ANALYSIS OF THE APPALACHIAN DEVELOPMENT HIGHWAY PROGRAM AS A POLICY INTERVENTION

A THESIS

Presented to

The Faculty of the Division of Graduate

Studies and Research

By

Choon Y. Park

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in the School of Industrial and Systems Engineering

Georgia Institute of Technology

August, 1978

ANALYSIS OF THE APPALACHIAN DEVELOPMENT

HIGHWAY PROGRAM AS A POLICY INTERVENTION

Approved:

A. L. Porter, Chairman

R. G. Heikes

P. S. Jones

Date approved by Chairman 8-21-78

ACKNOWLEDGMENTS

I wish to express my sincere appreciation and gratitude to my thesis advisor, Dr. Alan L. Porter, who introduced me to the area of policy analysis and provided the encouragement and guidance through the completion of this research.

Dr. Russell G. Heikes and Dr. Paul S. Jones who served on the reading committee and provided many stimulating suggestions receive my sincere thanks.

I owe my thanks to Dr. Srikanth Rao for providing the regression models. Also Messrs. Wright Aldridge of the Federal Highway Administration, Brindley Lewis of the Appalachian Regional Commission, and Robert Duis of E. S. Preston Associates have provided essential information. Fellow graduate student Loren Rees has made helpful suggestions as a colleague.

I sincerely acknowledge the financial support of the U.S. Department of Transportation (through contract DOT-OS-70036) without which this research would not have been realized.

Special thanks are due to Dr. Hahn Been Lee, Dr. David E. Fyffe, Dr. Clarence E. Prince, Jr., Mr. Ross W. Hammond, and Professor Chul Hwi Lee, whose efforts, through the financial support of an AID 211(d) grant, provided me the opportunity to pursue graduate study.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF ILLUSTRATIONS

Figure | Page

SUMMARY

This research addresses two major questions, one substantive and one analytical. The first is to identify the impacts of Federal-aid financing on the highway expenditures of state government. In particular, the focus is on the implications of the Appalachian Development Highway Program (ADHP). The second concern is to compare and contrast alternative analytical approaches - quasi-experimental and non-experimental analyses.

Substantively, the central finding is that the ADHP appears to have stimulated the Appalachian states involved to increase their state highway expenditures. An indicator of this is an increase in highway bond issues and state gasoline tax rates in these states relative to a comparison group, during the period following the onset of the ADHP in 1965. Construction effort on highway systems other than the Appalachian Development Highways did not decrease seriously. However, there were some apparent decreases in investment, particularly on the Federal Aid Primary System ("A System"), as states invested in the new ADHP. In contrast, there was a jump in the level of expenditure of the ADHP states on their non-Federal-aid system highways. More broadly, socio-economic gains in the Appalachian region appear related to the implementation of the ADHP. The success of the ADHP in stimulating highway effort can be attributed to both the Federal aid and the high level of commitment of the states involved.

In terms of methodology, a range of analyses were performed.

Initially, graphical comparisons were made on a number of indicators of transportation investment activity. These indicated the nature of the state response to the ADHP program and suggested sensitive areas for further analyses. Interrupted, multiple time series analyses were performed on the critical variable - state investment on the Federal-Aid System, exclusive of the Interstate System. Both linear and stochastic models were used to analyze the series. Results were compared and the implications of violating assumptions were examined (e.g., the linear model assumes independence of observations; the stochastic model demands longer time series for model identification). In addition, multiple regression analyses were compared with the time series analyses. The regression approach explicitly considers factors potentially influencing the state investment levels.

The multiple analyses complement each other. Initial search strategies lead naturally into more definitive, but restricted, analyses. Confidence in findings with respect to complex socio-technical systems is enhanced by convergence of results of analyses with different underlying assumptions. Furthermore, one approach can add insight to the results derived by another. For instance, previous regression analyses of the response of states to Federal aid have failed to consider the possibility of a "reverse stimulation" effect of Federal aid. Yet, the time series showed a distinctive period in which constant dollar Federal aid decreased, while state expenditures increased. In this light, a negative coefficient can be reasonably interpreted as indicating that states invested more to make up for the reduced level of Federal funds available.

CHAPTER I

INTRODUCTION

1.1 Objectives

This thesis addresses two major questions, one substantive and one analytical. The first is to identify the impacts of Federal-aid financing on the highway expenditures of state government. In particular, the focus is on the implications of the Appalachian Development Highway Program (ADHP). The second concern is to compare and contrast alternative analytical approaches to this complex problem.

Prior to 1965, state governments in the Appalachian region had been maintaining large Federal-aid and non-Federal-aid highway programs. The onset of the ADHP in that year can be seen as a major intervention in the ongoing state highway programs. The ADHP was intended specifically to increase accessibility to the lagging Appalachian area and thereby to stimulate economic development. The ADHP involved a specific network of roads to be constructed in a limited time period. As such, it is classified as a categorical funding program, i.e., it was established for a rather specific purpose.

An underlying proposition in this study is that the onset of this major new Federal highway program would stress the decision making of the state highway departments involved. The new program demanded state resources, and that strained state budgets, and raised questions such as the following:

(1) Did the ADHP stimulate total state highway investment?

(2) Did states reduce their level of effort on other highways to meet the demands of this new program? If so which other programs were affected?

(3) What are the implications of the funding structures used to finance the ADHP?

(4) What have been the direct and secondary effects of the ADHP? Is it fulfilling its objectives of providing mobility and spurring economic development?

The second key question of this research is to compare the effectiveness of alternative analytical approaches. Beyond descriptive statistics, this involves both quasi-experimental and non-experimental analyses. For quasi-experimental analysis, interrupted multiple time series are utilized, because highway expenditures are by nature time dependent on policy formation and implementation. Both line-fitting and stochastic models are used to estimate the intervention effects in this quasi-experimental analysis. The non-experimental analysis relies upon multiple regression modeling to explain changes in expenditure patterns. The interest is in comparing the effectiveness of these different analytical approaches. In addition, the potential convergence of findings from these alternative analyses can lend greater credibility to the overall conclusions.

It is hoped that these findings will be of use in current policy dialogues concerning methods of funding Federal transportation programs. Besides throwing light on programs directed at the Appalachian region (e.g., Coal-Haul Roads program is now being discussed), this comparative analysis can provide insights into the effects of Federal funding policies.

1.2 Organization of the Thesis

Chapter 2 includes a historical review of Federal highway financing policies. This defines the structural setting for the highway programs unto which the ADHP was introduced in 1965. Section 2.2 describes the socio-economic background of the Appalachian region, the setting for the ADHP. The following section describes this highway program. The last section of Chapter 2 reviews previous analytical studies perceived as relevant to this effort.

Chapter 3 summarizes the concept of quasi-experimental research designs. The present study design is then presented, with specific attention to the establishment of treatment and control groups. Considerations in the use of available data are then presented.

The next three chapters discuss the effects of the ADHP as assessed by different analytical approaches. Chapter 4 uses simple graphical techniques and descriptive statistics to investigate the effects of the program. Formal interruptive time series analyses are presented in Chapter 5 to estimate the ADHP effects on highway expenditures. Two models - linear and stochastic - are used. Efforts to estimate the effects of the ADHP intervention are continued in Chapter 6 using a structural equation approach.

Chapter 7 steps back to attempt to sort out the consequences of the particular funding structures used in the ADHP program.

Chapter 8 begins with a discussion of the factors that threaten the validity of the interrupted time series analysis. It then turns to critically review the results of the regression analyses taking into account the time series perspective. Finally the summary of findings and the policy implications of those findings are presented. Methodological recommendations and suggestions for further research are also made.

CHAPTER II

BACKGROUND

To understand the consequences of particular highway policies, it is important to be aware of the historical development of the Federal-Aid Highway Program (FAHP).[1] This chapter therefore begins with the summary of the major developments of the FAHP. We briefly trace this development from the germinal highway acts to those of current interest. It will be seen that principles of current operations have their roots in the early acts. Naturally, there have been tremendous increases in the volume of highway activities and the scale of highway expenditures. An important distinction can be made between the periods before and after foundation of the Highway Trust Fund in 1956.

Following this introduction to the Federal-Aid Highway Program, attention is turned to the Appalachian Development Highway Program (ADHP). To set the stage for that discussion Section 2 of this chapter presents a socio-economic and geographical background on the Appalachian region. Section 3 turns its attention to the structural and dimensional similarities and dissimilarities between the ADHP and the FAHP.

---

[1] In this study, the term Federal-Aid Highway Program refers to certain programs involving the apportionment of Federal funds to the states. These programs all have a requirement for states to contribute, so-called matching, funds for these programs. Specifically, the programs are the Interstate Highway System, the Federal-Aid Primary System (A), Federal-Aid Secondary (B), Urban Extentions of the Primary and Secondary Systems (C), and Urban System (D). Other federally supported programs such as the Forest Highways, Highway Beautification, and so on are not included under this term for present purposes.

2.1 History of the Federal-Aid Highway Programs

2.1.1 From the Early Acts to the Approval of the Interstate System

Federal interests in national transportation appears in the Constitution. Since that time, transportation policy in the United States has undergone tremendous changes to meet evolving national needs. Those changes have notably affected transportation practices through the various highway systems.

The nineteenth century and early part of this century can be considered as an experimental period in which the government explored various arrangements for roadways. Key questions concern issues of who would be most appropriate to take over the responsibility for highway financing? for determining what roads should be built? for actually performing construction and maintenance of those roads? In 1912 Congress passed the first highway act authorizing Federal aid to the states. The act was focused on rural roads to facilitate better mail delivery. States were expected to pay two times the amount provided from Federal funds. This plan was not notably successful.

The increasing popularity of the automobile exerted pressure on the Federal government to develop integrated road systems. The Federal-Aid Road Act of 1916 was a landmark in establishing the framework of Federal highway policy effective since that time. Four effective principles were established at that time:

- states were required to match the Federal funds provided
- the supervisory role of the Federal government was established through the vehicle of the U.S. Bureau of Public Roads
- funds were to be used only for roads approved by the Bureau of Public Roads (BPR)

- states would be the legal owners of the Federal-aid roads and responsible for planning, constructing, and maintaining those roads.

An additional point worth noting is that the Act required each state to establish a state highway department in order to be eligible for the Federal aid. The requirement was effective in leading all the states to establish highway departments.

Congress passed another important highway act in 1921. This Act formally recognized three basic types of highways eligible for Federal aid: primary roads, secondary roads, and urban extensions. This Act also established the apportionment formula that divided the highway authorizations among the states according to state's population, land area, and existing road mileage (see Table 2-1). As a minimum, no state would receive less than 0.5% of the total yearly authorization.

The Federal-Aid Highway Act of 1944 approved the National System of Interstate and Defense Highways (the Interstate System) not to exceed 40,000 miles. However, it did not appropriate funds for the system. This Act also divided the authorization among the primary, secondary, and urban extension (ABC) programs in the ratio of 45%, 30%, and 25% respectively. Table 2-1 illustrates the apportionment formula for each system.

2.1.2 The Modern Era

The Federal-Aid Highway Act of 1956 vastly reshaped the FAHP. A new highway financing system was established through the creation of the Highway Trust Fund (HTF). The Trust Fund became a moving force for continued construction of the Interstate highways and for continued work on the ABC systems. Federal funds were provided to the extent of 90% of the construction costs on the Interstate system. The ABC system remained

Table 2-1. Changes in the Parameters for Apportionment and Matching of Federal Aid Highway Funds

Federal-aid Highway Acts	Interstate	Primary (A)	Secondary (B)	Urban Extensions (C)	Urban System (D)
1944		Apportionment formula: 1/3 on land area 1/3 on state population 1/3 on rural postal route mileage Federal matching share: 50% on construction	Apportionment formula: 1/3 on land area 1/3 on state population 1/3 on rural postal route mileage Federal matching share: same as A system	Apportionment formula: population in urban places over 5,000 Federal Matching share: same as A system	
1956	Apportionment formula: cost estimate for completion Federal matching share: 90%	No change	No change	No change	D system was approved by the 1970 Act.
1973	No change	Apportionment formula: 1/3 on land area 1/3 on rural population 1/3 on intercity mail route Federal matching share: 70%	Apportionment formula: same as A system Federal matching share: same as A system	Apportionment formula: no change Federal matching share: same as A system	Apportionment formula: population in urban places over 50,000 Federal matching share: same as A system
1975	No change	Apportionment formula: 1/3 on rural population 1/3 on intercity mail route 1/3 on urban population	No change	No change	No change

at the level of a 50% Federal share. The Interstate system was obviously favored by these more attractive terms.

More recently increasing attention to the problems of urban transportation led to the creation of the urban system (so-called D) by the 1970 Federal-Aid Highway Act. The authorizations for this system initially in 1972 and 1973 were not large compared to that for the ABC or Interstate systems. The apportionment formula was based on the state population in urban areas larger than 50,000 people.

The 1973 Federal-Aid Highway Act was the most comprehensive highway legislation passed by Congress since the 1956 Act. Federal share for the ABC system was increased from 50% to 70% of the construction costs. Formulas for the apportionment of the Federal funds for the A and B systems were reconstituted (see Table 2-1). Emphasis on the D system was dramatically increased. The 1975 Federal-Aid Highway Act continued this trend to help the urban areas by altering the apportionment formula for the primary system to account for urban population instead of land area.

2.2 Appalachia

Punctuated by high, rolling hills and deep, narrow valleys, the Appalachian region includes in its 195,000 square miles all of West Virginia and portions of twelve other states - Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee and Virginia.[1] By the early

[1] States and portions of states currently included in the Appalachian Regional Development Program (c.f., Figure 3-1).

1960's, Appalachia was lagging behind the rest of the nation in terms of economic status and the standard of living. Per capita income in central Appalachia was only 52% of the U.S. average in 1965, (78% for Appalachia as a whole).[2] Poor social and economic conditions resulted in outmigration of people. The first to go were the young people in search of better economic opportunity, leaving families to support. This worsening social condition increased the states' burden with reduced tax income.

In an attempt to attack these critical social and economic problems, the Appalachian governors called for national recognition. President John F. Kennedy appointed a President's Appalachian Regional Commission in 1963 to study the problems facing the people in Appalachia. Accepting the Commission's recommendations, Congress passed the Appalachian Regional Development Act of 1965. The Act set up the Appalachian Regional Commission (ARC) and authorized a range of programs: transportation, energy, environment and natural resources, health and child development, education, and community development and housing.

Isolation was identified as a major factor contributing to Appalachia's relative economic stagnation. This isolation resulted primarily from the difficulties of transport in a rugged region. Narrow, winding roads followed the terrain, increasing travel distance and time. This, in turn, inhibited potential industrial developers because of the problems in getting products to market. Poor roads also made it difficult for Appalachians to reach jobs, schools, and health facilities.

---

[1]The Appalachian Regional Commission, 1975 Annual Report, Washington, D.C., 1975.

Yet, better roads were prohibitively expensive - double and often triple the average, national, per-mile construction costs.[1] Even the few Interstate routes which crossed the region tended to follow the topography, not crossing from east to west over the mountain ridges. The fundamental importance of highways was mirrored by emphasis on highway projects in the 1965 Act. For instance, through September, 1976, highway project costs amounted to $2.9 billion ($1.7 billion Federal aid) while eligible non-highway project costs were only $3.7 billion ($2.1 billion Federal).[2]

2.3 The Appalachian Development Highway Program

With the intention of effective development of the overall region, the Appalachian highway system was composed of two systems - Appalachian Development Highways (ADHP) and local access roads. The local access roads were designated to serve as roads connecting industrial sites and recreational areas with the larger highways nearby. Primary emphases were put on the ADHP. As of December, 1976, 95% of the Federal funds obligated for Appalachian highways went to the ADHS.[3]

The objectives of the ADHP, broadly speaking, are to increase mobility and, thereby, foster economic development. Some of the

---

[1] Ibid., p. 6.

[2] Appalachian Regional Commission, 1976 Annual Report, Washington, D.C., 1976, p. 33.

[3] Federal Highway Administration, News Release, Washington, D.C. FHWA 15-77, March 21, 1977.

operational objectives that have been advanced are:[1]

- to fill in gaps in the Interstate system so as to maximize the percentage of the population within 30 minutes (20 miles) of an ADHP or Interstate highway;

- design to the extent practicable to standards adequate for 1990 traffic;

- design and construction to achieve continuity and reasonable uniformity throughout the system, and to provide for an average travel speed of approximately 50 miles per hour between major termini;

- provision for partial or full control of access, where justified.

The ADHP can be characterized as a categorical program with a designated system of roads and a mileage ceiling (currently, 2900 miles for construction assistance). In this respect it is similar to the Interstate program. However, its 24 designated corridors are restricted to the Appalachian region, and the program is supported by general fund revenues, not the Highway Trust Fund. The ADHP program is administered by the Federal Highway Administration (FHWA, the successor to the Bureau of Public Roads) for the ARC. It utilizes the traditional partnership arrangement between FHWA and the state highway departments under which all Federal-aid highway programs are carried out.

Federal share in assistance for ADHP construction has been determined independently from that of FAHP. The 1965 Act limits the maximum Federal assistance to construction to 50 percent of the cost, unless the Appalachian Regional Commission determines that additional assistance is required. The Commission authorized the maximum 70 percent Federal share

---

[1] Appalachian Regional Commission, Highway Transportation and Appalachian Development, Research Report No. 13, Washington, D.C., September 1970.

in May 1965. But in August 1966, to meet budget constraints, the Commission adopted a policy reducing the Federal share to 50 percent for 4-lane ADHP construction. As the Federal-aid for highway programs other than Interstate system changed from 50 percent to 70 percent effective in fiscal year (FY) 1974, the Commission checked with the State Highway Departments to see if any policy changes were necessary to maintain construction progress. As a result, the Commission revised funding policy to apply 70 percent Federal share to all construction projects authorized after February 1974.

Among the thirteen Appalachian states, nine states (Georgia, Kentucky, Maryland, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia) shared the ADHP in the 1965 Act. The ARC included New York in the highway program in 1966 after study of New York's regional highway needs. The remaining three states (Alabama, Mississippi, and South Carolina) only participated in the access road program prior to 1973. They now also have some ADHP mileage. Construction status is shown in Table 2-2.

2.4 A Review of Previous Analytical Studies

The review of analytical studies is divided into two parts. The first concerns studies on highway expenditures in general, and on the Appalachian Highway Program in particular. The second concerns the use of interrupted time series analyses. It is noteworthy that such time series analyses or other quasi-experimental analyses have not been used in this context previously.

Studies of the impacts of Federal highway policy on state highway

Table 2-2. Appalachian Development Highway System Mileage and Expenditure Summary

State	ADHP construction completed as of June 30, 1975[a] (miles)	Total ADHP Expenditure as of June 30, 1975[b] ($ million)
Alabama	6.4	4.0
Georgia	24.0	22.0
Kentucky	175.1	193.6
Maryland	26.5	55.6
Mississippi	0.0	0.0
New York	150.0	140.5
North Carolina	83.6	58.1
Ohio	85.5	56.1
Pennsylvania	106.3	123.5
South Carolina	0.0	0.0
Tennessee	134.2	74.9
Virginia	108.7	63.9
West Virginia	175.2	278.5
Total	1075.5	1070.3

[a] The Appalachian Regional Commission, 1975 Annual Report. Washington, D.C. 1975.

[b] U.S. Department of Transportation, Washington, D.C.

expenditures have appeared as part of studies of inter-governmental financial relationships. These concern other Federal grant-in-aid programs as well, for instance, welfare and education programs. Early studies attempted to explain the development of both Federal and state highway policy through historical review, and in relation to political and socio-economic factors. A leading exemplar of this approach is the work of Thomas Dye. Dye (1966) summarized a comprehensive set of variables affecting highway policy and its outputs. Methodologically, his efforts relied upon the use of bivariate analyses (i.e., correlations) between highway outcomes and explanatory variables. For instance, state highway expenditure as a percentage of total state expenditures can be partly attributed to the extent of urbanization in a state.

The logical extension of this line of research has been to multivariate analytical methods, primarily multiple regression analyses (c.f., Sacks and Harris, 1964). Analytical efforts in this direction have evolved toward improved explanatory power of models by employing different sets of independent variables and different structural forms (e.g., logarithmic models, as by Strouse and Williams, 1972).

Further advances in the sophistication of these modeling efforts involve conceptual and technical advances. Conceptual advancement is characterized by the attempt to illucidate the characteristics of funding structure using econometric theory (Enns, 1974; Sherman, 1975). Technical advances involve the attempt to account for time-dependent relationships as incorporated in these econometric efforts by means of generalized least squares regressions and by time series analyses.

Several limitations of this line of research can be noted. First minimal effort has been given toward distinguishing the effects attributable to particular funding parameters involved. Second, little headway has been made in terms of understanding the interactions among the socio-economic factors and the funding parameters of the programs in question. In addition, evaluation of the highway programs against specific objectives specified for those programs has not been heavily pursued.

Turning to studies of the Appalachian Highway Program, per se, those have appeared as part of the Appalachian Regional Commission's efforts at self-evaluation.[1] These studies have reported on the progress of the ADHP and the consequences attributable to the development of that system. Methodologically, they have been straightforward, relying on descriptive statistics. There has been little effort to relate the ADHP to the broader Federal highway programs.

Porter (1976) suggested the utility of time series analyses in better addressing such questions as those just noted with respect to Federal highway policies. Cooper and Mckewn (1975) successfully employed graphical techniques to review highway expenditure patterns over the past three decades, indicating the usefulness of time series designs.

In particular, the use of intervention analysis in a time-series framework appears appropriate. Basic statistics have been derived by Mood (1950) and Walker and Lev (1953). They employ least squares criterion in a basic line-fitting technique that has been used with some popularity.

---

[1]The Appalachian Regional Commission, Research No. 13, Highway Transportation and Appalachian Development, Washington, D.C., September, 1970. ARC, Highway Policy Issues Report, Washington, D.C., June, 1974. ARC, Appalachian Highway Program, Progress, Impacts and Planning for the Future, Washington, D.C., December, 1975.

Three significant criticisms of this approach can be noted:

- the assumption of independent observations is often highly questionable

- use of the least-squares criterion may overweight outlier observations (and these may be attributable to random fluctuations)

- the implicit assumption that the trend of pre-intervention points would continue in the absence of the intervention may not always be valid.

Despite these objections, the line-fitting techniques do appear useful when used cautiously (Sween and Campbell, 1965).

A statistical approach based on assumptions more appropriate to most time series data has been evolved (Box and Tiao, 1965; Box and Jenkins, 1975; Glass, Willson, and Gottman, 1975). This approach accepts the possibility that observations may be autocorrelated in one way or another. Despite the apparent sophistication of this approach, Campbell (1975) has noted a number of problems that may endanger interpretations resulting from such analyses. In particular, in the context of the present highway expenditure time series data, the available number of data points are not large enough for fully satisfactory utilization of the stochastic model building methods involved. The so-called Box-Jenkins approach to such short series have not been satisfactorily developed. This study's response to the limitations noted for each method of analysis is to employ a number of different methods. Convergence of findings obtained by multiple methods lends considerable creditability to any results obtained.

CHAPTER III

DEVELOPMENT OF THE QUASI-EXPERIMENTAL SETTING

3.1 Quasi-Experimental Methods

The researcher who attempts to assess the effects of socio-technical programs is often faced with a lack of full control over the treatment in question. Real-world programs rarely allow one to randomly experiment. Nonetheless, it is often possible to apply some elements of good experimental design to the analysis of real programs. Such situations can be regarded as the so-called quasi-experimental design (Campbell and Stanley, 1963). The utilization of some elements of experimental control often is advantageous in comparison to non-experimental analytical procedures (e.g., regression analyses). Quasi-experimental designs involve:

- a treated and untreated group
- pre-treatment and post-treatment measures
- an explicit model that projects the differences between treated and untreated groups over time (Kenny, 1974).

In essence, the third requirement is a combination of the other two.

The interrupted time series design involves the repeated measurement of some pertinent parameter both before and after a treatment. That treatment is introduced abruptly and is presumed to interrupt the previ

interruption.

The interrupted time series design can be strengthened by adding a comparison group; it then becomes a multiple time series design. One group receives the treatment in a particular manner, while the comparison group does not. Considerable effort has been made in this study to establish treatment and control groups in such a manner that rival explanations of the hypothesized effects of the treatment (implementation of the ADHP in most instances) are minimized.

Quasi-experimental designs are no panacea. It is not easy to interpret any observed changes over time in the absence of a truly randomized experiment. A number of relevant threats to the interpretation of results of this study will be mentioned throughout this thesis. The following seven threats to validity from Cook and Campbell (1975) are noted as generally pertinent to the situation in question:

(1) History: changes observed may be due to simultaneous events other than the treatment of interest.

(2) Maturation: changes may be attributable to long-term trends or sudden redirections of the states involved.

(3) Instrumentation: measure changes may be due to changes in the measurement instrument or the way of obtaining measurements.

(4) Instability: changes may be random fluctuations.

(5) Regression Effect: interpretation of observations may be incorrect due to failure to take into account the statistical property that extreme observations are likely to be followed by less extreme observations (i.e., observations tend to regress toward the mean).

(6) Selection: observed effects may be due to differences between the members of the groups (the states involved).

(7) Mortality: the level of participation of the states involved may change over time, thus skewing the observed patterns.

3.2 Study Design

3.2.1 Selection of the Experimental States

Preliminary graphical analyses of the thirteen Appalachian states, considered as the treatment group, indicated the group to be heterogeneous. For instance, states such as New York appear to set their levels of expenditure on systems such as the Interstate in their own particular manner. This suggested that careful consideration should be taken of each of the thirteen states in terms of their participation in the ADHP and also state characteristics that could affect their highway performance patterns. The objective was to establish the most appropriate treatment group to determine the effects of the ADHP.

Despite the fact that all thirteen states are now involved in the ADHP, this has not always been the case. In particular, three states (Alabama, Mississippi, and South Carolina) did not begin to participate in the program until 1973. Their construction on the Appalachian Development Highway System as of 1975 is negligible (Table 2-2). Secondly, three states deviate significantly from the remainder of the Appalachian group in terms of their socio-economic conditions. These conditions have been taken as significant explanatory variables in consideration of highway expenditure (Dye, 1966). New York, Ohio, and Pennsylvania are among the most industrialized states in the country, and they also have a highly urbanized population. In addition the scale of highway expenditures in states such as New York and Pennsylvania is sufficiently large to make them relatively less dependent upon the ADHP. For these reasons these three industrialized states and the aforementioned three states without significant ADHP participation are excluded from the treatment group. Further consideration indicates that Georgia and Maryland receive relatively small ADHP apportionments. Therefore the stimulus attributable to the ADHP is considerably less than that expected in the other five Appalachian Regional Commission (ARC) states. Thus, the resultant experimental group is considered as the following five states:

- Kentucky
- North Carolina
- Tennessee
- Virginia
- West Virginia.

3.2.2 Selection of the Comparison Group

As in the case of a true experimental design, control of extraneous variation is not explicit in the quasi-experimental design. Instead, control rests inductively on the hypothesis that the variables being controlled behave in common for the experimental and the comparison groups. This criterion is likely to be satisfied when the units under examination are non-autonomous and externally dependent on the same sources of influence. It is thus desirable that the treatment and comparison groups be made as homogeneous as possible internally, while as heterogeneous as possible to increase the external validity (i.e., generalizability).

The overall data base available for this study consists of the 48 contiguous states. The first possibility was to simply use the 35 non-ARC states as the comparison group. However, states are extremely variable on a number of dimensions that can have considerable bearing on their highway performance. In particular, three factors are indicated from prior studies as deserving of consideration:

- characterization of the basic conditions for state highway activities
- attributes of state highway capital allocation behavior
- significant socio-economic variation previously related to highway activities.

It is desirable to consider these three factors to obtain a comparison group as similar as possible to the candidate treatment group (i.e. the five "core" ADHP states).

Specific variables were chosen to reflect the three comparison factors. <u>Area in square miles</u> and <u>population residing in urban area</u> were two variables chosen to measure the demographic and geographic conditions underlying state highway activities. Federal highway apportionment formulas indicate the importance of these two variables in determining the level of Federal-aid grants to the states. Overall state population was not separately considered because of its high correlation with urban population (r = 0.99 for the 48 continental states, for 1961). Urban population appeared to be the more appropriate choice to take better account of the increasing Federal and state interest in urban transportation development in recent years.

Another two variables were selected as indicative of a state's highway allocation behavior: <u>state-only highway capital expenditure as a percentage of total state highway capital expenditure</u>, and <u>state-capital expenditure for non-Federal systems as percentage of total highway capital expenditures</u>. It can be clearly argued that states' allocational preferences with respect to highway capital are a contributing factor to the state response to changes in Federal highway funding policies. Capital variables are converted to relative measures to best capture the structural characteristics of the states involved, independently of their size.

In addition to the Federal incentives and state highway consideration, per se, it is generally accepted that the socio-economic and institutional characteristics of individual states affect the implementation of highway programs. This is obviously a feature hard to measure in well-defined terms. Political scientists have made an effort to classify states on the basis of their similarities and dissimilarities in internal considerations. Among them, Luttbeg (1971) accomplished a comprehensive analysis by means of factor analysis on 118 variables perceived to be related to state policies and their outcomes (as identified by Dye, 1966). Luttbeg's factor analysis was directed toward discriminating among states in terms of their characteristic behavior on the 118 variables. He identified four factors, one of which was labeled "Southern factor." This provides a composite measure reflecting the socio-economic and political background of individual states on which the experimental group (the "core" Appalachian states) loads significantly.

Table 3-1 exhibits the simple correlations among the five variables just identified. Note the relatively low level of intercorrelation, indicating that each of the variables measures different aspects.

The five variables were then analyzed by use of discriminant analysis (Cooley, 1971). In order to relate particular states to the core Appalachian states, a measure x_{ij} was defined as follows:

Table 3-1. Correlations Among the Discriminating Variables[a]

	Lut	AREA	URPO6L	SCNPCN61	STSMR61
LUT	1.00000				
AREA	.12373	1.00000			
URP061	-.13572	.18717	1.00000		
SCNPCN61	.28363	-.17056	.18538	1.00000	
STSHR61	-.08080	-.19282	.37297	.37611	1.00000

[a]The correlations were obtained for 48 continuous states using following variables:

LUT = Luttbeg scale for "southern states" (See text)

AREA = State area in square miles

URP061 = State population (1,000)living in urban area (places with more than 5,000) in the year 1961

SCNPCN61 = State-only capital outlay for non-Federal-aid highway system as percentage of total state highway capital outlay for the year 1961

STSHR61 = State-only capital outlay for all state highway systems as percentage of total state highway capital outlay for the year 1961

$$x_{ij} = \left(\frac{V_{ij} - M_j}{SD_j} \right)^2$$

where V_{ij} is the value of variable j of state i, M_j is the mean of the experimental group for variable j and SD_j is the standard deviation for variable j. The results of these two analytic works are provided in Appendix B.

In summary, the results of the discriminant analysis classified the following states as similar: the five experimental group states, Alabama, Arkansas, Florida, Georgia, Louisiana, Maryland, Mississippi, Oklahoma, and South Carolina. Among these states, Georgia and Maryland were excluded because they participated in the ADHP from the beginning of the program, albeit to a relatively small degree. Delaware, Iowa, and New Mexico had very close scores to this group. However, Delaware differs from this group in having a very small geographical area and a low state share of participation in Federal-aid highway programs. For these reasons Delaware was not included in the comparison group. Iowa and New Mexico were included because of their general similarity. Obviously excluding the five states of the experimental group, the analysis resulted in nine states for the comparison group:

- Alabama
- Arkansas
- Florida
- Iowa
- Louisiana

- Mississippi
- New Mexico
- Oklahoma
- South Carolina

Geographical configuration of the two groups is illustrated in Figure 3-1.

3.3 Examination of the Data

3.3.1 Problems with the Highway Expenditure Data

The study drew upon highway expenditure data and a variety of other measures accumulated for the states over a period of time from the 1950's through the early 1970's. Not surprisingly, analysis revealed several problems in interpreting these data. Based upon consultation with ARC and Federal Highway Administration officials, the following points were determined:

- Due to a change in FHWA reporting practices (in Highway Statistics)[1] there is a discontinuity in total state A and B system outlays from calendar 1973 to 1974.

- Any disaggregations among A, B, C, and D systems for state-only outlays (exclusive of Federal aid) is somewhat in error because total state outlays are reported on the basis of where funds were spent while the Federal aid is reported on the basis of the system for which the funds were designated. Transfers among the systems can be substantial, causing the accounting problem.

- Study data include toll road expenditures in total state outlays, outlays on Interstate, and outlays on non-Federal-aid roads (all from Table SF-21 of Highway Statistics), but not on A, B, and C outlays (from Table SF-11).

- Study total (but not separate) A, B, C, and D outlay data are compatible before and after 1973; however, they include toll outlays to the order of 1%-3% of the total.

---

[1] Federal Highway Administration, Highway Statistics, Washington, D.C., annually.

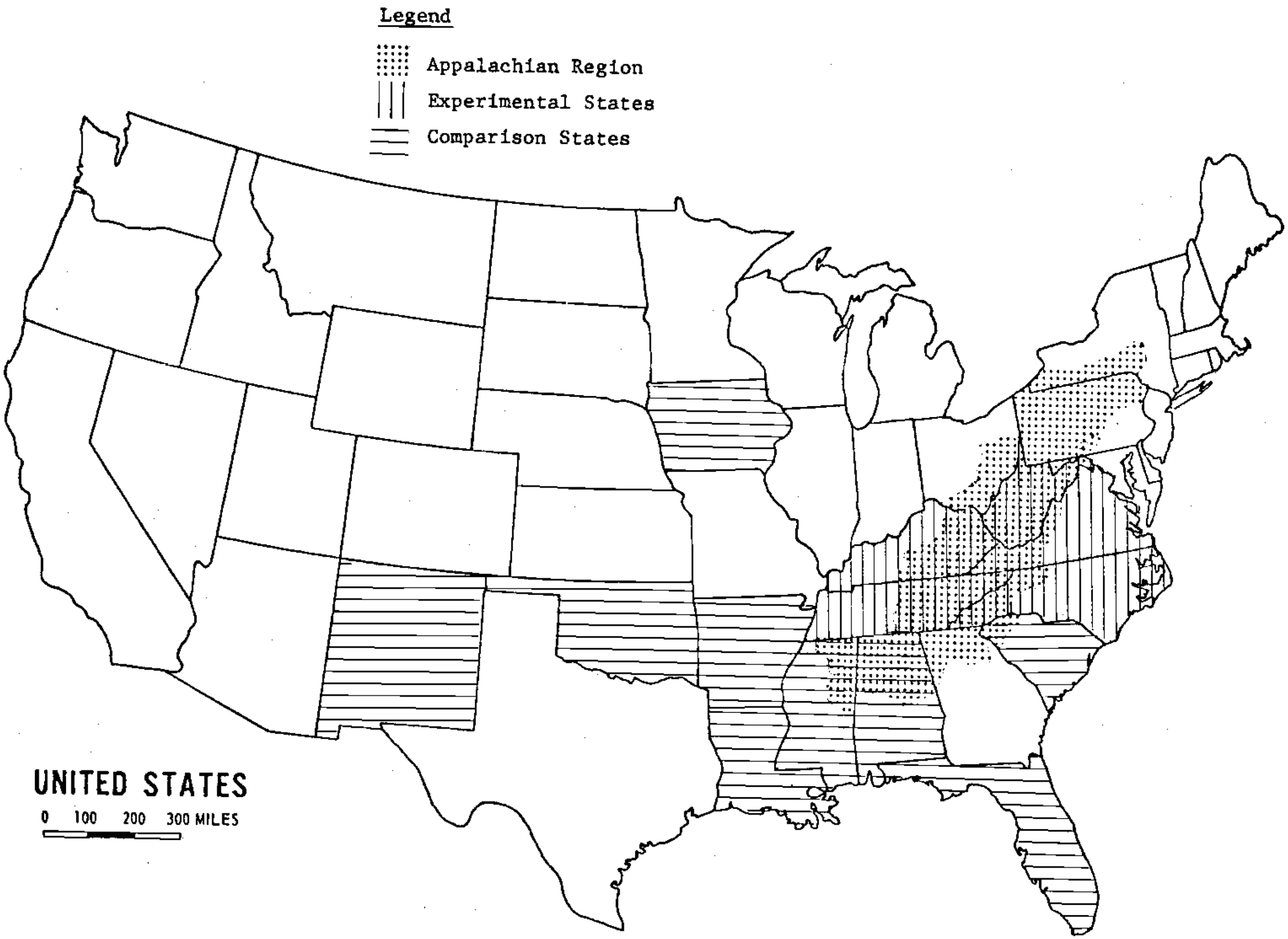


Figure 3-1. Geographical Configuration of the Experimental and the Comparison States

Tallies for "state-only, exclusive of Federal aid" outlays are imperfect because Federal aid reflects reimbursement for work completed, and this could often be work reflected in state expenditures for an earlier year.

- ADHP outlays are included in Highway Statistics reporting for the A (primary) system. [After construction is complete, ADHP roads are placed on the primary system.]

3.3.2 Gradual Start-up of the Appalachian Development Highway Program

A key element to this analysis is the observation of the state expenditure on the ADHP. The response of the states to this Federal-aid program is critical. For a variety of reasons, there is an inherent lag at the onset of any new highway program. This lag is attributable to many factors, including time necessary for planning and design of the system, establishment of regulations, and familiarization with the new program. Furthermore as defined in Appendix A, a number of discrete fiscal transactions are involved. In particular, following apportionment of the Federal aid, states can then obligate these funds for future payment on work to be completed. When the work is actually completed the states are reimbursed by the Federal government, and only at that time do amounts show up as Federal expenditures. As Table 3-2 indicates Federal ADHP expenditures began only slowly following enactment of the program.

3.3.3 Increasing Highway Construction Costs

Figure 3-2 compares the highway construction index with the consumer price index based on the year 1967. Note the significant inflation rate in highway construction. To take account of this rate, the use of constant dollars is sometimes appropriate. However, current

Table 3-2. Federal ADHP Expenditures[a]

($ Million)

Fiscal Year	Amount
1966	9
1967	40
1968	65
1969	113
1970	130
1971	145
1972	145
1973	156
1974	159
1975	179
1976	188

[a]These figures for ADHP were obtained from Mr. Brindley Lewis of the ARC, 1978.

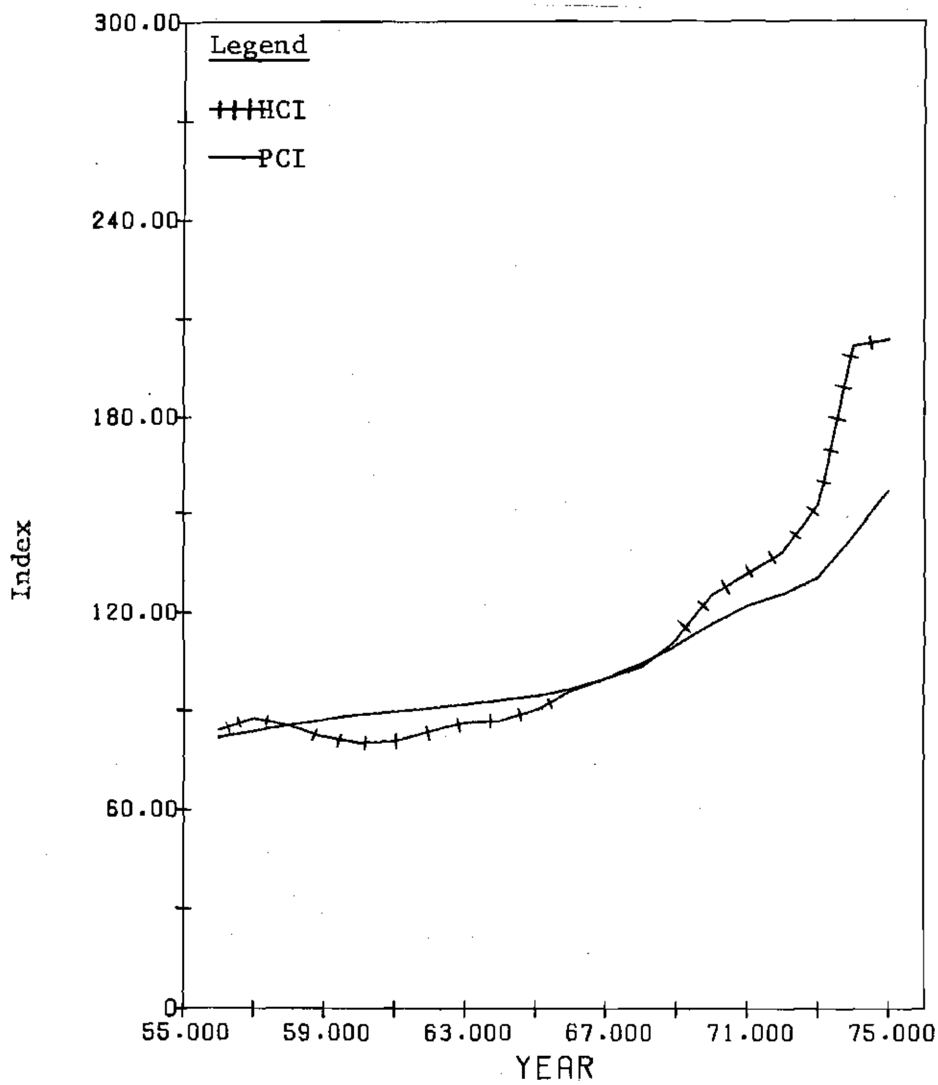


Figure 3-2. Federal-Aid Highway Construction Index (HCI) and Consumer Price Index (CPI) in U. S. Average (base year 1967)

dollars are used through most of this study to provide the least distortion with respect to actual expenditures.

Note the dramatic increase in highway construction costs from 1973 to 1974 (Figure 3-2). This corresponds with the timing of the oil crisis.

CHAPTER IV

EFFECTS OF THE APPALACHIAN DEVELOPMENT HIGHWAY PROGRAM: BASIC STATISTICS

This chapter focuses upon the highway outlays and financial environments of the experimental group of states, contrasted with the comparison group. Data cover the period 1956-1975. In most of the analyses, the intervention of interest is the onset of the ADHP. This program was enacted in 1965 and initial obligations of funds began in fiscal 1966 (for all practical purposes), but the actual implementation of the ADHP got underway gradually in '66 and '67.

A general strategy will be to present graphs that represent initial hypotheses as to the likely effects of the institution of the ADHP, and to contrast those with the actual data. Graphical techniques are incorporated with descriptive statistics for this purpose. (Note that the upward slope in the hypothetical graphs reflects an understanding of the effects of inflating highway construction costs in these two decades - see Figure 3-2.) The reader's attention is directed to the dual contrast: change from prior to the intervention in question to after the intervention, (e.g., the institution of the ADHP) for the experimental group as opposed to the comparison group. For many purposes the reform of the Federal-Aid Highway Program's funding structure by the 1970 and 1973 highway acts, effective FY 1974, puts a forward limit on the time series analyses.

Section 1 addresses the general state financial perspective with respect to the ADHP. Section 2 addresses the specific interactions between creation of the ADHP and continuation of efforts on the Interstate system, the "ABC" systems, and non-Federal-aid roads and non-capital expenditures. The last section of this chapter addresses the broader socio-economic impacts of the highway programs in question.

4.1 Stimulation of State Highway Construction

As a starting point, it is useful to first grasp the overall financial context in which these highway activities are taking place. For that purpose, the first variable of interest is the overall state expenditures (total outlays for the entire state budget). Figure 4-1a hypothesizes that the experimental states (the five core Appalachian states) were likely to have been boosted by a relative increase of Federal funds due to the Appalachian Regional Commission programs. Figure 4-1b tends to support this hypothesis.

Following a similar argument, total Federal aid for all purposes received by the states is also hypothesized to increase due to the implementation of the ARC programs (Figure 4-2a). This hypothesis also appears to be supported by Figure 4-2b (note the increasing discrepancy between the two series over the years after 1965).

This leads one to next examine overall state transportation expenditures. Figure 4-3 hypothesizes a relative increase in the Appalachian states due to the increase in Federal aid overall and, in particular, for transportation programs. Unfortunately, data are not available to directly test this hypothesis. However, total Federal aid for transportation to these states is hypothesized to have increased due to the initiation of the ARC programs (Figure 4-4). Table 4-1 accumulates the total Federal aid for highways, air transportation, and mass transit. It indicates support for this hypothesis.

Figure 4-5 addresses finances at a level of more direct interest to this study, total state highway outlays. It is important to note that these outlays include both the contributions made by the state itself and any Federal aid received. (In general, Federal aid constitutes about one-third of a state's highway budget; in some states, such as Rhode Island, Federal aid can amount to 50% of the total state highway outlays.) Figure 4-5a hypothesizes a small increase in total state capital outlays. This small increase is attributed to the increase in Federal aid; the presumption was that the states would not be able to augment this increase due to constraints on their own budgets. This implies that states would have to reduce the level of their existing highway outlays on other highway programs to accommodate the new programs (ADHP). Figure 4-5b suggests a real increase in the relative level of highway efforts in the experimental states. This implies that the ADHP stimulated the overall level of highway capital investment in the states involved. Federal highway aid (exclusive of Federal ADHP funds) was postulated to have remained relatively the same for the experimental and the comparison groups of states (Figure 4-6a). This hypothesis is plausible since Federal aid for the ADHP comes from a separate budget. Figure 4-6b is consistent with this hypothesis with respect to the period from 1965 on. There does appear to be a relative increase for the experimental states in the early 1960's - this can be attributed to a proportionately larger Interstate program in these states. (And that, in turn, may be partially attributable to the higher cost of construction in the mountainous Appalachian region.

Information indicates that highway activities in the experimental states greatly increased relative to the comparison states. However, whether that increment is attributable to the institution of the ADHP (keep in mind that ADHP expenditures are tallied in the Federal-aid Primary - A - System account) or not is not fully resolved. To look ahead briefly, Section 4-2 indicates that the increment is due to the ADHP - see that section for detailed discussion.

If indeed state highway efforts had been stimulated by the ADHP program one might expect to see evidence of this in terms of highway financing efforts. Tables 4-2 and 4-3 lend striking support to the hypothesis that the core Appalachian states did indeed increase their highway efforts. State highway bond debt increased dramatically (Table 4-2). Similarly, state gasoline tax rates show a substantial relative increase (Table 4-3). Because these are relative increases to the comparison group of states who were subject to similar situational influences (environmental pressures, urban transportation concerns, and major investments in the Interstate program), it is reasonable to ascribe these increases to the stimulus of the ADHP. In particular, the ADHP demanded a substantial amount of state funds to match the Federal aid. Interestingly, the expenditures of the experimental group of states on non-Federal-aid roads increased over this period as well. A tenable hypothesis is that the ADHP stimulated the states to increase their available highway funds by means of enlarged bonding programs and increased tax rates; some of these funds may then have become available for investment in the state-only system.

4.2 Relationship Between the Appalachian Development Highway Program and Other Highway Programs

The previous section indicated that total state highway outlays increased for the experimental states relative to the comparison group after 1965. By investigating particular categories of other highway programs, this study now attempts to confirm that the increment is attributable to the ADHP. Further, there is an interest in determining which of the other systems were affected, and in what ways. For each system the following considerations are developed:

- total outlay (that is state outlay inclusive of Federal aid received; this is the indicator of the total level of effort on the program in question)
- Federal aid
- state-only outlay (that is, state outlay exclusive of Federal aid received; this is the indicator of the states' level of commitment to a program).

4.2.1 Interstate System

One can reasonably hypothesize that total state outlays and Federal aid for the Interstate system would not be affected by the onset of the ADHP. This is because the Interstate program is primarily driven by Federal funds (recall the 90% Federal share on this program). These hypotheses are generally supported by the corresponding figures 4-7b and 4-8. Again, note that the Interstate system increased in the experimental group in the early 1960's relative to the comparison group. Due to the favorable matching ratio for the Interstate system, one would not anticipate that the states would let their Interstate efforts suffer due to the onset of the new program. As noted Figure 4-7b indicates that that is the case. However, Figure 4-9 does not unequivocably indicate that the states maintain their own outlay for the outlay levels on the Interstate system. There is some indication that the experimental states tapered off a bit (but note that the overall Interstate effort did not appear to suffer). The great instability of the state-only Interstate expenditure time series does not allow strong inferences.

4.2.2 ABC System

It was suspected that the ADHP effort would cause experimental states to cut back on their ABC capital investment. Figure 4-10 indicates that total ABC capital outlay:

- increased relative to the comparison states after 1965, reflective of the additional ADHP activity going on (and included in A system outlays);

- decreased relative to the comparison states when ADHP outlays are excluded.[1]

Table 4-4 further indicates that state-only ABC outlays decreased slightly after 1965, relative to the comparison states, exclusive of outlays on the ADHP.

Figure 4-11 shows the Federal aid for the ABC system (exclusive of Federal ADHP investments). This is remarkably constant over time, and, were plotted in constant dollars (recall the high rate of highway construction inflation, Figure 3-2), which show a severe drop from 1965

---

[1]Federal ADHP expenditures by states are available only from 1970: in Figure 4-10, state ADHP expenditures are estimated in proportion to the Federal expenditures (0.425:0.575), based on obligation records of the five experimental states. ADHP amounts from 1966 to 1969 are based on annual obligations.

to 1969, in particular. This is a critical observation when taken in conjunction with the increase in state-only ABCD outlays over this period (Figure 4-17).

Despite the problems in separating A, B, and C data (see Section 3.3), it is instructive to glance at the respective time series. Overall for the ABC system, the conclusion is that state-only and total effort increased in the experimental states relative to the other states when one includes ADHP outlays, but decreased when ADHP outlays are excluded (Figure 4-10; Table 4-4). The question of concern, then, is which of the systems (A, B, and/or C) suffered a decline at the expense of the ADHP?

Figure 4-12 suggests a contraction in the Federal-aid Primary (A) program when the ADHP effort is excluded. Federal aid received for the A system (Figure 4-13) does not appear to enter into this argument significantly. Figure 4-14 implies a significant contraction in the Federal-aid Secondary (B) program. Indeed, from 1967 on, the experimental states actually crossed back under the curve for the comparison group. In contrast, the Urban extensions (C) program grows substantially faster in the experimental states (Figure 4-15)! The competition of the new ADHP seems to have taken its greatest toll on the B program, somewhat less on the A, and effectively none on the C.

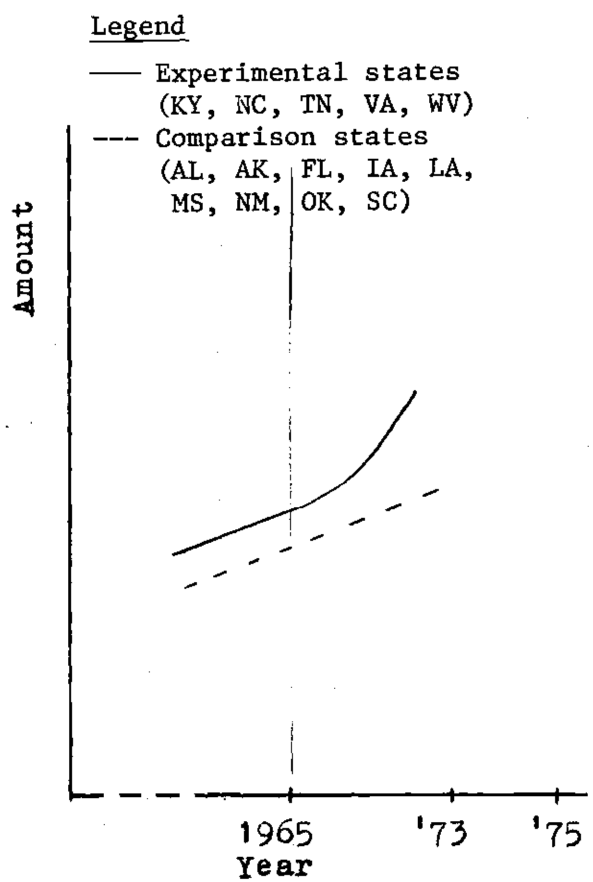
It is worthwhile noting that the ABC system was expanded primarily by state efforts, while the Interstate system was driven largely by Federal funds (see Figures 4-7, 4-8, 4-9, 4-10, and 4-12).

Initiation of the Urban highway system (B) by the 1970 Federal Aid Highway Act seems to have increased the level of Federal expenditures.

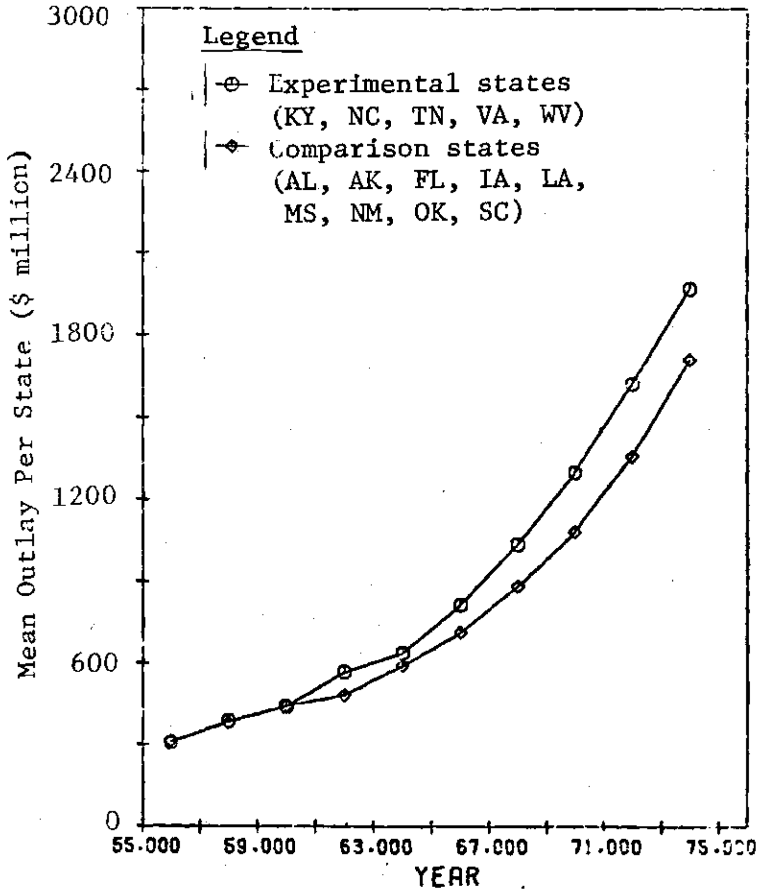
Authorizations for the Urban system actually began with 1972; note the upsurge for 1972 and 1973 indicated in Figure 4-16. The 1970 Act also increased the Federal matching share for the ABCD system, effective FY '74. Not surprisingly, Federal outlays thence began to increase at a much higher rate than total state outlays (see Section 7.1 for further discussion).

These various descriptive time series indicate that the ADHP program onset likely did have serious effects on state highway activities. To further investigate this possibility, it was decided to perform more formal interrupted time series analyses. For this purpose, it was essential to focus on an appropriate data series, given that study resources did not allow, nor warrant, investigation of all the possible series. ABC total expenditures were directly affected by ADHP expenditures, and the previous discussion indicates that the pattern was largely determined by the states' own interest in the ABC system. As discussed in Section 3.3, there are problems in continuing ABC time series across the 1973-1974 transition point. These are due to problems in accounting. Inclusion of D system expenditures eliminates the discontinuity at this point in time, and hence, the ABCD series is preferable. (Because the D system actually did not get underway until 1972 at the earliest, and 1974 on a massive scale, this does not markedly affect the analysis concerned with the onset of the ADHP in 1965-67). Federal aid for the ABCD system was then eliminated, leaving state-only ABC outlays as the most desirable series to focus upon the states' efforts.

It has already been noted that the increasing trend of highway expenditure is largely attributable to inflation. Figure 4-17 presents

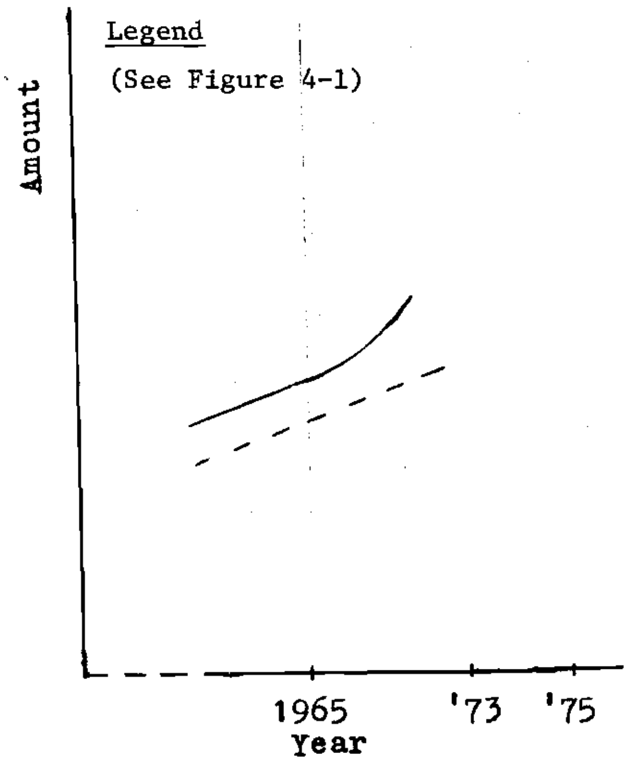


(a) Hypothetical Plot

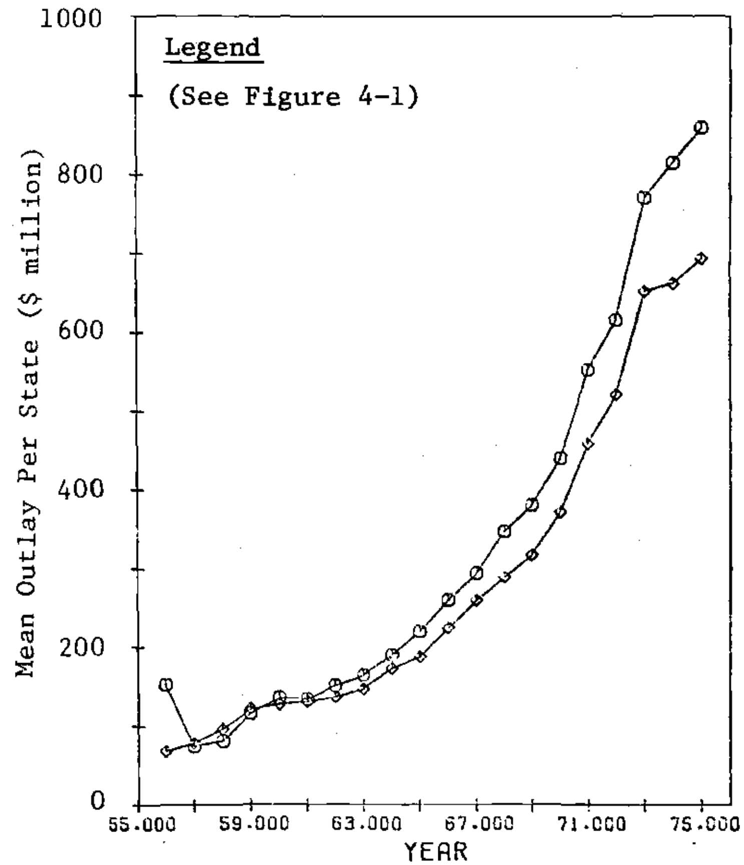


(b) Actual Plot

Figure 4-1. Total State General Outlay



(a) Hypothetical Plot



(b) Actual Plot

Figure 4-2. Total Federal Aid to State Government for All Purpose

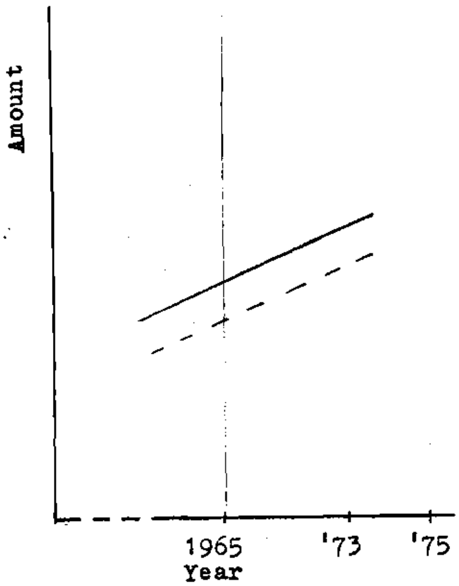


Figure 4-3. A Hypothetical Plot of Total State Expenditure for Transportation

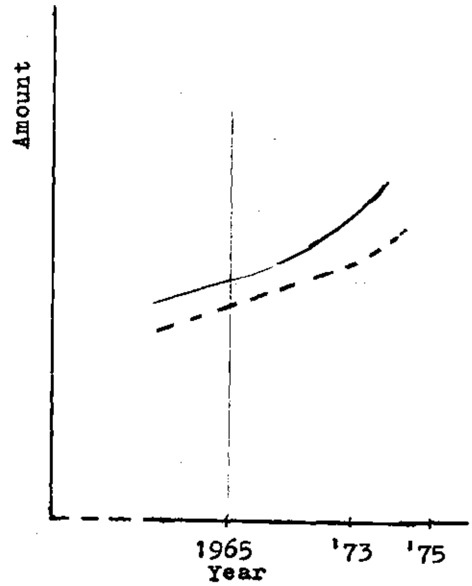


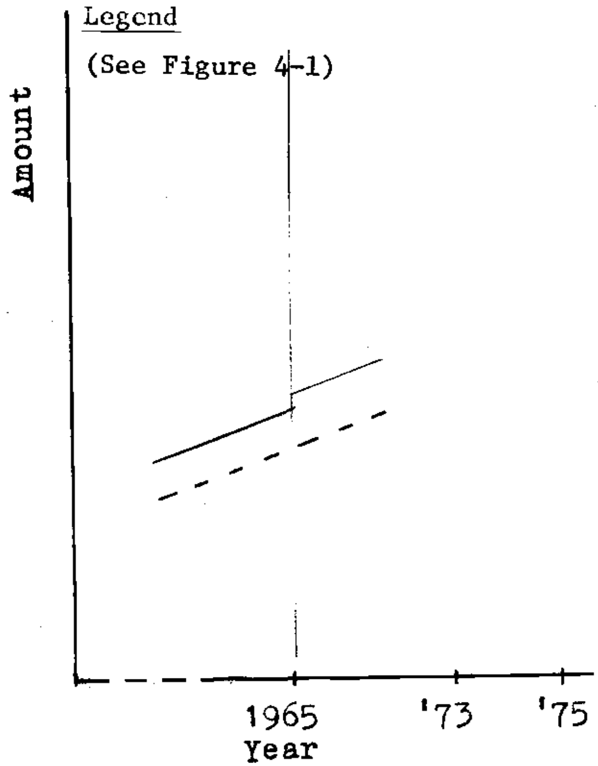
Figure 4-4. A Hypothetical Plot of Total Federal Aid Expenditures for Transportation

Table 4-1. Total Federal Aid Expenditures for Highways, Air Transportation and Mass Transit

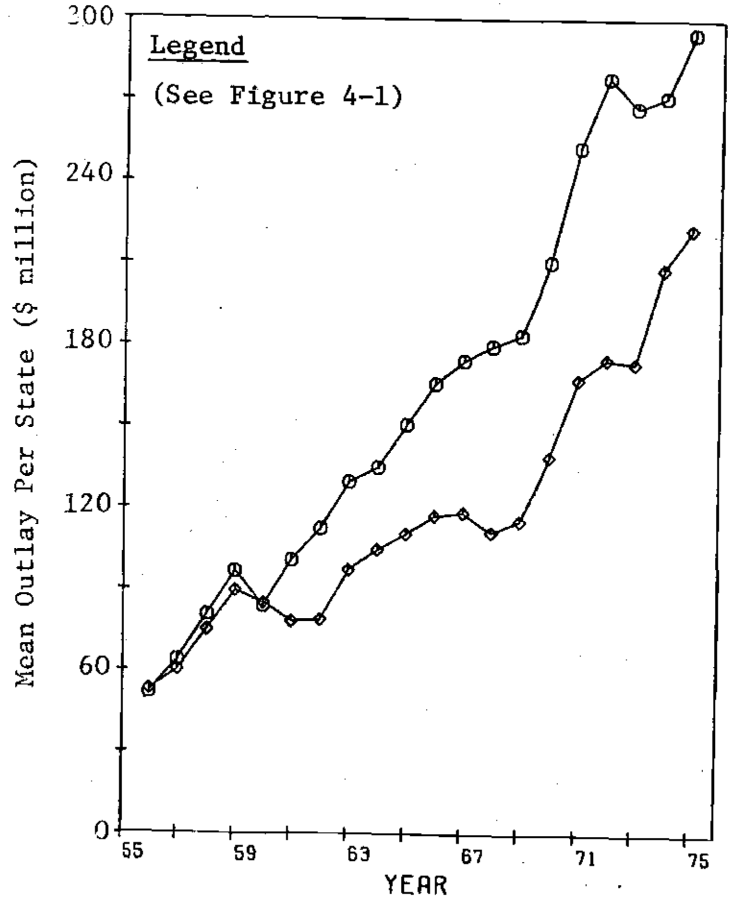
($1,000)

Year / Mean	1961	1965	1969	1973
Experimental states	50,232	90,398	99,551	113,300
Comparison states	40,176	66,473	61,174	75,136
Difference	10,056	23,925	38,377	38,164

Source: U.S. Department of Transportation, Washington, D.C.

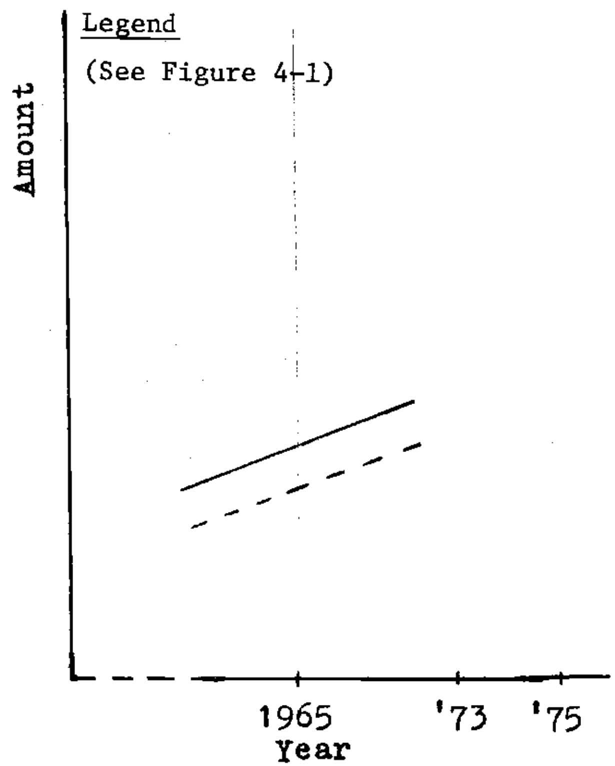


(a) Hypothetical Plot

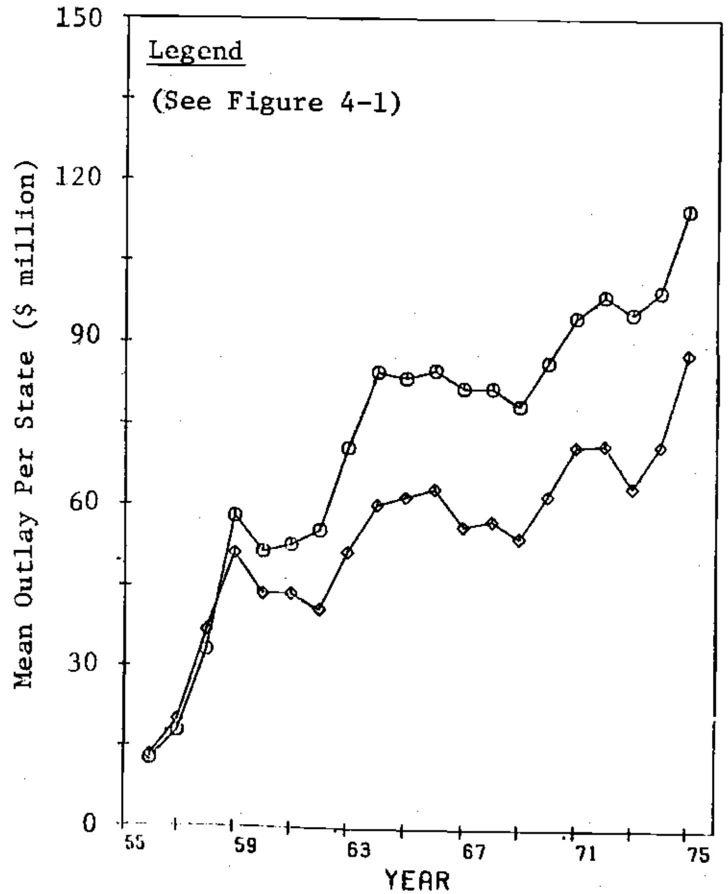


(b) Actual Plot

Figure 4-5. Total Capital Outlay for All Highway Systems



(a) Hypothetical Plot



(b) Actual Plot

Figure 4-6. Total Federal Aid for Highways

Table 4-2. State Highway Bonds - Outstanding Debt at the End of Year

($ million)

Mean \ Year	1961	1965	1969	1972
Experimental States	216.6	254.6	348.2	488.2
Comparison States	97.1	144.9	171.3	224.3
Difference	119.5	109.7	176.9	263.9

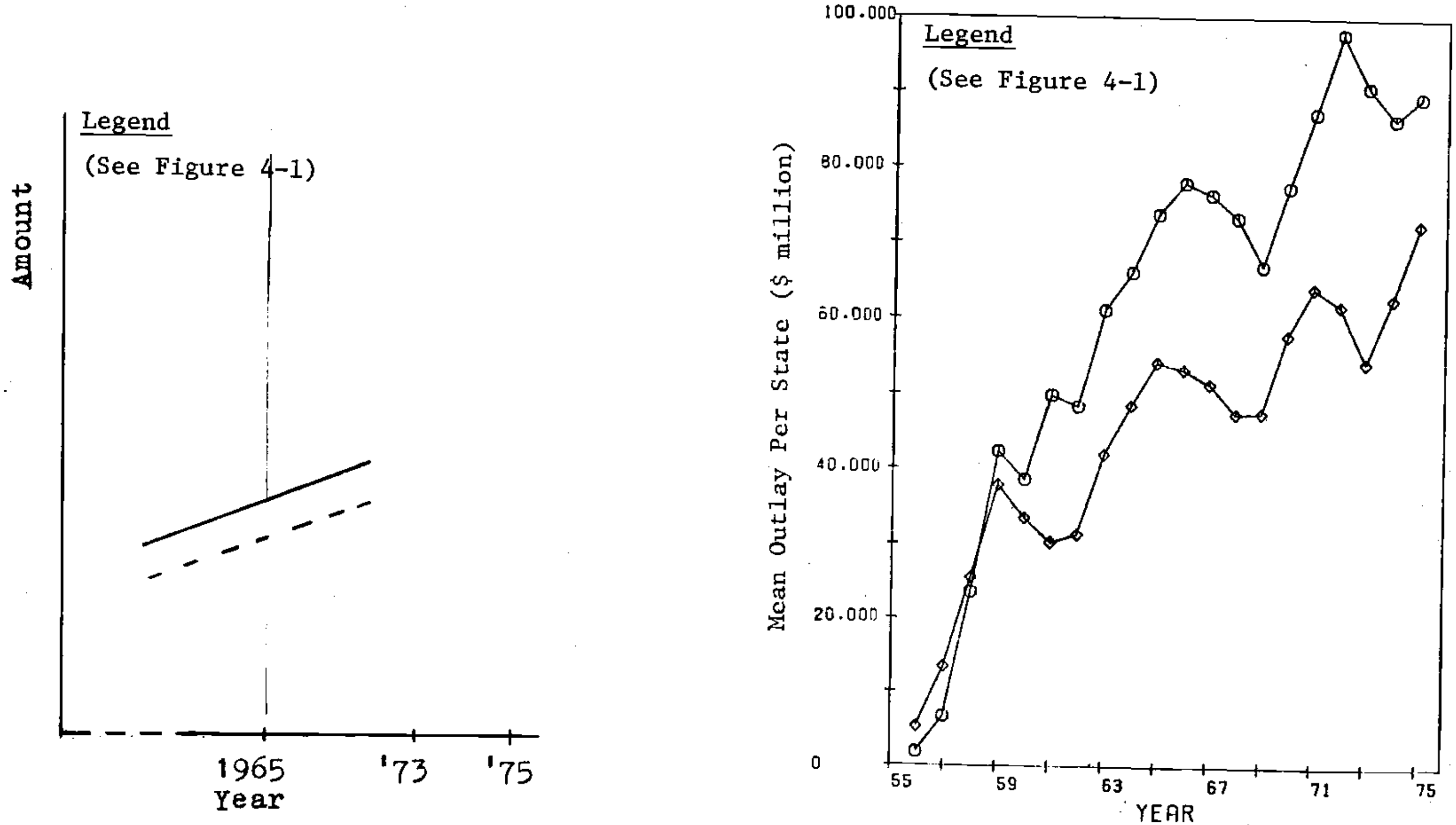
Source: U.S. DOT, Highway Statistics; Summary to 1975, Washington, D.C.

Table 4-3. State and Federal Gasoline Tax Rates

(Cents Per Gallon)

Mean \ Year	1961	1965	1969	1972	1975
Experimental States	7.0	7.0	7.4	8.2	8.5
Comparison States	6.7	6.9	7.1	7.4	7.6
Difference	0.3	0.1	0.3	0.8	0.9

Source: U.S. DOT, Highway Statistics, Summary to 1975, Washington, D.C.



(a) Hypothetical Plot

(b) Actual Plot

Figure 4-7. Total Capital Outlay for Interstate Highways

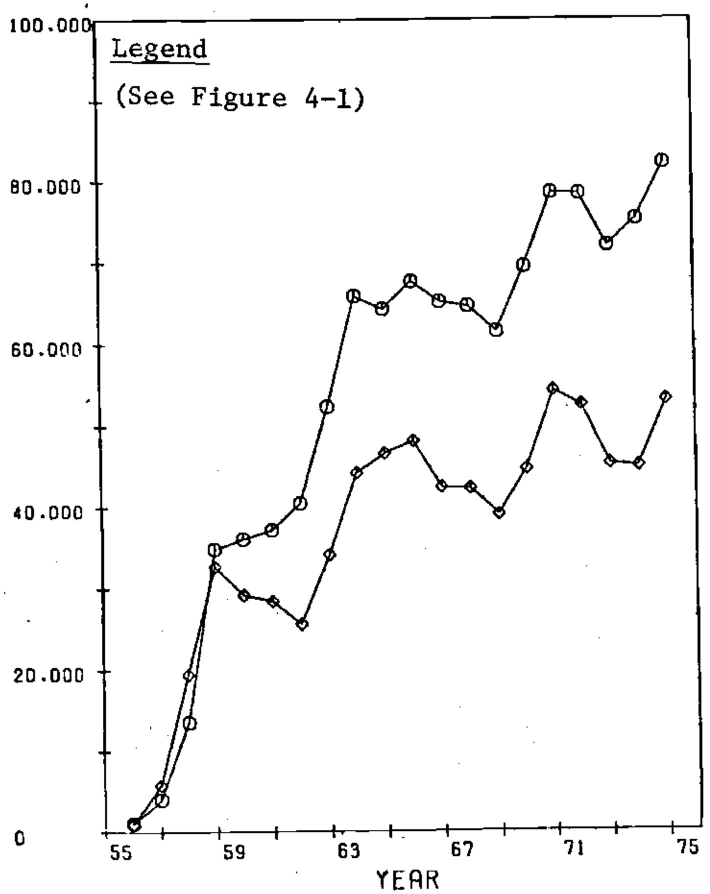


Figure 4-8. Federal Aid Expenditures for the Interstate System

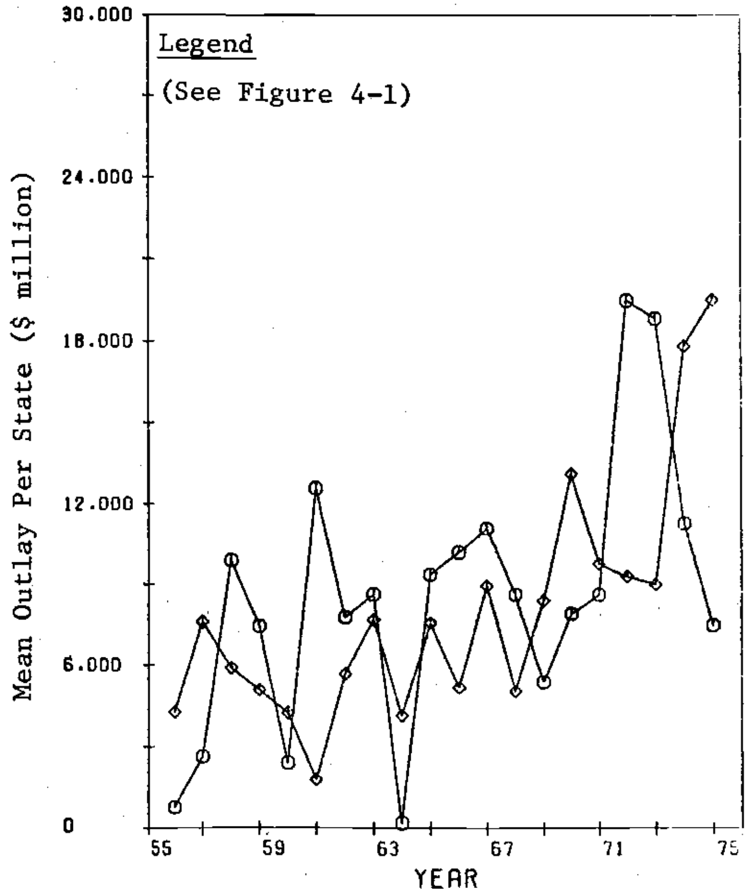


Figure 4-9. State-only Interstate Outlay

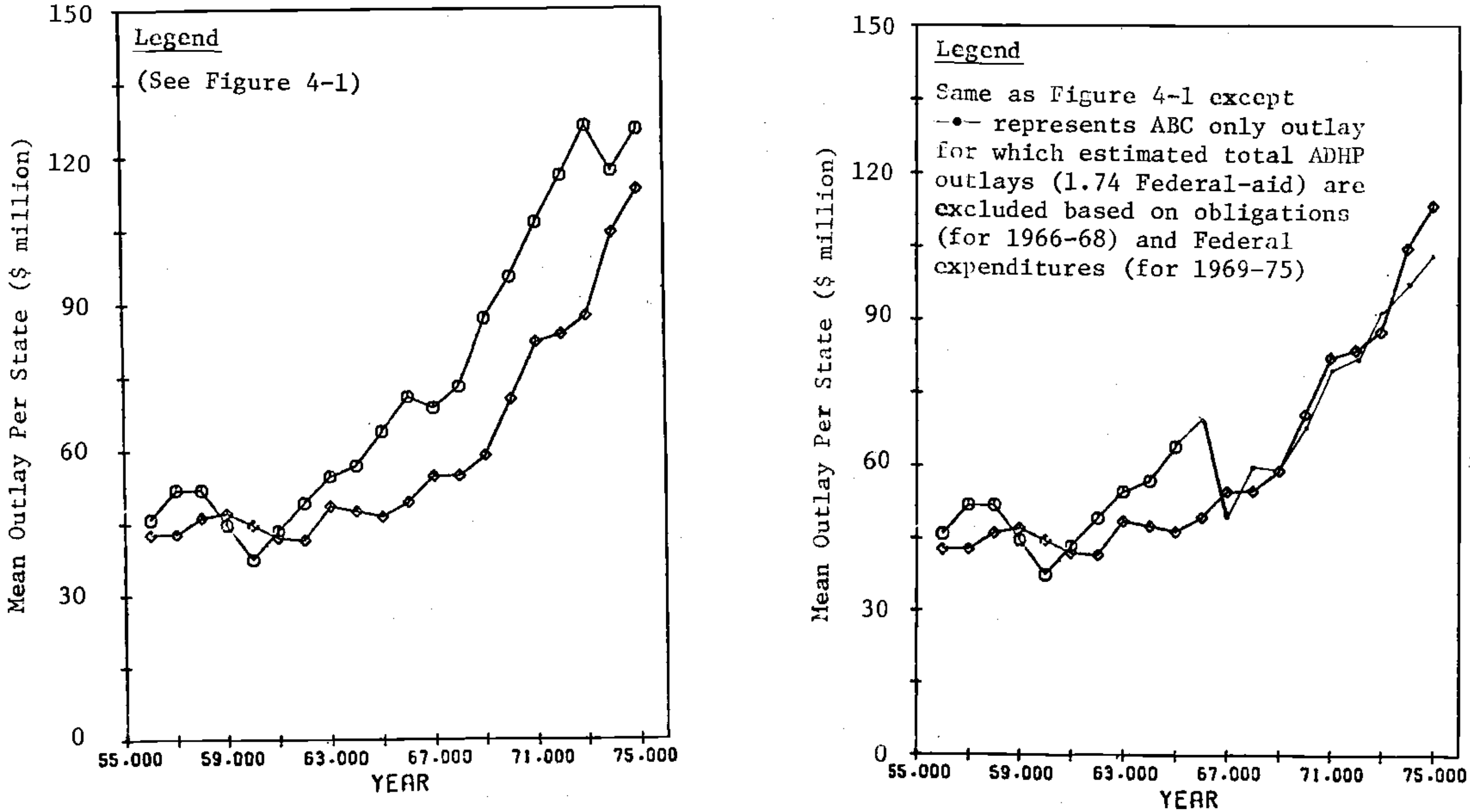
Table 4-4. State-only ABC Outlays

($ million)

	1963	1964	1965	1970	1971	1972
Experimental Group						
(1) ABC and ADHS	36.2	38.0	44.6	62.9	74.9	76.7
ABC only (2)[a]	36.2	38.0	44.6	51.4	63.4	62.6
(3) Comparison Group	31.2	31.5	31.2	53.3	65.3	64.8
Difference						
(1)-(3)	5.0	6.5	13.4	9.6	9.6	11.9
(2)-(3)	5.0	6.5	13.4	-1.9	-1.9	-2.4

[a] For 1970-72, estimated on the basis of a state share for the ADHP of 42.5% of total ADHP expenditures.

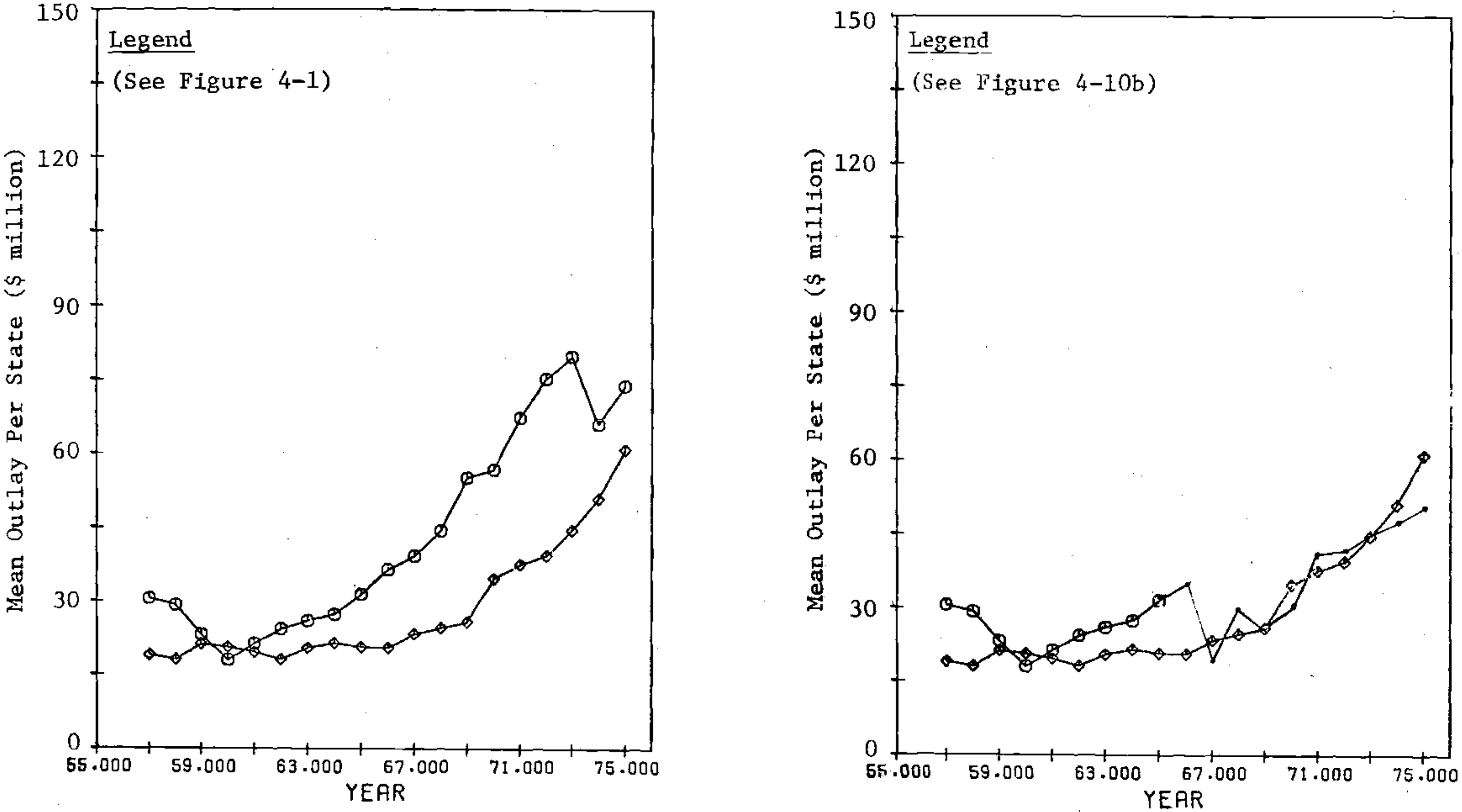
Source: U.S. Department of Transportation, Highway Statistics, Washington, D.C.



(a) Including ADHP Outlay

(b) Excluding ADHP Outlay

Figure 4-10. Total Capital Outlay for ABC Systems



(a) Including ADHP Outlay

(b) Excluding ADHP Outlay

Figure 4-11. Total Capital Outlay for Federal-Aid Primary (A) System

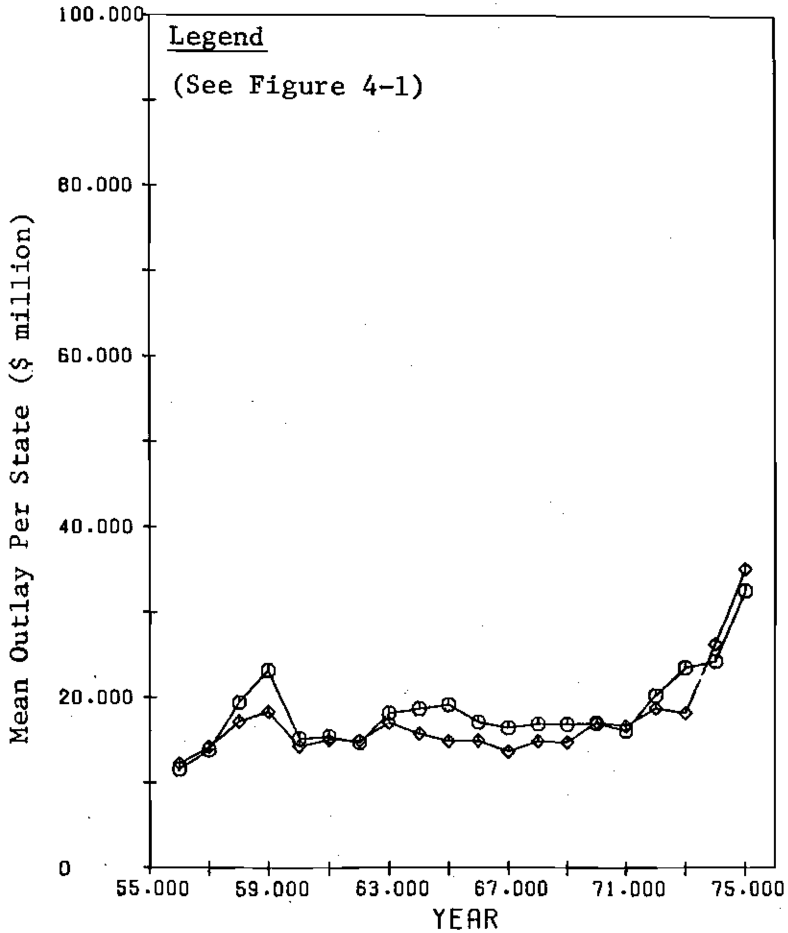


Figure 4-12. Total Federal Aid Expenditures for the ABC Systems

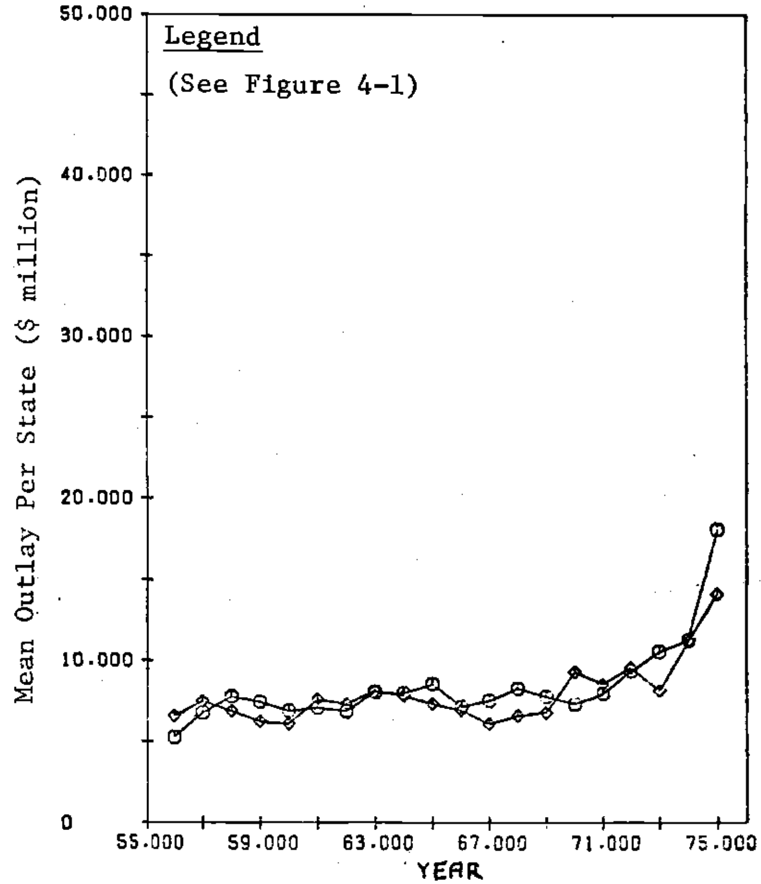


Figure 4-13. Total Federal-Aid Expenditures for the Primary (A) System

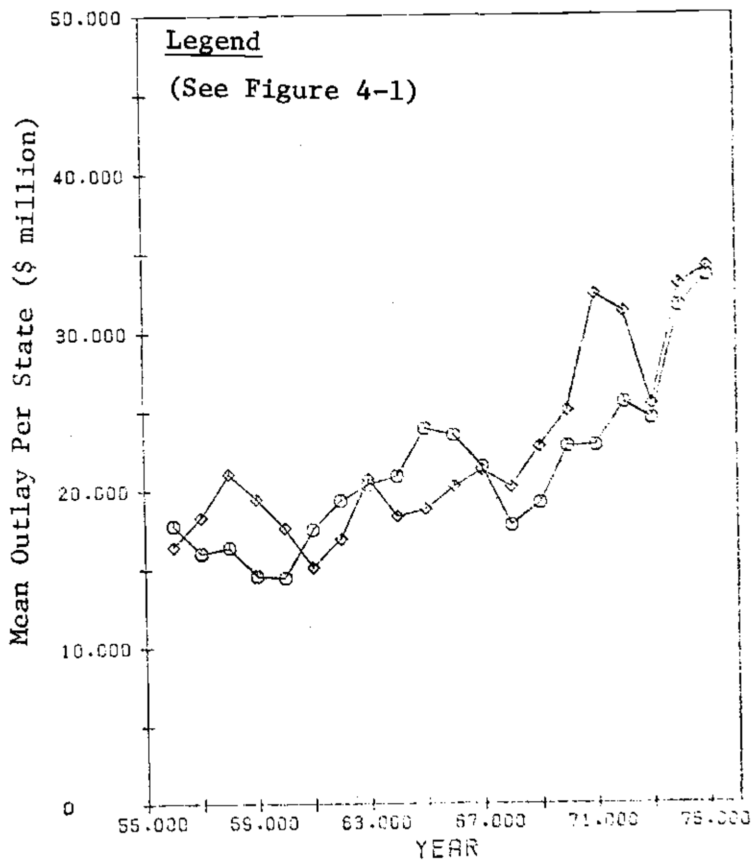


Figure 4-14. Total State (Inclusive of Federal Aid) Capital Outlay for the Federal-Aid Secondary System (B)

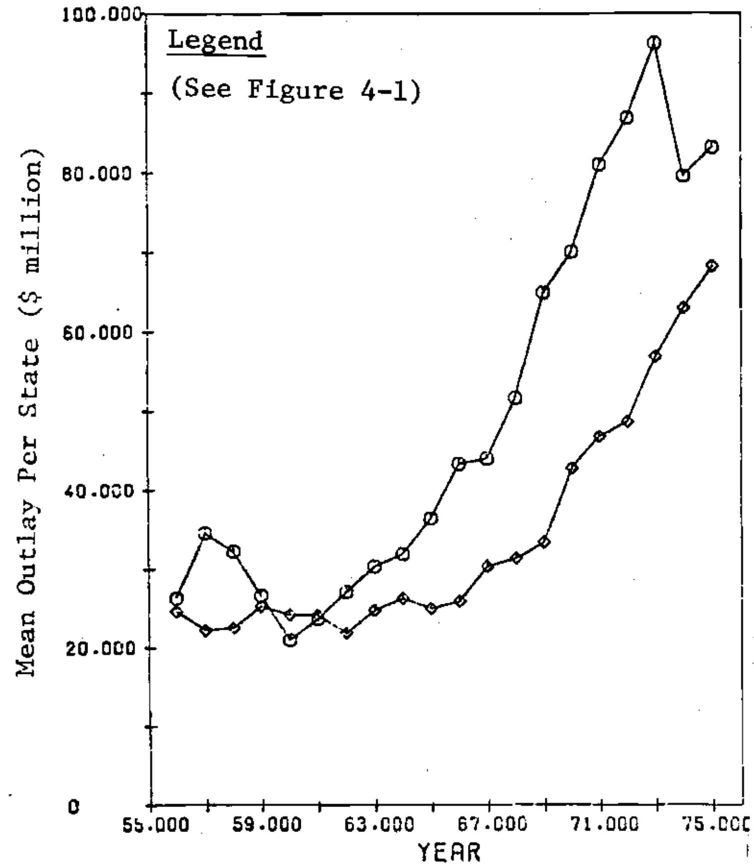


Figure 4-15. Total State (Inclusive of Federal Aid) Capital Outlay for the Urban Extensions of the Primary System

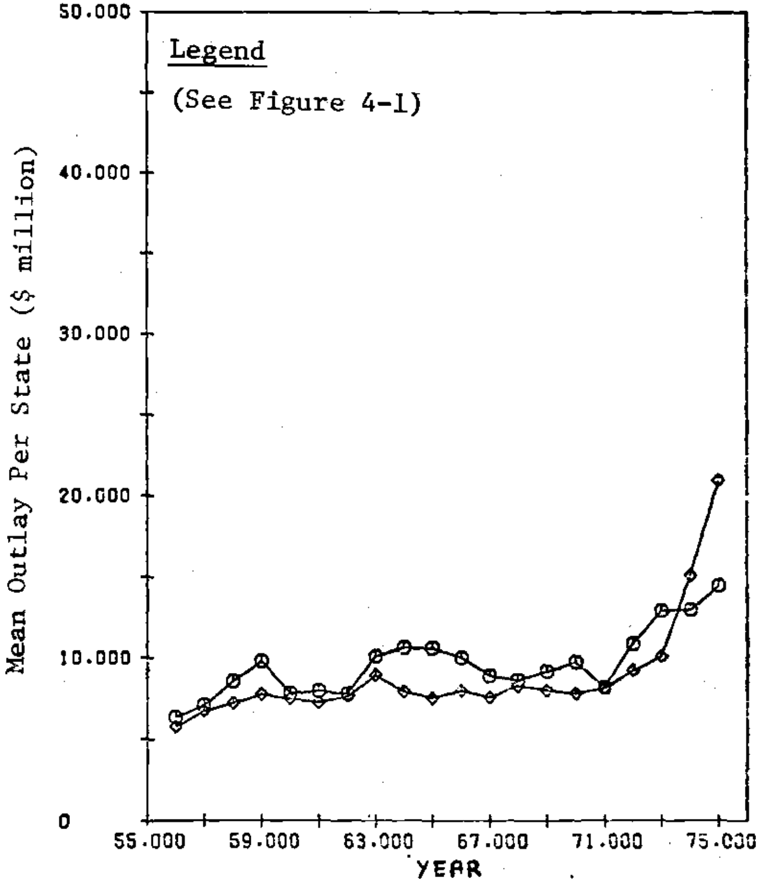


Figure 4-16. Federal-Aid Expenditures for the Secondary (B), the Urban Extensions of A and B, and Urban Highway (D) Systems

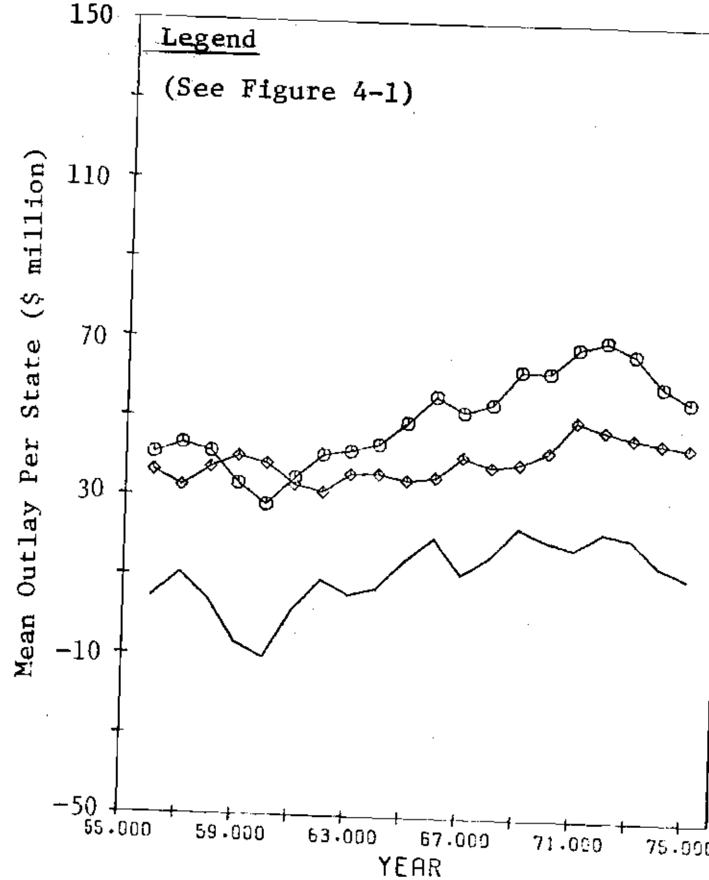


Figure 4-17. Deflated (by Highway Construction Index, 1967 base) State-only Capital Outlays for the Primary (A), the Secondary (B), the Urban Extensions (C) of A and B, and Urban Highway (D) Systems

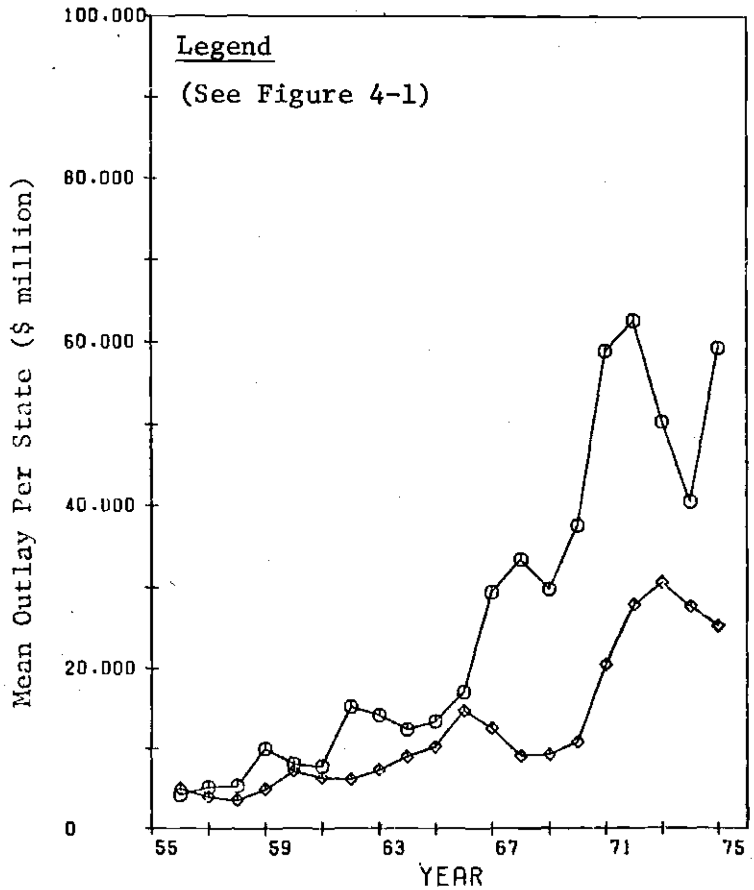


Figure 4-18. Capital Outlay for Non-Federal-Aid Highways

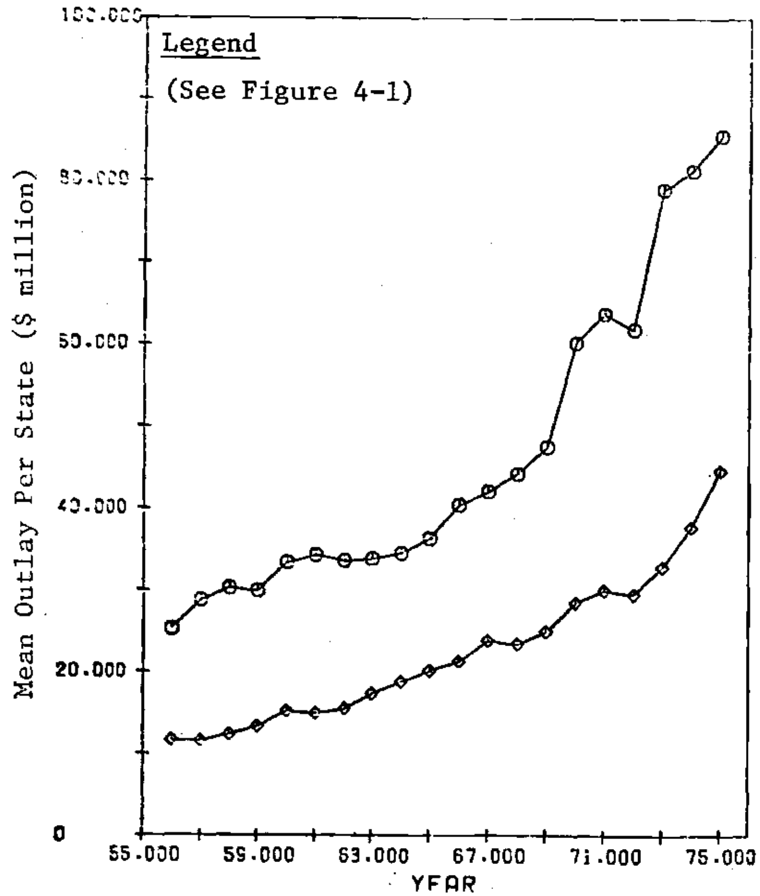


Figure 4-19. State Highway Maintenance Expenditures

the state-only ABCD outlays deflated using the Federal-aid highway construction index presented in Figure 3-2. The deflated series helps to understand the relative state efforts when comparing the experimental and comparison groups. This constant dollar, state-only ABCD expenditure series will be the focus for analysis in Chapter 5.

4.2.3 Non-Federal-Aid Roads and Non-Capital Expenditures

The stress of coming up with the necessary matching funds for the ADHP, while maintaining effort on systems such as the Interstate, would appear to have exerted heavy pressure on other state highway ventures. In particular, concern focused on the non-Federal-aid system construction and overall state highway maintenance. The results are surprising. As indicated in Figure 4-18, capital outlay on roads ineligible for Federal aid increased in the core ADHP states relative to the comparison group.[1] There is no indication that the ADHP program detracted from the non-Federal-aid road effort. Figure 4-19 indicates no slackening of these states' maintenance efforts.

If one wished to speculate, it might be postulated that the special ARC highway program stimulated the state effort on other roads as well. Overall highway effort increased, as discussed previously, and the core ADHP states generated higher highway revenues by increasing gas taxes and issuing more bonds. It is plausible that, spurred by ADHP

[1]The explanation does not lie in inclusion of ARC access road expenditures (some of which could so appear). As of December, 1976, the total access road obligations came to only $36.6 million for the 5 core ADHP states (an average of only $7.3 million in over 11 years). This is less than $1 million annually, and, furthermore, very similar to the $62.7 million for the eligible comparison states - Alabama, Mississippi, and South Carolina (yielding an average of $7 million per state for the 9 states of the comparison group).

needs, states went an extra step to generate additional revenues that could be used on non-Federal-aid roads and to meet matching requirements on the expanding urban Federal-aid roadways. In any event, while the ADHP program appears to have constricted the B and A programs a bit, it has not so affected other highway programs.

4.3 Socio-Economic Impacts

While socio-economic impacts are not a primary focus, it is interesting to gauge the ADHP program in light of such effects. At this time the ADHP is about 50% open to service (1300 miles). Hence, evaluation of its effects is partially based on analogies and forecasts, and partially on actual observed effects.

Appalachia has made useful gains since the onset of the ARC programs:[1]

- the emigration of the early '60's has been reversed to an average immigration;
- between 1960 and 1970 the Region's poverty level people declined by 41%, vs. 30% nationally;
- between 1965 and 1973, Appalachia gained more than one million industrial jobs;
- per capita income rose by 89% from 1965 to 1973, versus 81% nationally;
- the percentage of adults with a high school education and the number of doctors per capita have both increased significantly.

While these gains cannot be simply attributed to the ADHP, the highway program has been viewed as the cornerstone of development in the

---

[1] ARC, 1975 Annual Report, Washington, D.C., 1975, p. 1-2.

Region.[1] When completed, the ADHP and Interstate will be within 30 minutes of 85% of the Region's people.[2] Travel times between twenty major combinations of Appalachian centers and major trading centers should be reduced by 20-50% upon completion of the ADHS.[3] Some 65% of the ADHS mileage passes through or is adjacent to major coal fields[4] - a point conducive to emerging Regional development and national energy concerns.

Various economic benefits appear traceable to the ADHP. Most directly, some 7000 direct jobs and 7000 indirect ones are attributable to construction in 1975 alone (based on general highway construction estimates).[5] Public and private investments have taken place in highway-related businesses and highway-dependent industries. Employment gains from 1962-68 in counties on completed ADHP or Interstate segments outstripped those in other counties.[6] Correspondingly, a survey of 1354 new industrial plant locations in Appalachia found 56% located within 10 minutes of an Interstate or ADHS segment.[7] Another implication of

---

[1]Ibid., p. 2.

[2]ARC, The Appalachian Highway Program: Progress, Impacts and Planning for the Future, Washington, D.C., December, 1975, p. 25.

[3]ARC, Highway Transportation and Appalachian Development, Research Report No. 13, Washington, D.C., September, 1970, p. 36.

[4]ARC, 1976 Annual Report, Washington, D.C., p. 7.

[5]ARC, The Appalachian Highway Program, op. cit.

[6]ARC, Highway Transportation and Appalachian Development, op. cit., p. 48.

[7]ARC, The Appalachian Highway Program, op. cit., p. 27.

the improved roads is an increase in commuting to work outside the county of residence.[1] In sum, there is good support for the assertion that the combined Interstate-ADHP program will provide mobility and economic gains.

[1]Ibid., p. 31.

CHAPTER V

EFFECTS OF THE APPALACHIAN DEVELOPMENT HIGHWAY PROGRAM: FORMAL TIME SERIES ANALYSES

The estimates of intervention effects can vary depending on the models through which the time series are analyzed. The traditional linear (line-fitting) models offer advantages in their simplicity, but shortcomings in certain instances due to the assumptions involved (Sween and Campbell, 1965; Glass, Pechman, and Sanders, 1972). The more recent stochastic models offer several advantages, although they are by no means perfect (Box and Jenkins, 1975; Glass, Willson, and Gottman, 1975). In particular, the present data violate the requirements for a large (50 or so) number of observations in the time series. It is therefore decided to use both approaches so that more robust information is obtained than by a straightforward single analysis. Some important properties of the two approaches are summarized in Table 5-1.

5.1 Linear Model Analysis

The statistical assumptions necessary to interpret the results of the linear model analysis are a serious concern. The linear trend component can actually take account for interdependency among the observations, but the independence of the error terms must also be taken into account. The most satisfactory approach is that of Sween and Campbell (1965) who adjust the results to better accommodate violations of this assumption.

Table 5-1. Properties of Line-fitting and Stochastic Model Methods for Estimating Intervention Effects

	Formal Assumptions		Ways of Estimating Intervention Effects	Other Consideration
	dependent variable	error		
line-fitting	independent	$NID(0,\sigma^2)$	1. immediate change: single Mood test 2. slope change: Walker-Lev tests 3. composite measure: double Mood test	1. Implicitly assumes that the pre-change trend would continue for the whole period of interest, in the absence of the intervention 2. Need to refer to related statistics to interpret the obtained results 3. Least squares criterion may overweigh outlier observations.
stochastic modeling	serially correlated	$NID(0,\sigma^2)$	use a flexible design as appropriate	1. No need to refer to related statistics. 2. Iteration until adequate model is obtained 3. Requires number if observations.

[a] $NID(0, \sigma^2)$ indicates a normal independent distribution with mean zero and variance σ^2.

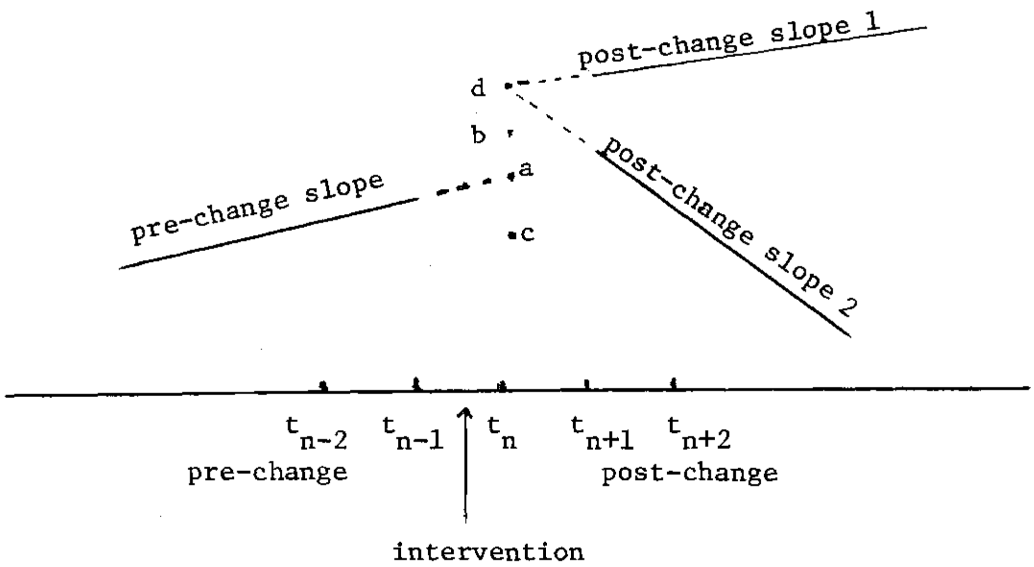


Figure 5-1. Illustration of Mood Tests

a = linear projection based on pre-intervention observations
b and c = actual observations after intervention
d = linear projection based on post-intervention observations

The linear model weights all observations equally. Therefore it was determined to use the period 1956-1965 as the pre-intervention period and 1967-1973 as the post-intervention period. The year 1966 is excluded from both periods. The rationale is that that year is only slightly affected by the ADH program, per se, because of the lag in commencement of the ADHP. However, because of the extensive planning involved (as exemplified by the President's Appalachian Commission of 1973), neither is it appropriate to consider that year as not affected by the ADHP.

To best estimate the effects of the ADHP on state-only ABCD expenditures, changes in the level of expenditures and changes in the drift (slope) of the time series are investigated. Four separate tests of significance are performed.

Mood Test. This is a t-test (Mood, 1950) for determining the significance of a change in value predicted by extrapolation of the pre-intervention observations. It uses a least squares criterion; and is particularly appropriate for testing the hypothesis of immediate post-intervention effects. In Figure 5-1, the quantity (b-a) or (c-a) is evaluated against the standard error of the dependent variable for the pre-intervention period. This test was applied separately to 1967 and 1968 observations (the latter, to give a more fully developed ADHP implementation).

Double Mood Test (Double Extrapolation Technique). This test is concerned with the significance of the difference between two separate regression estimates of the series value which lies midway between the last pre-intervention point and the first post-intervention point

(Walker, 1953). Such changes may be due to changes in either the level or the slope, or in both. Thus, separate examination of the slopes and pre- and post-intervention means must be accomplished. In Figure 5-1, the quantity (d-a) is evaluated against the standard error, giving a t-statistic. As indicated in that figure, note that very different post-intervention series may project to the same point d, thereby yielding the same statistical determination. For this reason, the obtained t-value in this test is to be evaluated without sign. In application of the Double Mood Test, the periods 1956-1965 and 1967-1973 are taken as the pre-intervention and post-intervention periods, respectively.

Walker-Lev Test One. This test concerns the existence of a common slope in the pre-intervention and post-intervention periods (Walker-Lev, 1953). Since the t-value in the Double Mood Test does not indicate the direction of change, Walker-Lev Test One is used to identify direction as illustrated by post-change slopes 1 and 2 in Figure 5-1.

Walker-Lev Test Three. This is a test of the hypothesis that a single regression line fits both the pre- and post-intervention series (Walker-Lev, 1953). This test builds upon the findings of Walker-Lev Test One. It is only applicable if the Walker-Lev Test One does not indicate a significant difference in the slopes for the two periods.

As described, each of the tests is performed to answer different questions about how the change occurred. Therefore the tests should be regarded as a complementary "package."

5.1.1 Adjustment of the Level of Significance

There is strong reason to believe that the ABCD highway expenditure data violate the assumption of independence. Consequently, Sween and Campbell's (1965) simulation results on proximally correlated time series are used. Their figures showing adjusted critical values for each test, except Walker-Lev Test One, are reproduced in Appendix D. Autocorrelations for the ABCD state-only expenditures are shown in Table 5-4 in adjusting the t-values and F-ratios in Table 5-2, the figures of Appendix D are employed. Note that some of the autocorrelation values exceed the range provided in those figures. In those cases the maximal autocorrelation values (0.50 for the Mood test, 0.40 for the Double Mood test, 0.35 for Walker-Lev Test Three) for which critical values are available are used. Note that the adjusted significance levels are set at 2.5% for a one-sided test.

5.1.2 Interpretation

First consider the results in Table 5-2 for the experimental group of states (the core ADHP states). Concentrating upon the tabulated values and the non-adjusted significance levels several observations can be made. Walker-Lev Test One tends to indicate that post-intervention drift differed from pre-intervention series drift. The Double Extrapolation (Double Mood) test indicates a change as well. Together, these appear to indicate that there was change both in level and drift. Non-significant results for the single Mood test imply that the change was not abrupt.

Looking at the comparison group of states, the results of both the Double Extrapolation test and Walker-Lev Test One are similarly at a significant level (on a non-adjusted basis). These tests would indicate that changes in this series due to the intervention are primarily in the series drift (slope). Considering the slopes and means for each

Table 5-2. Results of Significance Tests of the ADHP Effects Estimated Using Linear Models

	Single Mood test for 1967 (1)	Single Mood test for 1968 (2)	Double extrapolation test (3)	Walker-lev test one (4)	Walker-lev test three (5)	Significance (1) df=8	(2) df=8	(3) df=13	(4) df=13	(5) df=14	Adjusted Significance (1)	(2)	(3)	(4)
Experimental Series[a]	1.051	1.170	5.247	4.349	3.410			*	+	*			**	
Comparison Series[b]	1.713	1.049	5.542	7.918	1.897	+		*	*				**	
Difference[c]	.187	.525	1.617	.129	.263			+						
KY	2.826	3.664	1.402	.836	46.375	*	*	+		*	**	**		**
NC	1.256	1.310	3.142	12.071	2.169			*	*					
TN	-.422	.496	.946	.590	.158									
VA	1.451	1.174	1.671	.070	3.164			+		+				
WV	-1.488	-1.286	10.006	3.551	.568			*	+				**	
AL	-.742	.333	.397	.027	.042									
AK	1.627	2.526	6.916	3.010	11.045	+	*	*		*		**	**	**
FL	-.659	-.804	1.535	.736	.769			+						
IA	2.688	1.108	1.488	4.513	2.887	*		+			**			
LA	2.382	1.444	2.581	17.777	3.062	*	+	*	*		**			
MS	1.270	.964	12.691	16.625	54.633			*	*	*			**	**
NM	-.430	.345	1.438	.628	.224			+						
OK	.279	-.287	2.111	.147	.092			*						
SC	.307	.204	4.420	1.219	.000			*						

[a] KY, NC, TN, VA, WV
[b] AL, AK, FL, IA, LA, MS, NM, OK, SC,
[c] The difference between the means of the experimental and comparison groups.

* Indicates significance at 5% level in standard tables.
\+ Indicates significance at 10% level in standard tables.
** Indicates significance using the critical values in Appendix D.

Table 5-3. Intercepts, Slopes and Means of the Pre- and Post-Intervention Periods

($1,000,000)

	Pre-Intervention Period		Post-Intervention Period		Means		
	Intercept	Slope	Intercept	Slope	Pre-Intervention	Post-Intervention	Total
Experimental series[a]	36.0	0.69	17.5	3.01	39.8	62.6	49.2
Comparison series[b]	36.5	-0.15	18.6	1.67	35.6	43.7	39.0
Difference[c]	-0.5	0.84	-1.1	1.34	4.1	18.9	10.2
KY	34.7	-0.32	40.4	0.79	33.0	52.2	40.9
NC	66.3	-4.36	-14.4	3.78	42.3	42.2	42.3
TN	42.0	0.69	54.9	-0.23	45.7	51.5	48.1
VA	25.3	3.93	52.2	3.30	46.9	102.0	69.5
WV	11.6	3.49	-45.5	7.40	30.8	65.4	45.1
AL	34.8	0.50	36.8	0.20	37.5	39.8	38.4
AK	15.9	0.41	47.6	-1.02	18.1	32.3	23.9
FL	51.0	3.00	66.9	0.97	67.5	81.4	73.2
IA	69.3	-1.99	35.4	2.05	58.4	66.2	61.6
LA	83.5	-5.44	0.8	3.09	53.6	47.1	50.9
MS	18.1	1.15	-37.3	5.94	24.4	51.7	35.6
NM	13.3	-0.30	5.9	0.19	11.7	8.9	10.4
OK	28.8	-0.33	22.6	0.71	30.6	33.2	31.6
SC	13.5	1.00	-10.8	2.92	19.0	33.0	24.7

[a]Mean of KY, NC, TN, VA and WV

[b]Mean of AL, AK, FL, IA, LA, MS, NM, OK and SC

[c]The difference between means of the experimental and the comparison groups

Table 5-4. Autocorrelation for the State-only ABCD Outlay Time Series

	1956 - 1973			1956 - 1965
	Lag			Lag
	1	2	3	1
Experimental states[a]	0.86 (0.24)*	0.67 (0.37)	0.51 (0.43)	0.58
Comparison states[b]	0.70 (0.24)	0.35 (0.33)	0.17 (0.35)	0.22
Difference series[c]	0.74 (0.24)	0.46 (0.34)	0.43 (0.37)	0.52
KY	0.61	0.54	0.37	0.02
NC	0.52	0.06	-0.23	0.53
TN	0.15	-0.09	0.18	0.06
VA	0.86	0.70	0.57	0.66
WV	0.56	0.32	0.15	0.75
AL	-0.03	-0.57	-0.24	-0.13
AR	0.70	0.43	0.28	0.35
FL	0.37	0.01	0.05	0.41
IA	0.25	-0.01	0.10	0.05
LA	0.62	0.33	0.22	0.74
MS	0.75	0.66	0.45	0.25
NM	0.40	0.23	0.06	0.35
OK	0.06	-0.06	-0.18	-0.05
SC	0.81	0.61	0.41	0.49

[a] KY, NC, TN, VA, WV
[b] AL, AK, FL, IA, LA, MS, NM, OK, SC
[c] The difference between the means of the experimental and comparison groups

*Figures in the parentheses indicate the standard error.

period for each group in Table 5-3, note that the slope for the comparison states changed from negative to positive, and that the difference between pre- and post-intervention means is smaller for the comparison states than for the experimental states.

The different series is probably the one of greatest inherent interest. Referring to Figure 4-17, it appears that that series increased its level following the intervention. Coming back to Table 5-2, observe that the Walker-Lev Tests One and Three are non-significant, while the Double Extrapolation test is marginally significant at the 10% level. These results suggest that the pre-intervention series trend continued in the post-intervention period, and that there was a non-random change in level.

The tentativeness of the above discussion is heightened by consideration of the adjusted significance levels. Observing these adjusted values in Table 5-2, one could hardly say that the change in experimental states is strictly attributable to the intervention (implementation of the ADHP) since Walker-Lev Test One results are significant for both, and no other results are significant at all. On the other hand, differences between the means, pre- and post-intervention, are notably larger for the experimental states than for the comparison states.

In any such statistical analysis it is important to observe the performance of the individual units. The performance of aggregates, in this case the experimental group and the comparison group, can often be better understood in terms of the performance of the individual units that make up the groups. It is also at the level of the individual states that one can get the best insights from interviews as to what actually takes place. In this vain, several observations are worthy of note. North Carolina was decreasing its ABCD outlays from 1956 to 1966 (see Appendix C). The results of this somewhat extreme trend can be seen for North Carolina's Walker-Lev Test One results. The significance test is merely reflecting the fact that the pre-intervention trend is implicitly assumed to continue on its course, in this case, on down towards zero. This is inherently dubious, and an indication that the statistical test cannot be taken at face value in this case (from another perspective, this is an example of a regression artifact at work - see discussion of Section 3.1). Similar suspicions may be raised about the results for Louisiana (see Table 5-2 and Table 5-3). West Virginia appears to have been decreasing its ABCD outlays due to the intervention, according to the Mood tests for 1967 and 1968. However, as seen in Table 5-3, the post-intervention mean for West Virginia actually increases. This is a situation in which a serious lag is involved. Interview results corroborate this finding - West Virginia's highway program moved ahead vigorously with the approval of a major bond issue in the late 1960's (stimulated by ADHP needs). All in all, examination of the individual states does not suggest that increases were restricted in any neat way to the experimental states. In summary, although the formal tests do not indicate strong ADHP effects, mean values and slopes lend some support to a stimulation effect of the ADHP on state-only ABCD expenditures. (Recall again that these outlays include state expenditures on the ADHP per se.)

5.2 Stochastic Model Analyses[1]

The ABCD expenditure series appears to exhibit significant autocorrelation (Table 5-4). This suggests that use of stochastic models to estimate the ADHP effects is appropriate.

A stochastic intervention model, the so-called ARIMA (p,d,q,) model (Glass, Willson, and Gottman, 1975) where p, d, and q represent the order of the autoregressive component, degree of differencing, and order of the moving average component, respectively, is written:

$$Z_t = f_t(L, I_1, I_2, \ldots) + \sum_{j=0}^{t-1} \psi_j a_{t-j}, \qquad t = 1, \ldots, N$$

where Z_t are the observed values; $f_t(L, I_1, I_2 \ldots)$ is a linear function of a level parameter, L, and intervention parameters $I_1, I_2, \ldots$; ψ_j is the j^{th} ψ-weight in a white-noise-process; and a_{t-j} is noise assumed of the form:

$$a_t \sim NID(0, \sigma_a^2) .$$

After appropriate transformation of Z_t into Y_t to obtain a general linear function, one obtains:

---

[1]Computational work in this section is based on the computer programs (CORREL and TSX) developed by C. P. Bower, W. L. Padia and G. V. Glass, Laboratory of Educational Research, University of Colorado, October 1974.

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_N \end{bmatrix} = \begin{bmatrix} x_{11} & x_{12} & \cdots \\ x_{21} & x_{22} & \cdots \\ \vdots & \vdots & \\ x_{N1} & x_{N2} & \cdots \end{bmatrix} \begin{bmatrix} L \\ I_1 \\ I_2 \\ \\ \end{bmatrix} + \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_N \end{bmatrix} ,$$

and in matrix notation, $\bar{Y} = \bar{X}\bar{\beta} + \bar{a}$, where x_{ij} are the weights of the intervention effects in a design matrix $\bar{X}$. Particular design matrices and intervention parameter vectors will be illustrated.

The least-squares estimator of $\bar{\beta}$, $\hat{\beta}$, will minimize the sum of squares of the error term (LE):

$$LE = \bar{a}^t\bar{a} = (\bar{Y} - \bar{X}\bar{\beta})^t(\bar{Y} - \bar{X}\bar{\beta}) ,$$

where the superscript t denotes the transpose of a matrix. Hence, $\hat{\beta}$ must satisfy the normal equation

$$\left.\frac{\partial LE}{\partial \bar{\beta}}\right|_{\hat{\beta}} = -2\bar{X}^t\bar{Y} + 2\bar{X}^t\bar{X}\hat{\beta} = 0 .$$

Thus the least-squares estimator is

$$\hat{\beta} = (\bar{X}^t\bar{X})^{-1}\bar{X}^t\bar{Y} ,$$

and the variance is

$$V(\hat{\beta}) = (\bar{X}^t\bar{X})^{-1}\sigma_a^2 .$$

The least-squares estimator of the residual variance σ_a^2 is

$$\hat{\sigma}_a^2 = (\bar{Y} - \bar{X}\hat{\beta})^t(\bar{Y} - \bar{X}\hat{\beta})/(N - m) ,$$

where N is the number of observations and m the number of elements in the parameter vector. Then the t-statistic for testing the significance of the difference of the k^{th} element of $\hat{B}$, $\hat{B}_k$, from zero is computed,

$$t_{N-m} = \frac{\hat{\beta}_k}{\hat{\sigma}_a \sqrt{C_{kk}}} ,$$

where C_{kk} is the k^{th} diagonal entry in $(\bar{X}^t\bar{X})^{-1}$.

5.2.1 Model Identification

Autocorrelations and partial autocorrelations were first obtained separately for the experimental group, the comparison group, and the difference series, respectively, and for the individual states. These were separately computed for the pre- and post-intervention periods (see Tables 5-5, 5-6, and 5-7; as well as Appendix E for the individual states). Rarely are autocorrelations larger than twice the estimated standard deviations found. This might be interpreted as an indication that the series reflect a white noise process. In fact, it is more reasonable to assume that the standard errors may be inflated because of the small number of observations. Hence one should be more concerned with the patterns and the relative size of the autocorrelations than with their size relative to the standard errors.

Table 5-5. Autocorrelations and Partial Autocorrelations of the Experimental Series

1956-65	Lag							Standard errors	
	1	2	3	4	5	6	7	min	max
ACF° [a]	.58	.13	-.06	-.18	-.38	-.45	-.20	0.30	0.47
ACF'	.43	-.28	-.19	.15	.01	-.32	-.26	0.32	0.41
PACF°	.58	-.30	.02	-.16	-.33	-.10	.17		
PACF'	.43	-.57	.43	-.20	-.19	-.06	-.12		
1966-73									
ACF°	0.57	0.10	-0.16	-0.43	-0.41			0.38	0.55
ACF'	-0.31	0.04	0.12	-0.38	0.03			0.41	0.50
ACF°	0.57	-0.34	-0.07	-0.41	0.08				
Weighted [b]									
ACF°	.58	.12	-.10	-.29	-.39				
PACF°	.58	-.32	-.02	-.27	-.16				

[a] i (of ACF^i) indicates the degree of difference.

[b] See text for a discussion of the weighting formulation.

Table 5-6. Autocorrelations and Partial Autocorrelations of the Comparison Series

1956-65	Lag							Standard errors	
	1	2	3	4	5	6	7	min	max
ACF° [a]	0.22	-0.54	-0.38	0.14	0.19	-0.11	-0.05	0.30	0.44
ACF^{1}	0.01	-0.62	-0.24	0.30	0.26	-0.22	-0.05	0.32	0.48
PACF°	0.22	-0.62	-0.09	-0.09	-0.19	-0.22	0.07		
PACF^{1}	0.01	-0.62	-0.38	-0.25	-0.20	-0.42	-0.07		
1966-73									
ACF°	0.60	0.02	-0.42	-0.42	-0.21			0.38	0.59
ACF^{1}	0.00	-0.39	-0.34	0.13	0.10			0.41	0.51
PACF°	0.60	-0.51	-0.28	0.15	-0.11				
Weighted [b]									
ACF°	0.40	-0.32	-0.40	-0.11	0.02				
PACF°	0.29	-0.58	-0.34	-0.08	-0.16				

[a] i (of ACF^{i}) indicates the degree of difference.

[b] See text for a discussion of the weighting formulation.

Table 5-7. Autocorrelations and Partial Autocorrelations of the Difference Series

1956-65	Lag							Standard errors	
	1	2	3	4	5	6	7	min	max
ACF° [a]	0.52	-0.02	-0.11	-0.03	-0.26	-0.46	-0.25	0.30	0.44
ACF'	0.27	-0.53	-0.29	0.30	0.17	-0.24	-0.20	0.32	0.47
PACF°	0.52	-0.40	0.19	-0.09	-0.43	-0.07	0.08		
PACF'	0.27	-0.65	0.21	0.04	-0.03	0.05	-0.09		
1966-73									
ACF°	0.19	-0.35	0.11	0.02	-0.32			0.38	0.44
ACF'	-0.13	-0.38	0.22	-0.12	-0.09			0.41	0.49
PACF°	0.19	-0.40	0.34	-0.34	-0.05				
Weighted [b]									
ACF°	0.39	-0.17	0.04	-0.01	-0.29				
PACF°	0.39	-0.40	0.26	-0.20	-0.28				

[a] i (of ACF^{i}) indicates the degree of difference.

[b] See text for a discussion of the weighting formulation.

In applying the Box-Jenkins approach to interrupted, short time series, one must be concerned with the best method of estimating the autocorrelation and partial autocorrelation functions (PACF). Vaught and Jones (1974) offer a useful approach to this problem. Their method involves the separate computation of the autocorrelation function (ACF) for the pre-intervention and post-intervention periods; then each value is transformed using Fisher's formulation:

$$r'_{\ell i} = 0.5[\log_e (1 + r_{\ell i}) - \log_e (1 - r_{\ell i})]$$

where $r'_{\ell i}$ is the transformed value of $r_{\ell i}$ (the autocorrelation at log ℓ within region i). A weighted mean of $r'_{\ell i}$ is computed for the m regions by:

$$\bar{r}'_{\ell} = \frac{\sum_{i=1}^{m} w_i r'_{\ell i}}{\sum_{i=1}^{m} w_i}$$

where w_i equals $n_i - 2$ and is the weight for the i^{th} region. The average autocorrelation coefficient is then obtained by

$$\bar{r}_r = (e^{2\bar{r}'_{\ell}} - 1)/(e^{2\bar{r}'_{\ell}} + 1) .$$

Weighted ACFs and PACFs obtained by using this technique are included in Tables 5-5, 5-6, 5-7 and Appendix E. Hypothesizing initial models by comparing these weighted ACFs and PACFs with theoretical behavior, one can hardly find good evidence whether any of the series is nonstationary. So ACFs and PACFs of the original series were evaluated and the best hypothetical models are predicted as shown in Table 5-8.

5.2.2 Fitting[1] and Diagnostic Check

As mentioned on several occasions, the Appalachian Development Highway Program did not start instantaneously (see Section 3.3). To reflect the nature of this start-up period, as understood through interviews and inspection of the data, a suitable design matrix must be established. The following design matrix appears well-suited to capture the implementation of the ADHP in 1966, 1967 and 1968.

$$X^t = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/10 & 1/4 & 1/2 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

where $\bar{X}^t$ is the transpose of the design matrix. And parameter vector,

$$\bar{\beta} = \begin{bmatrix} L \\ I \end{bmatrix}$$

where L is a level parameter; I is an intervention parameter measuring level change. Particular figures, 1/10, 1/4, and 1/2 for the years 1966, 1967 and 1968, respectively, were chosen to weigh the gradual effects (exponentially).

---

[1](0, 1, 0) model is not fitted because no iteration is provided in the program to minimize variance. However, this model is to be well approximated by (1, 0, 0) if the series is a true (0, 1, 0) process. See discussion on alternative model (e.g., Box and Jenkins, 1975, pp. 189-193).

Table 5-8. "Best" Hypothetical ARIMA (p,d,q) Models for State-only ABCD Outlays

	ARIMA $(p,d,q)^a$
Experimental Series	(0, 0, 1)
Comparison Series	(1, 0, 1)
Difference	(0, 0, 1)
Kentucky	(0, 1, 0)
North Carolina	(0, 0, 1)
Tennessee	(0, 1, 0)
Virginia	(0, 0, 1)
West Virginia	(1, 0, 1)
Alabama	(0, 1, 0) cyclical at a multiple of 3
Arkansas	(0, 1, 0)
Florida	(1, 0, 1)
Iowa	(0, 1, 0)
Louisiana	(1, 0, 0)
Mississippi	(0, 0, 1)
New Mexico	(0, 1, 0)
Oklahoma	(0, 1, 0)
South Carolina	(0, 0, 1)

[a] ARIMA (0, 1, 0), or $Z_t = Z_{t-1} + a_t$ means a pure random-walk process. Note that no ARIMA parameter would be estimated.

Adequate models may be established through an iterative procedure: initial model identification, fitting, diagnostic checking, and fitting with alternative models if the diagnostic check fails. The present strategy for finding an adequate model is somewhat modified to overcome the uncertainties underlying the estimation of the ACFs and PACFs. Rather than focusing solely on the hypothetically best model, estimations were made for three simple models in all cases. As shown in Table 5-9, ARIMA models (0, 0, 1), (1, 0, 0) and (1, 0, 1) are computed. These are then examined against the criteria of:

(1) minimum variance

(2) inspection of the parameters in the (1, 0, 1) model as an indicator of whether the moving average or autoregressive factors is dominant in a given series. To illustrate the application of this criterion, observe that the experimental series shows values of $\phi = 0.50$ and $\theta = -0.90$ for the (1, 0, 1) model. The greater value of θ than ϕ is interpreted to indicate that the moving average component is the more powerful term. This interpretation can be verified by comparing the variances accounted for by the (0, 0, 1) and (1, 0, 0) models of the same series (Table 5-9).

(3) The hypothetical model indications (see Table 5-8) based upon the ACFs and PACFs. To continue the illustration for the experimental series, recall that the (0, 0, 1) model was entertained on the basis of the pattern of ACFs and PACFs.

(4) Obviously inclusion of more terms in the model enables that model to explain more of the variance. That issue is the relative improvement due to the added complexity. Model selection based on the four criterion resulted in the <u>intermediate</u> selection as shown in the last column of Table 5-9.

(5) Analysis of residuals. Residual examination was based on the assumption of zero mean and independent noise terms. In particular the "pormanto" test (Box and Jenkins, 1975, pp. 290-291) was relied upon to check for independence. t-values for change in series level before to after the intervention for the finally selected models are circled in Table 5-10.

5.2.3 Discussion

Table 5-10 indicates a significant increase in state-only ABCD outlays in both groups of states. This implies that expenditures were growing in the comparison states, which were not influenced by the presence of the ADHP. Note also, however, that the difference series also shows an increase in the level of expenditures. This implies that the experimental states increased their outlay significantly more than the comparison group.

Examination of individual state results does not appear to support this result. For the experimental states, three out of the five show a significant increase; while six out of the nine comparison states show such an increase. This point could be further examined through interviews with the states involved.

Comparison of the stochastic model results with the previous linear model estimation, are not particularly clear (see Table 5-2). In particular, it is important to compare the results for the difference series for which the linear model estimation indicated no significant changes. An important observation is that the linear model weights all observations equally, whereas the stochastic model used in this section was able to estimate on the basis of gradual implementation of the ADHP. The following illustration may help resolve the different results.

In place of the design matrix used in the analysis of this section, assume that the change was abrupt. The following design matrix can then be written:

Table 5-9. Minimum Variance and Estimated Parameters of ARIMA Models for the State-only ABCD Outlays

	ARIMA (p,d,q)							Intermediate Models Selected
	(0, 0, 1)		(1, 0, 0)		(1, 0, 1)			
	θ	Variance	ϕ	Variance	ϕ	θ	Variance	
Experimental States[a]	-0.98	0.1329	0.72	0.1932	0.50	-0.90	0.1132	(1, 0, 1)
Comparison States[b]	-0.58	0.0778	0.26	0.0927	-0.10	-0.60	0.0776	(0, 0, 1)
Difference Series[c]	-0.72	0.2758	0.56	0.3243	0.30	-0.60	0.2628	(0, 0, 1)
KY	-0.42	0.4576	0.36	0.4731	-0.50	-0.90	0.4371	(1, 0, 1)
NC	-0.66	1.4818	0.60	1.5235	0.40	-0.40	1.4422	(0, 0, 1)
TN	-0.30	0.2862	0.08	0.2923	-0.40	-0.80	0.2775	(1, 0, 1)
VA	-0.62	1.9401	0.98	1.1518	0.90	-0.20	1.2790	(1, 0, 1)
WV	-0.98	0.7312	0.62	0.9530	0.10	-0.90	0.7688	(1, 0, 0)
AL	0.98	0.3661	-0.06	0.6186	0.10	0.90	0.3883	(0, 0, 1)
AR	-0.52	0.2646	0.36	0.2863	-0.10	-0.60	0.2641	(1, 0, 0)
FL	-0.54	1.2198	0.30	1.3653	-0.10	-0.60	1.2127	(0, 0, 1)
IA	-0.16	0.8779	0.06	0.8829	0.80	0.90	0.8513	(1, 0, 1)
LA	-0.98	1.0012	0.82	1.1156	0.50	-0.90	0.8841	(1, 0, 1)
MS	-0.32	0.6213	0.26	0.6368	0.70	0.90	0.6209	(1, 0, 0)
NM	-0.22	0.0661	0.26	0.0658	0.20	-0.10	0.0658	(1, 0, 0)
OK	0.04	0.1881	-0.04	0.1882	0.60	0.90	0.1652	(1, 0, 1)
SC	-0.56	0.1562	0.98	0.1693	-0.20	-0.50	0.1555	(0, 0, 1)

[a] KY, NC, TN, VA, WV

[b] AL, AK, FL, IA, LA, MS, NM, OK, SC

[c] The difference between the means of the experimental and comparison groups.

Table 5-10. Estimated t-values for Level Change After 1965 in State-only ABCD Expenditures 1956-1973[a]

Series Name	ARIMA (p,d,q)			Significance
	(0,0,1)	(1,0,0)	(1,0,1)	(d.f)=16
Experimental Series[b]	8.39	4.06	5.71[e]	*
Comparison Series[c]	4.20	4.42	4.54	*
Difference Series[d]	3.49	2.73	2.95	*
KY	3.81	3.43	4.27	*
NC	0.02	-0.02	-0.19	
TN	1.64	1.91	1.82	*
VA	4.98	0.61	1.24	
WV	6.45	4.06	5.73	*
AL	3.44	0.97	2.93	*
AK	3.42	3.23	3.58	*
FL	1.60	1.61	1.70	
IA	1.52	1.68	2.00	*
LA	-0.44	-0.53	0.24	
MS	6.06	5.89	10.29	*
NM	-1.86	-1.68	-1.67	
OK	1.18	1.18	2.35	*
SC	5.01	0.76	4.37	*

[a] t-values test whether the level change is different from zero

[b] KY, NC, TN, VA, WV

[c] AL, AK, FL, IA, LA, MS, NM, OK, SC

[d] The difference between the means of the experimental and comparison groups

[e] Circled values indicate result of the most adequate model

*Indicates significance at the 5% level for a one-sided hypothesis test based on the t-value of the most adequate model

$$\bar{X}^t = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

where $\bar{X}^t$ is the transpose of $\bar{X}$.

Using parameter vector, as before,

$$\bar{\beta} = \begin{bmatrix} L \\ I \end{bmatrix}$$

one obtains the results in Table 5-11.

In Table 5-11, the estimated level change for the difference series is notable though not significant (at the .05 level in a two-sided test). This is probably due to overweighing the immediate post-intervention outlays as being affected substantially by the ADHP funds.

Table 5-11. Estimated Level Changes Assuming Abrupt Effects

Series Name	Level Change	t-values Level Change	ARIMA (p,d,q)
Experimental Series	-0.09	-0.27	(0,0,1)
Comparison Series	0.11	0.65	(0,0,1)
Difference Series	-0.78	-1.97	(0,0,1)

Compare the results of Table 5-11 with those of Table 5-10. By altering the design matrix (i.e., the underlying model) the results are radically altered. In the new model the results are not significant (although the difference series approaches significance for a two-sided test). Furthermore, neither the experimental series nor the comparison series shows significant changes, and the difference series direction is reversed. This highlights the importance of model selection in the estimation of intervention effects.

All in all, the gradually implemented ADHP program appears to have resulted in a significant increase in state-only outlays on the ABCD system (remember that this includes state outlays on the ADHP itself).

CHAPTER VI

EFFECTS OF THE APPALACHIAN DEVELOPMENT HIGHWAY PROGRAM: STRUCTURAL EQUATION MODEL ANALYSIS

6.1 Model Specification[1]

In contrast to the time series intervention analyses discussed in the previous section, the structural equation approach explicitly attempts to represent the underlying influences upon the dependent variable in question. It should be noted that in establishing the comparison series attention has been paid to the possible exogenous variables exerting an influence on state highway expenditures. The most fundamental problem in the structural model approach is to obtain a good causal description (Hibbs, 1976). In Hibbs' words:

> Perhaps . . . many areas of inquiry, especially outside of macroeconomics, are simply not sufficiently rich in theory and/or data to permit specification and estimation of adequate structural models.

In this section, the work of Rao in extending the framework of previous studies (Enns, 1974; Sherman, 1975) provides the basis for the present analysis. These regressions develop partial models differentiated by time periods and by groups of states. Chow's (1963) method for estimating changes in structural models in comparison of the coefficients obtained

---

[1]The regression models were developed by Dr. Srikanth Rao (Statistical Analysis of the Impact of Federal Highway Aid on State Allocation Decisions, Pennsylvania Transportation Institute, Pennsylvania State University, April, 1978). But, any erroneous discussion of this model is the author's responsibility.

in those models is used.

The basic model is presented in Figure 6-1. The underlying idea of this model is to estimate the effects of the ADHP by examination of the role of Federal grants in determining states' capital outlays on highways. Details of the model building are available elsewhere (Rao, 1978).

States are divided in the same manner as in the previous analyses - the experimental group of five core ADHP states and the comparison group of nine other states. Time periods are subdivided to take into account the introduction of the interstate system program, the ADHP intervention, and the changes commencing in fiscal 1974 (see Table 6-1).

Serial correlation structure is an important consideration in such multiple regression analyses. To address this issue, both generalized least squares and ordinary least squares regressions were computed and compared for several different data series (Rao, 1978). Results were very similar and the Durban-Watson test did not indicate serious problems. Therefore, the results of ordinary least squares are used as the bases for the analysis presented in Table 6-1.

6.2 Methods of Estimating Changes in the Structural Models

Estimation of changes in structural models may be done either by means of error component analysis or coefficient comparison, or both. Both are now considered. Chow's (1963) approach involves error component analysis; it proceeds as follows. Suppose one has two regression equations,

$$CAPOUT = a_0 + a_1*UFAC + a_2*PCY + a_3*POPDEN + a_4*BIPTCX + a_5*MFC + a_6*AVIGP + a_7*AVNIGP \quad (1)$$

CAPOUT = per capita state outlay for all highways

UFAC = urbanization factor - the percentage of population residing in urban areas

PCY = per capita income

POPDEN = population density

BIPTCX = expenses for bond interest and retirement as a percentage of total capital expenditures

MFC = per capita motor fuel consumption

AVIGP = per capita federal interstate apportionment (moving average)

AVNIGP = per capita federal non-interstate apportionment (moving average)

Figure 6-1. A Regression Model for Per Capita State Total Highway Outlay

Table 6-1. Determinants of Per Capita State Total Highway Outlay[a]

	Constant	AVIGP	AVNIGP	UFAC	PCY	POPDEN	BIPTCX	MFC	Sum of Squares	R-Square	F-Ratio
Experimental States											
1957-66	32.360	1.095*	-0.946	0.130	0.028*	0.691*	-0.117*	-0.015	2044.4	0.793	22.98
	(25.287)	(0.275)	(2.895)	(0.216)	(0.008)	(0.163)	(0.045)	(0.039)			
1967-73	142.60	1.139*	-8.617	-0.127	0.042*	-1.096*	-0.162	-0.174*	2110.1	0.911	39.66
	(90.716)	(0.305)	(8.230)	(0.311)	(0.019)	(0.403)	(0.194)	(0.087)			
1957-73	55.072	1.445*	-1.370	-0.075	0.022*	-0.600*	-0.095	-0.052*	5016.8	0.870	73.85
	(21.209)	(0.130)	(2.289)	(0.167)	(0.006)	(0.138)	(0.048)	(0.029)			
Comparison States											
1957-66	12.868	0.658*	0.558	0.034	0.015*	-0.083	-0.150*	0.558	5327.9	0.582	16.32
	(11.043)	(0.207)	(0.952)	(0.113)	(0.006)	(0.093)	(0.076)	(0.952)			
1967-73	35.400*	0.708*	-0.084	0.007	0.010*	-0.131*	-0.130*	-0.048*	1715.3	0.620	12.35
	(10.188)	(0.216)	(0.768)	(0.132)	(0.004)	(0.064)	(0.051)	(0.017)			
1957-73	24.570*	0.563*	0.979*	0.088	0.012*	-0.098*	-0.150*	-0.055*	7661.5	0.557	26.05
	(6.917)	(0.131)	(0.485)	(0.079)	(0.003)	(0.054)	(0.045)	(0.017)			
Experimental States											
1962-66	20.373	0.495	2.643	0.863	0.047*	-0.929	-0.207	-0.152	1005.2	0.791	9.20
	(136.264)	(0.689)	(14.732)	(0.790)	(0.016)	(0.626)	(0.124)	(0.116)			
1967-70	113.805	1.340*	-3.776	-0.648	0.002	0.067	0.128	-0.125	467.9	0.922	20.45
	(140.662)	(0.581)	(11.207)	(0.532)	(0.035)	(0.791)	(0.235)	(0.128)			
1962-70	17.193	1.072*	4.016	-0.023	0.031*	-0.429	-0.107	-0.101	1987.9	0.820	24.06
	(73.614)	(0.227)	(7.151)	(0.373)	(0.010)	(0.335)	(0.092)	(0.063)			
Comparison States											
1962-66	15.213	1.115*	0.170	0.064	0.011	-0.109	-0.085	-0.025	1742.0	0.702	12.44
	(19.911)	(0.372)	(1.300)	(0.214)	(0.011)	(0.132)	(0.109)	(0.074)			
1967-70	39.735*	0.586*	0.447	0.005	0.015*	-0.197*	-0.154	-0.077*	488.2	0.823	18.56
	(12.307)	(0.321)	(0.864)	(0.224)	(0.006)	(0.077)	(0.101)	(0.027)			
1962-70	39.313	0.565*	1.091	0.116	0.015*	-0.189*	-0.125*	-0.098*	2548.2	0.712	25.83
	(9.972)	(0.196)	(0.684)	(0.142)	(0.005)	(0.075)	(0.073)	(0.028)			

*indicates significantly different from zero at the 5% significance level.

[a]Figures in parentheses under the coefficient values indicate the standard error.

$$Y_1 = X_1\beta_1 + U_1$$

$$Y_2 = X_2\beta_2 + U_2 \tag{6-1}$$

where the subscripts 1 and 2 denote the observations for pre- and post-intervention, respectively, so that X_1 is of order $n \times k$, and X_2 of order $m \times k$ (where n is the number of pre-intervention observations and m that for post-intervention observations), and β_1 and β_2 are vectors of coefficients. Assume that U_2 has the same normal distribution as U_1 with variance-covariance matrix $\sigma^2 I$. If we set up the hypothesis $\beta_1 = \beta_2 = \beta$, the model becomes

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \beta + \begin{bmatrix} U_1 \\ U_2 \end{bmatrix}, \tag{6-2}$$

where β is the vector of coefficients in the model fitting the whole period. Letting Q_1 and Q_2 denote the sum of squared residuals from (6-2) and (6-1), respectively.

$$Q_1 = \begin{bmatrix} Y_1 - X_1\hat{\beta} \\ Y_2 - X_2\hat{\beta} \end{bmatrix}^t \begin{bmatrix} Y_1 - X_1\hat{\beta} \\ Y_2 - X_2\hat{\beta} \end{bmatrix}$$

$$Q_2 = \begin{bmatrix} Y_1 - X_1\hat{\beta}_1 \\ Y_2 - X_2\hat{\beta}_2 \end{bmatrix}^t \begin{bmatrix} Y_1 - X_1\hat{\beta}_1 \\ Y_2 - X_2\hat{\beta}_2 \end{bmatrix}$$

where $[X]^t$ is used to denote the transpose of matrix $[X]$. $\hat{\beta}$, $\hat{\beta}_1$, and $\hat{\beta}_2$ are the least square estimates of β, β_1, and β_2, respectively.

One has the identity

$$\begin{bmatrix} Y_1 - X_1\hat{\beta} \\ Y_2 - X_2\hat{\beta} \end{bmatrix} = \begin{bmatrix} Y_1 - X_1\hat{\beta}_1 \\ Y_2 - X_2\hat{\beta}_2 \end{bmatrix} + \begin{bmatrix} X_1\hat{\beta}_1 - X_1\hat{\beta}_1 \\ X_2\hat{\beta}_2 - X_2\hat{\beta}_2 \end{bmatrix} \tag{6-3}$$

Taking the sum of squares of both sides of (6-3), and rearranging the results yields

$$Q_1 = Q_2 + Q_3$$

where

$$Q_3 = \begin{bmatrix} X_1(\hat{\beta}_1 - \hat{\beta}) \\ X_2(\hat{\beta}_2 - \hat{\beta}) \end{bmatrix}^t \begin{bmatrix} X_1(\hat{\beta}_1 - \hat{\beta}) \\ X_2(\hat{\beta}_2 - \hat{\beta}) \end{bmatrix}$$

Under the hypothesis $\beta_1 = \beta_2 = \beta$, Q_2/σ^2 and Q_3/σ^2 have independent χ^2 distributions with m + 2 - 2k and k degrees of freedom, respectively. Thus in the case where $m > k$, the hypothesis $\beta_1 = \beta_2 = \beta$ may be tested by computing the F-ratio

$$F_0 = \frac{Q_3/k}{Q_2/(m + n - 2k)}$$

with degrees of freedom (k, m + n - 2k). Explicitly, if $F_0 > F_{k,m+n-2k,\alpha}$, reject the hypothesis $\beta_1 = \beta_2 = \beta$, where α is the chosen significance level.

6.3 Results and Interpretation

Results of the error component analysis are shown in Table 6-2. These are obtained by the method just described based upon the relevant statistics listed in Table 6-1. Between the periods 1957-1966 and 1967-1973, the experimental states appear to have exhibited a non-random structural change (at least at the 10% level of confidence). The change for the comparison states is smaller and non-significant. Because of the dynamic character of the changes in the late 1950's associated with the onset of the major Interstate effort, it seemed appropriate to examine a more limited time duration to better understand the implications of the ADHP intervention in 1965. For the more limited time periods 1962-1966 and 1967-1970, results are not significant, as shown in Table 6-2.

Table 6-3 exhibits the changes in the regression coefficients between the two time periods (e.g., in Table 6-1, the experimental states' AVIGP coefficient for 1962-66 was 0.495; for 1967-70, 1.340, yielding a difference of 0.845). Except for motor fuel consumption (MFC), coefficients for the experimental states show larger changes than those for the comparison states. This suggests possible effects of the ADHP intervention. Two potentially causal influences are of particular interest in this study addressed to the effects of Federal funding parameters - Interstate apportionment (AVIGP) and ABCD apportionment

Table 6-2. F-ratios for Estimation of Changes in Structural Models

	Experimental States	Comparison States
1957-66 to 1967-73	$F_{8,69}=2.04^{+}$	$F_{8,137}=1.50$
1962-66 to 1967-70	$F_{8,29}=0.96$	$F_{8,65}=1.11$

$^{+}$indicates significance at the .10 level.

Table 6-3. Changes in Coefficients from 1962-66 to 1967-70 Models[a]

(Absolute Values)

	AVIGP	AVNIGP	UFAC	PCY	POPDEN	BIPTCX	MFC
Experimental states	0.845	6.419	1.511	0.045	0.996	0.335	0.027
Comparison states	0.529	0.277	0.059	0.004	0.088	0.059	0.052

[a]For definitions of the variables, see Figure 6-1.

NOTE - changes in the magnitude of coefficients between the two periods are shown. Except for MFC, coefficients for the experimental states changed more than those for the comparison states, which indicates possible effects of the availability of the ADHP funds.

(AVNIGP; in other words, non-Interstate).

For the period 1967-1970, Federal Interstate grants appear to have stimulated total per capita state outlay in the experimental states more than could be expected (Table 6-1, AVIGP term shows a value of 1.340). This is so because the states are only required to match each 90¢ of Federal Interstate aid with 10¢ of their own money. In contrast the coefficient of 0.586 for the comparison states, for the same AVIGP term in the same time period implies that the Interstate grants did not effectively stimulate the state outlay. This suggests that increased Interstate funds may confound any effects due to the presence of ADHP funds for this period of time.

However it is extremely interesting to note the negative (-3.776) coefficient for the AVNIGP term for the experimental states for this same time period. This presents a problem for those attempting a causal interpretation within the framework of this regression model. It would imply that increasing Federal grants would occasion states to decrease the total outlay.[1] One could therefore decide that it would be more proper to not put a simple causal interpretation upon the coefficients of the regression analysis. Another interesting perspective is provided by observing the actual time series involved (see Figure 4-17 and Figure 6-2). The actual

---

[1] Sherman (1975) faced a similar dilemma in interpreting a negative coefficient for a non-Interstate grant term. His resolution was to note that the coefficient, as in the present case, was not significantly different from an interpretable level namely, his coefficient of -1.1 was not significantly different from -1 in a regression where he was attempting to explain state-only outlays. A coefficient of -1 in that situation would imply that an extra dollar of Federal aid simply substituted for the same dollar of state outlay. However it is notable that in a number of similar regressions he consistently obtained coefficients of about -1.1.

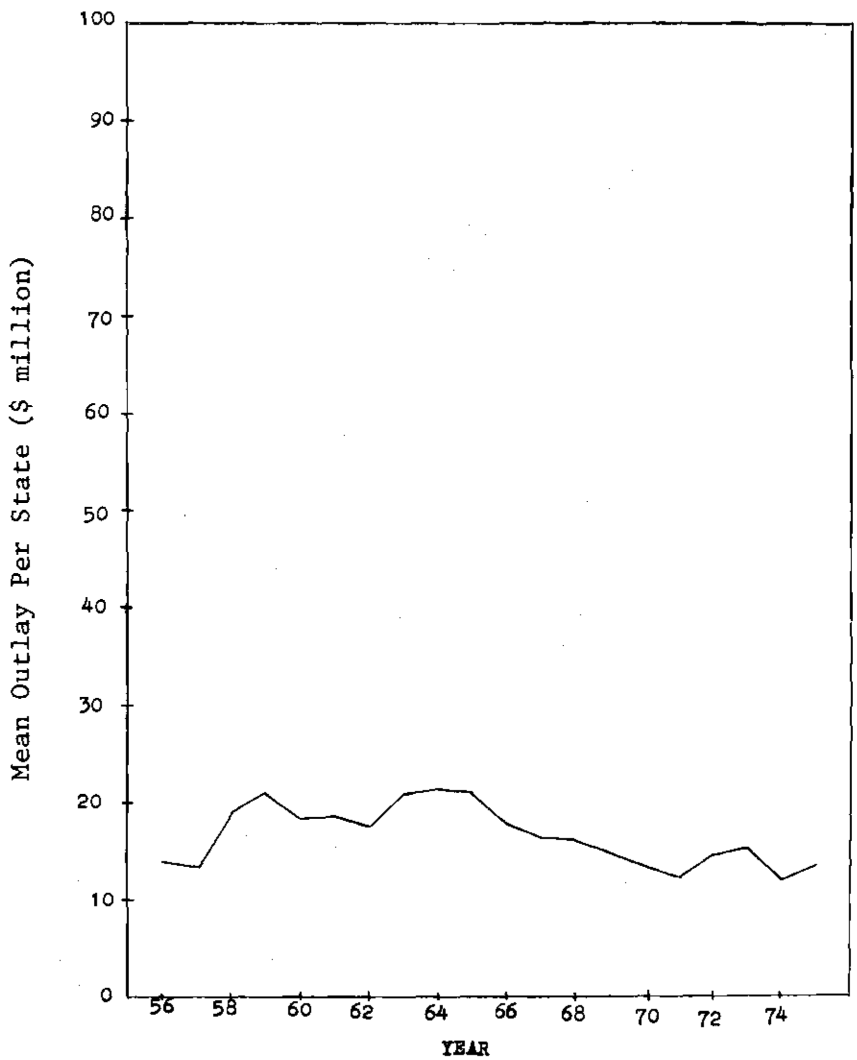


Figure 6-2. Deflated Federal Aid for ABC Systems in the Experimental States (1967 base)

data show that in constant dollars (as are also used in this regression) Federal aid actually decreased over this period. Thus, one sees an increase in state-only outlay that can be interpreted as an effort to make up for the decrease in available Federal funds for work on the ABCD system. This is quite reasonable if one simply assumes that the ABC system is held in some importance by these states. Further discussion of this interpretation that bears upon a conjunction between time series and regression perspectives appears in Section 8.2.

The structural model analysis lends support to the existence of a change in the behavior of the experimental states following the introduction of the ADHP program. As with the previous analyses, it is not unequivocal. Probably the most fruitful result of this analysis of the structural model approach is the insight that a negative coefficient in the non-Interstate Federal grant term can be interpreted in a reasonable way - a way totally disregarded by previous researchers (see Section 8.2).

CHAPTER VII

CONSEQUENCES OF THE FUNDING CHARACTERISTICS OF THE APPALACHIAN DEVELOPMENT HIGHWAY PROGRAM

7.1 Different Matching Ratios

In addition to the question of whether the ADHP program in itself affected state highway behavior, a number of other specific inquiries can be made. Of much interest in considering the consequences of Federal funding parameters is the sequence of changes and contrasts provided in the Federal matching shares established for the ADHP. At the onset, the ARC set the Federal matching share at 70% of construction costs to expedite progress on the system construction. In 1966, due to a perceived shortfall in available funds to construct the system, the 4-lane share was reduced to 50% (although preliminary engineering and right-of-way remained at 70%). In 1974, all ADHP construction was again authorized at 70% Federal share because the ABCD system was so set. Thus for the main ADHP construction effort to date - from August, 1966 through February, 1974 - there was a substantial inducement to construct 2-lane instead of 4-lane ADHP roads.

Rather surprisingly, the evidence indicates that the states roundly ignored this matching differential and predominantly built 4-lane roads. Table 7-1 presents the best information available on this topic - namely the estimates of projected 2-lane and 4-lane construction at various times, compared with actual construction. From this it is clear that

Table 7-1. 2-Lane vs. 4-Lane Appalachian Development Highway Estimates and Actual Construction

	2-Lane Mileage	4-Lane Mileage	Total Mileage	% 2-Lane
1963 Estimate[a]	1227	570	1777	69%
1966 Estimate[b]	687	1573	2260	30%
1969 Estimate[c]	553	1729	2282	24%
1972 Estimate[d]	264	2505	2769	10%
1976 Estimate[d]	294	2476	2770	11%
Actual Construction Through June 30, 1972[e]	140	941	1081	13%

[a]Computation derived from Figures 21 and 22 in ARC, Highway Transportation and Appalachian Development, Research Report No. 13, Washington, D.C., September, 1970.

[b]Also from that source, Figure 27.

[c]Same source, Figure 32.

[d]Calculated from the individual state estimates of cost to completion of the ADHS for 1972 and 1976 as indicated. Figures exclude corridor W in North Carolina and corridors T and U in Pennsylvania (total mileage about 84) because these were late additions to the ADHS.

[e]ARC, tabulation dated 10/31/72 (obtained from Mr. B. Lewis of the ARC).

states were not seriously swayed by the matching ratio in determining the number of lanes to construct. Interviews support this interpretation.[1] For instance, J. Chiles, of Penn DOT, noted that Pennsylvania was moving to high design standards not appropriate for 2-lane roads and set policy to build 4-lanes whenever average daily travel exceeded 5000 vehicles.

7.2 Comparison of the ADHP and Interstate Programs

The ADHP and Interstate programs are intended to be complementary in Appalachia. On a broader front, the two programs present some interesting comparisons. Both are defined networks, with established routes and mileages. They differ in that the Interstate has been funded at a higher Federal share, drawing Federal support from the Highway Trust Fund instead of general funds.

In terms of accomplishment, the ADHP stacks up almost equally with the Interstate. After ten years of program existence, 40% of the ADHP was constructed versus 42% for the Interstate.[2]

Cost to completion estimates rose steeply on both - 92% of the ADHP from 1965-74 versus 86% on the Interstate from 1956-74 (72% during the 1966-74 period)[3]. These figures are reasonably comparable given a larger precentage mileage increase on the ADHP, stricter social and environmental concerns, and higher construction cost escalation during

---

[1]For interviews, the author is indebted to Drs. T. D. Larson and S. Rao of Pennsylvania State University.

[2]Ibid., p. 24.

[3]Ibid., Appendix A.

the 1965-74 period when the ADHP was getting underway.

Most impressive is the ADHP achievement given the fiscal and other pressures. It has been accomplished while the Interstate development continued at a high level. It has endured the 1973 oil embargo and attendant state financial crunch. And it has taken place without seriously jeopardizing other highway programs (albeit, the B and A capital investments have slipped somewhat). The achievements of the ADHP program support the viability of special categorical transportation programs.

CHAPTER VIII

METHODOLOGICAL CONSIDERATIONS

8.1 Threats to the Validity of Interrupted Time Series Analyses

A number of considerations can be raised as factors threatening the validity of the conclusions drawn from the quasi-experimental (interrupted time series) analyses. In addition consideration of threats can yield insight into the results of the structural model analysis.

Recall that the series used in Chapter 5 for estimation of the ADHP effects was state-only ABCD outlays (exclusive of Federal funds received). Exclusion of the Federal ABCD aid was intended to eliminate influences directly attributable to those Federal grants. However, this effort fails to exclude any indirect effects due to stimulation or substitution occasioned by that Federal aid. In other words, did the receipt of that Federal aid influence the states to alter their own expenditure patterns over and above receipt of that aid? Referring back to Table 6-1, coefficients of both the experimental and control groups over the period 1957-1973 do not indicate stimulation effects (-1.370 and 0.979, respectively). This agrees with conclusions drawn by Sherman (1975) and Miller (1971).

The univariate time series approach is impoverished in relation to the regression approach in its inability to take into account the effects of exogenous variables. In particular, highway revenue factors and socio-economic considerations have been shown to be important in previous and current regression analyses (c.f., Sherman, 1975; Rao, 1978). Highway revenues are influenced by such factors as gasoline tax rates and bond income, which in turn establish constraints on highway expenditures. As discussed previously, this study hypothesizes that the experimental group of states increased these revenue sources in response to the onset of the ADHP program and its financial requirements. Turning to the socio-economic considerations Table 8-1 presents some relevant data. Population does not appear to have been a significant factor in increasing the experimental states' highway outlays. Indeed, population growth was slightly greater in the comparison states. Urbanization follows a similar pattern. Per capita income also appears to have lagged in the post-intervention period relative to the comparison states, although differences are extremely small. On balance, these socio-economic factors do not appear to seriously threaten the validity of the graphical and formal interrupted time series analyses. This is reassuring, but not surprising, because such factors were taken into account in the formulation of the experimental and comparison groups. It should be obvious that the quasi-experimental design involving multiple time series (in this case, two) is far superior to the single interrupted time series analysis. The latter has almost no defense against the actions of such exogenous influences in altering the time series patterns observed.

8.2 Problems in Interpreting the Results of Structural Equation Model Analyses

Serious issues can be raised with regard to the structural equation models with respect to the interpretation and adequacy of the

Table 8-1. Population, Urbanization and Per Capita Income in the Experimental and the Comparison Groups

	(Means)	1960	1965	1970
Experimental States	Population (1,000) Urbanization (%) Per Capita Income ($)	3,434 43.5 1,716	3,556 47.6 2,238	3,686 48.2 3,251
Comparison States	Population (1,000) Urbanization (%) Per Capita Income ($)	2,732 51.6 1,649	2,853 56.4 2,144	3,018 58.3 3,166
Difference	Population (1,000) Urbanization (%) Per Capita Income ($)	702 -8.1 67	703 -8.8 94	668 -10.1 85

results. Concerns are thus both of a statistical and a substantive nature. This discussion will focus upon the interpretation of the Federal grant terms, particularly the non-Interstate term (i.e., ABCD) in the regression on state-only capital outlay. Several basic observations may help clarify the issues:

(1) If the coefficient, b, is less than -1 interpretation is awkward because this would imply that Federal highway grants serve to reduce the total highway expenditures.

(2) If b = -1, this implies perfect substitution - i.e. that is each additional dollar of Federal funds replaces a dollar that the state would have to spend.

(3) If $-1 < b < 0$, it indicates that total expenditures on those highway programs will increase due to the Federal aid, but by less than the amount of the Federal aid itself. For instance, if a state were planning to spend \$10 in the absence of Federal aid, and it now receives \$5 of Federal aid, it may decide to spend only \$8 of its own money.

(4) If $b > 0$ this implies that the Federal funds stimulate the states to spend more of their own money on the system in question than they otherwise would have in the absence of the Federal aid. For instance, if a state were planning to spend \$10 on a system in the absence of Federal aid, and it receives \$5 in Federal aid, it then decides to spend \$12 of its own funds.

Instead of looking at state-only capital outlay as the dependent variable in the regression, one can look at total outlay (state inclusive of Federal) (Enns, 1974; Rao, 1978). In this case, the previous conclusions are shifted upward by the dollar of Federal aid itself. For instance stimulation of the states' own expenditures would be indicated by a coefficient, b, greater than 1 rather than a $b > 0$ (i.e., for each dollar of Federal aid, the total outlay must increase more than that dollar). It is also appropriate to take into account the required matching ratio in these considerations. For instance for the ABCD system until 1973, each dollar of Federal aid had to be matched by a dollar of state outlay. In practice, however, states were spending sufficiently in excess of the available Federal aid on the ABCD system so that there was really no pressure put on the states in investing the required matching amount.

As noted previously, interpretation of certain coefficients in a causal sense has been awkward in regressions on highway outlays. For instance, focusing on the ABC grant term computed by Sherman (1975, p. 264) of -1.103 (standard error of 0.092) is awkward. If one prefers not to simply state that this coefficient is non-significantly different from -1, the problem is explaining why state outlay drops more than the amount of perfect substitution for the additional Federal ABC aid received. (And, furthermore, one must ignore the matching requirement for an additional dollar!) Again, both the negative coefficients obtained by Sherman and by Rao appear in a "gray" region - i.e., they are not significantly different from an explainable level. However, by abandoning the traditional regression assumptions of a causal relationship and an inevitable increasing nature of Federal aid, one can proffer interesting and suitable explanations for these coefficients. Simply put, there was a period of decreasing Federal aid and increasing state-only outlay (see in particular Figures 4-17 and 6-2). Thus, a negative coefficient reflects that while Federal aid was decreasing state outlay was increasing. This can be understood in terms of the states maintaining effort on an important highway system in the face of decreasing available Federal support. It undermines the simple causal interpretation of the coefficient with respect to "the effects of an additional dollar of Federal aid." The perspective, enriched by observation of the actual time series data, can lend other insights as well.

Returning to the issue of model adequacy, raised at the onset of this discussion, there is clearly considerable leeway in the hands of the analyst. The choice of the independent variables, the form of the dependent variable, the time period selected, and the entities included can yield highly variable results. Table 6-1 amply demonstrates the variability of coefficients over time periods for well-matched groups of states. Rao's (1978) study, that takes account of subsets of states and time periods, is clearly an improvement over the prior analyses that aggregated everything in one formulation.

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

9.1 Summary of Factual Findings and Policy Implications

This thesis has investigated the impacts of the Appalachian Development Highway Program on state highway efforts. It has taken a national policy perspective and has employed multiple analytical methods. Results indicate that the ADHP program has effectively moved toward its goal of construction of a high quality highway system. It has done so at little sacrifice of other highway construction activities. The Interstate and Urban roads do not appear to have suffered; the secondary and primary Federal aid roads appear to have constricted in terms of construction activity to some extent. Interestingly, non-Federal-aid system activity accelerated during this period of time and maintenance efforts were maintained. In addition the Appalachian states generated additional highway revenues through bonds and gasoline tax increases, probably attributable to the demands of the ADHP program. As a result of the ADHP mobility gains and economic benefits have been developed.

The ADHP is a truly categorical Federal-aid highway program, restricted in terms of the road system involved, the time period in which to construct that road system, and the benefactor states. Its success can be attributed in part to the Federal-aid program, but also to the high level of commitment by the states involved. The fact that it stimulated overall state highway investment should be considered in that light.

Future ADHP progress may not be able to maintain the previous pace. The ARC prioritized segment construction based on need; they have worked on the worst segments first. Hence, future ADHP investment will edge toward a point of diminished returns. Present ADHP authorizations extend through 1981; much more Federal aid will be needed to complete the system. The increase in overall ADHP matching share to 70% by the Federal government may also slow down progress depending on the availability of state funds.

9.2 Methodological Recommendations

This thesis was also oriented to observation of the relative merits of several analytical techniques. Simple observation of time series of various highway-related measures over a period of two decades proved informative. This was complemented by formal time series analyses to better estimate the particular effects of a given program. These effects were not clearly established by the graphical analysis, nor could they be by straightforward application of a regression approach. On the other hand, the regression approach lends greater insight into the exogenous factors exerting an influence on the data series of interest. Consequently, multiple analytical methods appear particularly worthwhile in the analysis of real world, complicated systems. They appear fruitful both in lending complementary insights, not available in one or the other methods, and in increasing the credibility of the overall analysis. Development of better statistical means to treat short, multiple time series would have considerable utility in policy analysis.

9.3 Suggestions for Further Study

In a substantive sense, this study has focused on the Appalachian Development Highway Program to better understand the effects of categorical Federal funding structures. The generality of the findings can be enhanced by comparison with other analyses directed at understanding Federal funding policies in transportation. The particular insights gained concerning the Appalachian region may also serve toward understanding other Appalachian transportation programs. In particular, policy analysis of the proposed coal-haul road system would be a useful extension. Moving in a broader transportation direction, it would be useful to analyze the effects of the ARC involvement in other transportation areas, notably air transportation. These involve supplemental aid programs quite different in nature from the stand-alone highway program.

APPENDIX A

GLOSSARY

Apportionment - Division or assignment of funds. The legislative apportionment is based on prescribed formulas and consists of dividing authorized obligational authority for a specific program among the states. The administrative apportionment is performed by the Office of Management and Budget and involves limitations on obligations incurred within a given fiscal year or established time period.

Appropriation - An act of a legislative body which makes funds available for expenditure with specific limitations as to amount, purpose, and duration.

Authorization - Basic substantive legislation which empowers an agency to implement a particular program and which also, in many cases, establishes an upper limit on the amount of funds which can be appropriated for that program.

Expenditures (Outlays) - A term signifying disbursement of funds for repayment of obligations incurred.

Obligations - Commitments made by Federal agencies to pay out money, as distinct from the actual payments, which are "outlays."

Obligation Ceiling - The maximum amount of funds a state can commit in a fiscal year.

APPENDIX B
Discriminant Scores and Distance Measures

STATE	Discriminant* Scores	Distance from Mean of the Experimental Group				
		(1)	(2)	(3)	(4)	(5)
Alabama	1.781	12.9	1.0	23.6	2.5	69.0
Arizona	**	526.5	11.1	1.0	**	111.9
Arkansas	1.562	16.4	20.5	86.6	23.4	20.5
California	-1.476	1358.6	4273.7	8.5	6.0	480.1
Colorado	-.664	397.8	2.5	42.9	19.4	328.8
Connecticut	-.287	118.4	4.5	1.2	1.0	660.0
Delaware	.511	139.2	49.8	281.1	9.4	660.0
Florida	.718	33.0	138.1	0.2	47.4	9.1
Georgia	1.691	34.2	10.1	0.3	44.4	69.0
Idaho	-.805	182.7	47.9	155.6	23.6	328.8
Illinois	-1.471	25.8	1246.0	42.7	1.8	660.0
Indiana	-.537	1.3	50.1	51.2	20.9	480.1
Iowa	.412	25.4	0.6	22.8	23.0	328.8
Kansas	-.199	172.0	2.1	4.9	24.9	328.8
Kentucky	1.302	0.0	1.8	2.4	15.4	0.5
Louisiana	1.432	6.9	6.2	0.3	5.5	0.5
Maine	-.321	4.5	35.9	20.8	38.0	480.1
Maryland	1.275	83.8	12.5	7.5	23.6	111.9
Massachusetts	-.736	97.5	209.7	22.5	1.1	660.0
Michigan	-.151	31.8	514.6	80.3	20.3	660.0
Minnesota	-.950	187.0	8.3	9.9	24.3	660.0
Mississippi	2.111	5.6	17.7	22.1	9.7	69.0
Missouri	.298	84.8	48.7	26.8	20.7	111.9
Montana	-1.686	1106.9	46.5	65.9	24.1	660.0
Nebraska	-1.055	133.4	20.2	24.8	10.8	660.0
Nevada	-1.450	479.6	56.9	198.7	21.2	480.1
New Hampshire	-.743	91.2	45.6	16.1	3.7	660.0
New Jersey	-.726	100.1	419.7	40.5	12.7	660.0
New Mexico	.527	642.9	27.2	21.7	5.7	9.1
New York	-.662	8.7	4639.4	33.5	5.0	660.0
North Carolina	1.496	15.1	1.8	4.5	6.0	0.5
North Dakota	-1.036	90.4	55.4	32.7	10.2	660.0
Ohio	-.223	0.1	895.2	1.6	16.5	480.1
Oklahoma	.920	86.1	0.5	46.1	25.1	9.1
Oregon	-1.535	312.8	7.4	117.0	15.6	660.0
Pennsylvania	-.829	2.7	1213.8	30.4	108.8	480.1
Rhode Island	-.328	145.5	21.4	2.8	4.4	660.0
South Carolina	1.854	7.7	11.3	9.5	31.1	69.0
South Dakota	-1.091	132.1	51.9	133.2	13.1	480.1
Tennessee	1.872	0.4	2.1	0.9	0.1	20.5
Texas	-.457	4986.1	929.3	4.7	1.8	9.1
Utah	-.568	194.3	25.3	46.5	11.2	328.8
Vermont	-.427	89.4	61.6	25.4	23.2	660.0
Virginia	1.161	0.0	11.1	14.3	5.7	9.1
Washington	-.354	76.4	3.4	41.6	8.0	660.0
West Virginia	1.884	24.2	23.0	17.6	12.5	9.1
Wisconsin	-.568	25.0	27.1	0.0	19.9	660.0
Wyoming	-1.474	323.2	58.2	83.6	8.1	660.0

*Obtained using DISCRIMINANT in H. N. Norman et al., Statistical Package for the Social Sciences, McGraw-Hill Book Company, New York, 1975. (The computer program used is Version 6.50.)

(1) AREA in square miles
(2) Urban population
(3) State share as percentage of total state highway outlay
(4) State outlay for non-federal-aid highways as a percentage of total highway outlay
(5) Luttbeg scales for "southern factor"

**Non-federal-aid system outlay was none. So not, included discriminant analysis and distance value for (4)

APPENDIX C

STATE-ONLY ABCD OUTLAYS 1956-1975[a]

($1,000)

Year	Mean of Experimental Group	Mean of Comparison Group	Difference
1956	40745	36192	4553
1957	43194	32490	10704
1958	41341	37241	4099
1959	33315	40171	-6855
1960	28201	38504	-10303
1961	34927	33218	1708
1962	40823	31432	9391
1963	41917	36106	5811
1964	43718	36268	7449
1965	49353	34631	14721
1966	55976	35590	20386
1967	52230	40843	11387
1968	54275	38485	15790
1969	60701	39379	23322
1970	62478	42409	20069
1971	68698	50414	18283
1972	70628	48094	22533
1973	67398	46352	21045
1974	59549	45210	14339
1975	55677	44218	11459

[a]Deflated by highway construction index to 1967 base.

($1,000)

Year	Kentucky	North Carolina	Tennessee	Virginia	West Virginia
1956	33990	66735	39876	37946	25179
1957	36824	66415	41539	45286	25907
1958	38042	58394	52497	39918	17857
1959	3482	28329	50454	36497	16475
1960	2165	36065	36127	26969	20188
1961	2742	47714	38915	37959	22617
1962	3640	28945	54395	43700	40675
1963	3583	32830	46158	53150	41613
1964	3492	30015	48445	60168	45045
1965	2960	27867	49011	87443	52834
1966	4967	33130	53748	88845	54486
1967	5010	29576	46861	96032	38573
1968	5533	26044	53645	94006	42341
1969	5372	35832	57081	96978	69890
1970	4162	52060	52756	103230	62723
1971	5212	57217	49504	100668	83979
1972	5261	59421	52371	100404	88328
1973	5979	35432	48103	121383	72281
1974	4426	24641	49977	130848	48017
1975	56850	11506	73698	82301	54029

($1,000)

Year	Alabama	Arkansas	Florida	Iowa	Louisianna
1956	39748	21830	43860	75639	70579
1957	36908	12943	52460	58344	68301
1958	30100	15158	73264	58547	70153
1959	34244	14512	75391	56848	83021
1960	50475	14720	71542	68287	60076
1961	37516	18005	53735	61616	40000
1962	22890	24446	68475	44596	42779
1963	33944	24228	74020	56490	36143
1964	37516	21638	83509	56824	29169
1965	51435	13808	78542	46340	35760
1966	27884	17978	78188	56697	47322
1967	32278	30259	78775	70268	47765
1968	44022	35728	77442	52830	30800
1969	49388	39588	67093	57626	35597
1970	37648	27767	90072	58695	50146
1971	36116	35969	102154	82785	57937
1972	33303	32902	79558	75032	54128
1973	45693	23851	74708	66250	53600
1974	36137	27580	83729	67434	56279
1975	36160	28364	57071	60334	79560

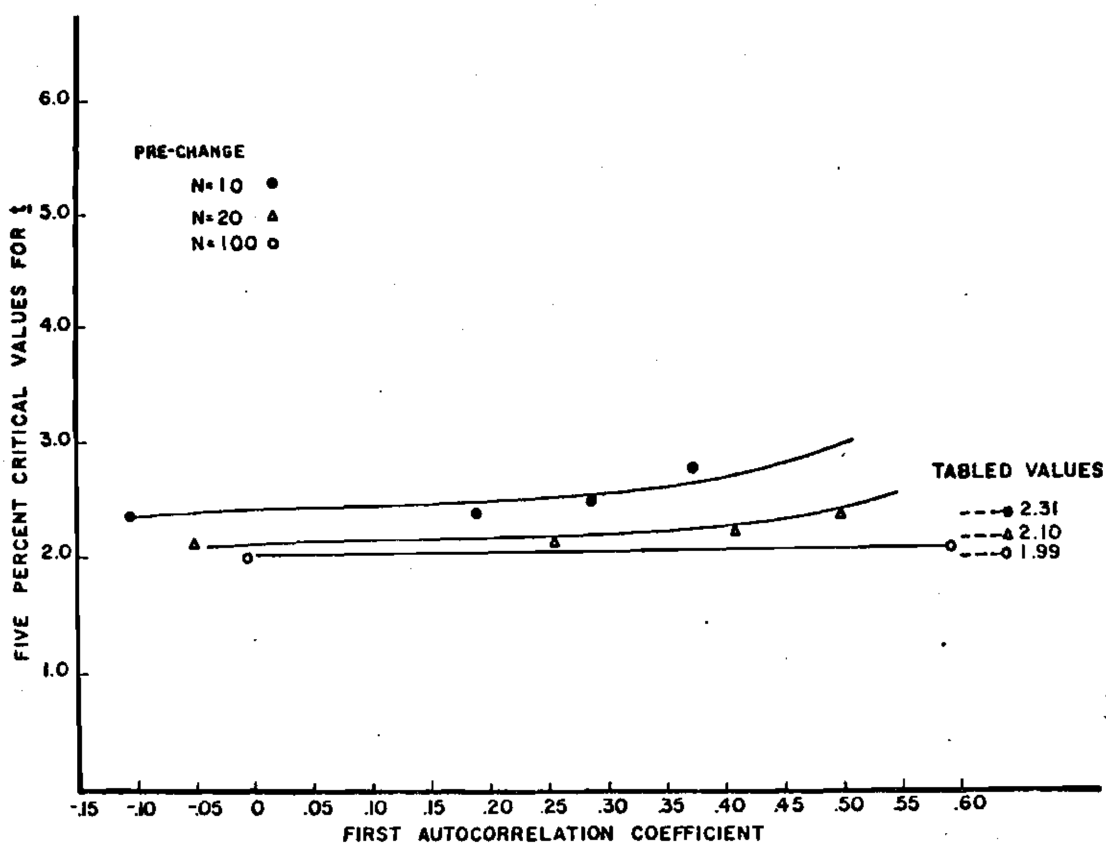
($1,000)

Year	Mississippi	New Mexico	Oklahoma	South Carolina
1956	15894	11021	35400	11753
1957	16900	9065	23715	13775
1958	22358	13480	34392	17726
1959	30005	17564	28294	21656
1960	23275	14023	23352	20785
1961	26735	13923	27903	19533
1962	22546	7572	32007	17576
1963	34385	8372	35093	22277
1964	27980	12099	35228	22449
1965	23823	9437	30264	22270
1966	23164	10443	33216	25421
1967	39478	7995	34379	26391
1968	38105	10647	30365	26422
1969	38709	6810	31412	28188
1970	47860	8791	30483	30216
1971	66908	6054	30140	35660
1972	60338	10163	41643	45784
1973	70659	10311	33896	38204
1974	58505	6268	31660	39296
1975	72828	7625	25010	31006

APPENDIX D

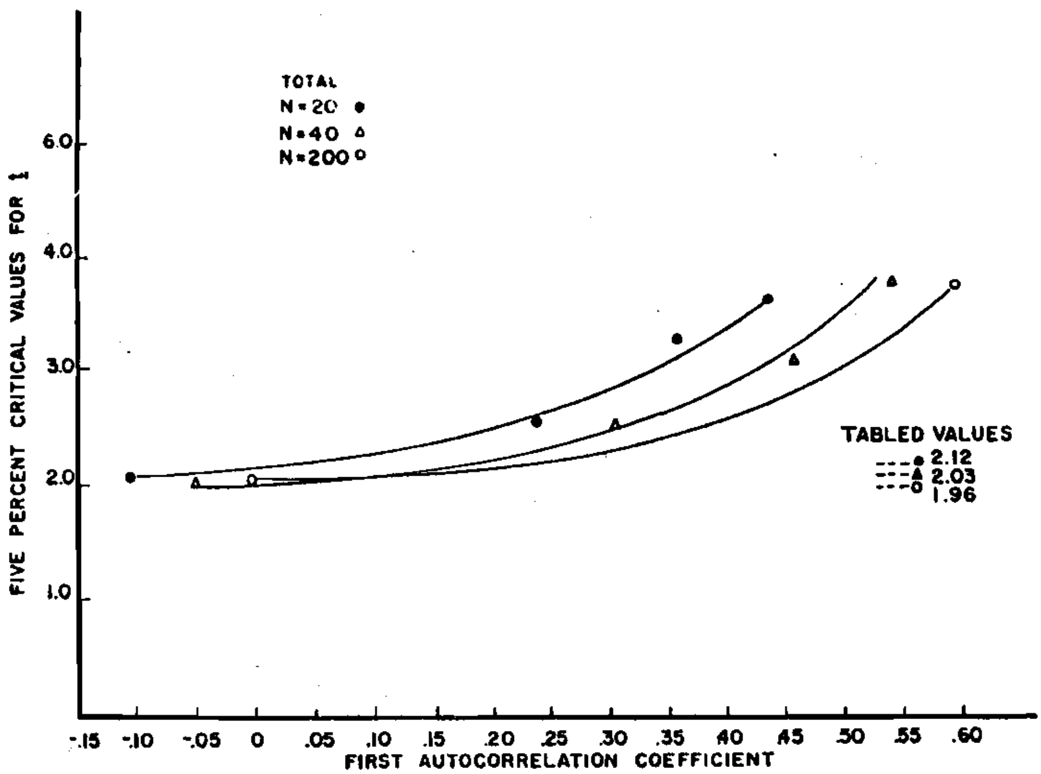
SERIALLY ADJUSTED SIGNIFICANCE LEVEL FOR THE MOOD TEST, DOUBLE MOOD TEST, AND WALKER-LEV TEST 3

Mood test: five percent critical values of t as a function of the first autocorrelation coefficient

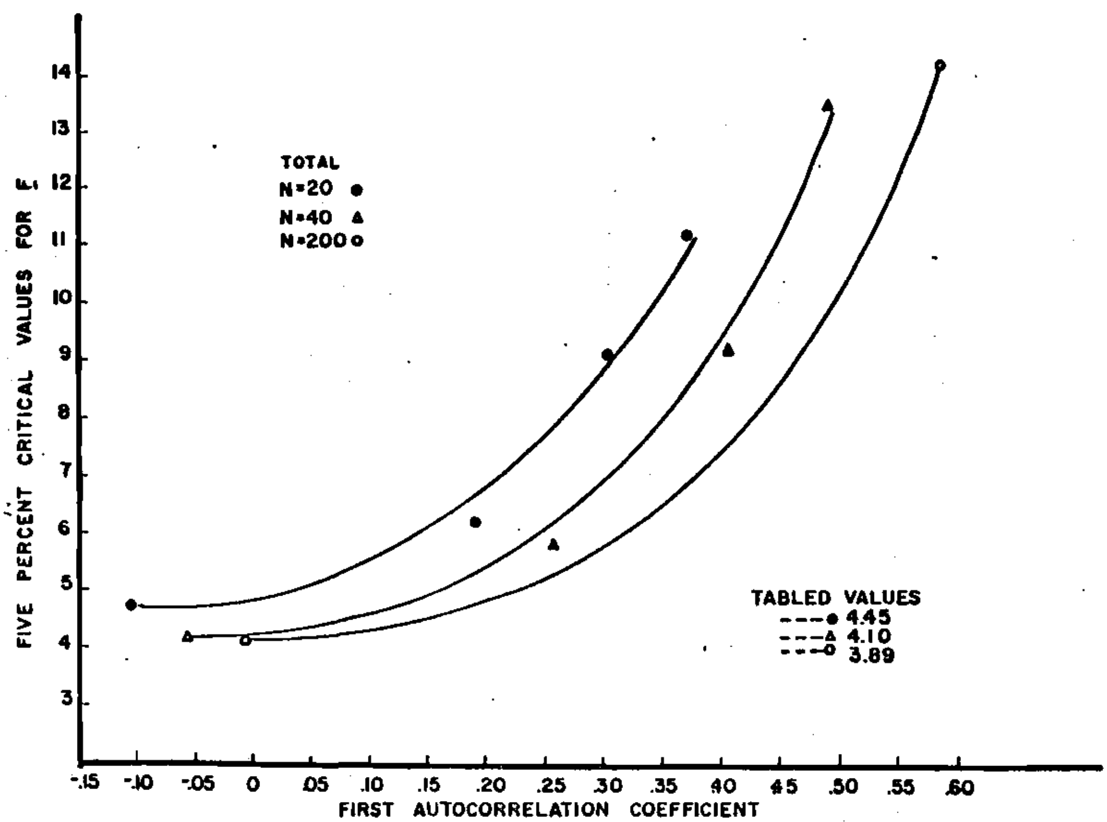


[a]The three figures in Appendix D are reproduced from Sween and Campbell (1965)

Double Mood test: five percent critical values of t as a function of the first autocorrelation coefficient



Walker-Lev test 3: five percent critical values of F as a function of the first autocorrelation



APPENDIX E

AUTOCORRELATIONAS AND PARTIAL AUTOCORRELATIONS
OF STATE-ONLY ABCD OUTLAY[a]

KENTUCKY

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^0	0.02	-0.17	-0.13	0.11	-0.07	0.30	0.32
ACF^1	-0.11	-0.26	-0.17	0.22	0.28	0.32	0.36
$PACF^0$	0.02	-0.17	-0.13	0.09	-0.12		
1966-73							
ACF^0	-0.07	-0.22	-0.31	0.07	0.12	0.38	0.43
$PACF^0$	-0.07	-0.23	-0.37	-0.09	-0.05		
Weighted							
ACF^0	-.02	-.19	-.21	.09	.01		
$PACF^0$	-.02	-.20	-.24	.01	-.09		

[a] i (of ACF^i) indicates the degree of difference

NORTH CAROLINA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{o}	0.53	0.12	0.01	0.00	-0.05	0.30	0.38
ACF^{1}	-0.24	-0.41	0.35	-0.13	0.03	0.32	0.41
$PACF^{o}$	0.53	-0.21	0.06	-0.01	-0.08		
1966-73							
ACF^{o}	0.47	-0.10	-0.48	-0.38	-0.09	0.38	0.56
$PACF^{o}$	0.47	-0.41	-0.35	0.05	-0.05		
Weighted							
ACF^{o}	.50	.03	-.22	-.17	-.07		
$PACF^{o}$	.50	-.30	-.12	.15	-.07		

TENNESSEE

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{0}	0.06	-0.50	0.04	0.42	-0.16	0.30	0.41
ACF^{1}	-0.19	-0.56	0.11	0.31	-0.11	0.32	0.44
PACF^{0}	0.06	-0.50	0.16	0.20	-0.21		
1966-73							
ACF^{0}	0.03	-0.35	-0.13	-0.11	-0.15	0.38	0.43
PACF^{0}	0.03	-0.35	-0.12	-0.26	-0.31		
Weighted							
ACF^{0}	.05	-.18	-.03	.21	-.16		
PACF^{0}	.05	-.44	.04	.00	-.25		

VIRGINIA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{o}	0.66	0.28	0.05	-0.13	-0.31	0.30	0.43
ACF^{1}	0.08	0.20	-0.16	0.07	-0.42	0.32	0.34
$PACF^{o}$	0.66	-0.28	-0.01	-0.17	-0.22		
1966-73							
ACF^{o}	0.10	-0.00	0.07	-0.15	-0.29	0.38	0.39
$PACF^{o}$	0.10	-0.01	0.07	-0.17	-0.26		
Weighted							
ACF^{o}	.46	.16	.06	-.14	-.30		
$PACF^{o}$	.46	-.17	.02	-.17	-.24		

WEST VIRGINIA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^o	0.75	0.46	0.17	-0.14	-0.39	0.30	0.49
ACF^1	0.06	0.03	0.03	-0.44	-0.02	0.32	0.37
$PACF^o$	0.75	-0.22	-0.20	-0.31	-0.19		
1966-73							
ACF^o	0.47	0.04	-0.12	-0.45	-0.35	0.38	0.52
$PACF^o$	0.47	-0.23	-0.05	-0.48	0.13		
Weighted							
ACF^o	.65	.29	.05	-.28	-.37		
$PACF^o$	.25	-.08	-.00	-.46	.04		

ALABAMA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^o	-0.13	-0.49	-0.26	0.38	0.29	0.30	0.42
ACF^1	-0.22	-0.34	-0.22	0.23	0.32	0.32	0.39
$PACF^o$	-0.13	-0.52	-0.60	-0.33	-0.21		
1966-73							
ACF^o	-0.07	-0.47	-0.28	0.22	0.28	0.38	0.56
$PACF^o$	-0.07	-0.48	-0.48	-0.28	-0.19		
Weighted							
ACF^o	-.10	-.48	-.27	.31	.29		
$PACF^o$	-.10	-.50	-.55	-.31	-.20		

ARKANSAS

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{o}	0.35	-0.05	-0.37	-0.36	-0.27	0.30	0.40
ACF^{1}	-0.06	-0.09	-0.25	-0.05	-0.20	0.32	0.34
$PACF^{o}$	0.35	-0.19	-0.33	-0.15	-0.20		
1966-73							
ACF^{o}	-0.20	-0.21	0.37	-0.38	-0.17	0.38	0.50
$PACF^{o}$	-0.20	-0.26	0.29	-0.37	-0.18		
Weighted							
ACF^{o}	.12	-.12	-.06	-.37	-.23		
$PACF^{o}$	.12	-.22	-.07	-.25	-.19		

FLORIDA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{o}	0.41	-0.12	-0.27	0.06	0.24	0.30	0.37
ACF^{1}	0.01	-0.19	-0.61	0.16	0.21	0.32	0.43
$PACF^{o}$	0.41	-0.35	-0.09	0.28	0.00		
1966-73							
ACF^{o}	0.13	-0.57	-0.18	0.06	0.04	0.38	0.50
$PACF^{o}$	0.13	-0.60	0.02	-0.40	-0.02		
Weighted							
ACF^{o}	.30	-.33	-.23	.06	.16		
$PACF^{o}$	.30	-.23	-.04	-.02	-.01		

IOWA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{o}	0.05	-0.13	0.18	0.19	-0.09	0.30	0.33
ACF^{1}	-0.30	-0.34	0.23	-0.06	0.08	0.32	0.39
$PACF^{o}$	0.05	-0.13	0.20	0.15	-0.06		
1966-73							
ACF^{o}	0.22	-0.21	-0.48	-0.07	0.05	0.38	0.49
$PACF^{o}$	0.22	-0.27	-0.42	0.09	-0.15		
Weighted							
ACF^{o}	.12	-.16	-.12	.08	-.03		
$PACF^{o}$	.12	-.19	-.08	.12	-.10		

LOUISIANA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{0}	0.74	0.40	0.18	-0.20	-0.44	0.30	0.48
ACF^{1}	0.08	-0.38	0.12	-0.03	-0.39	0.32	0.37
PACF^{0}	0.74	-0.30	0.02	-0.60	0.15		
1966-73							
ACF^{0}	0.48	-0.15	-0.38	-0.29	-0.16	0.38	0.53
PACF^{0}	0.48	-0.49	-0.07	-0.11	-0.28		
Weighted							
ACF^{0}	.65	.18	-.07	-.24	-.33		
PACF^{0}	.65	-.39	-.02	-.08	-.04		

MISSISSIPPI

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^o	0.25	-0.00	-0.23	0.17	-0.02	0.30	0.32
ACF^1	-0.40	0.11	-0.32	0.28	0.10	0.32	0.41
$PACF^o$	0.25	-0.06	-0.23	0.32	-0.20		
1966-73							
ACF^o	0.53	0.23	-0.29	-0.46	-0.31	0.38	0.57
$PACF^o$	0.53	-0.08	-0.53	-0.15	0.33		
Weighted							
ACF^o	.38	.10	-.26	-.11	-.15		
$PACF^o$	.38	-.07	-.37	.12	.03		

NEW MEXICO

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{o}	0.35	-0.11	-0.25	-0.37	-0.03	0.30	0.39
ACF^{1}	-0.16	-0.20	-0.05	-0.38	0.35	0.32	0.38
PACF^{o}	0.35	-0.27	-0.14	-0.30	0.20		
1966-73							
ACF^{o}	-0.36	0.12	-0.40	0.48	0.11	0.38	0.48
PACF^{o}	-0.36	-0.01	-0.41	-0.26	0.06		
Weighted							
ACF^{o}	.05	-.01	-.16	-.19	.03		
PACF^{o}	.05	-.16	-.26	-.28	.14		

OKLAHOMA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^0	-0.05	0.04	-0.04	-0.24	-0.10	0.30	0.32
ACF^1	-0.42	-0.07	0.14	-0.09	0.05	0.32	0.38
$PACF^0$	-0.05	0.03	-0.03	-0.25	-0.13		
1966-73							
ACF^0	-0.05	-0.14	-0.12	-0.28	0.08	0.38	0.42
$PACF^0$	-0.05	-0.14	-0.13	-0.33	-0.02		
Weighted							
ACF^0	-.05	-.04	-.04	-.26	-.02		
$PACF^0$	-.05	-.04	-.07	-.28	-.08		

SOUTH CAROLINA

1956-65	Lag					Standard errors	
	1	2	3	4	5	min.	max.
ACF^{0}	0.49	0.09	-0.09	-0.05	0.10	0.30	0.37
ACF^{1}	0.02	-0.29	-0.19	-0.00	0.03	0.32	0.35
$PACF^{0}$	0.49	-0.19	-0.06	0.06	0.12		
1966-73							
ACF^{0}	0.58	0.58	-0.24	-0.40	-0.38	0.38	0.55
$PACF^{0}$	0.58	-0.43	-0.06	-0.29	-0.04		
Weighted							
ACF^{0}	.53	.07	-.16	-.21	-.11		
$PACF^{0}$	.53	-.30	-.06	-.09	.05		

LITERATURE CITED

Appalachian Regional Commission, Highway Transportation and Appalachian Development, Research Report No. 13, Washington, D.C., September 1970.

Appalachian Regional Commission, Appalachian Highway Program: Progress, Impacts and Planning for the Future, Washington, D.C., December 1975.

Appalachian Regional Commission, 1975 Annual Report of the Appalachian Regional Commission, Washington, D.C., December 1975.

Appalachian Regional Commission, 1976 Annual Report of the Appalachian Regional Commission, Washington, D.C., 1976.

Box, G. E. P. and Tiao, G. C., "A Change in Level of a Non-stationary Time Series," Biometrica, Vol. 52, No. 1 and 2, 1965, pp. 181-192.

Box, G. E. P. and Jenkins, G. M., Time Series Analysis: Forecasting and Control, Holden-Day, San Francisco, 1975.

Campbell, D. T. and Stanley, J. C., Experimental and Quasi-Experimental Designs for Research, Rand McNally College Publishing Company, Chicago, Illinois, 1963.

Campbell, D. T., "Social Change and Policy Process." In G. M. Lyons (Ed.), Social Research and Public Policies, The Public Affairs Center, Dartmouth College, Hanover, New Hampshire, 1975.

Chow, G. C., "Tests of Equality between Sets of Coefficients in Two Linear Regressions," Econometrica, Vol. 28, No. 3, July 1960, pp. 591-605.

Cooley, W. W. and Lohnes, Paul R., Multivariate Data Analysis, John Wiley and Sons, Inc., New York, 1971.

Cook, T. D. and Campbell, D. T., "The Design and Conduct of Quasi-experiments and True Experiments in Field Settings." In M. D. Dunnette and J. P. Campbell (Eds.), Handbook of Industrial and Organizational Research, Rand McNally, Chicago, 1975.

Cooper, T. W. and Mckeown, S. N., The Highway Capital Problem, U.S. Federal Highway Administration, Office of Program and Policy Planning, Washington, D.C., August 1975.

Dye, T. R., Politics, Economics and the Public, Rand McNally, Chicago, 1966.

Enns, J. H., The Response of State Highway Expenditures and Revenues to Federal Grants-in-Aid, Rand, Santa Monica, CA, February 1974.

Glass, G. V., Pechman, P. D. and Sanders, J. R., "Consequences of Failure to Meet Assumptions Underlying the Fixed Effects Analysis of Variance and Covariance," Review of Educational Research, Vol. 42, No. 3, 1972, pp. 237-288.

Glass, G. V., Willson, V. L. and Gottman, J. M., Design and Analysis of Time-Series Experiments, Colorado Associated University Press, Boulder, Colorado, 1975.

Hibbs, D. A., "On Analyzing the Effects of Policy Interventions: Box-Jenkins and Box-Tiao vs. Structural Equation Models." In H. L. Costner (Ed.), Sociological Methodology 1976, Jossey-Bass, San Francisco, 1976.

Kenny, D. A., "A Quasi-Experimental Approach to Assessing Treatment Effects in the Nonequivalent Control Group Design," Psychological Bulletin, Vol. 82, No. 3, 1970, pp. 345-362.

Luttbeg, N. R., "Classifying the American States: An Empirical Attempt to Identify Internal Variations," Midwestern Journal of Political Science, Vol. 15, No. 4, 1971.

Miller, Edward, "The Economics of Matching Grants: The ABC Highway Program," National Tax Journal, Vol. 27, No. 2, 1974, pp. 221-229.

Mood, M., Introduction to the Theory of Statistics, McGraw-Hill Book Company, Inc., 1950.

Porter, A. L. and Kuehn, T. J., "Evaluating State Implementation of Federal Highway Policy: Methods and Findings; Technical Supplement Volume (2)," a report to National Science Foundation, Grant ERP74-20740, May 1976.

Sacks, S. and Harris, R., "The Determinants of State and Local Government Expenditures and Intergovernmental Flows of Funds," National Tax Journal, Vol. 17, No. 1, 1964, pp. 75-85.

Sherman, L., "The Impacts of the Federal Aid Highway Program on State and Local Highway Expenditures," Ph.D. Dissertation, Massachusetts Institute of Technology, February, 1975.

Strouse, J. C. and Williams, J. O., "A Non-Additive Model for State Policy Research," The Journal of Politics, Vol. 34, 1972, pp. 648-657.

Sween, J. and Campbell, D. T., "A Study of the Effect of Proximally Autocorrelated Error on Tests of Significance for the Interrupted Time Series Quasi-Experimental Design," Mimeographed, Department of Psychology, Northwestern University, 1965.

U.S. Bureau of Public Roads, Highway Statistics 1956, (Yearly editions to 1975), Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

U.S. Bureau of Public Roads, Highway Statistics Summary to 1975, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Vaught, R. S. and Jones, R. R., "Autocorrelation of Time-Series Data," paper presented at the annual convention of the American Psychological Association, New Orleans, Louisiana, 1974.

Walker, H. M. and Lev, Joseph, Statistical Inference, Holt, Rinehart and Winston, Inc., 1953.

OTHER REFERENCES

Appalachian Regional Commission, The Appalachian Experiment 1965-1970, Washington, D.C., 1971.

Appalachian Regional Commission, Guidelines for Funding Appalachian Projects, Development Districts and Research, Washington, D.C., July 1971.

Appalachian Regional Commission, Highway Policy Issues Report, Washington, D.C., June 1974.

Blalock, H. M., Jr., "A Causal Approach to Nonrandom Measurement Errors," The American Political Science Review, Vol. 64, 1971, pp. 1099-1111.

Box, G. E. P., "Use and Abuse of Regression," Technometrics, Vol. 8, No. 4, November 1966, pp. 625-629.

Box, G. E. P. and Tiao, G. C., "Intervention Analysis with Applications to Economic and Environmental Problems," Journal of the American Statistical Association, Vol. 70, March 1970, pp. 70-79.

Box, G. E. P., Tiao, G. C. and Hamming, W. J., "A Statistical Analysis of the Los Angeles Ambient Carbon Monoxide Data 1955-1972," Journal of the Air Pollution Control Association, Vol. 25, No. 11, November 1975, pp. 1129-11 .

Campbell, D. T., "Reforms as Experiments," The American Psychologist, Vol. 24, No. 4, 1969, pp. 409-429.

Caporaso, J. A. and Pelowski, A. L., "Economic and Political Integration in Europe: A Time-Series Quasi-Experimental Analysis," The American Political Science Review, Vol. 65, 1971, pp. 418-433.

Caporaso, J. A. and Roos, L. L., Jr., (Eds.), Quasi-Experimental Approaches: Testing Theory and Evaluating Policy, Northwestern University Press, Evanston, 1973.

Ellingstad, V. S. and Westra, D. P., "Evaluation Methodologies for Traffic Safety Programs," Human Factors, Vol. 18, No. 4, 1976, pp. 313-326.

Fisher, G. W., "Interstate Variation in State and Local Government Expenditure," National Tax Journal, Vol. 17, No. 2, 1964, pp. 57-74.

Fisher, G. W., "Determinants of State and Local Government Expenditures: A Preliminary Analysis," National Tax Journal, Vol. 19, No. 3, 1966, pp. 349-355.

Friedman, R. S., "State Politics and Highways," Politics in the American States, Chapter 11, H. Jacob and K. N. Vines (Eds.), Little, Brown and Co., Boston, 1965.

Gabler, L. R. and Brest, J. I., "Interstate Variations in Per Capita Highway Expenditures," National Tax Journal, Vol. 20, No. 2, 1967, pp. 78-85.

Gramlich, E. M., "Alternative Federal Policies for Stimulating State and Local Expenditures: A Comparison of Their Effects," National Tax Journal, Vol. 21, No. 2, 1968, pp. 119-129.

Heikes, R. G. and Connolly, T., "Causality in Linear Regression," School of Industrial and Systems Engineering of the Georgia Institute of Technology, Report Series J-76-4, February 1976.

Hibbs, D. A., "Problems of Statistical Estimation and Causal Inference in Time-Series Regression Models." In H. L. Costner (Ed.), Sociological Methodology 1974, Jossey-Bass, San Francisco, 1974.

Jones, R. H., "Change Detection Model for Serially Correlated Data," Psychology Bulletin, Vol. 17, No. 5, 1969, pp. 352-358.

Johnston, J., Econometric Methods, McGraw-Hill Book Company, Inc., New York, 1963.

Kurnow, E., "Determinants of State and Local Expenditures Re-examined," National Tax Journal, Vol. 16, No. 3, 1963, pp. 252-254.

O'brien, T., "Grants-in-Aid: Some Further Answers," National Tax Journal, Vol. 24, No. 1, 1971, pp. 65-71.

Osman, J. W., "The Dual Impact of Federal Aid on State and Local Government Expenditures," National Tax Journal, Vol. 19, No. 4, 1966, pp. 362-372.

Perkins, D. N. T., "Evaluating Social Interventions: A Conceptual Schema," Evaluation Quarterly, Vol. 1, No. 4, November 1977, pp. 639-656.

Ross, H. L., Campbell, D. T. and Glass, G. V., "Determining the Social Effects of a Legal Reform," American Behavioral Scientist, 1970, pp. 493-509.

Schnelle, J. F. and Lee, J. F., "A Quasi-Experimental Retrospective Evaluation of a Prison Policy Change," Journal of Applied Behavioral Analysis, Vol. 7, No. 3, 1974, pp. 483-496.

Sharkansky, I., "Some More Thoughts about the Determinants of Government Expenditures," National Tax Journal, Vol. 22, No. 4, 1969, pp. 171-179.

Tiao, G. C., Phadke, M. S. and Box, G. E. P., "Some Empirical Models for the Los Angeles Photochemical Smog Data," Journal of the Air Pollution Control Association, Vol. 26, No. 5, 1976, pp. 485-490.

U.S. Federal Highway Administration, Highway Planning Technical Report: Financing Federal-Aid Highways, Report No. 34, Washington, D.C., January 1974.

U.S. Federal Highway Administration, Office of Program and Policy Planning, "Financing Federal-Aid Highways Revisited," a report prepared by Barry Felrice, July 1976.

Wichern, D. W. and Jones, R. H., "Assessing the Impact of Market Disturbances Using Intervention Analysis," Management Science, Vol. 24, No. 3, November 1977, pp. 329-337.

Young, K. H., Sales Management's Survey of Buying Power, (Yearly editions 1950-1976), Bill Brothers Publications, New York, New York.