, whether they be associated with regulatory agencies, or the legislative, judicial, or executive branches of the government. Consequently, a major effort must be undertaken to analyze current transportation policies to determine their goals (implicit as well as explicit) and how they have evolved over time. Such an analysis will enable us to evaluate the consistency of these policies and to determine a number of policy scenarios that can be evaluated by our policy models.

Chapter Three summarizes the work that has been undertaken to develop a number of integrated models that can be used to evaluate the impact of a wide range of transportation policies upon the following kinds of variables for the intercity transport modes: traffic allocations, rates, profitability, costs, employment by transportation industries; outputs, employment, prices, and factor prices by industries for the nation as a whole; employment, income, and wage by industry and by region. This analysis provides a vehicle for quantifying the impact of transportation policy upon a wide range of fairly aggregative economic variables that not only provide measures of economic efficiency, but also provide measures of the gainers and losers of a given change in transportation policy by industry (both within transportation and elsewhere), by region, and by factor. However, because this level of analysis is fairly aggregative, it fails to encompass questions of the pattern or level of service to various users.

Chapter Four considers the question of pattern of service over the transport network within the context of the air industry. This chapter presents a programming model that can be used to analyze the impact of alternative air policies with respect to rates, routes, entry and so forth upon the provision of air service over a given network, its frequency of service, its rates, and so forth. This chapter presents some specific policy experiments that can be used to evaluate the consequences of alternative policies.

Chapter Five provides a broad summary and outlines future work.

Chapter Two

Policy Review and Scenario Development

I. Introduction and Overview

The federal government has traditionally played an active and diverse role in domestic transportation. Federal regulatory policies directly affect rates, routes, entry and mergers in the intercity transportation industries: rail, trucking, barge, and air. The federal government largely determines the quantity, quality and costs of the infrastructure in the trucking, barge and air transport industries through its investment and user charge policies. While its role is somewhat less direct, it also affects the quantity and quality of the infrastrucutre in the railroad industry through its abandonment policies, and, with the establishment of Amtrack and the reorganization of the Northeast railroad into Conrail, is beginning to enter into a new phase of direct subsidy and operations in, at least, rail activities.

In addition to these major promotional and regulatory roles, the federal government undertakes a number of other activities that affect the intercity transportation industries. Energy policy directly affects fuel costs and thus the relative costs of the various intercity modes. In addition, environmental controls affect emissions and noise levels of motor vehicles and aircraft and thus their relative costs. Finally, federal policies with respect to safety, union work roles, and loan guarantees can have substantial impacts upon the transportation industries.

With such a diverse spectrum of activities, it would be surprising if all federal policies were aimed at the same goals or affected all transportation industries consistently. Indeed, one need only look at the Preamble in the National Transportation Policy of the Transportation Act of 1940, which called for the Interstate Commerce Commission (ICC) "to preserve the inherent advantage of each mode" and the federal funding of the Interstate Highway System and the extensive network of waterways to realize that these policies may often be in direct conflict.

Nevertheless, it is our belief that while regulatory and investment/user charge policies may often pursue overtly conflicting goals, they have a certain rationality when viewed within a somewhat broader perspective of the multiple objectives of the policy maker. By recognizing that federal transportation policy attempts to satisfy a broad range of goals, which themselves may not be entirely consistent, it is usually possible to explain policy action on the basis of implicity or explicity tradeoffs among these several objectives.

The recognition that transportation policy is aimed at multiple objectives is obviously important for policy analysis and the development of alternative scenarios for federal transportation policy. If we focus on one objective at the expense of the others, our analysis will be less relevant and useful for policy evaluation than if it had encompassed all of the relevant dimensions. If, for example, policy makers are concerned about issues of equity and the income distribution, they will tend to discount policy evaluations that concentrate on aggregate efficiency impacts of transportation policy. Conversely, however, to the extent that issues of economic efficiency are important to policy makers, analyses that solely consider the income transfers implied by transportation policies will be inadequate. Insofar as policy makers (whether they be legislators, administrators or even judges) make implicity or explicity trade-offs among various objectives, their actions may appear to be irrational when viewed from the perspective of any single objective. Thus if we are to build models that can be useful for policy evaluation, it is essential that we include the relevant objectives in our analysis. Consequently, this chapter attempts to identify the major objectives of transportation policy and demonstrate how they can then be incorporated into the analytical models that are being developed for policy analysis.[1/]

Part II of this chapter analyzes existing transportation policy and identifies the major goals that transportation policy has tried to meet. Its major argument is that transportation policy has implicitly or explicitly made trade-offs among the various goals encompassed in economic efficiency and various aspects of the income distribution and that it has in fact presented a kind of consistency if not economic rationality.

Part III then indicates how these policy goals can be incorporated into analytical models that quantify the impact of changes in federal transportation policies and develops a number of illustrative scenarios for the air and surface freight industries.

[1/] For a full description of these models see Friedlaender _et al._ (1977), and Simpson _et al._ (1977).

II. Federal Transportation Policy

As we have indicated above, federal transportation policy includes a diverse number of activities that serve a diverse number of goals. It is the purpose of this section to identify these goals and indicate the implied trade-offs among these goals. In particular, it is our belief that questions of income gains and losses to specific groups, of industry stability, and of shipper equity have tended to dominate questions of economic efficiency in regard to regulatory and investment policies. Consequently, although measuring the efficiency impacts of transportation policy is an important activity, it will necessarily fail to consider the full dimension of the problem.

Although federal transportation policies encompass a wide range of activities, regulatory and investment/user charge policies dominate the others in terms of their pervasiveness, the magnitude of their impacts and their political importance. We will consequently focus upon these policies and only discuss other aspects of federal transportation policy when relevant to the objectives contained in regulatory and investment policies.

A. The Efficiency Costs of Regulatory and Investment Policies

In recent years, a large literature has developed assessing the impact of federal regulatory policies in terms of economic efficiency.[2/]

[2/] The seminal work in this area is that of Meyer *et al.* (1959). Subsequent analyses focusing on intercity freight include the Doyle Report (1960), Friedlaender (1969), Moore (1972), Keeler (1976). Studies focusing on the air industry include Jordan (1970), Eads (1972), Keeler (1972), and Douglas and Miller (1974).

While these studies differ in details of methodology and approach, they are remarkably consistent in arguing that present regulatory policies encourage excessive rates and capacity, as compared to the competitive norm. Thus, they argue, in the absence of regulation, rates and capacity could be expected to fall, leading to lower costs, more efficient utilization of resource, increased shipper profits, and consumer satisfaction. The total costs of these inefficiencies have been variously estimated to range between $5 and $10 billion.[3/]

Although the efficiency impacts of investment policies and user charges have received considerably less attention by economists than the efficiency aspects of regulatory policies, a number of studies have attempted to assess the federal investment programs in highways and waterways.[4/] While it is clear that certain highway or waterway investments can be shown to be desirable in terms of the usual cost-benefit criteria, it is equally clear that a large number of them cannot.

Moreover, economists have long been unanimous in condemning the absence of any user charge for waterway improvements. Since other modes are either forced to pay user charge for the publicly provided infrastructure (trucks) or are forced to provide it themselves (rail), the lack of any user charge for waterways clearly distorts relative costs in favor of barges. Thus the observed cost differentials that exist among these modes does not reflect true differences in resource costs, but

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[3/] See, for example, Moore (1972), Keeler (1976), Phillips (1975).

[4/] See, for example, Friedlaender (1965), The Doyle Report (1960).

rather artificial differences due to federal investment and pricing policies.

If the economics profession has been remarkably consistent in its condemnation of federal regulatory and investment/user charge practices, the political process has been equally remarkably consistent in its unwillingness to change these practices and policies.[5/] This indicates that other goals served by regulation and investment in infrastructure are given more weight than economic efficiency by the relevant policy makers. Alternatively stated, the behavior of the political process indicates that policy makers have felt that the achievement of these other goals is worth the efficiency costs. Thus the response of the policy makers to the documentation of these costs cannot be called irrational. But it does indicate that economic efficiency must be receiving a very low weight relative to other goals in their objective functions.

B. The Rationale of Regulation

If economic efficiency does not appear to be a major goal of policy makers concerned with transport regulation, it is important to identify the major goals, for only by making the trade-off between these alternative goals and economic efficiency explicity can we develop a framework that can be useful for rational policy analysis.

Nevertheless, identification of these goals is made difficult because the American political process tends to make implicit rather than explicit trade-offs and to react to rather ill-defined goals rather than well-

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[5/] The recent passage of the Railroad Regulatory Reform and Revitalization Act in 1976 (RRRR Act) indicates that this may be changing.

defined goals. Thus it is probably impossible to understand present regulatory policy and its evolution without understanding the nature of the political process in the United States.

1. The Politics of Change in the United States

The United States' political system differs sharply from those in other countries such as Britain or France in that there is no central authority that can decide upon the desirability of change and then ensure its implementation. Political power in America is deliberately divided among the various branches of government, between the central government and the States, and between the States themselves. Each of these entities has some power to frustrate, delay and even veto proposals for change. Thus no regulatory or administrative proposal stands much of a chance of being implemented unless it commands widespread acceptance by most of the interest groups involved in the issue.

Consequently, problems must be widely recognized as legitimate and important if they are to receive serious consideration for resolution in the political process. The policy problems that will command sufficient attention to attain resolution are, thus, those that arise from broadly-based public perceptions of deficiency between what is and what could be. These are the issues that policy makers may feel are worth spending effort and political capital on.

Conversely, policy problems are only rarely, if ever, defined by groups of experts relying solely on their professional standards as to what is right. An economist may see that the regulation of transportation creates inefficiencies. An engineer may find that this same regulation is a barrier to technical innovation. Although both may be correct, little change in policy is likely to result from these observations until public sentiment is sufficiently aroused to motivate the many interest groups to cooperate in doing something about the situation.

While something of an oversimplification, one can argue that changes in regulatory policy only come about in time of crisis in response to widely held views that major change were necessary. Thus the original passage of the Interstate Commerce Act in 1887 was not so much a response to the specific special interests, but instead a response to a wide range of divergent interests that desired regulation. As Friedlaender (1969, p. 2) has stated:

> When regulation of railroads was first introduced in 1887, it was widely supported. Small, isolated shippers wanted it to protect them from the monopoly power of the railroads. Western communities wanted it to limit the railroads' heavy-handed exercise of economic power over rates, routes, and the placement of depots. The general public wanted it to control the frequent rate wars, the watered stock, the irresponsible land speculation, and the many bankruptcies and reorganizations. The federal government wanted it to ensure relatively low freight rates on goods coming from the West to encourage the continued settlement and development of this region. The railroads supported it (or at least acquiesced to it) to formalize the existing rate structure and to end the instability created by frequent rate wars. Thus, the Interstate Commerce Act of 1887 and the regulatory structure it established enjoyed wide support. Regulation controlled the monopolistic excesses of the railroads while permitting them to maintain a rate structure that benefited not only the railroads but society. [6/]

6/ For an elaboration of these views see Buck (1913), Kolko (1965), Benson (1955), Tarbell (1904), MacAvoy (1965).

Similarly, the Transportation Acts of 1935, 1938 and 1940, which respectively introduced the regulation of motor carriers, air carriers and inland water carriers resulted from attempts to deal with the crises and disruptions caused by the Great Depression. Faced with bankruptcy of many firms, excess capacity and cutthroat competition, the carriers favored regulation which would help control the competitive excesses of the industry and stabilize rates and profits. Shippers favored regulation because it would lead to stability and reduced uncertainty concerning rates. Agricultural interests favored regulation to ensure that the traditional value-of-service rate structure would be maintained. Thus, again, major changes in regulatory practices only came about when a wide concensus developed that existing practices led to intolerable situations as perceived by broad groups of shippers and carriers.

Even in time of crisis that may engender major institutional changes, however, it is only realistic to expect that these changes will be directed toward the issues of the moment. For example, instead of effecting major changes in the regulatory framework, the Acts of 1935 and 1940 each brought trucking companies and water carriers under regulation, thus leaving the basic structure of regulation unchanged. Consequently, even if major changes in institutional arrangements occur, it is likely that they will do so in a piecemeal fashion instead of by comprehensive legislation that covers all aspects of transport regulation.

The implementation of change in a piecemeal fashion is also consistent with the tendency of the American political process to compromise and accommodate diverse interests. Since change requires the acquiesence of many different groups, explicit efforts must be made to bridge their differences. This desire for accommodation should affect the nature of the proposals that are acceptable for change. Because policy makers attempt to maximize the political acceptability of innovation, they try to structure the legislation to appeal to as many diverse groups as possible.

This desire for compromise and accommodation was evident in the creation of Amtrack and Conrail. Instead of outright nationalization or abandonment of service, Amtrack and Conrail attempt to preserve service within a private framework. Even though operating companies were found that belong to the federal government, the autonomy of the private companies was preserved and service was maintained. Although the formation of these companies may well facilitate the eventual nationalization of the vast network and abandonment of service, this change (if it occurs) will necessarily come in a slow and piecemeal fashion. Similarly, although the construction of the Interstate Highway System marked a fundamental departure in policy by providing massive amounts of federal funds for the highway infrastructure, which caused a dramatic change in the relative costs of rail and truck transportation, its significance as transportation legislation was minimized by labeling it as a defense measure.

Since the American political process is based upon compromise and accommodation, which often attempt to blur the magnitude and significance of the change, it is usually difficult to identify the key motivations for any piece of regulatory legislation or any important regulatory decision. The preambles or rationales for the documents tend to include all the elements that have any political support. Consequently, the major forces leading to regulatory change generally have to be deduced from their ultimate consequences instead of from the documents themselves.

Moreover, since the political process stresses compromise among conflicting forces, the identification of the major themes that have motivated and shaped transport regulation in the United States is essential if we are to develop politically viable alternatives to the existing regulatory structure. Without identifying these themes, it is impossible to understand which problems the public will accept as legitimate and, thus, which problems may present a reasonable possibility for effective political action. In short, the major themes motivating the existing regulations must be known by anyone wishing to develop feasible strategies for change.

2. Major Issues

The identification of the major motivations that have led to the existing regulatory structure is difficult, however, since they are not clearly defined by the Acts of Congress, the decision of the regulatory agencies, or the rulings of the Courts. As suggested earlier, this lack of clarity of purpose is an expected feature of the American political process. Since our system essentially requires that issues be blurred and compromised, it is necessary to interpret the overall patterns that have emerged over time to determine the principal motivations for regulation.

Nevertheless, examination of the record indicates that policy makers have fairly consistently been concerned with the following issues:

- Fairness
- Support of Rural and Agricultural Interests
- Industry Stability.

Let us consider each of these in turn.

Fairness. The issue of fairness was a major one in the passing of the Interstate Commerce Act of 1887 and has continued to be a dominant theme in subsequent regulatory changes. Prior to the passage of this Act in 1887, the railroad rate structure was characterized by pervasive price discrimination among shippers, localities and commodities. Small-lot shippers and isolated communities with no alternative means of transport were charged rates far in excess of those charged for comparable service where railroads faced competitive pressures. Large volume shippers, communities served by several means of transport or alternative sources of supply generally enjoyed low rates, while the railroads exploited their monopoly power with respect to their captive shippers.

Thus it is not surprising that the bulk of the initial Interstate Commerce Act of 1887 was aimed at the prohibition of disciminatory practices among persons and locations. In particular, this Act effectively prohibited the monopoly exploitation of small shippers by requiring that rates be just and reasonable (Section 1), by explicitly prohibiting personal price discrimination (Section 2), undue preferences between persons, localities and type of traffic (Section 3), and the practice of charging more for a short haul than a long haul over a common line (Section 4).

Although the Act has been considerably altered during the ensuing 90 years, virtually no efforts have been made to alter its prohibitions against personal price discrimination. Indeed, the market dominance provision of the recent RRRR Act can be interpreted as an effort to ensure that discriminatory pricing will not occur as the railroads undertake more flexibility in rate making.

Fairness or nondiscriminatory pricing has also played an important role in the CAB's decisions concerning rate differentials. While it has always been willing to permit rate differentials for service differentials, i.e., rate difference for first-class and economy service, it has been somewhat ambivalent about permitting rate differentials for other classes of service. During the past decade the Board has vacillated between permitting rate differentials for less convenient service (the family excursion plan, the Bicentennial fares, student discounts), and feeling that these differentials were discriminatory and hence unacceptable. Current policy appears to permit rate differentials that are clearly based on service differentials in terms of convenience, but to prohibit differentials that are based on the characteristics of the traveller. Thus Bicentennial fares that force the traveler to fly at certain times and to make reservations in advance are acceptable, while student discounts are not.

In addition, the CAB requires a uniform fare taper or relationship between fare and distance. Thus people flying between Grand Forks, North Dakota and Des Moines, Iowa face essentially the same fare structure as those flying between Boston and Washington, D.C., even though the airlines are able to achieve substantial economies of density on the heavily traveled routes. Since rate differentials based on route density would appear discriminatory, even though they would in fact reflect cost differentials, the CAB has resisted them.

Nevertheless, price discrimination is pervasive in the transportation industries; price-marginal cost ratios differ among different types of commodities and different types of users. The value-of-service rate structure is frankly discriminatory and the cross subsidization of various types of traffic in the air and surface freight industries is widely recognized and accepted. Thus while considerations of fairness prohibit certain forms of price discrimination, they do not prohibit all of them. It is consequently instructive to analyze the nature of the permissible price discrimination, which will indicate the role that regulatory practices have played in supporting agricultural and rural interests.

Support of Rural and Agricultural Interests. Value-of-service pricing is a key characteristic of the freight rate structure. Under this structure low-value agricultural and bulk commodities are charged low rates relative to costs while high-value manufactured commodities are charged high rates relative to costs. Thus although the Interstate Commerce Act of 1887 prohibited all forms of personal price discrimination, it permitted the retention of a major form of discriminatory pricing. in the value-of-service rate structure.

Since the value-of-service rate structure clearly favors rural and agricultural interests, it is entirely consistent with a more general public policy that has tended to favor these interests. Indeed, the support of agricultural and rural interests has been a dominant theme of American political life. Thus just as direct price supports or subsidies can be viewed as vehicles of income maintenance for agricultural and rural groups, so can the transportation policies of the value-of-service rate structure, the construction of the Interstate Highway System, and the construction of the extensive waterway network with its lack of user charges.

When regulation was initially instituted, the value-of-service rate structure met a number of important goals. It not only made sense as a vehicle for social policy by ensuring low rates on agricultural commodities but also made sense from the point of view of the railroads who could obtain higher profits with a discriminatory rate structure than a nondiscriminatory one. As Friedlaender (1969, p. 16) has argued:

> The rate structure that maximized the railroads' profits was also the one that encouraged the development of the West. At that time regulation unquestionably served important social goals and created few, if any, losses in terms of economic efficiency.

Nevertheless, with the growth of truck competition, the value-of-service rate structure was no longer the profit maximizing rate structure. Nelson and Greiner (1965) have argued convincingly that the railroads consistently attempted to raise rates on non-competitive agricultural commodities between the passage of the Transportation Act of 1920, which in principle permitted rate-of-return rate making,[7/] and the passage of the Transportation Act of 1935, which brought motor carriage under regulatory control. Nevertheless, the ICC consistently

[7/] The Transportation Act of 1920 estiablished "fair return on fair value" as the rule of rate making to be followed by the ICC.

prevented these rate increases, citing the depressed state of agriculture and the Hoch-Smith resolution of 1925 which gave a clear legislative sanction to the value-of-service rate structure. Indeed, the extension of regulation to motor carriers and water carriers can be interpreted as an effort to maintain the traditional rate structure in the face of competitive pressures that would otherwise have eroded it.

Recent transportation policy also indicates the importance of rural and agricultural interests. With respect to regulatory policies, the ICC has consistently prohibited charges that would tend to undermine the traditional rate structure. To this end, it has insisted that railroads prove that their rates are compensatory and cover long-run marginal costs and hence will not place an undue burden on other traffic. Similarly, the ICC has generally been unwilling to permit the railroads to cut rates to "retain or regain a fair share of [the high-value] traffic," even though the rate is "remunerative."[8/] Apparently, the ICC feels that such reductions would erode the profitability of the high-value traffic and hence place pressure on the traditional rate structure.

As indicated above, federal investment and user charge policies also seem to be oriented toward agricultural and rural interests. In several cases, high freight rates are explicitly cited as the rationale for construction of inland waterways.[9/] Moreover, the pro-

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[8/] For a full discussion of these points see Friedlaender (1969).

[9/] See, for example, the Doyle Report (1960, p. 95).

cedures used by the Corps of Engineers to measure benefits are frankly related to the railroad rate structure. Since benefits are measured by the differentials between rail rates and barge costs, there is a clear presumption that waterway construction will lead to lower rates to producers of bulk agricultural commodities. Since one of the goals of waterway construction is reduced freight rates, it would thus be counterproductive to impose user charges that would tend to offset these rate reductions. Consequently, the federal investment and user charge policy in waterways has a clear political rationale, if not an economic one.

Although the Interstate Highway System was sold in terms of its general national impacts upon all regions of the country, it seems clear that it has dramatically improved the accessibility of rural areas and reduced, if not eliminated, the latent monopoly power of the railroads with respect to rural and agricultural areas that do not enjoy water competition. While the completion of the urban segments of the Interstate System has often been delayed by excessive costs and local opposition, the rural segments of the System have largely been completed on schedule. Thus virtually all areas of the country now have a viable (if more expensive) alternative to rail transportation.

Whether considerations of the traditional rate structure entered explicitly into the decision-making calculus of the legislative process when the Interstate Highway Act was passed in 1958 is impossible to say. It is clear, however, that by virtually any cost/benefit calculus, much of the rural Interstate System was not economically justified.[10/] From this we can only infer that accessibility and low-cost transport to rural areas were viewed as being sufficiently important to merit the construction of a large number of links of questionable merit in terms of economic efficiency.

Finally, the abandonment provisions of the Railroad Revitalization and Reform Act of 1976 also indicate that a concern with rural and agricultural interests still persists. As high-value traffic has increasingly been diverted to trucks at the expense of the railroads (partially due to the lowered trucking costs occasioned by the Interstate Highway System), increasing amounts of rail lines have been subjected to falling traffic densities. Since there is considerable evidence that there are substantial economies of density,[11/] this means that costs have risen substantially on these lines. Because the railroads are prevented from raising rates on this traffic, either by regulatory controls or by truck or water competition, it is likely that much of this traffic has become uneconomic for the railroad to carry. The rational behavior of the railroads in this situation would be to abandon this traffic. Thus if the railroads were free of all capacity controls, it is likely that they would abandon a substantial amount of their light density lines.

However, the Regulatory Reform and Revitalization Act of 1976 has made abandonment considerably more difficult than it previously has been. Specifically, the Act prevents abandonment in the face of sufficient

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10/ See, for example, Friedlaender (1965).

11/ See, for example, Keeler (1974), Caves and Christenson (1976).

shipper opposition and instead provides modest subsidies for the continuation of service. Since rural and agricultural interests would presumably be the hardest hit by massive abandonment of light-density lines this provision is clearly consistent with the traditional stance in favor of these interests at the expense of urban and suburban interests.

Finally, the structure of air rates has also discriminated in favor of rural areas. While there is a certain amount of controversy concerning the existence of cross subsidies between rural and urban interests in the sense that the airlines actually suffer losses on their light density traffic,[12/] it is generally agreed that a cross subsidy exists in the sense that rates to rural areas are lower and service is higher than each would be in the absence of regulatory controls. In addition, the Board grants explicit subsidies to local carriers.

The problem facing the airlines is quite similar to that facing the railroads. In both cases, economies of density would dictate a rate structure that was characterized by lower rates on high density traffic characterized by large traffic volumes over a given link. In fact, however, rates for "similar" traffic are the same regardless of the traffic density. Thus the rate structure discriminates in favor of the low density areas since the price-marginal cost ratios they experience are much lower than those associated with high density areas.

In the absence of regulation, it is highly likely that the airlines would either reduce service or raise rates (or both) to low density

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[12/] See, for example, Douglas and Miller (1974), and Eads (1972).

regions to make their returns on this traffic commensurate with the returns to other traffic, particularly since the demand functions of this traffic are probably quite price and service inelastic. This, of course, would not be in the best interests of these rural communities which have enjoyed service on a general parity with other regions. Thus, again we see that regulation has tended to favor these regions.

Im sum, it seems clear that one of the major themes of transportation policy has been the support of rural and agricultural interests. The freight rate structure and the air rate structure clearly discriminate in favor of small communities and rural regions. The federal investment and user charge policies in highways and waterways can largely be explained in terms of a desire to provide alternative sources of transportation to regions that are subject to potential monopoly power on the part of the railroads. The abandonment provisions of the Regulatory Reform and Railroad Revitalization Act of 1976 act to ensure continued rail service to rural regions that generate light traffic density.

Income redistribution from urban and suburban areas to rural and agricultural regions has also been a major theme of American public policy. The farm subsidy, the stockpiling procedure for raw materials, and the tariff structure have all been designed to aid rural and agricultural groups. Thus the income redistribution implicit in the transportation policies concerning rates and infrastructure is entirely consistent with broader policy goals and actions.

This indicates, however, that in the absence of a major shift in public opinion and public policy, any changes in transportation policy that adversely affect rural and agricultural interests will probably not be politically or socially acceptable.

Industry Stability. While probably somewhat less important than fairness, or support of agricultural and rural interests, the issue of industry stability has consistently been a concern of regulatory authorities. The following quote in the Railway Review of 1886 expresses the general attitude toward stability quite well.[13]

> The rate wars which have of laté years so devastated the finanaces of the railroad companies, are all inaugurated and carried out upon interstate traffic . . . they introduce elements of chance into the transactions of business. . . In the interests of the producer, transporter and consumer, governmental regulation of inter-state traffic is necessary and desirable. . .

Congress has repeatedly endorsed the notion of price stabilization (or fixing) in transportation. The Transportation Act of 1920 established regulation of minimum rates for railroads and reinforced the railroads' capabiltiy to prevent rate wars and set prices. Later, when these practices came under attack under the antitrust laws, Congress exempted them from these statutes through the Reed-Bulwinkle Act of 1948.

More recently, Congress has endorsed the notion of price stability in the surface freight industries in the Transportation Act of 1958 and the RRRR Act of 1976. In the first case, Congress flirted with passing legislation that specifically prohibited umbrella rate-making, under which rates of the low-cost carrier are maintained to protect

[13] Quoted in Kolko (1965), p. 40.

the high-cost carrier.[14] However, when it became clear that the passage of such legislation would free the railroads to reduce rates to attempt to capture the high-value traffic, Congress retreated from this position.[15] The recently passed RRRR Act is rather ambiguous on this point. Although it does permit railroads to charge rates within a seven percent band, it can prevent these changes in the face of market dominance, which presumably means situations in which such rate reductions would hurt competitors. Thus concerns with industry and market stability still appear to be very strong.

Generally, the regulatory agencies have consistently acted to preserve the status quo and to maintain threatened firms or industries. The Civil Aeronautics Board has consistently attempted to save specific airlines firms from collapse by giving troubled airlines advantageous routes.[16] When all else fails, the Board arranges rescuing mergers, as it did between Capitol and United and between Northeast and Delta. Similarly, the Interstate Commerce Commission carefully examines proposed railroad rates to see if they might lead to "destructive competition" and impose a risk of driving a competitor or competing mode out of business.[17]

14/ For a full discussion of this see Friendly (1962).

15/ This retreat could also be interpreted as an effort to maintain the traditional rate structure.

16/ For example, the CAB gave Northwestern lucrative routes to Florida and California. It also arranged route exchanges between TWA and Pan American to bolster their international operations.

17/ For a full discussion of these points see Friedlaender (1969).

The ICC has also been extremely reluctant to grant certification of entry to motor carriers in new markets. Even if existing shippers argue that existing service is inadequate, the Commission will generally refuse to grant a new certificate in the face of opposition from existing carriers.[18/]

The way in which regulatory agencies respond to innovations further illustrates their desire to prevent rapid dislocations. It takes years for them to incorporate threatening new technology into the pattern of service. The Interstate Commerce Commission, for instance, long resisted the introduction of the "Big John" railroad cars. This was only accomplished after protracted legal maneouvers which eventually permitted the railroads to operate these cars, but only under conditions that prevented the railroads from fully exploiting their economic advantage. Difficult as it is for existing modes of transportation to introduce new technology, it appears even more difficult for new modes to gain recognition. The nonscheduled airlines in the United States have, for example, been trying for decades to inaugurate the kind of charter services so common in Europe. The Civil Aeronautics Board has resisted these proposals and today similarly resists the proposals of Federal Express to provide all-cargo service.

It is clear, however, that the carriers are as anxious to maintain stability as the regulatory agencies and Congress. Proposals for deregulation have consistently met opposition from the various modes.

[18/] For a full discussion of this point see Fulda (1961), Williamson (1958).

The trucking industry is unanimous in its condemnation of regulatory reform that would ease present restrictions concerning rates and entry in the trucking industry. The airlines have consistently voiced strong opposition to the deregulation of airline fares. They assert that deregulation would encourage airlines to desert routes during off-seasons when traffic is low, thus failing to provide adequate service to the public. Although the airlines are ostensibly complaining on behalf of their passengers, the lack of concern about deregulation from consumer groups--indeed, their general endorsement of this proposal--leads one to suspect that the airlines are really concerned about instabilities they themselves might encounter.

This concern with stability on the part of Congress, the regulatory agencies, and the carriers has prompted numerous critics to argue that regulation is really aimed at cartelization of the industry.[19/] Thus, it is argued, regulation does not really serve the public interest, but the interests of the regulated industry.[20/]

While being outwardly appealing, this argument is probably too simplistic. Although regulation does indeed increase the stability of the regulated carriers, it also ensures the other goals of fairness and support of rural and agricultural interests, which are also benefited by industry stability. Since, for example, instability with respect to rates of entry could threaten the traditional rate structure or encourage the industry to attempt new and novel ways of price discrimina-

19/ See, for example, Huntington (1952).

20/ See, for example, Fellmeth (1970).

tion, it appears that the other two goals are entirely consistent with industry stability. Indeed, present regulatory practices are such as to ensure that the goals of fairness, support for agricultural and rural interests, and industry stability generally act in harmony.

Economic Efficiency. While these three goals are generally consistent with each other, it should be clear that they are not generally consistent with economic efficiency. The efficiency costs of regulation have been extensively documented elsewhere.[21/] Thus we need only summarize what should by now be a well-known argument.

With respect to intercity freight transportation, it is generally agreed that present regulatory practices encourage excess capacity and an inefficient rate structure. Specifically, because the railroads are constrained from abandoning their unprofitable track, they are forced to operate along an inefficient short-run cost curve instead of an efficient long-run cost curve. Since the railroad trackage was built for volumes far in excess of those that exist now, a rationalization of the railroad roadbed could lead to annual savings of \$2 to \$3 billion.[22/] Moreover, because of the rate differentials between high-valued manufactured commodities and low-valued bulk commodities, society incurs a dead weight loss of approximately \$500 million. Thus, it is argued, a rationalization of the rate structure in conjunction

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[21/] See, for example, Meyer et al. (1959), Friedlaender (1969), Moore (1972), Keeler (1974, 1976), Jordan (1970), Eads (1972), Douglas and Miller (1974).

[22/] For a full discussion see Keeler (1974) and Friedlaender (1972).

with appropriate abandonment could lead to annual resource savings in excess of $3 billion.[23/]

Regulation also encourages excess capacity in the air and trucking industry. Although regulatory authorities control the rate structure, they fail to control the level of service or number of vehicles utilized by any given firm. Since firms believe that their market share is associated with frequency of service, they have an incentive to offer more trips. Thus firms will tend to provide excess capacity and eliminate the potential profits associated with the regulated rate. Consequently, service and capacity will be directly linked to the regulated rates. Since the regulated rates are greater than those expected under competition, capacity is also greater than that expected under competition. Consequently, regulation not only imposes a dead weight loss from the rate structure, but also imposes a capacity cost. In a deregulated environment, it is likely that air and trucking rates would be lower and that there would be less excess capacity.[24/]

Finally, it is well documented[25/] that investment and user charge policies are inefficient. With respect to investments, a large number of inland waterways and links on the Interstate Highway System have been shown to be uneconomic in terms of the usual cost-benefit criteria. With regard to user charges, it is generally agreed that the lack of

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[23/] See Keeler (1976).

[24/] See Douglas and Miller (1974) for a full discussion of these points.

[25/] See Friedlaender (1965), Meyer et al. (1969), The Doyle Report (1960).

user charges on inland waterways distorts relative costs in favor of barges. Moreover, there is some evidence that heavy diesel trucks do not pay their full share of highway costs. Consequently, the private costs of barge and trucking activities fail to reflect their true social costs.

Since the present regulatory and investment policies appear to impose a considerable efficiency cost upon society, we can only infer that the attainment of the goals of fairness, support of agricultural and rural interests, and industry stability are thought to be worth these efficiency costs. Thus the issue facing regulatory and investment policy is not so much whether it leads to efficiency costs, but whether the attainment of these goals is deemed sufficiently important to warrant the present magnitude of these efficiency costs. Alternatively, we can also ask whether new institutional arrangements could be found that would reduce these efficiency costs while permitting the achievement of the other goals.

C. Implications for Scenario Development

Having reviewed major policy actions with respect to the intercity transportation modes, let us summarize our analysis. In terms of evaluating policy change, the most important conclusion is that since transportation policy attempts to satisfy a multiplicity of goals, any policy evaluation must attempt to assess the impact of change upon this multiplicity of goals. While obvious, this point is extremely important since critiques of existing policies have been notable for their concern with economic efficiency at the expense of other goals.[26/]

[26/] See, for example, Moore (1972), Keeler (1976), and Douglas and Miller (1974).

Since critiques of existing policies have generally been made by economists, their concern with economic efficiency is understandable. Indeed, these critiques have performed an extremely important function in demonstrating that in achieving their goals of fairness, income maintenance and industry stability, existing transportation policies have imposed considerable efficiency costs upon society.

Since the policy maker must be concerned with trade-offs at the margin, however, these analyses have not been particularly useful for policy analysis because they have failed to indicate the nature of the trade-offs between economic efficiency and the other goals. To cite an extreme, for example, if a relaxation of regulation would lead to marked locational price discrimination, a reduction in real income in agricultural and rural areas, and a marked increase in industry instability as measured by bankruptcies and variance in rates, it is likely that the present regulatory policies would be thought to be worth their efficiency costs. If, on the other hand, a relaxation of regulation would have few, if any impacts, upon locational price discrimination, agricultural and rural incomes, and industry stability, then the prospects for deregulation would become considerably brighter. Thus, unless policy makers have some notion of the mangitude of the trade-offs involved, they will generally fail to act to change the status quo.

Consequently, it is the purpose of this research to analyze and quantify the nature of the trade-offs among the various goals of transportation policy. To this end, we are developing a number of linked policy-sensitive models that are summarized in Chapters Three and Four of this report. The next section of this chapter will thus briefly describe our modeling approach and indicate how alternative policies could be evaluated by our models.

III. Scenario Development

Having argued that meaningful policy evaluation must include a number of alternative objectives, let us now consider the question of how these various goals can be incorporated into quantitative analysis. To this end, this section discusses the general modeling approach used in this research and indicates how various policies can be evaluated within its context.

The purpose of this research is to develop and implement a number of models that can be used to evaluate transportation policies with respect to the surface freight and air industries. Because of differences in the availability of data, the focus of the freight models and the air models is necessarily somewhat different. The freight models are relatively aggregative and consider the impact of policy changes upon the rate structure, profitability, and outputs of the transportation and related industries and upon regional incomes and employment. In contrast, the air models are highly disaggregate and focus upon the behavior of a single firm over a network. Thus the freight analysis is aimed at evaluating industry and regional impacts of alternative transportation policies, while the air analysis is aimed at evaluating specific network effects of a given firm (or a group of firms acting in concert).[27/]

[27/] For a full discussion of these models see Friedlaender *et al.* (1977) and Simpson *et al.* (1977).

Nevertheless, the basic structure of the freight and air models is quite similar in that each assumes profit maximization with known cost and demand functions. Changes in transportation policy are then transmitted through changes in the relevant cost functions, the relevant demand functions, or the competitive behavior of the firms in the industry, which in turn lead to changes in rates, outputs, income, profits and so forth. Thus by linking measures of fairness, income maintenance, industry stability and economic efficiency to changes in transportation policy, it is possible to provide quantitative information about the nature of the trade-offs among these various goals. This section therefore discusses how various general policies can be evaluated in the freight and air models that are being developed as part of this research and considers specific policy scenarios that could be evaluated using these models.

A. Evaluating Frieght Transportation Policies

1. The Modeling Structure

The basic premise of the analysis is that relative prices matter. Thus any change in transportation policy should lead to a change in the transportation rate structure, which in turn will affect a wide range of regional and national variables concerning income, output, employment. To measure these inputs, we are developing the following linked models.

- A regional transportation model that determines costs, revenues profits, outputs, shipment characteristics, rates and factor demands by firm, by mode, by broad commodity type and by region.

- A regional income model that determines factor prices, consumer prices, increases, outputs, and employment by broad commodity type.
- A national interindustry model that determines interindustry coefficients, commodity prices, commodity outputs, and factor employment by broad commodity type.
- A small-scale national macroeconometric model that determines factor prices, final demands and consumer prices.

Since these models are quite aggregative, they cannot indicate the impact of policy changes in great detail. Nevertheless, they are of sufficient scope to permit a quantitative evaluation of changes in policy upon the goals of fairness, income maintenance, industry stability and economic efficiency. Thus before turning to specific policies, it is useful to consider how changes in the variables used in this analysis can be interpreted as changes in the relevant goals.

Fairness. Questions of fairness basically relate to discrimination or price-marginal cost ratios. Our anlaysis will be able to identify relatively broad differences in price-marginal cost ratios for the relevant modes by broad commodity type and by region, and by traffic volume. It will thus be able to indicate whether discrimination among commodities, regions and traffic densities will rise or fall as a result of change in regulatory policy; it will not, however, be able to indicate whether specific shippers would face more discriminatory rates.

Income Maintenance. The impact of changes in transportation policy upon agricultural and rural income can be taken into account in a number of ways. First, since the analysis will identify the changes in the price-marginal cost ratios by region, commodity and traffic density, it will indicate the extent to which the traditional rate structure will be altered by changes in transportation policy. Second, the regional models will directly link changes in regional incomes by broad industrial category to changes in the rate structure. Third, further linkages between the rate structure and agricultural and regional income will be made via wealth effects, which reflect the capitalized value of changes in the rate structure, and interregional effects, which measure the impact of change in one region's income upon another region. Thus by assessing the impact of transportation policy upon the rate structure and the measures of regional and agricultural incomes, it should be possible to determine the impact of change in transportation policies concerning regulation, abandonment, investment in infrastructure, user charges and so forth upon fairly broad measures of agricultural and rural incomes.

Industry Stability. Changes in profitability, rates, and firms are usually thought to be reasonable measures of industry stability. These are captured reasonably well by the freight policy model which should be able to quantify the impact of a change in transportation policy upon the level of profits by mode and firm, the rate structure by mode, and the likely number of firms that would exist under different forms of market structure. In addition, these models should also be able to assess the impact of policy changes upon employment and wage rates by mode.

Efficiency. Economists are generally interested in opportunity costs, or the relationship between actual resource utilization and the least-cost resource utilization. Since our analysis is concerned with measuring the trade-offs between economic efficiency and other goals, the policy models must necessarily incorporate a broad range of efficiency variables. In particular, these models will enable policy makers to estimate short-run marginal costs and long-run marginal costs by mode and by broad output category and to estimate the price marginal cost ratios and the resulting dead-weight loss for different commodities and different modes. Resource savings from adjustments in capacity and traffic allocations can also be measured, as can changes in productivity, industrial concentration and aggregate service measures by mode. Thus in addition to the fairly gross efficiency measures that have usually been presented, this analysis should permit considerably more detail with respect to specific modes and regions.

To summarize then, this analysis should permit policy makers to assess the impact of change in transportation policy upon the following variables that are respectively assocaited with the goals of fairness, income support, industry stability and economic efficiency.

Fairness

- price/marginal cost ratios by region of origin and destination and by mode
- price/marginal cost ratios by commodity and mode
- price/marginal cost ratios by traffic density and mode

Support of Rural and Agricultural Groups

- Rates by commodity and by mode
- Income by region and broad industrial group (agriculture, mining, manufacture, etc.)
- Employment by region and broad industrial group

Industry Stability

- Profitability by mode and firm
- Rates by mode and firm
- Employment by mode and firm
- Number of firms

Economic Efficiency

- Long-run and short-run marginal costs of different outputs by different modes
- Price-marginal cost ra .os by different outputs and different modes
- Resource cost savings from "optimal" adjustments in capacity and labor utilization.
- Resource savings (or costs) associated with traffic allocations resulting from competitive, monopolistic, or oligopolistic market structures as opposed to the present regulatory environment
- Measures of productivity by transport mode
- Measures of industrial concentration by transport mode
- Measures of aggregate level of service by mode

B. Specific Policy Analysis

Although it is premature to attempt to analyze specific transportation policy in much detail, it should be useful to consider how the major provisions of the Railroad Act of 1976 could be handled in the context of the present research.

The basic provisions of the Railroad Revitalization and Regualtory Refor Act of 1976 include the following:

- Financial restructuring of the Northeast and Midwest railroads
- Reform of rate regulation
- New subsidies and abandonment procedures for branch lines
- New procedures for mergers and consolidations
- Organizational changes in the ICC
- Subsidies and loan guarantees for improved passenger service

Of these provisions, those having to do with rate regulation, subsidies, and abandonment should be able to be evaluated within the context of the present analysis, while those having to do with the financial structure of the rail industry and procedures for evaluating mergers and rates probably fall outside the scope of the present analysis.

1. Rate Regulation

The Railroad Act of 1976 contains the following important provisions with respect to rate setting:

- Rates that are greater than or equal to variable (marginal cost) will not be judged too low.
- Rates will not be found too high unless the firm exhibits excessive "market dominance."
- Rates for a given carrier will not be held to a particular level to protect a competing carrier unless the ICC finds that such rates reduce the "going concern value" of the competing carrier.

- For the next two years, railroads may raise or lower specific rates by as much as 7 per cent from the level in effect at the beginning of each year without fear of suspension.

Each of these provisions can be analyzed within the framework that is being developed in this research. The question of whether rates are greater than or equal to marginal costs can be answered quite easily. In the railroad industry we plan to estimate short run and long run cost functions for the industry and for the firms in the industry. By differentiating these with respect to the relevant output variables we can then determine the marginal cost of each output. By comparing this with the rate at which the good is carried, we can then determine whether price is greater than, less than, or equal to marginal cost. Of course, the marginal cost figures derived from this analysis will be quite aggregate and may not reflect deviations due to specific circumstances regarding a specific haul. Nevertheless, they should be indicative of the general relationship between rates and marginal costs for a wide range of commodities.

Questions of market dominance are somewhat more complicated to handle. By postulating market structures characterized by perfect competition, monopolistic competition, oligopoly, and joint profit maximization, it should be possible to determine the rate charged for each commodity and the output of each firm under alternative market structures. By comparing this to the actual rate levels and outputs, it should be possible to obtain an idea of the actual market structure that the industry follows. For example, if we found that the price/marginal cost ratio for a given firm was high, but that the industry behavior under perfect competition corresponded closely to the actual industry behavior, we could assume that there was little if any market dominance by that firm. Alternatively, if we found that a monopolistic market structure gave a good characterization of actual industry behavior, we could infer that some elements of market dominance existed.

The question of umbrella rate-making can be analyzed within the context of a multi-mode equilibrium. Suppose that we jointly analyze the equilibrium that would exist between two modes (say rail and truck), based on existing cost functions, demand functions, and a specified rate structure. We can then compare the profitability of the firms in each mode under the free rate structure with that of the "umbrella" rate structure. If the profitability of the firms in the "protected" mode were substantially less under free rate competition than under the "umbrella" rate structure, we could infer that rates were actually set to protect the competing mode. If, on the other hand, no significant difference in rates or profitability occurred, we could probably infer that umbrella rate making was not an issue.

Whether the 7 per cent annual rate change will act as a constraint can similarly be analyzed by postulating free rate determination under a reasonable market structure. If the difference between the initial rate structure and the projected rate structure is more than that permitted by the legislation, we can infer that firms will probably take advantage of these provisions. Alternatively, if the difference between the initial and the projected rate structure is less than 7 per cent, we can infer that this provision is not of substantive importance.

2. Subsidies and Abandonment

The Railroad Act of 1976 contains provisions for subsidy and abandonment of light density lines, and provision for subsidies for passenger service.

a. Light Density Lines. Under the new legislation, abandonment of light density lines is made more difficult, while the federal government provides $360 million for assistance to local rail services. Whether this sum is adequate to meet the need can be analyzed within the context of the railroad cost functions. Suppose we define secondary track and main-line track as two distinct fixed factors and estimate a short-run cost function accordingly. By assuming that the railroads can adjust their secondary track in an optimal fashion, we can then derive the long-run cost function that would exist if the railroads were able to adjust their secondary track to minimize their costs. By then comparing the short-run total costs at the actual level of output with those that would obtain if the railroads adjusted secondary track in an optimal fashion, we can then determine the magnitude of the potential cost savings that could be obtained from abandonment of light density lines. If these savings were less than $360 million, we could infer that the present subsidy would be adequate to encourage the railroads to maintain existing service. If these savings were greater than $360 million, we would have to infer that these subsidies were inadequate to encourage the railroads to maintain service on their secondary lines.

b. Passenger Service. The Railroad Act of 1976 also contains a number of provisions aimed at improving service on the Northeast corridor. Specifically, the roadbed of the Washington-Boston corridor is to be upgraded so that the trip time between Washington and New York would be 2 hours, 40 minutes and the trip between New York and Boston would be

3 hours, 40 minutes. To implement this USRA is authorized to make up to $1.75 billion available to Amtrack in interest-free loans. In addition, $600 million in loans for working capital will be made available as well as a loan guarantee of up to $1 billion.

It is difficult to see how these provisions can be handled within the context of the present analysis. Basically, the issue is an engineering one rather than an economic one. Specifically, to determine the adequacy of these provisions, it is necessary to determine the cost of upgrading the roadbed to permit the prescribed travel times. By comparing this figure with the loan guarantees and other sources of railroad capital it should be possible to determine the adequacy of the loan guarantees. However, this is not a problem that the models that are being developed in this research can shed much light on.

Similarly, the existing research is not well adapted to analyze questions having to do with the financial structure of the firms. Many of the provisions of the Railroad Act of 1976 deal with the financial structure of the bankrupt railroads in the Northeast and Midwest. Since the financial structure of the railroads does not enter into the cost or demand functions, there is no mechanism to translate changes in financial structure into changes in the cost and demand functions. Thus questions of the impact of financial reorganization are beyond the scope of this analysis. Nevertheless, questions of physical reorganization are entirely within the scope of the analysis framework followed here, and it would be quite possible to evaluate the impact of system consolidation. This analysis would closely follow that of mergers, outlined above.

3. Organizational and Procedural Changes

This research is not particularly well suited to evaluating organizational and procedural changes with regard to review of rates, mergers or similar matters. As explained above, this research is based on comparative statics, which compares alternative equilibria under different sets of initial conditions. As such, however, it does not consider the time path of the equilibrium. Since the analysis is essentially static, it cannot incorporate dynamic questions of the timing of review. While it would obviously be desirable to extend the research to encompass these dynamic elements, such an extension is presently beyond the scope of analysis.

C. Summary and Conclusions

While hardly exhaustive, it is hoped that this discussion should indicate the kinds of transportation policies that can be evaluated within the framework of this research, and the methodological approach used in performing this evaluation. The basic methodology is firmly grounded in conventional economics and consists of comparative statics. We thus determine an initial equilibrium with respect to the relevant transportation and related industries. By translating changes in transportation policies into changes in the cost functions, demand functions, or market structures of the relevant transportation industries and determining the resulting equilibrium, we can then assess the impact of the policy not only upon the firms in the transportation industries themselves, but in other industries, upon regional incomes and so forth. Thus while the outlined methodology is admittedly limited in terms of its static nature, it should yield valuable insights into the impact of alternative transportation policies.

Chapter Three

An Integrated Policy Model for the Surface Freight Industries

I. Introduction

Federal transportation policies have wide ranging impacts upon the transportation industries, and, through them, upon the allocation of economic activity among industries and regions throughout the nation. Federal regulatory policy directly affects rates, entry, routes, etc. in the intercity transportation industries: rail, highway, water, and air. Federal promotional policies directly affect the infrastructure and thus the costs of these various modes, as do federal policies with respect to use charges, subsidies, safety, energy, loan guarantees, environmental impacts, etc.

Clearly, a change in any given federal transportation policy with respect to any given mode will have a direct impact upon the costs and/or demands facing the firms in that mode, and thus upon the equilibrium configuration of rates, traffic allocations, service levels, etc. within that mode; but it will also affect the rates, traffic allocations and service levels of the competing modes by changing the relative prices of the various transport services. Moreover, since transportation is used as an intermediate good in virtually all industries in all regions of the economy, changes in the costs of transportation relative to those of other inputs will alter the allocation of economic activity and consequently the level of incomes and employment among regions, among industries, among different kinds of labor and capital, and among cities of different sizes.

When viewed in this context, it is clear that most studies of transportation policy have had an excessively narrow focus. Economic studies have tended to look at the question from the point of view of economic efficiency alone, and have thus concentrated upon providing global measure of user savings, resource savings, or welfare losses.[28/] While informative, these studies have tended to ignore questions of the income distribution as well as broader questions of efficiency concerned with full employment and transfer costs. Thus, what happens to employment and wages in a given transportation industry; what happens to regional income levels and the regional allocation of economic activity; what happens to the level of service to given communities have been questions that economists have generally not raised, much less answered.

Clearly, however, if one looks at legislative or regulatory proceedings, issues of the income distribution have tended to dominate the discussion. Whether service will be curtailed to a given city or class of cities; whether labor income and/or employment will fall within a given transportation industry or a given region; whether industry incomes and outputs will rise or fall; are all questions that the policy maker has tended to weigh more heavily than questions of aggregative economic efficiency. Thus, if economic analysis is to be used to help evaluate changes in transportation policy, it must not only provide answers concerning aggregative efficiency impacts, but also provide answers relating to a whole host of distributional questions. Consequently, one of the major goals of this research is to provide analytical models that can be used to quantify the magnitude of the various distributional effects as well as to quantify the

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[28/] See, for example, Keeler (1972), Moore (1972), Douglas and Miller (1974) magnitude of the efficiency effects of a given change in transportation policy.

This chapter describes such a modeling effort. The next section provides an overview of the models that will be used to evaluate transportation policy and describes their interrelationships. The subsequent sections then discuss each sub-model.

II. Overview of the Analysis

A. The Modeling Structure

The basic premise of the analysis is that relative prices matter. Thus any change in transportation policy should lead to a change in the transportation rate structure, which in turn will affect a wide range of regional and national variables concerning income, output, employment, etc. Since these, however, can influence transportation costs and/or demands, the entire system is interrelated and simultaneously determined.

These propositions are illustrated in Figure 1, which depicts four linked models:

- A regional transportation model that determines costs, revenues, profits, outputs, shipment characteristics, rates, and factor demands by firm, by mode, by broad commodity type and by region.
- A regional income model that determines factor prices, consumer prices, increases, outputs, and employment by broad commodity type.
- A national interindustry model that determines interindustry coefficients, commodity prices, commodity outputs, and factor employment by broad commodity type.
- A small scale national macroeconometric model that determines factor prices, final demands, and consumer prices.

With the exception of the exogenous variables in the national macroeconometric sub-model, every variable that is exogenous to a given sub-model is endogenous to another sub-model. Hence, the entire system is interrelated and interactive; a full solution to the model must be simultaneously determined.

An Integrated Policy Model for the Transportation Industries

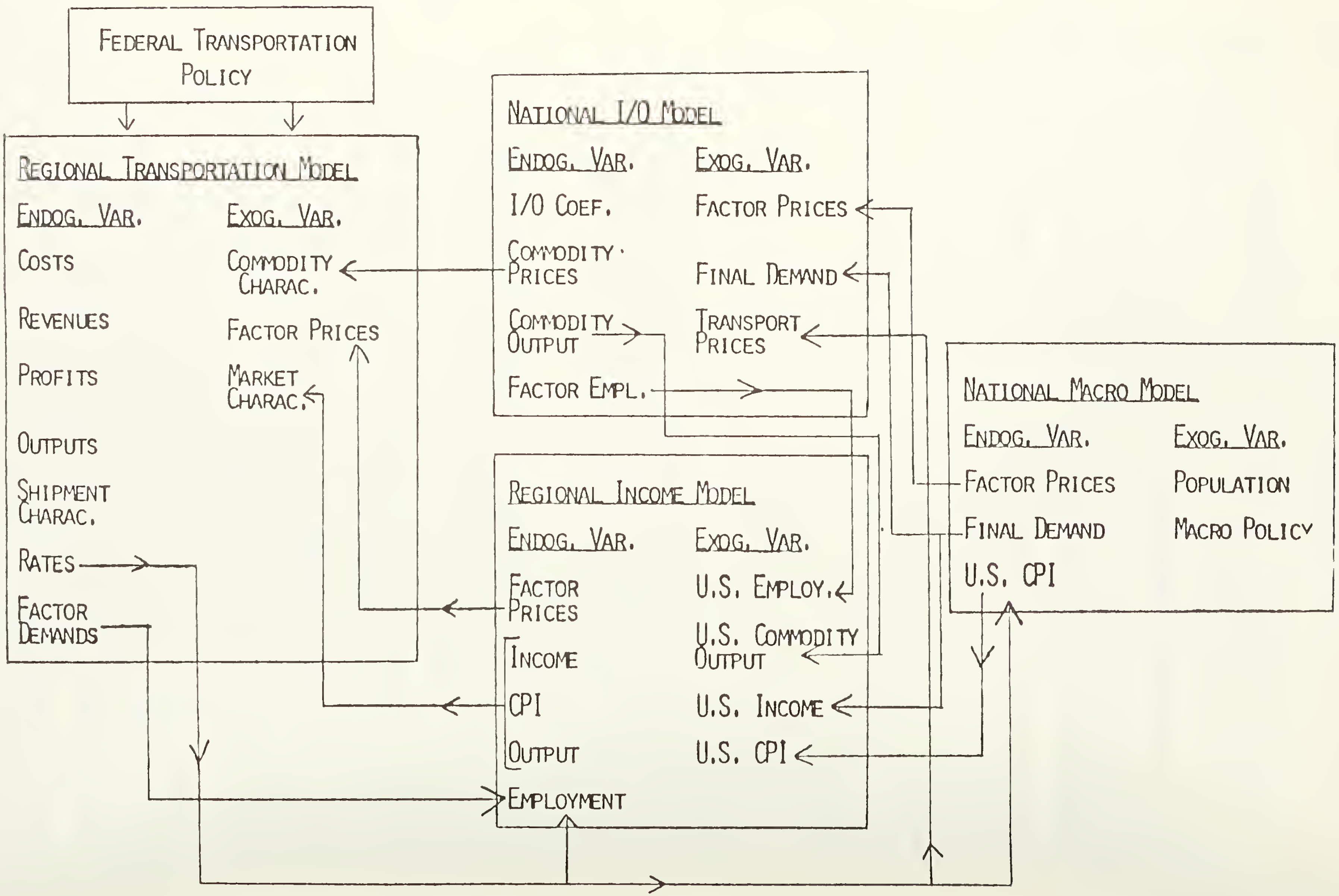

Figure 1

In terms of policy analysis, we can postulate a change in transportation policy that affects costs, demands or the nature of market equilibrium in the transportation industries in a given region or the nation as a whole. This, in turn, affects transportation rates and factor employment, which, in turn, affect regional and national outputs, employment, factor prices and so forth. However, these, in turn, affect the nature of the equilibrium in the transporation industries. Thus by using these interrelated models, we can analyze the impact of a wide range of transportation and related policies upon a wide range of variables that measure distributional as well as efficiency impacts.

B. Scope of the Analysis

To make the problem tractable, our initial efforts will be quite aggregative and deal with broad categories with respect to modes, regions, commodities, and factors. We thus plan to consider the following:

1. Modes. Initially we plan to focus upon the rail and trucking industries.[29] Because of data limitations, we will probably have to confine our analysis to regulated trucking, although it would obviously be desirable to extend it to private and exempt carriage.

2. Regions. A wealth of regional data exist from the Census of Transportation and the Carload Waybill samples. Hence, it is possible to perform our regional analysis on a fairly fine level of detail. At this time, however, we are primarily interested in developing an integrated model that can be used for aggregative policy analysis. Consequently we plan to limit ourselves to the five ICC rail regions:

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[29] In so far as data and resources permit, we will also consider the water and pipeline industries.

The Official, Southern, Western, Southwestern, and Mountain-Pacific Territories. Once we have this aggregative regional model working, we can always extend the analysis to more regions.

3. Commodities. Similarly, a wealth of commodity detail exists. Nevertheless, for reasons of tractability, we plan to limit our initial analysis to the following broad commodity groups: durable manufacturers; nondurable manufacturers; grains, other agricultural commodities; coal; petroleum and petroleum products; minerals, chemicals and others.

4. Factors. The regional transportation models will consider labor, fuel, and capital as the relevant factors of production,[30/] while the regional models will only consider labor. The national interindustry model will treat transportation as a factor of production as well as labor, capital, energy, and materials.

C. Policies

As indicated in the previous chapter, our basic approach is one of comparative statics, with transportation policy as the primary exogenous variable. We thus determine an initial equilibrium and postulate a change in transportation policy. After determining the new equilibrium as well as its time path, we can then assess the impact of the policy change.

We thus translate a change in transportation policy into a change in the cost functions, demand functions, or the competitive structure of the affected transportation industry. By tracing through the impact of these changes upon the relevant variables contained in each

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30/ For a full discussion of the treatment of factors of production see Friedlaender et al. (1977).

of the interrelated models, we can analyze the impact of a wide range of transportation and related policies upon a wide range of variables that measure distributional as well as efficiency impacts. Specifically, by utilizing this framework, it should be possible to consider the following:

Transportation Policies

- Setting rate levels or rate bands in the regulated transportation industries.
- Total deregulation of rates.
- Elimination of rate bureaus or other cartelization in the regulated transportation industries.
- Relaxation or tightening up of restrictions concerning entry in the regulated transportation modes.
- Relaxation or tightening up of restrictions concerning mergers in the regulated transport modes.
- Relaxation of restrictions concerning abandonment and capital adjustments in the transportation industries.
- Relaxation of restrictions upon the utilization of labor in the regulated transportation industries.
- Construction and maintenance of transportation infrastructure and its related user charges.
- Explicit subsidies for specific kinds of transportation services.
- Energy policy in so far as it affects relative fuel costs in the transportation industries.

Efficiency Variables

- Long-run and short-run marginal costs of different outputs by different modes.
- Price-marginal cost ratios by different outputs and different modes.
- Resource cost savings from "optimal" adjustments in capacity and labor utilization.

- Resource savings (or costs) associated with traffic allocations resulting from competitive, monopolistic, or oligopolistic market structures as opposed to the present regulatory environment.
- Measures of productivity by transport mode.
- Measures of industrial concentration by transport mode.
- Measures of profitability, costs, and revenues by firm and by transport mode.
- Measures of factor utilization (employment) by firm and by transport mode.
- Measures of aggregate level of service by mode.

Distributional Variables

- Traffic allocations and profitability by firm and by mode.
- Employment and wages and firm and by mode.
- Employment and wages by national industry, regional industry, and by broad geographical regions.
- Price-marginal cost ratios by class of user and by geographical region.
- Income levels by broad geographical regions and by national industry.
- Producers' prices by broad industry category.

III. The Regional Transportation Model

The heart of the analysis lies in the model of the regional transportation market. Conceptually, this is quite straightforward, and is illustrated in Figure 2. Thus we postulate that there is a known industry or firm cost function, which relates costs to outputs, factor prices, and (in the case of the short-run cost function) the amounts of the fixed factors. Similarly, we assume that there is a known firm or industry demand function relating shipments to market characteristics, commodity characteristics, shipment characteristics of own and competing modes, and rates of own and competing modes. Given these cost and demand functions, and assuming profit maximizing behavior as the part of the firms in the industry,[31] we can determine the equilibrium level of rates, shipments, profits, costs, revenues, shipment characteristics, and factor demands in the short-run and the long run under a number of different market structures: perfect competition, joint profit maximization, rate regulation, oligopoly, and monopolistic competition.

Let us now discuss the specification of the cost and demand functions, and how we plan to utilize them for policy analysis.

A. Cost Functions

The validity of econometric estimates of the costs of the various transportation modes remains an issue surrounded by controversy. While there have been numerous econometric studies of rail, trucking,

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[31] We could also make different assumptions about the firms; objective functions such as sales maximization subject to a profit constraint or profit maximization subject to a rate of return constraint.

REGIONAL TRANSPORTATION MODEL

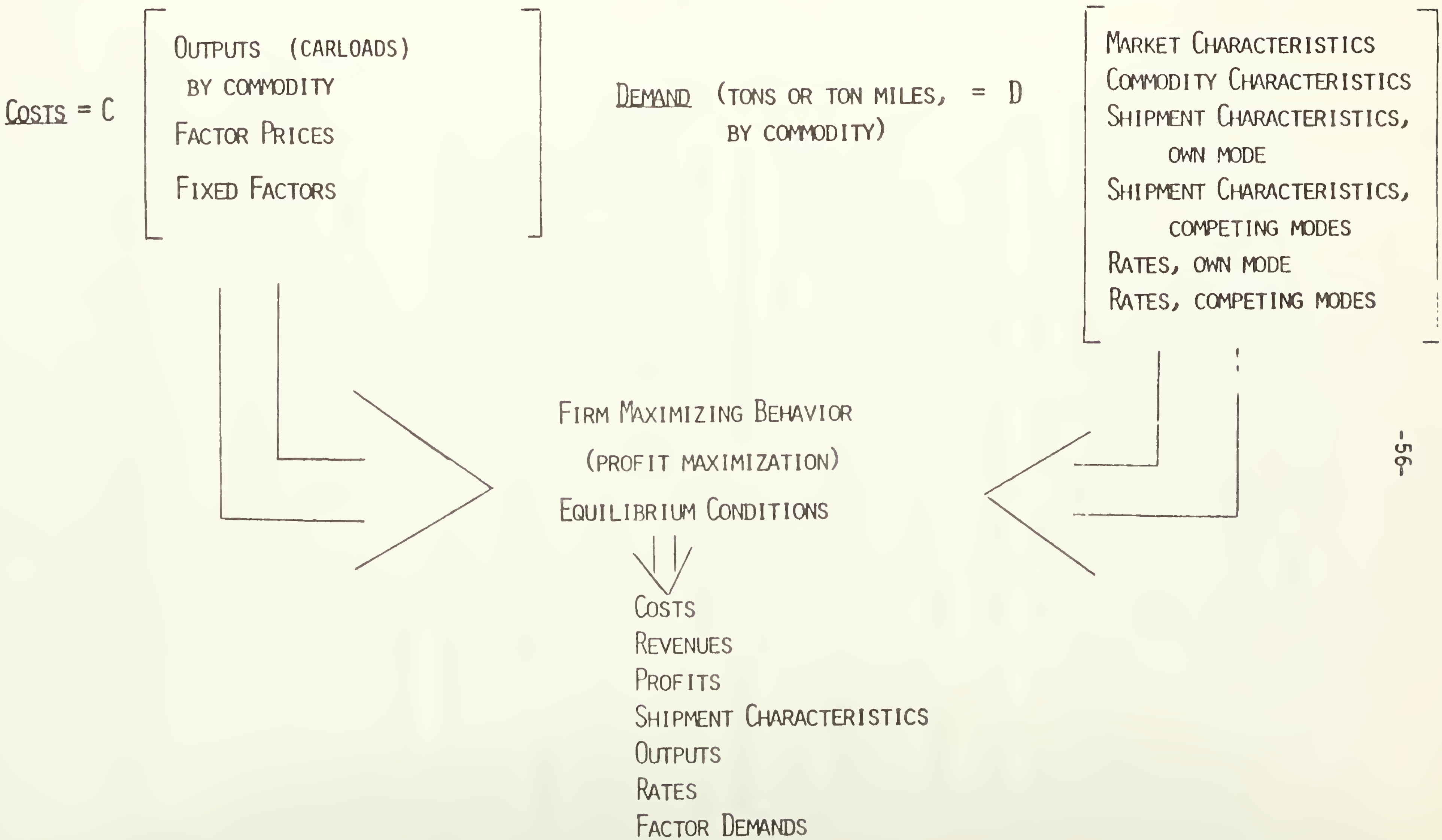

FIGURE 2

and airline cost,[32/] no one has yet developed a cost methodology that has yielded results that are generally accepted as valid. This inability to obtain a concensus concerning costing methodology and/or the validity of the empirical results arises not so much from a lack of effort, but rather from the failure to specify the cost functions that appropriately characterize the structure of technology.

Specifically, there appear to be three fundamental problems that one must address in specifying and estimating cost functions for the transportation industries.

First, the output of a transportation firm, whatever the mode, is multidimensional by its very nature. Not only does the firm produce different types of transportation services for different users at different origins and destinations, but also at different levels of quality. Consequently, the mix of output can have a major impact upon the costs of any given firm. For example, railroads specializing in coal traffic have very different cost characteristics than those specializing in general manufactured commodities for a given density of line.

Since the mix of output affects the firm's costs, it is clearly inappropriate to estimate cost functions by using a single aggregate measure of output such as ton miles or passenger miles. To the extent that the mix of traffic and quality levels affect costs, a vector of outputs and quality levels that characterize the range of activities undertaken by the firms in a given transportation mode should be

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[32/] For a review of the literature, see Kneafsey (1975) for rail, Oramas (1975) for truck, and Douglas and Miller (1974) for air.

incorporated into the analysis. While it is unlikely that the available data will permit the fully desired degree of output disaggregation, it is clear that considerably more disaggregation is possible than has been undertaken in existing studies of transportation costs.

Second, it is generally agreed that the activities of each of the transportation modes are characterized by joint and common costs, implying that their technology is characterized by joint production. Although Hall (1973) has shown that a separable technology will always imply joint production, he has also shown that the converse is not true. We cannot assume, therefore, that cost functions based on a separable Cobb-Douglas technology are good representations of reality.[33/] Instead, a flexible form is needed that will permit the determination of the underlying structure of technology from its estimated coefficients.

Third, to the extent that regulatory or other constraints prevent the firms in each mode from making optimal adjustments in capacity, they are not generally in a position of long-run equilibrium operating along their long-run cost function. Consequently, efforts to estimate long-run cost functions directly from cross-sectional data will yield seriously biased coefficients and resulting measures of marginal costs. The sign of this bias will depend upon the relationship between the size of the firm and the degree of excess capacity.[34/]

[33/] See, for example, Keeler (1974), Kneafsey (1975) and Eads, Nerlove, and Raduchel (1969).

[34/] See Friedlaender (1969) for a discussion of this point.

Since, however, this relationship is not generally known, it is impossible to make any adjustment to correct for this bias.

This implies that one should estimate short-run functions when one suspects that an industry may be in long-run disequilibrium with chronic excess capacity. Since the long-run cost function is merely the envelope of the short-run cost function, it is always possible to derive the unobserved long-run cost function from the observed short-run cost function.[35/] Thus, to the extent that the short-run cost function has been correctly specified, and its coefficients are therefore unbiased, the coefficients of the derived long-run cost function will also be unbiased and the long-run marginal costs obtained from the derived long-run total cost curve will also be unbiased.

These arguments imply that in estimating cost functions for the transportation industries, one should specify a multiple-output cost function in a sufficiently flexible form to permit the testing of a number of hypotheses concerning the separability, homogeneity, and jointness of the underlying production function. Moreover, if there is reason to believe that regulatory or other institutional constraints prevent "optimal" capacity adjustment, one should estimate a short-run variable cost function, which can be used to derive the associated long-run total cost function and the underlying production function.

Friedlaender et al. (1977) report on the general methodology used in this research to estimate cost functions in the transportation industries. Briefly stated, the cost functions used in this analysis

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[35/] This approach has been utilized by Keeler (1974) and Kneafsey (1975) in the railroad industry and by Eads, Nerlove, and Raduchel (1969) in the airline industry.

will be estimated by a translog approximation that meets the objections raised with respect to most cost functions: it permits multiple outpus and quality levels; it is of a sufficiently flexible form to test hypotheses concerning the underlying structure of production; and it can be used in either its short-run or long-run form.

Alhtough the specific functional form of the estimated cost function is given by a rather complicated expression, for notational simplicity, we write the short-run variable cost function for mode m in region d as:

$$\tilde{C}^d_m = \tilde{C}^d_m \, (\tilde{y}^d_m \, , \, \tilde{x}^d_m \, , \, \tilde{w}^d_m) \qquad (3.1)$$

where y, $\tilde{x}$, and $\tilde{w}$ respectively represent the vector of outputs, fixed factors, and variable factor prices; the d's range over the ICC Territories; and the m's range over the relevant modes (rail and truck; possibly water and pipeline).

The long-run cost function derived from this is given by:

$$C^d_m = C^d_m \, (y^d_m \, , \, q^d_m) \qquad (3.2)$$

where y represents the vector of output and q represents the vector of all factor prices (fixed and variable).

The respective marginal costs are denoted by $\tilde{C}^d_{im}$ and C^d_{im}, where $C^d_{im} = \partial C^d_m / \partial y_i$.

Finally, since the cost functions are derived from cross sectional and time series data, as long as all firms in a given mode face the same technology, we can derive firm-specific cost functions for each mode and write:

$$\tilde{C}^d_{mf} = \tilde{C}^d_{mf}(y^d_{mf} , \tilde{x}^d_{mf} , w^d_{mf}) \qquad (3.3a)$$

$$C^d_{mf} = C^d_{mf}(y^d_{mf} , q^d_{mf}) \qquad (3.3b)$$

where the variables have their previous meaning and f ranges over the firms in the mode.

We can similarly obtain the firm's marginal cost curves and write $\tilde{C}^d_{imf}$ and C^d_{imf} as the respective short-run and long-run marginal cost curve associated with shipment type i by firm f in mode m in region d.

B. Demand

In general, we expect the demand for the services of any given mode to depend upon the following elements: the size of the market in the region of origin and the region of destination; the characteristics of the commodity shipped; the characteristics of the shipment of the given mode and that of its competitors; and the rates of the given mode and those of its competitors.[36/]

[36/] Note in this formulation, we neglect the possibility of price discrimination with respect to class of service. In so far as data are available to include this dimension in the analysis, we will certainly do so.

If we take ton-miles as the relevant unit of demand, we can then write the market demand for commodity i of mode m between origin r and destination d as:

$$T_{im}^{rd} = T_{im}^{rd}\,[Y^r,\ Y^d,\ V_i,\ D_i,\ S_{im}^{rd},\ S_{ic}^{rd},\ L_{im}^{rd},\ L_{ic}^{rd}, P_{im}^{rd},\ P_{ic}^{rd}] \qquad (3.4)$$

where T_{im}^{rd} = ton-miles shipped of commodity i by mode in between origin i and destimation d.

Y^r, Y^d = personal income in the region of origin r and the region of destination d.

V_i = Value of commodity i.

D_i = Density of commodity i.

S_{im}^{rd}, S_{ic}^{rd} = Size of shipment of commodity i between origin r and destination d for mode m and its competing mode(s) c.

L_{im}^{rd}, L_{ic}^{rd} = Length of haul of commodity i between origin r and destination d for mode m and its competing mode(s) c.

P_{im}^{rd}, P_{ic}^{rd} = Rate per ton-mile of commodity i between origin r and destination d for mode m and its competing model(s) c.

The above expression is supposed to represent a market demand function for a given mode, commodity, and pair of regions. Thus, the demand function facing a given mode for a given commodity in a given region equals the sum of all the shipments of that commodity carried into that region on that mode.[37] Thus:

$$T^{d}_{im} = \sum_{r}^{D} T^{rd}_{im} \tag{3.5}$$

Given the market demand function facing a given mode, we can readily derive the total revenue function facing that mode by multiplying the rates and the volume and summing appropriately. Thus:

$$R^{d}_{m} = \sum_{i} \sum_{r} P^{rd}_{im} \, T^{rd}_{im} \tag{3.6}$$

where the subscript m ranges over the relevant modes and the superscript d ranges over the relevant regions.

We assume that each firm's demand function is some proportion of the market demand function and write:

$$T^{d}_{imf} = \mu^{d}_{mf} \, T^{d}_{im} \tag{3.7}$$

where $^{d}_{mf} = \dfrac{T^{d}_{mf}}{\sum_{i} \sum_{r} T^{rd}_{im}}$

Thus, μ^{d}_{mf} represents the share of the total ton-miles carried in region d by mode m accruing to firm f. If data permit, we can, of course, disaggregate this market-share variable into commodities and regions of origin.

Since service is a major competitive weapon in the transportation industries, it is quite likely that a firm's share of total freight

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[37] Strictly speaking, this may not be true if interlining occurs. As a first approximation, however, it seems reasonable to assume that the mode in the region of destination obtains the revenues from shipments sent to that region.

shipments also depends upon its level of service relative to other firms. In the airline industries where data on flight frequency are readily available, frequency is generally taken to measure levels of service.[38/] In the surface freight industries, however, such data do not exist. Hence, we must find another proxy for level of service.

In so far as firms with large amounts of rolling stock are able to meet shipper demands more quickly than firms with small amounts of rolling stock, it is likely that the level of service offered by the former firms is greater than that of the latter. Hence, as a first approximation we can postulate that

$$\mu^d_{mf} = \mu^d_{mf}[E^d_{mf}/E^d_m] \quad (3.8)$$

where E^d_{mf} represents the rolling stock of firm f in mode m in region d, and E^d_m represents the total rolling stock of mode m in region d.

C. Market Equilibrium

Having specified the industry and firm cost and demand functions within a given region, we are now in a position to analyze the nature of equilibrium in the regional transportation market under a number of different assumptions concerning the competitive structure of the industry. Note that since we are dealing with a number of regions and modes, a partial-equilibrium analysis of a given mode within a given region will not in general be sufficient.

In this chapter we limit ourselves to presenting the analysis of the equilibrium under a perfectly competitive market structure. The interested reader is referred to Friedlaender et al. (1977) for a detailed

[38/] See, for example, Douglas and Miller (1974).

analysis of the nature of the equilibrium under each of the following market structures: joint monopoly profit maximization, oligopoly, and monopolistic competition.

Perfect Competition

Under perfect competition, equilibrium is given when the supply price equals the demand price. The market demand for commodity i in region d for mode m is given by:

$$T^{d}_{im} = \sum_{r} T^{rd}_{im}(P^{rd}_{im} , P^{rd}_{ic} , A^{d}_{m}) \qquad (3.9)$$

where P^{rd}_{im}, P^{rd}_{ic} refer to the own and competitive price of shipping the commodity and A^{d}_{m} refers to the other variables in the demand function; see eq. (3.4). In perfectly competitive equilibrium, the market must clear at the common price. Hence, there can be no regional price discrimination and

$$T^{d}_{im} = T^{d}_{im}(P^{d}_{im}, P^{d}_{ic}, A^{d}_{m}) \qquad (3.10)$$

The long-run total cost function for firm f in mode m in region d is given by:

$$C^{d}_{mf} = C^{d}_{mf}(y^{d}_{imf},\ldots,y^{d}_{Nmf}, q^{d}_{mf}) \qquad (3.11)$$

where the y's represent shipment carried by the firm and the q's represent the vector of factor prices facing the firm. Note that since we will estimate the short-run cost function directly, we will also undertake an analysis of market equilibrium using the relevant short-run cost functions. Hence, our use of the long-run cost function is purely for expositional and notational simplicity.

The firm's marginal cost function for commodity i is similarly given by

$$mc^d_{imf} = mc^d_{imf}(y^d_{imf},\ldots,y^d_{Nmf},\ q^d_{mf}) \tag{3.12}$$

In equilibrium, the firm equates its marginal cost with its price. Hence:

$$P^d_{im} = mc^d_{imf}(y^d_{imf},\ldots,y^d_{Nmf},\ q^d_{mf}) \tag{3.13}$$

Note that in this formulation, the marginal costs of shipment i not only depend upon its own level of output, but also upon the levels of output of all other commodities. Therefore, we must solve the system of equations given in (3.13) for all of the output levels and thus obtain the firm's supply function in terms of all price. Thus:

$$y^d_{imf} = S^d_{imf}(P^d_{im},\ldots,P^d_{Nm},\ q^d_{mf}) \tag{3.14}$$

Having obtained each firm's supply functions, we can then obtain the market supply function by summing over all firms.

$$y^d_{im} = \sum_f {}^d_{imf}(P^d_{im},\ldots,P^d_{Nm},\ q^d_{mf}) \tag{3.15}$$

As long as the supply units (the y's) and the demand units (the T's) are the same, equilibrium requires that the quantity supplied equals the quantity demanded. If we take the prices of the competing modes as given, then equilibrium of any given transportation mode is given by the following expression:

$$y^d_{im}(P^d_{im},\ldots,P^d_{Nm},\ q^d_m) = T^d_{im}(P^d_{im},\ P^d_{ic},\ A_m) \tag{3.16}$$

This yields a set of N equations that can be used to solve for the N equilibrium rates, and thus the equilibrium levels of output for the industry as a whole as well as for each firm.

Of course, the problem is considerably more complicated than this because we cannot analyze the equilibrium of a transportation industry apart from the equilibrium of its competitors. Hence, instead of solving eq. (3.16) on the assumption that P^d_{ic} is constant, we must also analyze the full general equilibrium solution of the transportation industries. This, however, is a relatively straightforward, if computationally complex, problem. Hence, we simply extend our system of equations in (5.16) to

$$y^d_{im}(P^d_{im},\ldots,P^d_{Nm}, q^d_m) = Y^d_{im}(P^d_{im}, P^d_{ic}, A_m) \qquad (3.17a)$$

$$y^d_{ic}(P^d_{ic},\ldots,P^d_{Nc}, q^d_c) = Y^d_{ic}(P^d_{im}, P^d_{ic}, A_c) \qquad (3.17b)$$

where c ranges over the relevant competing modes. We thus obtain a system of MN equations to obtain the full competitive equilibrium of the rates in each mode, the traffic allocations in each mode, and the traffic allocations in each firm.

IV. Interindustry Model

Federal transportation policy not only influences transportation rates and the allocation of shipments among the various modes, but also affects the allocation of economic activity among industries. By causing changes in transportation rates, changes in federal transportation policy cause changes in the price of transportation services relative to other commodities or services. This, in turn, leads to changes in the allocation of economic activity among industries and the producer prices of these industries, which in turn can affect the demand for transportation services. Consequently, it is desirable to develop an interindustry model that can be used to analyze the impact of transportation rates upon the allocation of economic activity among industries. This, in turn, can be used to feed back into the models of equilibrium in the transportation industries.

Conventional input-output analysis assumes that the technology of each industry is characterized by fixed coefficients. Consequently, factor and materials utilization are independent of relative factor and commodity prices. Indeed, given the input-output coefficients and the prices of primary factors of production, commodity prices are uniquely determined. Thus, once final demands, primary factor prices, and the input-output coefficients are specified, interindustry flows and factor income are uniquely determined. Consequently, within the conventional input-output framework, there is no mechanism for changes in transportation rates to influence the general equilibrium configuration of the economy.

The principle innovation of this research is to treat the input-output coefficients as endogenous variables that depend upon commodity and factor prices.[39] Traditional input-output analysis assumes that these coefficients are exogenously determined and derives commodity prices in terms of factor prices and these input-output coefficients. In contrast, the flexible input-output analysis described here derives commodity prices in terms of factor prices, and then derives the input-output coefficients in terms of commodity and factor prices. Hence, the basic structures of the traditional and the flexible input-output analyses are fundamentally different.

More improtantly, however, the role of factor prices in the two approaches is fundamentally different. In traditional input-output analysis, factor prices affect commodity prices. But since there is no link between commodity or factor prices and the input-output coefficients, changes in factor prices have no affect upon the levels of output, interindustry flows, or factor demands.[40] In contract, since flexible input-output analysis relates commodity prices and the interindustry coefficients to factor prices, changes in factor prices can have a wide ranging impact upon the general equilibrium configuration of the economy.

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[39] This appoach was pioneered by Hudson and Jorgenson (1974) in their analysis of energy policy.

[40] This can be seen by considering the traditional input-output structure, which determines outputs, prices, and factor demands by the following relationships:

$$X = (I-A)^{-1}D$$

$$P' = w'F(I-A)^{-1}$$

$$X_f = FX$$

Where X represents the vector of outputs; A represents the matrix of exogenously determined interindustry coefficients; D represents the vector of final demands; P represents the vector of commodity prices; w represents the vector of primary factor prices; F represents the matrix of primary factor coefficients; and X_f represents the vector of factor demands. Since the A's are exogenously determined, changes in the w's will affect the p's but have no further impact.

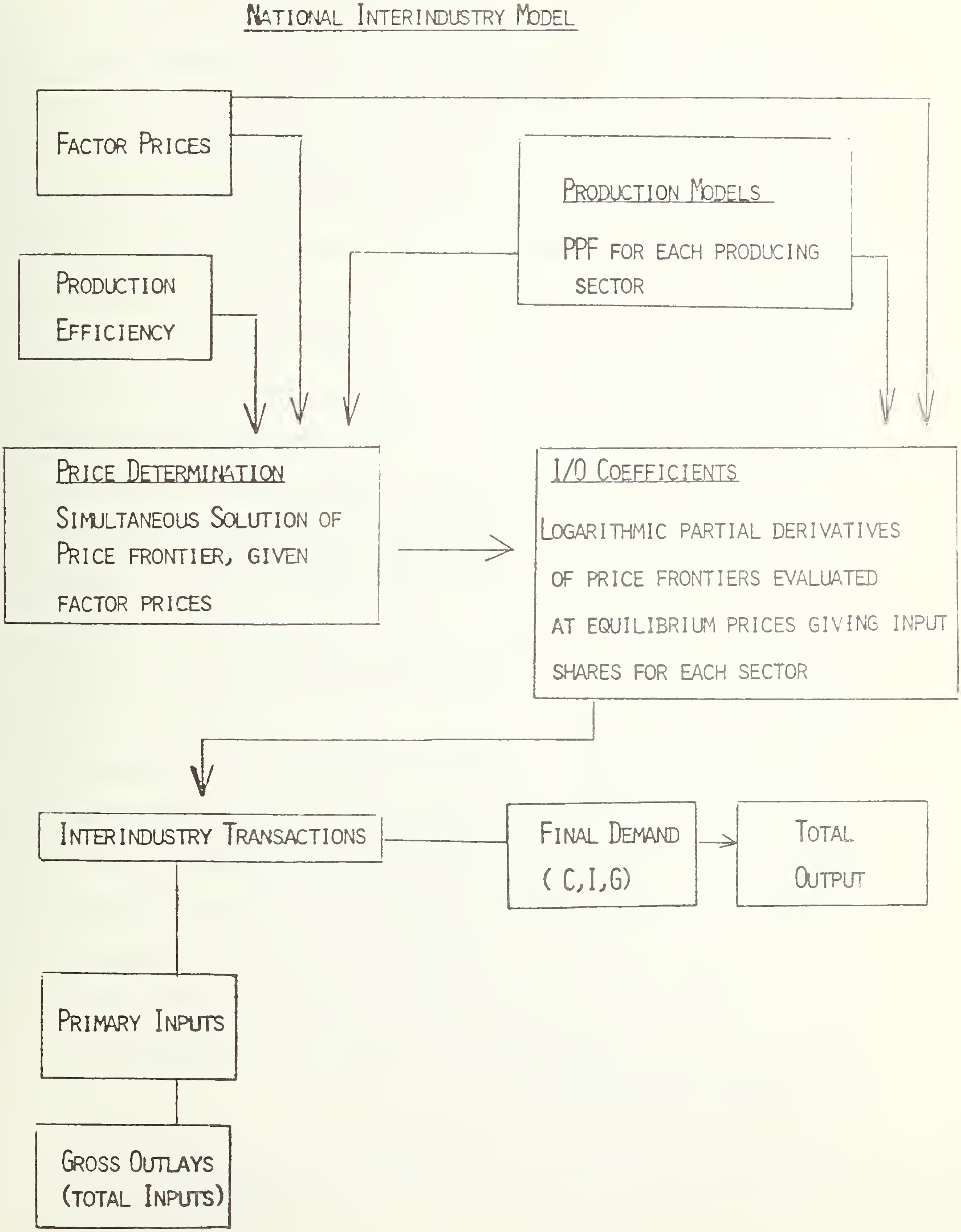
Although transportation is clearly a produced activity, since the prices of its services are determined by the regional transportation models described above, transportation can be taken as a primary factor of production for the purposes of this interindustry analysis. Consequently, by using a flexible input-output analysis, we can determine how changes in the transportation rate structure affect interindustry coefficients, commodity prices, industry outputs, and factor demands.

The basic structure of the flexible input-output analysis is illustrated in Figure 3, which clearly indicates the central role of factor prices. Given primary factor prices and certain assumptions concerning production efficiency and the nature of the price possibility functions, which will be described below, it is possible to determine commodity prices and the input-output coefficients. Once these have been determined, the basic analysis of the determination of gross inputs and factor utilization follows along the lines of conventional input-output analyses.

Since changes in factor prices not only affect commodity prices, but also affect the input-output coefficients (both commodity and factor), they can have a wide ranging impact upon the equilibrium of the economy that traditional input-output analysis does not permit. Consequently, by treating transportation (or its component industries) as primary factors of production in a flexible input-output framework, we can anlayze the impact of transportation rates upon interindustry flows, industry outputs, factor demands, and the demand for transportation services in the aggregate and by industry.[41/]

[41/] See Friedlaender _et al._ (1977) for a more detailed discussion.

FIGURE 3


NATIONAL INTERINDUSTRY MODEL
FACTOR PRICES
PRODUCTION MODELS
PPF FOR EACH PRODUCING SECTOR
PRODUCTION EFFICIENCY
PRICE DETERMINATION
SIMULTANEOUS SOLUTION OF PRICE FRONTIER, GIVEN FACTOR PRICES
I/O COEFFICIENTS
LOGARITHMIC PARTIAL DERIVATIVES OF PRICE FRONTIERS EVALUATED AT EQUILIBRIUM PRICES GIVING INPUT SHARES FOR EACH SECTOR
INTERINDUSTRY TRANSACTIONS
FINAL DEMAND (C,I,G)
TOTAL OUTPUT
PRIMARY INPUTS
GROSS OUTLAYS (TOTAL INPUTS)

V. Regional Income Model

Let us now consider the interrelationships between the regional transportation model and the regional income model. Briefly stated, the equilibrium in the regional transportation market affects the levels of regional economic activity in two important ways. First, the demand for labor in the transportation industries has a direct impact upon regional employment and income. Second, the transportation rate structure in any region relative to that of the nation as a whole can influence the location and investment decision of firms and thus affect regional income and employment. Similarly, regional income levels can have a direct impact upon the demand for transportation services, while regional wage structures can affect the demand for labor within the transportation industries. Thus, if we view the transportation industries as only one sector within a regional economy, it is clear that there are bound to be many linkages between the equilibrium in the transportation industries and that of the entire regional economy.

This analysis attempts to capture the major linkages and concentrates upon the interrelationships among regional income, employment, and transportation. To this end, we will develop employment, wage, and personal income relationships and show how they interact with the regional transportation model. In doing this, our goal is not to develop a fully specified model of regional income determination, but rather to utilize a somewhat aggregative model that will capture the main elements of the problem.

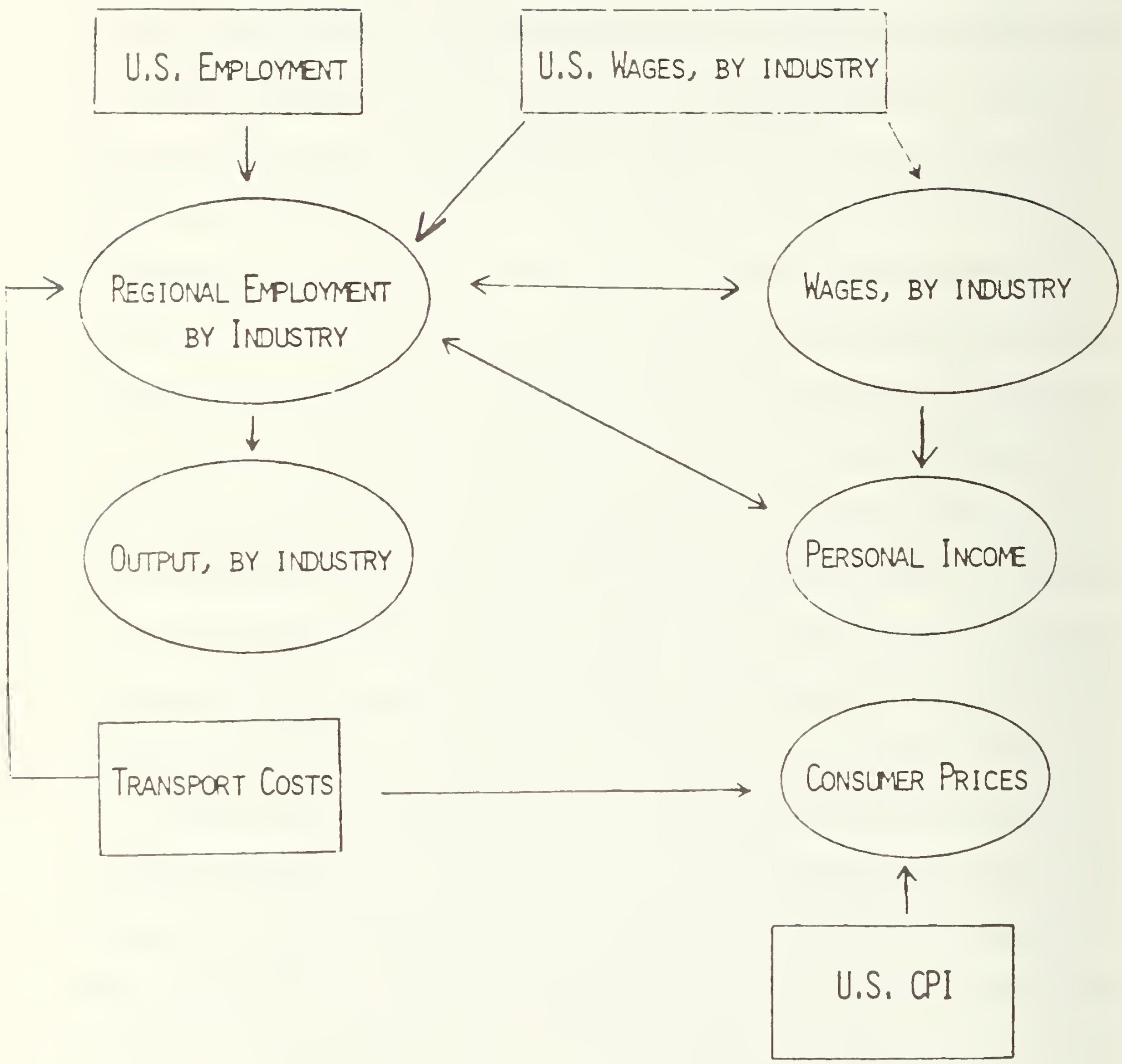
Since the level of transportation rates relative to other prices plays a key role in an integrated transportation policy model, it seems logical to adopt a neoclassical approach, which incorporates relative price differentials, in modeling regional income levels. As such, we draw upon the analytical framework developed in the Massachusetts Model (1975) and its predecessors. Because, however, the focus of this analysis is the interrelationships among the transportation industries and the rest of the regional economy, transportation rates and employment will play a central role in this modeling effort that they have not had in previous regional models.

The structure of the regional income model is illustrated in Figure 4. Regional employment is assumed to depend upon regional factor costs (transportation, labor, capital, and energy) relative to those of the nation and regional income. Regional wages are related to national wages and regional employment growth. Given wages and employment, we can then determine labor income, and from that, we can derive measures of gross state product. Personal income is given by the sum of labor and nonlabor income. Finally, the regional consumer price index is determined by the regional transportation rate structure and the national CPI.[42/]

42/ See Friedlaender et al. (1977) for more detail on the regional modeling effort.

FIGURE 4

REGIONAL INCOME MODEL



VI. Macroeconometric Model

A number of variables are required to close the various sub-models. The national interindustry model needs data on final demand by sector and the price of capital and labor, while the regional model needs data on national personal income, consumer prices, and the unemployment rate. Since these variables are all interrelated, we must develop a small-scale macroeconometric model to specify these interrelationships and to estimate equations for these variables.

As indicated above, the art of macroeconometric model building is well advanced, and there are a large number of existing models that range in size from the small-scale Fair model (1971) to the enormous FMP model (1968). Since questions associated with fiscal and monetary policy are not particularly relevant to the problem at hand, it probably makes sense to deal with fairly aggregative models that do not consider in great detail the channels through which monetary or fiscal policy work. Thus it may be reasonable to adapt the Fair model (1971) to our analysis. As an alternative, we could also adapt the model developed by Hudson and Jorgenson (1974) in their analysis of energy policy.

Since we have not fully explored the structure of the existing small-scale macroeconometric models, little would be gained from making a specification of such a model *de novo*. Clearly such a model would require the determination of gross national product by broad sector and its components: consumption, investment, government, and net exports. It would similarly require the determination of sectoral wages, consumer prices, the interest rate and the unemployment rate. These are the traditional elements of a full Keynsian model, and their analysis and estimation is well grounded in macroeconomic theory and its applications in the existing macroeconometric models. Thus, although we have not yet developed the specification of the macroeconometric model needed to close the system, this is a straightforward task that we will undertake at the appropriate time.

VII. Summary and Conclusions

This chapter has outlined a number of linked models that can be used to analyze the impact of federal transportation policy upon the transportation industries and the rest of the economy. Since it has ranged over a wide number of subjects, it might be useful to consider how a specific policy change could be analyzed in the context of this model and trace the various linkages through.

Let us assume that the ICC and other government bodies removed all restrictions on abandonments and permitted the railroads to adjust their track to its optimal levels. This is formally equivalent to a movement from the short-run cost curve to the long-run cost curve on the part of the railroads. Thus, our comparative static experiment requires a shift in the railroads' cost curves and a determination of the new equilibrium.

Given the existing market and firm demand schedules, we can then determine a new equilibrium level of rates and traffic allocations between firms and between modes. We can also determine the new quantities of labor utilized by each mode and the profitability of each mode and the firms within it.

The change in rates and labor utilization provide the main inputs into the other models. From the change in regional rates by mode, we can derive estimates of the changes in the aggregate rate index that is used in the interindustry model. This in turn will generate changes in producer price, labor employment and industry outputs, as well as the aggregate demand for transportation services.

The changes in the regional transportation rates and transportation employment also feed into the regional income model as do the changes in the national employment levels. Thus, regional employment, income and wages will change in response to the new levels of transport rates, transport employment, and national employment.

Since, however, the various models are interactive, changes in the equilibrium in the interindustry or regional models will have repercussions on the regional transportation markets. Changes in regional incomes will affect the demand for transport services, while changes in regional wage rates may affect transport costs. Similarly, changes in producer's prices will affect energy costs and thus transport costs as well as the value of the marginal product of transportation and hence the demand for transport services. Consequently, a full solution to any given policy change cannot be determined sequentially, but requires a full solution to the entire model that will generate a new equilibrium in each of the sub-models. By comparing the new equilibrium value of rates, incomes, outputs, interindustry allocations and so forth, we can then determine the full general equilibrium impact of the change in the policy.

Chapter Four

Network Models for Transportation Policy Analysis

I. Introduction

This work is aimed at developing improved methods of economic analysis for common carrier transportation systems operating over a network of transportation markets. We feel that it represents an extension of the theory of the firm operating in a single market, which is quite necessary for a complete and valid understanding of the behavior of such transportation firms operating under the regulatory constraints of the CAB or the ICC.

Our work, which is reported in detail in Volume IV of this report, is divided into three main parts: an explanation is made of why it is necessary to perform economic analysis at the network level for common carriers; secondly, the development of the network models is described; thirdly, a brief overview is given of some initial applications of these models to a trunk airline industry scenario, which investigates several policy issues; and at the level of the firm, a case study of the behavior of Continental Airlines under free entry conditions is provided.

II. Transportation Economics at the Network Level

The reasons why we feel economic analysis of transportation firms at the network level is necessary are as follows:

1) Marginal Costs for Service depend on Network Routing:

If transportation firms confined their supply to a single market, it would be possible to determine the average and marginal costs for a unit of supply. However, when they operate services along routes within the network, it becomes impossible to determine the incremental costs of increasing the supply in a market without looking at the adjacent sets of markets and the services offered in them.

2) Services along a Vehicle Route are jointly produced.

The basic supply decision for a transportation firm is the dispatch of one vehicle along a route which serves more than one market. The basic demand decisions is to buy space available on one of the services offered in a market. Different classes of service may be jointly offered on the same vehicle route operation. In these circumstances, it is impossible to isolate a true marginal cost for a given service in a market, and consequently economic analysis at the market level is impossible.

3) The transportation firm is optimizing over its network.

In making its supply decisions, the firm will be performing an optimization over the complet set of markets in its network. It may not be otpimizing in any individual market, so analysis at the modal level of firm behavior cannot be based on this presumption.

4) Extensive network operations provide a firm with market power.

Intensive networks provide a firm with the capability to route vehicle different ways through the network in making efficient use of its vehicles. The firm has a variety of options in making use of its empty space, and can arbitrarily direct it at zero or low cost into any market to compete with local carriers. This routing capability gives it unusual competitive powers in the market and is usually regarded as unfair competitive behavior. To determine whether the competitive behavior is predatory, we must know the costs of adding these services to the market. This can only be determined from examining the adjacent markets in the network.

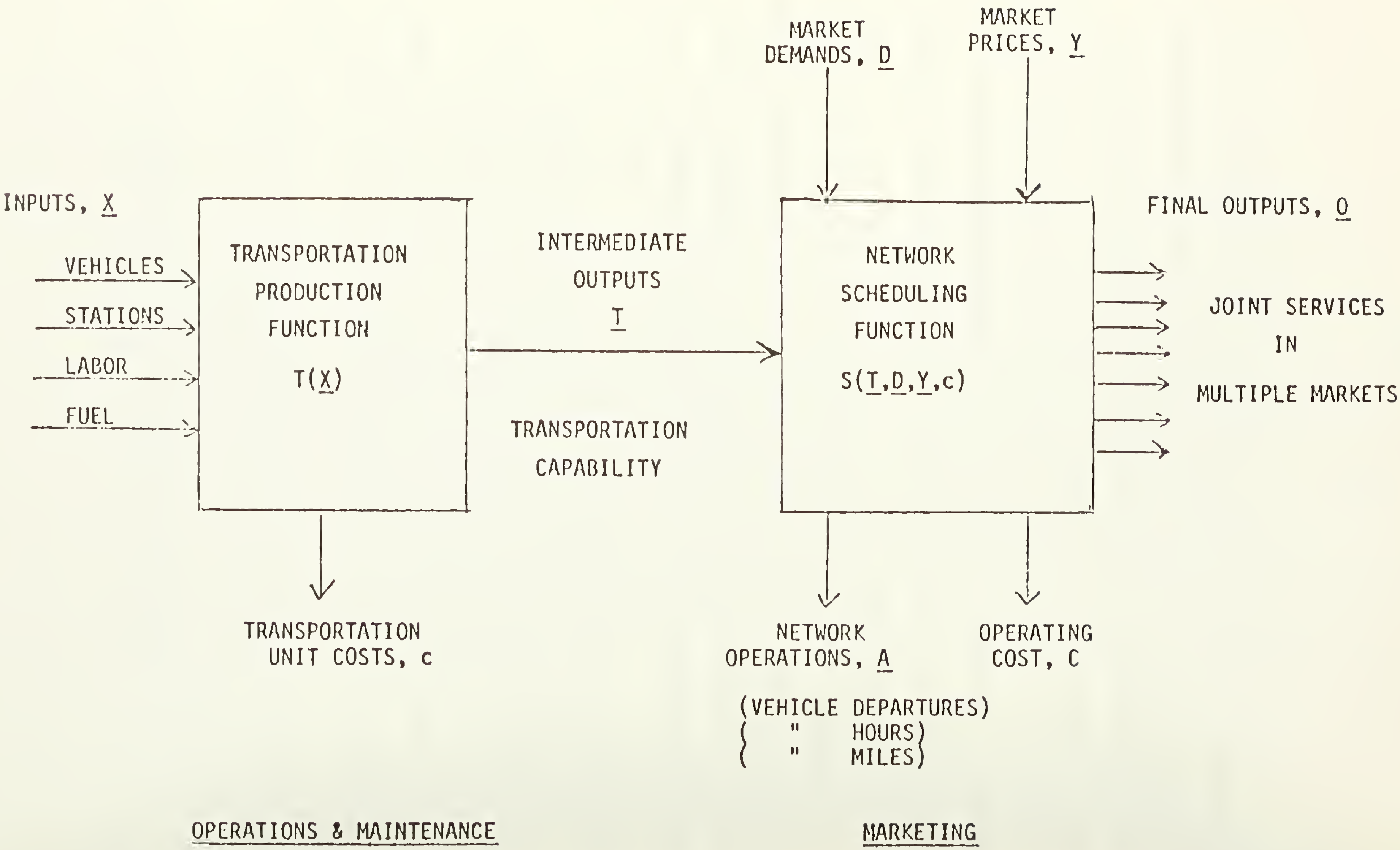
For these reasons, it becomes necessary to build a network model for the transportation firm which properly relates the supply processes to the set of market demands in the network. In particular, we must account for the routing decisions which such a firm can make.

III. Modeling the Transportation Firm

The process of producing transportation services is best explained conceptually as a two stage process as shown in figure IV-1. The first stage uses resources such as labor, fuel, and capital facilities in the form of vehicles, guideways, and stations to produce an intermediate output of transportation capability (such as vehicle hours or miles). We may call this stage the production function for a transportation firm. It uses the firm's capabilities in operations and maintenance.

The second stage uses the inputs of this transportation capability and marketing information to produce the final transportation output which

Figure IV-1. THE TRANSPORTATION PRODUCTION PROCESS ON A NETWORK



is consumed by users - the set of multiple services of given quantity and quality offered in the markets of the network. This is called the network scheduling and routing function. It uses the firm's capabilities in marketing and sales. In fact, some carriers just provide these capabilities and lease the transportation operating capabilty from another firm.

In the first stage, we are interested in determining the costs of producing vehicle and station operations for input to the second stage. This may be found using inferential methods on the available accounting statistics for a given firm or industry. In the second stage, it becomes necessary to build an optimization model which logically relates demand and supply operations on the network. This can be done using current computer methods in mathematical programming. By building pre-processor and post-processor codings, a computer tool of wide versatility can be constructed to study the netwrok behavior of transportation firms in an industry.

The set of mathematical equations are derived in Simpson et al. (1977). Figure IV-2 gives a summary of these sets of equations. Briefly, the firm is profit maximizing over the network by making simultaneous decisions about routing a given type of vehicle at a given frequency of service. The demand can be served on non-stop or multi-stop vehicle trips, or by connecting between portions of vehicle trips. The demand in a market may be a function of price, or it may be a function of the frequency of service classified into quality levels of non-stop, multistop, or connecting service. On the supply side, we ensure that the capacity of vehicles are not exceeded in any link in a given route; that station capacity in terms of vehicles or demand units handled is not exceeded; and that the limited availability of vehicles of a given type is not exceeded.

The input data set can be fairly extensive. Vehicle data on available hours or miles, operating costs, and capacity must be specified by vehicle type. Station data on vehicle and demand, handling costs, and vehicle and demand handling capacities, must be specified. Route data with operating times, distances, and costs (and perhaps fuel burn) must be known. Modal data in the form of demand functions of price, or frequency of service, or trip time must be known, and there may be limits on minimum or maximum levels of service.

Similarly, an extensive set of output data is obtained. For each market, we obtain the demand levels and its routing, the prices of services and the supply levels of service frequency by vehicle type. For each route, we see the frequency of service along the route by vehicle type, and the vehicle loads along the route. For each segment, the onboard loads are known so that segment load factor is obtained as an output, and the frequencies by vehicle type and route is obtained. For each station, the originating and connecting demand is obtained, as well as the vehicle departures by type. For the system, results are obtained in terms of total originating demand, in system revenue passenger or ton miles, in system available passenger or ton miles, system load factor, vehicle departures, vehicle average stage length, total fuel burn,

Figure IV.2. (Continued)

i) for vehicles

$$FL_k \leq \sum_{r \varepsilon R_k} \sum_v F_{vr} \leq FV_k \quad \text{for any station } k$$

ii) for demand units

$$D_k + DC_k = \sum_{m \varepsilon M_k} (Dm + \sum_{m \varepsilon M_p} \sum_p Dnp) \leq DV_k$$

c) Vehicle Availability must not be exceeded

$$\sum_r F_{vr} \cdot V_{vr} \leq U_v \quad \text{for all markets, } v$$

Figure IV-2. The Complete Network Model

1) Objective Function - maximize profit (operating income)

$$\text{Maximize PROFIT} = {}_{m}REVm - \left(\sum_{v} \sum_{r} C_{vr} \cdot F_{vr} + \sum_{m} C_{m} \cdot D_{m} + \sum_{k} C_{k} \cdot DC_{k} \right)$$

2) Demand Relationships

a) Market Demand may be served on a route or path.

$$Dm + \sum_{m \Sigma Mp} \sum_{p} D_{np} + \sum_{r \Sigma Rm} D_{mr} + \sum_{p \Sigma Pm} D_{mp} \quad \text{for markets, m}$$

b) Market Demand can be a function of market price

$$Dm = dm^{\circ} + \sum_{i} d_{m}^{i} \cdot y_{m}^{i} \qquad \text{for all markets, m}$$

$$REV_{m} = \sum_{i} r_{m}^{i} \cdot y_{m}^{i}$$

c) Market Demand can be a function of marketing frequency

$$D_{m} \leq \sum_{i} b_{m}^{i} \cdot f_{m}^{i} \qquad \text{for all markets, m}$$

$$Fm = \sum_{i} f_{m}^{i} = \sum_{r \Sigma Rm} W_{mr} \cdot F_{r} + \sum_{p \Sigma Pm} W_{mp} \cdot F_{p}$$

$$REVm = \sum_{m} Y_{m} \cdot D_{m}$$

d) There are other related demand constraints not shown here.

3) Supply Relationships

a) Vehicle Capacity must not be exceeded.

$$\sum_{v} S_{v} \cdot F_{vr} > \sum_{m \Sigma M_{1r}} D_{mr} \qquad \text{for all links of any route (1,r)}$$

b) Station Capacity must not be exceeded:

and finally the financial results for the system in terms of revenue, operating cost, and profit.

By varying input data, or the operating constraints on the system we can study the affects of various policy variables on system behavior and system results. Some preliminary results from studies of the domestic airline system are presented in the next section.

IV. Airline Policy Analysis

Some preliminary results are described in greater detail in Simpson _et al._ (1977). Work has been started at an industry level looking at the top 91 markets of the U.S. airline system; as well as a case study of Continental Airlines behavior under postulated conditions of free entry and exit in U.S. airline markets.

For the industry analysis, average trunk airline operating costs per block hour for vehicles of capacity from 100 to 400 seats were obtained from 1974 CAB data. For the same year, average industry costs for onboard passenger service were stated in terms of dollars per passenger boarded and dollars per revenue passenger mile; costs for handling aircraft in terms of dollars per aircraft departure, dollars per passenger boarding and dollars per revenue passenger mile; promotion and sales costs, and general and administrative costs were stated as a percentage of system revenue. On the demand side, 1974 traffic data for these markets was obtained from CAB data, and split into business and pleasure segments. From other studies, the price elasticity in the business markets was assumed to be -0.5, and for pleasure markets to be -2.0. The time elasticity of business markets is taken as -2.1. To simulate the existence of competitive airline scheduling in these markets and obtain the industry response, we assume an index of competition for each market and assume generally that the market share situation remains similar under changed scenarios. From a series of runs using the network models, the following results can be postulated:

a) Current Airline Discounting appears to be Optimal

By fixing discount fares at their present value, and then allowing them to be selected by the model, we obtained a result where very small price increases occurred. This result states that for our assumptions on pleasure price elasticity, the industry is correctly pricing its discount services.

b) Joint Costs and Network Effects are Significant

When comparing the model results with actual industry levels of service, we found that eight markets in the model were not being served at anything like actual levels. In tracing the reasons for this deviation, it became clear that the additional traffic from yet other industry markets was missing from the model. As well, if we allowed only nonstop services in these top 90 markets, a total of sixteen markets were served at unusually low levels. We needed to include the historical multistop routings to get results comparable to actual service.

c) Monopoly Services Cost Less and Carry More

By changing the index of competition in each market to eliminate the wasteful head to head scheduling, we can see the improvement which would result if we had only one carrier in each market. This turned out to be a 14 percent increase in profits, a 9 percent increase in business travel from higher service levels, and a minor increase in some pleasure fares.

d) Economics of Scale Exist even in High Density Markets

By increasing the levels of demands in all markets by 20 percent, a cost increase of less than 19 percent was incurred. This would indicate that marginal costs are 6 percent below average costs for this high density netwrok. We would suspect much larger differences for low density markets, and were surprised to find it present here. It arises from the use of larger sized aircraft.

For the analysis at the level of an individual firm, the operations of Continental Airlines in 1974 were selected to study its possible behavior under conditions of free market entry and exit. Using actual reported operating costs for Continental (excluding vehicle depreciation and ownership costs); the actual fleet of aircraft available and their daily utilization; the actual traffic share for Continental and our estimates of frequency elasticities (no split into business and pleasure markets was used); the 1974 prices corrected for net yields; and the existing route authority with all its restrictions, a base run was made to compare with the Continental service offerings in its markets, and its system traffic and financial results. The model gave a very close replication of Continental service patterns and traffic and financial results for the year. One exception was the service to Hawaii where the network model refused to operate the DC-10 aircraft at the low loads experienced by Continental and substituted B-720 B aircraft even though their unit operating costs were higher. By adding a constraint which prevented the B-720 B from flying these routes, and insisting on minimal levels of service in the market, we were able to get reasonable Hawaii service in the model.

To study the profit seeking behavior of Continental when there is free entry and exit into other U.S. airline markets, it was necessary to create a strategy which focussed the system expansion on certain cities. Results are given in Simpson et. al. (1977) for the case where this expansion was focussed on adding New York City to the Continental system, and at the same time removing all the present operating authority restrictions. This allowed the model to consider entering 17 new markets from New York to other points in its system, and 35 new markets between current points in its system. We assumed that when Continental entered a new market, it would become an equal competitor amongst the existing airlines, and would thus obtain its proportional share of traffic.

The result showed extensive entry into these new markets, and varying levels of abandonment of current markets depending upon whether new aircraft were purchased for the expansion, and whether or not fares in these new markets were lowered with the competitive entry. For example, if fares remained at current levels and no new aircraft were obtained, Continental entered 35 of these 52 new markets, and abandoned 76 current markets. Most of these abandoned markets were low density markets on the Continental system which were served at a small profit in the base run. They were abandoned simply because higher profits could be found in the competitive high density markets. There were reduced levels of service in many other current markets of the Continental system.

If we assumed that under free pricing, the levels of competition would reduce yields by 10% in these new markets, then the model results showed the Continental system entering only 26 new markets and abandoning only 45 current markets. Then, if we allow the purchase of new aircraft and operate them including the depreciation and ownership costs, the number of new markets entered increased to 49 while the number abandoned was further reduced to only 23 current markets. But the levels of service in markets were now increased. In this case Continental purchased 29 new DC-10 aircraft and 57 new B-727-200 aircraft. It roughly tripled the number of passengers carried and its profit. New York became its busiest station.

If we then assumed that competitive pressures would reduce the yield in these new markets to 20% below current levels, Continental still entered 38 new markets while abandoning only 22. Results were still roughly triple the present Continental system with 16 new DC-10's and 53 new B727-200's purchased.

Similar case studies are being performed for possible new markets for Continental focussed on Chicago, Miami, Dallas-Fort Worth, and a combination of Los Angeles/San Francisco. As can be seen from the results quoted for the New York case, there is a potential for quite a dramatic change in the operating activities of a typical domestic trunk airline as it tries to find a nationalized route system which increases its profitability. It is not clear that there would be airport gates available for Continental's invasion of New York unless it used Newark airport. Entry into new markets might be restricted by airport space mode available by airport authorities or non-competitive airlines. It is also clear that the assumption that other airlines remain fixed in their present service patterns is unrealistic. Further work with other airline systems is called for to see the possibilities which can occur under various proposals for relaxing the present market entry controls for the domestic trunkline industry.

Chapter Five

Summary and Extensions

This report has summarized our first year's efforts in the following three major areas of research:

- policy analysis and scenario development
- freight policy models
- air network models

This chapter will briefly summarize our major findings and indicate areas for future research in each of these areas.

Policy Analysis. A detailed evaluation of federal transportation policy with respect to the intercity transportation industries (rail, truck, inland water, and air) has indicated that policy makers have generally stressed issues of fairness, support of rural and agricultural interests, and industry stability instead of issues of economic efficiency. In particular, federal policy with respect to rates has generally attempted to ensure that they are nondiscriminatory with respect to specific shippers or specific locations. However, commodity price-discrimination exists in the value-of-service rate structure, which clearly favors producers of bulk and agricultural commodities relative to producers of manufactured commodities. Moreover, since the rate structures also ensure that rates are low relative to costs in areas that generate light traffic volumes, shippers in rural regions are favored relative to those in urban areas. Thus this rate structure has generally acted as an income transfer from urban and manufacturing interests to rural and agricultural interests.

Similarly, federal investment and user charge policies have generally acted to ensure low freight rates in rural areas. The calculation of waterway benefits is frankly related to the railroad rate structure, and a sufficient difference between railroad rates and waterway costs is typically sufficient justification for waterway investments. The construction of the Interstate Highway System ensured that all areas in the country could have access to good highways and thus diminished the latent monopoly power of the railroads in areas where there was no water competition. To the extent that these investments are aimed at providing cheap alternatives to rail transport, the lack of user charges for waterways and relatively low user charges on large diesel trucks is entirely consistent with this goal.

Finally, policies with respect to mergers and entry have generally tried to maintain industry stability, which is essential to the maintenance of the traditional rate structure. This is particularly true in the trucking industry, where entry has been restricted through the issuance of operating rights and authorities. While maintaining the profitability of existing carriers, this policy also ensures that relatively high rates can be maintained on manufactured commodities thus enabling the continuation of relatively low rates on bulk commodities.

Even though economists have documented the efficiency costs of these policies, the lack of Congressional enthusiasm for reform indicates that these non-efficiency goals are given considerable weight by policy makers. Thus any analysis of alternative federal transportation policies must include the dimensions of fairness, rural and agricultural income maintenance, and industry stability as well as dimensions of economic efficiency. Consequently the models that are being developed to evaluate policy must include distributional as well as efficiency variables. Similarly the development of alternative policy scenarios must show a sensitivity to these various goals.

Frieght Policy Models. We have developed the following linked models that can be used to evaluate the impact of federal transportation policy upon relatively broad transportation, regional, and industry aggregates such as output, employment, income, profits, etc.

- A regional transportation model that estimates cost and demand functions for the various modes that can be used to evaluate the impact of alterantive transportation policies upon modal and firm equilibrium with respect to rates, costs, traffic allocations, factor utilization, shipment characteristics, profitability, etc.
- A regional income model that can be used to evaluate the impact of alternative transportation policies upon interregional commodity flows, regional incomes, and regional employment, by broad industry type.
- An interindustry model that can be used to evaluate the impact of alternative transportation policies upon interindustry

and factor utilization by industry group.

By using these models it should not only be possible to quantify the impact of alternative transportation policies upon efficiency variables such as price-marginal cost ratios, capacity utilization, productivity, etc., but it should also be possible to measure their impact upon distributional variables such as regional and factor incomes, industry projects, the freight rate structure, etc.

Since these models involve an enormous number of variables, the bulk of our efforts during the coming year will involve the consistent estimation of these relationships.

Once these models have been calibrated, they can be used to evaluate alternative transportation policies. By translating change in transportation policy into change in demand functions, cost functions, or the market structure of the transportation industry, it is possible to simulate the response of the system to changes in transportation policy. Thus a major research effort must be devoted to analyzing the way in which changes in specific transportation policies would alter the cost functions, demand functions, or market structure inthe transportation industries. Policies that affect rates, capacity utilization, entry, factor costs can easily be hurdled in the context of these models. Thus we must develop alternative scenarios with respect to rate policy, user charges, abandonment, and mergers that can be evaluated by these freight policy models.

Air Network Models. In the first year most of the effort in the area of network transportation models has been pointed towards developing extended codings for new versions of these models (which include demand-price relationships and connecting paths) and gathering data for the airline applications. Preliminary runs for the industry scenario, and for the Continental Airlines case study were made. These are of an exploratory nature to test the model, validate input data, and to determine the sensitivity of model results to various policy issues.

The low density scenario is focussed on an area between St. Louis and Chicago including Springfield, Peoria, Champaign and Decatur, Illinois. We intend to study the efficiency of the traditional hub and spoke route system, as opposed to introducing longer haul bypass routes. At present this area has such routes to Washington and New York. With the free optimal pricing versions of our models, it is possible to see the fares which might be charged in various low density markets for an airline with a given type of resources. The response of a new commuter airline which uses present 30 passenger and the proposed 56 passenger aircraft will also be examined.

Data has been obtained from United Airlines on the split of business and pleasure travel in its major markets by quarter for the past several years, along with the average yields for this traffic.

This is currenlty being analyzed to determine price and frequency elasticities which then can be incorporated into the airline industry model.

We are considering the possibility of extending the network models to handle surface freight problems in common carrier trucking and rail. Here the major problem is creating several demand functions for each market corresponding to a given class of commodities. We would like to know the price and frequency elasticities for these commodity classes. The ability to route freight over connecting paths is important to these applicatons, and we should have good estimates of terminal handling costs. The lack of available cost and demand data for freight is a serious block to applying network models to surface freight policy scenarios.

The extensive impact of relaxing entry/exit restrictions on Continental Airlines has made us consider whether or not case studies of other airline systems should be developed. The transition provisions of proposed deregulatory legislation for relaxing entry/exit restrictions gradually can be studied for Continental, but to fully evaluate the industry behavior during the transiton period at least a few other airlines should be studied. Similarly, the current proposals to prepare a list of cities between which nonstop service authority will be granted needs some evaluation as to its impact on individual carriers.

An issue which will be studied using the current airline industry model is whether or not a set of independent charter airlines (or divisions of scheduled carriers) should be established to promote the development of low cost mass travel. The alternatives are to allow split charter operations, or to create a new "tourist" class of service which moves in the empty space on board scheduled flights. These alternatives can be established in the industry model by creating a set of "charter only" aircraft for the price sensitive demand. We expect that there is some efficiency in placing both business and pleasure traffic on board scheduled flights, but it is not clear what the size of cost savings will be.

Finally, there is the possibility that long haul "commuter" airlines can be established by new entry carriers who purchase small jet transports available in Europe and place them in service on the smaller city pair markets which do not receive long haul non-stop service today. By finding a set of such markets, postulating a set of routes to serve them, and estimating the costs of oeprations for these newer expensive jet aircraft, it is possible to see if viable long haul "commuter" airlines can exist as a result of proposed legislative changes.

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