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This study addresses the reliability of toll road revenue forecasts by analyzing historical data from existing toll roads in the United States. The aggregation of these data, along with an understanding of the relationships between revenues, traffic, and toll charges, leads to the development of applicable regression models. Elasticity of demand is the key link associated with these three toll road elements. The ability to combine elasticity with the toll road relationship provides the reader with a better understanding of forecast reliability. The groundwork for establishing a computer-based error prediction model can then be explained.

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RELIABILITY OF TOLL ROAD REVENUE FORECASTS FOR SELECTED TOLL ROADS IN THE UNITED STATES

by

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Research Report Number 1281-2

Research Project 0-1281
Highway Privatization in Texas

conducted for the

Texas Department of Transportation

in cooperation with the

U.S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

July 1993

IMPLEMENTATION STATEMENT

Private investment in highways will occur only if rates of return are considered sufficiently high and the risks are sufficiently low. Risks recognized by potential investors come primarily from uncertainty in forecasts of toll highway traffic demand. Since the majority of toll roads currently in the United States are publicly owned, the issue of measuring the reliability of revenue forecasts based on elasticity of demand has typically been neglected. The goal of this report is to develop the groundwork for a forecast error prediction model that can take as input any toll road revenue or traffic forecast and produce a reliability assessment of this forecast as measured in percent deviation.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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ABSTRACT

This study addresses the reliability of toll road revenue forecasts by analyzing historical data from existing toll roads in the United States. The aggregation of this data, along with an understanding of the relationships between revenues, traffic, and toll charges, leads to the development of applicable regression models. Elasticity of demand is the key link associated with these three toll road elements. The ability to combine elasticity with the toll road aspects' relationship provides the reader with a better understanding of forecast reliability. The groundwork for establishing a computer-based error prediction model can then be explained.

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SUMMARY

This report analyzes forecast and actual revenues and costs of several public toll roads in the United States. A comparison between the forecasts and the actual values is conducted on an aggregate level in order to determine the reliability of the toll road forecasts. Utilizing the relationship between elasticity of demand and the elements of revenue, traffic, and toll rates, the establishment of an error prediction model is viable. The development of an error forecast model is an important step toward establishing some semblance of standardization in the forecasting process. This standardization is important because it allows private investment in highways to have a feasible basis for road project comparisons.

CHAPTER 1

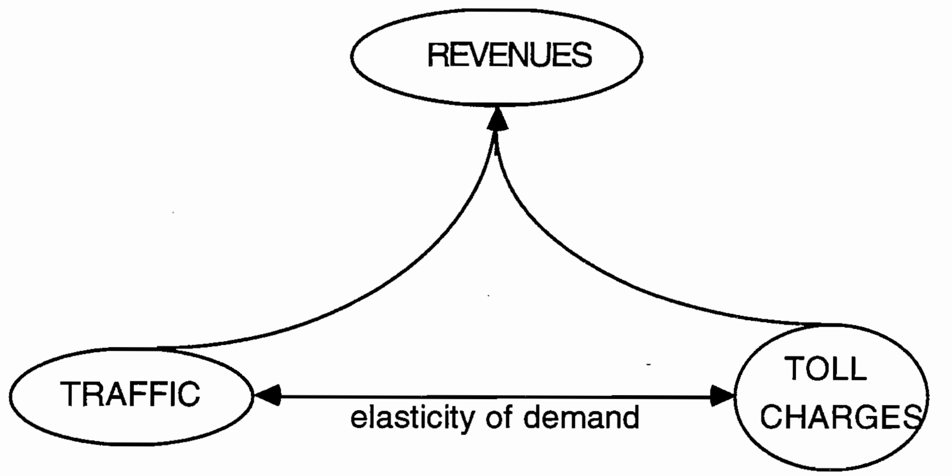
INTRODUCTION

With the passage of the Intermodal Surface Transportation Efficiency Act of 1991, the federal government has changed the focus of transportation issues from that of the interstate era which existed during the past 35 years. This landmark act embodies various new or enhanced programs to address the changing needs of surface transportation in this country. One of the key provisions of this act is the potential of tapping the private sector as a funding source for transportation improvements. The involvement of the private sector brings two key considerations. The first is a closer examination of operating expenses (i.e., making transportation operations more efficient), and the second involves some assurance of profitability.

This latter concern can be mitigated to some degree by having transportation users pay for transportation services -- either through fares on mass transit systems or tolls on high-speed motor facilities. This report addresses the second type of transportation service by discussing the reliability of toll road revenue forecasts. Figure 1 broadly illustrates the relationship of revenues to traffic and toll charges. This figure will be discussed in much more detail in Chapter Two.

Private investment in highways will occur only if rates of return are considered sufficiently high and the risks are sufficiently low. Risks recognized by potential investors come primarily from uncertainty in forecasts of toll

Figure 1 - Revenue-Traffic-Toll Charges



highway traffic demand. Such forecasts have frequently, in the past, been rather unreliable. The principal issue determining whether private investment will occur in future road projects is whether the revenues are sufficient to cover the estimated share of operating expenses and debt service <u>and</u> to provide an acceptable investor rate of return.

In order to obtain a reliable assessment of toll road demand, we need to understand the relationship between traffic and toll charges. This relationship is shown in Figure 1 as the *elasticity of demand*. Elasticity is the percent change in traffic volume due to a 1 percent change in toll rates. Although a simple concept, elasticity is in fact rather difficult to calculate. The difficulty lies in its variability with respect to human behavioral decision-making. There are many different types of road users, many of whom have dissimilar elasticities. Add in the different toll rate structures based on vehicle classification, and the result is a complex web of elasticity-controlled demands.

Since the majority of toll roads currently in the United States are publicly rather than privately owned, the issue of measuring the reliability of revenue forecasts based on elasticity of demand has typically been neglected. Revenue bond issues used in the construction of publicly owned toll roads are presently assessed on only three degrees of rate of return: best scenario (highest predicted traffic volume for a given set of toll charges); worst scenario (lowest predicted traffic volume); and medium scenario (moderate predicted traffic volume). This breakdown provides, at most, only three demand elasticity measures for a toll road. The reliability of such forecasts, therefore, can be challenged. One of the major problems that has prevented public toll authorities from making more reliable forecasts is the poor reliability of input variables to their forecast models. For example, projecting future land use is a difficult and inexact science. But future land use is probably the single most important variable input to a traffic forecast model (Ref 9). Another issue that private toll roads will have to address in assessing forecast reliability is the method used in predicting traffic. The majority of public toll authorities (as well as the majority of state highway authorities) use one of the following three approaches to forecast traffic in both urban and rural areas (Ref 20):

(1) Simple trend lining of historic traffic counts,

(2) Growth-factor procedure based on changes in socio-economic characteristics, and

(3) Traditional four-step urban modeling process.

This report will not address forecast techniques employed by different toll road authorities. Rather, the focus will be to accept the forecasts provided by the authorities and measure them against actual numbers in order to get a better understanding of the forecast reliability. The hope is to take these measurements and develop the groundwork for a forecast error model. Such a model is envisioned to have the ability to take as input any toll road revenue (or traffic) forecast and produce a reliability assessment of this forecast as measured in percent deviation. Naturally, the error model would have to take into consideration the unique toll road characteristics.

The report is divided into four chapters plus an Appendix. The second chapter breaks down Figure 1 (described in this chapter) into its finer components. Each component will be examined in detail. Chapter Two also explains the collection of data for the report as well as expected results. Chapter Three provides a comprehensive analysis of the collected toll road data and contrasts the actual findings with the expected results. Finally, Chapter Four is the concluding chapter. It provides some recommendations regarding how the results found in Chapter Three can be used in measuring the revenue forecast reliability of any toll road, public or private.

CHAPTER 2

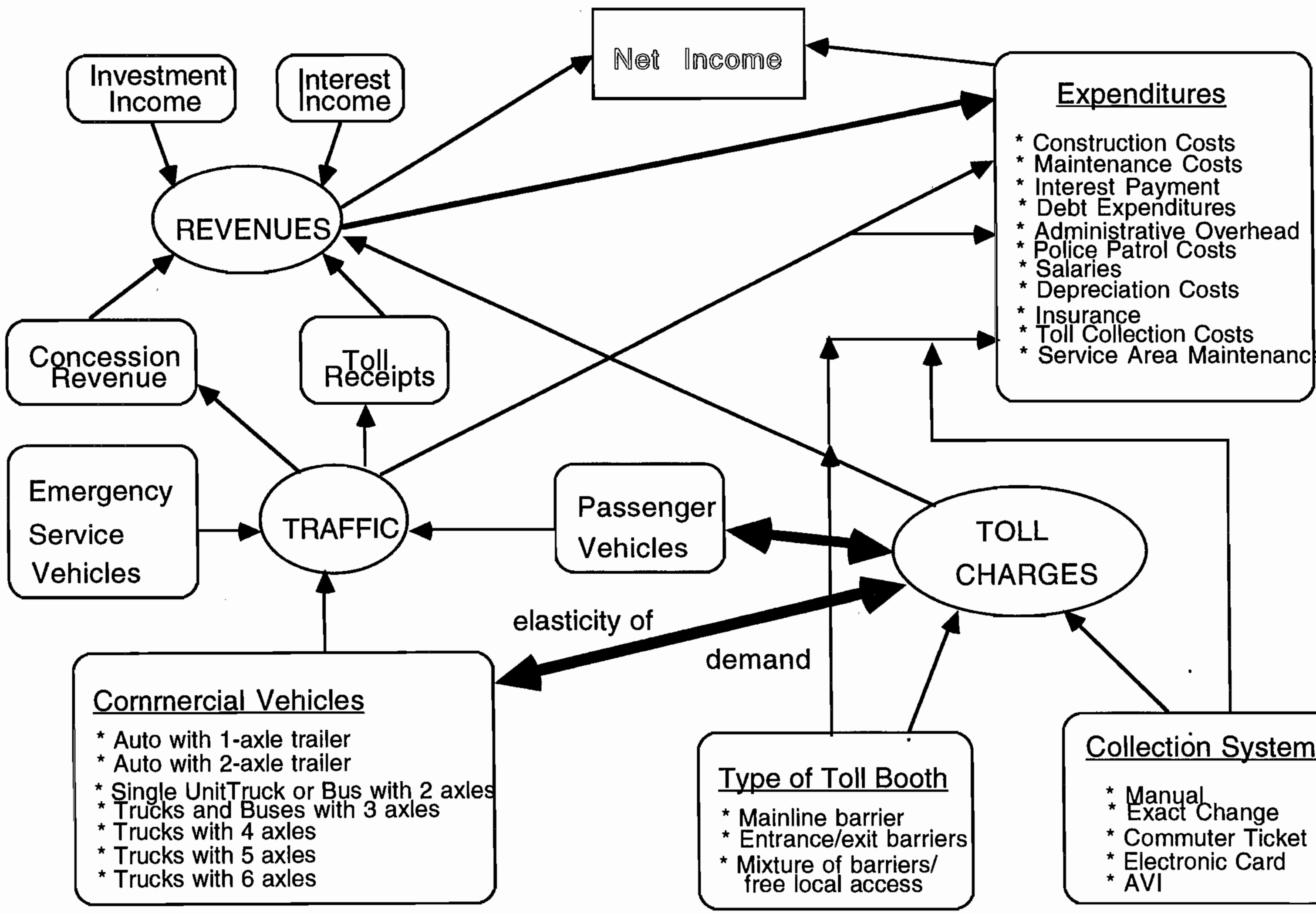
THE REVENUE-TRAFFIC-TOLL CHARGES RELATIONSHIP, EXPECTED FINDINGS AND DATA COLLECTION

This chapter is composed of three major sections. The first section examines the Revenue-Traffic-Toll Charges relationship that was first described in Chapter One. As promised in that chapter, each element in this tripartite will be described in some detail, along with its relationship to the other elements. The diagram will be broken into smaller segments in order to better examine the complexity of the connections between the various components. Using this conceptual diagram, the chapter then gives a preview of the results that are possible from a study of existing toll roads. These expected findings form the second section of this chapter. This section then segues directly into the third section, which explains the methodology used in collecting the data. The collection of the data consumed a considerable portion of time, and therefore how it was gathered is relevant. A different approach to the assembly of data may perhaps have led to a different approach in the data analysis, and even, perhaps, to different conclusions.

2.1 Revenue-Traffic-Toll Charges

Figure 2, shown on the following page, is the enhanced version of Figure 1 from Chapter One. In order to describe the associations among the various components, it is best to start from the top and work down. This

Figure 2



Net Income
Investment Income
Interest Income
REVENUES
Expenditures
* Construction Costs
* Maintenance Costs
* Interest Payment
* Debt Expenditures
* Administrative Overhead
* Police Patrol Costs
* Salaries
* Depreciation Costs
* Insurance
* Toll Collection Costs
* Service Area Maintenance
Concession Revenue
Toll Receipts
Emergency Service Vehicles
TRAFFIC
Passenger Vehicles
TOLL CHARGES
elasticity of
demand
Cornmercial Vehicles
* Auto with 1-axle trailer
* Auto with 2-axle trailer
* Single UnitTruck or Bus with 2 axles
* Trucks and Buses with 3 axles
* Trucks with 4 axles
* Trucks with 5 axles
* Trucks with 6 axles
Type of Toll Booth
* Mainline barrier
* Entrance/exit barriers
* Mixture of barriers/ free local access
Collection System
* Manual
* Exact Change
* Commuter Ticket
* Electronic Card
* AVI

should provide the reader with an understanding of the complexity associated with toll roads. It is important to stress, however, that this diagram, although seemingly complex, is still only a simplified model of the actual relationships and considerations that must be dealt with in existing toll facility projects.

2.1.1 Revenue

The revenue element is the most important consideration when debating the feasibility of a toll road; it is also the most complicated. Depending on the accounting procedures used by different toll road agencies, revenues usually include the following four categories: toll receipts, interest income, investment income, and concession revenues. Toll receipts, in all but the most unusual cases, form the majority of the revenue. However, these sources of income cannot be considered by themselves. These revenues are typically used by the toll road agencies as monies for various expenditures. The variety of expenditures exceeds the diversity of revenue sources. A partial list that covers some of the larger expenses is mentioned below:

(1) Construction costs for increasing capacity of the tollway,
(2) Maintenance and operating costs,
(3) Debt expenditures for revenue bonds,
(4) Interest payment on loans,
(5) Administrative overhead,
(6) Salaries,
(7) Insurance,
(8) Depreciation and amortization costs,
(9) Police patrol costs,
(10) Toll collection costs, and
(11) Service area maintenance.

This list is only a partial index of the different types of expenditures encumbering toll road agencies. Every agency that was examined during the course of this report used its revenues to pay expenses. This is where the commonality stopped. The 28 authorities from whom initial revenue and expense data were collected provided almost 28 different groupings of revenues and expenditures. This led to different calculations of net income for each agency, making it difficult to compare the solvency of one authority with that of another.

2.1.2 Traffic

The second major element in the tripartite diagram is the tollway traffic volume. At the outset, one might be convinced that there exists an exact positive correlation between the number of vehicles using a road and the revenue produced. However, once the sub-elements of traffic volume are examined, the correlation is observed to be less than exact. The key explanation for this is the traffic volume mixture. Some types of vehicles tend to subsidize other types of vehicles on the same road. For example, a heavily laden oversize truck with four axles (e.g., a large dump truck) causes much more damage to the pavement than an empty six-axle semi-trailer. The latter truck, however, sometimes pays more at the toll booth because of the typical practice of charging per axle rather than per axle-load. An interesting note about this practice is that the Ohio Turnpike is the only known toll road in the United States that automatically weighs all vehicles as they enter the highway and then charges them according to weight class.

In the collection of data accumulated for this report, the differentiation among traffic types becomes apparent. Some small, entirely private toll roads accept only passenger cars which travel on low-maintenance and usually scenic routes. Other toll roads, such as the New Hampshire Turnpike System, have as many as twelve separate vehicle classes. Other unusual toll roads include uni-directional tolled portions of expressway such as the John F. Kennedy Memorial Highway in Maryland, where only the northbound lanes are tolled, and the Garden State Parkway (New Jersey), which does not permit commercial trucks having a registered gross weight exceeding 6,999 pounds (3,175 kg) to travel on the northern 68 tollway miles (109 tollway kilometers). Situations like these influence the traffic counts for these toll roads in a significant manner. For the most part, however, toll roads can be divided into passenger vehicle traffic and commercial vehicle traffic. In the collected data, the percentage of passenger vehicle traffic by actual count varied from 79.7% on the Ohio Turnpike to 99.1% on the Dallas North Tollway. The average percentages for the collected data turn out to be 87.4% passenger vehicles and 12.6% commercial vehicles.

2.1.3 Toll Charges

We now come to the last major element in the tripartite diagram -- toll charges. Toll charges are the numerical factor by which the traffic volumes are multiplied in order to obtain the revenues shown near the top of the diagram. The toll charges are quite difficult to set for a publicly operated toll road, and are even more burdensome for a private toll road. Not only do they have to be computed for each of the different vehicle classes discussed in the previous paragraphs, but they must also incorporate the necessary debt obligations and, in the case of private roads, a profit factor. Toll rates range from simple flat annual fees of $25 to $250 per car on a small private toll road in California to a more complicated system involving charges of $0.75 per two-axle vehicle for token and exact change users; $1.00 for manual toll booth users; and $0.50 per additional axle for all other vehicles on the Sam Houston and Hardy toll roads in Texas. These are only two examples, but they are an indication of the wide array of toll rates used by different agencies. The same variability is evident in how those agencies report toll charges. Some authorities disclose figures of average cents toll per mile for different vehicle classifications. Some agencies provide actual toll charges per toll booth per vehicle type, while others furnish only average passenger and commercial tolls per vehicle traveling the toll road length. One interesting toll road, Mount Washington Auto Road, charges $12 per passenger vehicle including the driver, $5 per additional adult, and $3 per child ages five to eleven. Children under the age of five travel free.

Toll charges are affected not only by price elasticity of demand, which will be explained later, but also by the physical apparatus utilized in collecting the tolls. These include both the barriers with toll booths and the collection system present at these barriers. Naturally, the more barriers on a toll road, the higher the associated toll collection costs; but there is also a higher propensity for increasing the toll receipts as a result of vehicles paying more often. A mixed system of barriers and some free local access is usually observed only in rural areas, where most of the toll road traffic is through-traffic.

The collection system is equally as important as, if not more important than, the toll booth layout. The exact change and manual collection system have both been in operation for many years on almost all toll roads in the United States. The electronic card and commuter ticket systems are more recent additions. They are used primarily by commuter traffic that travels the same segment of a toll road ten or more times per week. Usually, toll agencies provide these consistent travellers with up to 50% off the regular manual charge as gratitude for their steady toll revenue contribution.

The newest collection system, less than five years old, is Automatic Vehicle Identification (AVI). As opposed to other collection systems, AVI does not require vehicles to stop in order to pay a toll. Instead, electronic signals in a transponder carried in the car are read by roadway detectors. These detectors, in turn, automatically deduct the toll amount from the user's prepaid account. Many of the larger toll road agencies are currently experimenting with this technology. It is believed that AVI will definitely boost the traffic volumes using a toll road since it significantly decreases the delay time incurred in paying the toll. Studies have shown that this toll booth waiting time is one of the key factors in the driver's decision not to use toll roads. There exist other issues associated with AVI, such as enforcement and uniformity of electronic equipment across different authorities, but it is not necessary to address them in this report. One agency in particular, the Oklahoma Turnpike Authority (OTA), has been instrumental in creating one of the world's most successful AVI collection systems on all ten of its toll roads. Its PIKEPASS electronic system is currently providing 17% of the total OTA toll revenues, and, when OTA recently raised its cash tolls by 30%, there was no significant negative impact on traffic volumes, since travellers simply switched to the PIKEPASS system whose rates were still equivalent to the 1979 cash toll charges. OTA estimates that its toll collection costs will be reduced by at least $8.6 million over the first five years of AVI operation.

Increases in traffic also mean increases in the police patrol costs and toll road maintenance costs. For those agencies that have restaurants and service stations operating in their rights-of-way, an increase in toll traffic often translates into an increase in concession revenues. One example is an 82-mile (132-km) segment of the New York State Thruway which does not have any tolls whatsoever. Instead, the New York State Thruway Authority raises all of its operating and maintenance funds for this segment strictly from concession revenues.

2.1.4 Links Between the Elements

So far the discussion has focused upon each of the three key components from Figure 1 as modified in Figure 2. It is now appropriate to concentrate on the links between these components. In order to minimize confusion, only the important links are displayed in Figure 2. The link between traffic and revenue was tentatively explored in a preceding paragraph. Revenue — in most cases, but definitely not in all — increases with increasing volumes of traffic, no matter what the mixture of vehicle types using the road. This is readily apparent when one considers the fact that toll charges are positive and that each vehicle must pay a toll charge. (Some vehicles such as police patrols and EMS vehicles pay no tolls, but they constitute a negligible percentage of the toll road traffic.)

2.1.5 Elasticity of Links

A link that is of more importance is the one between toll traffic and toll charges. This relationship is highly dependent on something called *price elasticity of demand*. This elasticity of demand is what primarily determines how many vehicle classifications should exist for a particular toll facility, and the elasticity of demand can then be used to formulate the toll charges for these classes. Elasticity is not a constant, and that is why toll rates are increased or decreased periodically. The length of time between toll rate adjustments is affected by the elasticity of demand as well. But what exactly is elasticity?

Elasticity, in our case, can be defined as the percentage change of traffic volume for a 1 percent toll rate change. It indicates the sensitivity of auto ridership to the trip maker's perceived travel cost. Since the toll rates for the toll roads vary widely among the different agencies, it is presumed that the elasticities of raising or lowering toll charges for any one of the various vehicle classes will have some impact on decreasing or increasing the volume of vehicles in that particular class.

The topic of elasticity has been widely studied in the context of public transit fare changes. These studies show that an increase by 1 percent in transit fares does not decrease the ridership by 1 percent; rather, the typical decrease is about -0.30% (Ref 1). However, the transit studies have also indicated that elasticity measured under one particular set of circumstances does not necessarily have any relevance under a different set of circumstances. Frequently, it is impractical to estimate price elasticities for the individual trip maker; so, in most studies, aggregate estimates are used to assess the impact of pricing strategies over widely heterogeneous travel conditions. The evidence collected over many years and from many different transit systems has firmly established that the demand for transit is quite inelastic with respect to fares. In other words, a decrease in fares will never generate enough additional riders to compensate for the lost revenues. Peak ridership is even less elastic with respect to fares than off-peak ridership, and, in general, short trips are more elastic than long trips (Ref 1).

All of these facts about transit elasticity are mentioned here because it is believed that many of the same aspects exhibited by transit users are equally valid for toll road users. For example, commuter-oriented toll roads appear to be less elastic towards toll rate changes than other types of toll roads. This is analogous to transit peak ridership. Other studies have shown that higher-income toll road commuters are more likely to exhibit inelastic behavior. This is in contrast to the transit studies mentioned earlier. Auto cost elasticity is also lower (inelastic) for short- and long-distance trips than for medium-distance trips. The higher elasticities for medium-distance trips reflect greater transit use in this range and more mode choices available to the trip maker. No matter how elastic or inelastic the aggregate population is with respect to price changes, every individual trip maker usually has the following options in order to minimize the effects of toll charges (Ref 15):

(1) A change in route, through which trip makers seek to bypass areas where tolls are in effect;
(2) A shift from auto use to transit or to some other competing mode;
(3) A change in time of travel to avoid congestion tolls that are in effect during peak periods; and
(4) In the long run, a change in the origin-destination flows by which those areas where tolls are in effect lose population and/or employment opportunities.

The problem with using elasticity for predicting travel volumes given a set of toll charges is not the direct elasticity mentioned above. Instead, the concern is with cross-elasticity of other changes beside toll rate increases or decreases. For example, the time cost of traveling is usually valued at approximately three times the fare cost of traveling, so that, if a parallel free facility (within 5 miles [8 km] of the toll road corridor) were to be built, the traffic volumes on the toll road would drop dramatically, even if the toll charges were reduced substantially. We can also consider this case in reverse by using an actual situation. Currently, a north-south untolled highway in Dallas is being completely reconstructed over a four-year period. This highway, which is heavily congested most of the day, will remain open during reconstruction. Just a few miles west of this highway is the Dallas North Tollway, a clean, well-maintained toll road. At the present time, the Dallas North Tollway is used heavily only during the morning and evening peak hours by commuters traveling between the northern Dallas area and downtown. With the start of reconstruction of the parallel free facility, the toll road agency is predicting a large increase in its traffic volume, especially by trucks, which currently comprise less than 1 percent of the total traffic. The reason for this increased traffic is the reduction in average speeds on the parallel facility (i.e., cross-elasticity) and not a direct reduction of fares on the toll road. Of course, it is important to note that a large increase of traffic, especially truck traffic, will also increase the maintenance cost of the toll roadway, which has a direct effect on reducing the total revenue.

The amount of traffic diverted to a toll road depends upon the advantages that the new facility offers with respect to (a) convenience, (b) time saving [mostly for cars], (c) distance saving [mostly for trucks], and (d) amount of the toll. The greater the time saving for any given toll, the larger is the percentage of traffic diverted from a parallel free facility (Ref 17). A toll increase will probably have little impact on the timing of long-distance trips passing through the region, so its effect on reducing congestion on a heavily traveled toll road will be larger if peak-period traffic consists primarily of intra-regional travellers. Earlier studies have shown that elasticities range from -0.13 to -0.29 in hourly vehicle volumes for toll increases of $1.00 depending on the availability of alternate free routes (Ref 18).

2.2 Preview of Expected Results

Given the rather detailed discussion of linkages among the major and minor elements in Figure 2, it is now appropriate to explain how the collected data may be used to address the objective of this report -- namely, the uncertainty in toll revenue forecasting. It is hoped that this objective will be accomplished in the rest of the report. It is relevant at this time to list some of the expectations that were entertained before the data collection was started. The hope was to gather forecast toll revenues, traffic volumes, and annual operating and maintenance expenses for the past ten years, and then compare these numbers against actual values over the same time period. Since numbers from each toll road agency would probably exhibit some variation between forecast and actual values, we hoped to combine the numbers received into larger aggregate groupings and then analyze these groupings. We wanted to know if there existed any noticeable trends in the deviations of actual revenues, costs, and traffic counts from forecast numbers. The aggregation would serve to separate the data from the annual deviations expected for each toll road agency. The aggregation of data would also allow for the use of some elasticity tools as measures of reliability of the overall forecasting ability of the toll road agencies.

Since every toll road project is individually financed based on its own special considerations and environment, an aggregate elasticity predictor model would not be sufficient. Another goal of this study was to create the framework of inputs required for developing a systematic prediction model that can be used to determine the errors associated with forecasts. In other words, one objective was the development of a listing of base elements needed as inputs to an error forecasting computer model. This base model could then be developed in subsequent research by utilizing actual data and modified for any particular toll road project. Such a model would be useful to any financial institution or private investor interested in building or operating toll roads. It would also be useful to the many public agencies that are now involved in the toll road business.

2.3 Collection of Data

The collection of data began in June 1992. At that time, the author was involved in a transportation research project examining the feasibility of having private investors or operators involved in building, operating, and/or maintaining roads in the state of Texas. In order that such a venture be feasible for a private company, the road must provide some sort of return on the company's investment. Usually this return was a portion of the revenue generated by the road. For the most part, the generated revenue would have to be money raised through user toll charges. Thus it was easily concluded that most private roads must also be toll roads. With that determination, the author began to contact as many toll road operations as possible, using the International Bridge, Tunnel and Turnpike Association (IBTTA) list of active or proposed United States toll facilities.

2.3.1 Initial Collection

Approximately 40 different agencies were contacted by phone during the initial data collection period. The agencies varied from large state-owned public facilities to small, scenic roads operated by a few private citizens. The diversity was important, because we wanted to examine the different aspects of the elements that produce a successful toll road, be it small or large, public or private. Each authority* was asked to furnish a recent financial statement which indicated its revenues and expenditures.

* *Authority* and *Agency* will be used interchangeably in this report. The latter term is usually defined as being a public entity, while the first term encompasses both public and private entities. It should be noted that most of the toll road companies in this report are state *agencies* but are called *authorities*.

Each was also asked to provide any other pertinent information about its roads such as major expansion projects or planned toll rate adjustments.

Although it took a fair amount of time, we eventually received some of the requested information from 28 authorities (a 70% response rate). Some of the data provided were more helpful than others, and it became clear that the larger an authority, the more information it could, and did, provide. Coincidentally, the larger agencies also tended to be public rather than private entities. This occurrence is no surprise, and it actually benefits the study of forecast reliability, since data for larger areas are more readily available and more statistically reliable and therefore provide a better basis for projection (Ref 5). Table 1 lists by state all authorities that responded to our request, along with the length of their facility.

2.3.2 Subsequent Data Collection

After compiling and analyzing all of the initial data, the author embarked on a subsequent mission of examining the forecasts from a number of these authorities. This second compilation of more detailed information eventually became the basis for this report. The collection of data for this second part of the study began in September 1992 and lasted for approximately three months. Only eleven authorities were selected for the second round, because the information being requested required more effort on the part of the authority. The data sought from these eleven authorities were the following:

Table 1 - Initial Data Response

State	Authority	Toll Miles	/ km
California	Del Monte Properties, Inc.	17.3	27.8
	Transportation Corridor Agencies	68	109
Colorado	City of Colorado Springs	10.8	17.4
	E-470 Public Highway Authority	48	77
	W-470 Public Highway Authority	32.3	52.0
Delaware	Delaware Transportation Authority	11.3	18.2
Florida	Orlando-Orange County Expressway Authority	59	95
Illinois	The Illinois State Toll Highway Authority	273.4	439.9
Indiana	Indiana Department of Transportation -- Toll Road Division	156.9	252.5
Kansas	Kansas Turnpike Authority	236	380
Kentucky	Kentucky Turnpike Authority[1]	366.4	589.5
Maine	Maine Turnpike Authority	106	171
Maryland	Maryland Toll Facilities Administration	41	66
New Hampshire	Department of Transportation -- Bureau of Turnpikes	94	151
	Mount Washington Summit Road Company	8	13
New Jersey	New Jersey Expressway Authority	44.1	71.0
	New Jersey Highway Authority	173	278
	New Jersey Turnpike Authority	128	206
New York	New York State Department of Environmental Conservation	5.9	9.5
	New York State Thruway Authority[2]	641	1,031
Ohio	Ohio Turnpike Commission	241.3	388.3
Oklahoma	Oklahoma Turnpike Authority	563.3	906.4
Pennsylvania	Pennsylvania Turnpike Commission	570.5	917.9
	Vacation Charters Limited	2.5	4.0
Texas	Harris County Toll Road Authority	49.6	79.8
	Texas Turnpike Authority	14.4	23.2
Virginia	Virginia Department of Transportation	72.9	117.3
West Virginia	West Virginia Parkways, Economic Development and Tourism Authority	88	142
	Total Mileage / km	4,123.4	6,634.6
	Average Mileage / km[3]	147.3	237.0

[1]Kentucky's system includes 91.7 untolled miles (147.6 km).
[2]New York's system includes 82 untolled miles (132 km).
[3]Applying footnotes 1 and 2, the average mileage becomes 141.1 miles (227.0 km).

(1) Forecast toll revenue for the past ten years,
(2) Forecast toll traffic for the past ten years,
(3) Forecast annual maintenance and operating expenditures for the past ten years,
(4) Toll rate increases or decreases implemented during the past ten years affecting either commercial or passenger vehicles,
(5) Actual toll revenues for the past ten years,
(6) Actual toll traffic for the past ten years, and
(7) Actual annual maintenance and operating expenditures for the past ten years.

The selection of the chosen eleven authorities was highly dependent on how much of the above information was provided during the initial study period earlier in the summer. It was felt that authorities who had already provided some of what was needed would be more willing -- and had the ability -- to provide the rest of the requisite data. These eleven authorities are listed in Table 2. Note that most are large state agencies, which could result in some bias during the analysis of the data taken up in the next chapter.

Table 2 - Final Data Response

Authority
Delaware Transportation Authority
Orlando-Orange County Expressway Authority
Kansas Turnpike Authority
Maine Turnpike Authority
New Hampshire Department of Transportation -- Bureau of Turnpikes
New Jersey Turnpike Authority
New York State Thruway Authority
Ohio Turnpike Commission
Oklahoma Turnpike Authority
Texas Turnpike Authority
West Virginia Parkways, Economic Development and Tourism Authority

2.4 Summary

This chapter has presented a detailed breakdown of the Revenue-Traffic-Toll Charges relationship and the various associated links within this relationship. The elasticity of demand is further defined and illustrated in this chapter, since it plays an important role in determining the toll road pricing structure. The preliminary expected results through the use of actual data are also discussed. These results can better define some of the key links in the Revenue-Traffic-Toll Charges diagram. Finally, the data collection methodology is mentioned, since it is relevant to the data analysis.

CHAPTER 3

ANALYSIS OF COLLECTED DATA

This chapter provides a comprehensive analysis of the collected data, which consist of information provided by eleven toll road authorities during the project's second phase described in Chapter Two. After the analyses are presented, Chapter Three will juxtaposition the actual results with the expected results of the previous chapter. An explanation of why some of the expected results were not achieved will also be provided.

3.1 Description of Collected Data

Tables A1 - F4 in the Appendix display the data that were obtained during the collection period. The time span of the data was ten years for most authorities, beginning in either 1981 or 1982. The New York State Thruway Authority is the only exception; it provided only five years of data, starting in 1987. Most of the data contained in these tables came from annual reports provided by the toll road authorities. Some data were also extracted from Revenue Bond Statements. These Statements are public acknowledgments of debt obligations proposed by authorities in order to finance projects such as roadway reconstruction or toll facility extensions.

Most of the column headings in Tables A1 - F4 clearly indicate what the contents of that column represent. For clarification, however, some of the headings will be explained here.

3.1.1 Toll Roads Column

With the exceptions of the Orlando-Orange County Expressway Authority, the New Hampshire Bureau of Turnpikes, and the Oklahoma Turnpike Authority, each of the state agencies examined in this study operates only one toll road. This is an important observation, since all traffic, revenue, and cost data are calculated per authority and not per toll road. Recalling the Revenue-Traffic-Toll Charges diagram from the previous chapter, we emphasize, however, that elasticity of demand varies with each toll road and not just with each authority. This means that the three authorities which are operating more than a single toll road may have an aggregate demand elasticity that differs in absolute value from the average of their individual toll facility demand elasticities.

One could carry the argument further and state that there are distinct demand elasticities for each segment (a few miles [a few kilometers] in length) of every toll road, and that a more mathematically exact analysis would examine all of the different toll road segments operated by the eleven authorities. Unfortunately, amassing such a collection of data would be excruciatingly difficult, and, moreover, the differences in demand elasticities across the segments for the same toll road may be realistically negligible. This statement is partially substantiated by the fact that many toll plazas, whether mainline or entrance/exit, charge the same fare per vehicle classification at all locations. Applying this toll charge analogy, one could tentatively assume that the demand elasticities for the different roads operated by the same authority do not vary significantly from one another, just as different segments of the same roadway do not vary significantly. An indication of the possible veracity of this analogy is seen when a toll authority decides to raise toll rates; it usually does so across the board, affecting all toll roads in its jurisdiction by the same percentage.

As an aside, the author would like to point out that the New York State Thruway includes 82 untolled miles (132 untolled kilometers) for which the Thruway Authority collects only concession revenue. This may lead to some discrepancies between the actual toll traffic and the actual toll revenues, discrepancies that do not reflect the true demand elasticity between traffic counts and toll rates applicable on the rest of the Thruway.

3.1.2 Notes Column

The **Notes** column in Tables A1 - F4 is significant since it explains when the authorities adjusted their toll rates. This column also provides the opening date of toll road extensions or new toll roads. These dates will later be shown to correlate strongly with increases in toll revenue and traffic volumes.

3.1.3 Revenue, Traffic, and Cost Deviation Columns

The numbers in the **Revenue Deviation** column are calculated using the following formula:

$$\text{R.D.} = \frac{\text{Forecast T. R. - Actual T.R.}}{\text{Actual T.R.}} \times 100\%$$

The sign of the Revenue Deviation explains whether the Forecast Toll Revenue overpredicted (positive sign) or underpredicted (negative sign) the

Actual Toll Revenue for a particular year. The **Traffic Deviation** and **Cost Deviation** numbers are similarly calculated.

3.1.4 Annual Revenue, Traffic, and Cost Increase Columns

The column entitled **Annual Revenue Increase** contains numbers computed in the following manner:

$$\text{A.R.I.} = \frac{\text{Actual Toll Revenue(i)} - \text{Actual Toll Revenue(i-1)}}{\text{Actual Toll Revenue(i-1)}} \times 100\%$$

where i = year

Obviously, a negative sign indicates that the annual revenue has declined from the previous year. The **Annual Traffic Increase** and **Annual Cost Increase** columns are similarly calculated.

3.1.5 Annual Revenue and Cost Forecast Increase Columns

The Maine Turnpike Authority, Ohio Turnpike Commission, Oklahoma Turnpike Authority, and Texas Turnpike Authority all have values in the column entitled **Annual Forecast Cost Increase.** The numbers in this column are computed in the same way as the numbers in the **Annual Cost Increase** column; the only difference is that the word *Actual* is replaced by the word *Forecast* in the equation. The Ohio and Texas toll authorities also provided enough data to create yet another column. This one is entitled **Annual Revenue Forecast Increase**. Again, the numbers are computed as they are for A.R.I. described in Section 3.1.4, with the word *Actual* being replaced by the word *Forecast* in that equation.

3.2 Initial Analysis of Data

When the reader examines the collected data shown in the Appendix, he or she may be disappointed by the blank spaces, especially in the three **Forecast** columns. Of the 115 Authority-year combinations possible for every "Forecast" column, only 28 **Forecast Revenues**, 4 **Forecast Traffic**, and 41 **Forecast Operating Expense** combinations are listed. In addition, some of these forecast values do not have a corresponding "Actual" value with which a comparison can be made. Thus the aggregation of average deviations used in analyzing the data represents less than a quarter of the sample size. However, we must do the best with what we have, and so the analysis is conducted on this reduced sample.

The first approach to the analysis was to average each Authority's **Increases** and **Deviations** columns and then to take aggregate averages. The results are shown in Table 3 on the next page. For simplicity, only the name of the state is used to identify the authority, since each one is located in a separate state.

3.2.1 Annual Revenue Increase Column (Table 3)

In examining the **Annual Revenue Increase** column, we observe three states that have particularly high average annual revenue increases. These are Florida, New Hampshire, and Texas. If the reader turns to each Authority's data in the Appendix, he or she can understand the relationship that exists between the annual toll revenue increases and the contents of the previously mentioned **Notes** column. For the most part, it seems that a toll charge increase or an opening of a new or expanded toll facility in year i led

TABLE 3

State	Column 1 A.R.I.*	Column 2 A.T.I.	Column 3 A.C.I.	Column 4 R.D.	Column 5 C.D.	Column 6 A.F.E.I.	Column 7 A.F.R.I.	Column 8 T.D.
Delaware	9.58%	5.10%			1.47%			
Florida	22.38%	9.30%						
Kansas	5.55%	5.35%	8.36%					
Maine	7.88%	8.65%	10.22%	3.02%	3.54%	10.59%		
New Hampshire	13.54%	7.59%	14.09%	0.50%				
New Jersey	9.29%	3.91%	8.28%					
New York	9.31%	0.05%	6.37%					
Ohio	3.35%	4.12%	6.03%	-1.69%	6.30%	7.47%	3.67%	
Oklahoma	6.08%	3.66%	8.01%	-3.84%	3.48%	6.43%		
Texas	16.03%	10.41%	12.33%	5.22%	13.16%	11.99%	16.04%	-1.37%
West Virginia	8.78%	14.02%	10.57%					
AGGREGATE	10.16%	6.56%	9.36%	0.64%	5.59%	9.12%	9.86%	-1.37%

*A.R.I. = Annual Revenue Increase
A.T.I. = Annual Traffic Increase
A.C.I. = Annual Cost Increase
R.D. = Revenue Deviation
C.D. = Cost Deviation
A.F.E.I. = Annual Forecast Expense Increase
A.F.R.I. = Annual Forecast Revenue Increase
T.D. = Traffic Deviation

to a significant (over 10%) increase in toll revenues in year i or in year i+1, depending on how early in year i the rate changes were implemented.

3.2.2 Annual Traffic Increase Column (Table 3)

The **Annual Traffic Increase** data had a lower aggregate average than the **Annual Revenue Increase** data. The prime reason for this is that many authorities saw declines in traffic volume in the time period immediately following a rate increase -- and almost all toll authorities had at least one rate increase during the ten-year period. The New York State Thruway Authority provides an excellent example of how the traffic volume varied with rate increases. If we examine not just the aggregate values shown in Table 3, but also the actual annual data in the Appendix, we observe that during some years of rate increases, the traffic volume also increased. This can again be explained by referring back to the **Notes** column. The increase is usually caused by an extension of a toll facility to an area previously not served by a high-speed facility. Such an extension encourages drivers who have not really used the toll road in the past to now become more frequent users -- thereby increasing the volume, especially if any parallel facilities are comparatively inadequate.

3.2.3 Annual Cost Increase Column (Table 3)

An interesting comparison between the **Annual Traffic Increase** and **Annual Cost Increase** columns in Table 3 shows that four states which consistently have higher-than-average traffic increases also have higher-than-average expense increases. These four states are Maine, New

Hampshire, Texas, and West Virginia. These states will be discussed in more detail later in this chapter.

3.2.4 Comparisons Between A.R.I., A.T.I., and A.C.I.

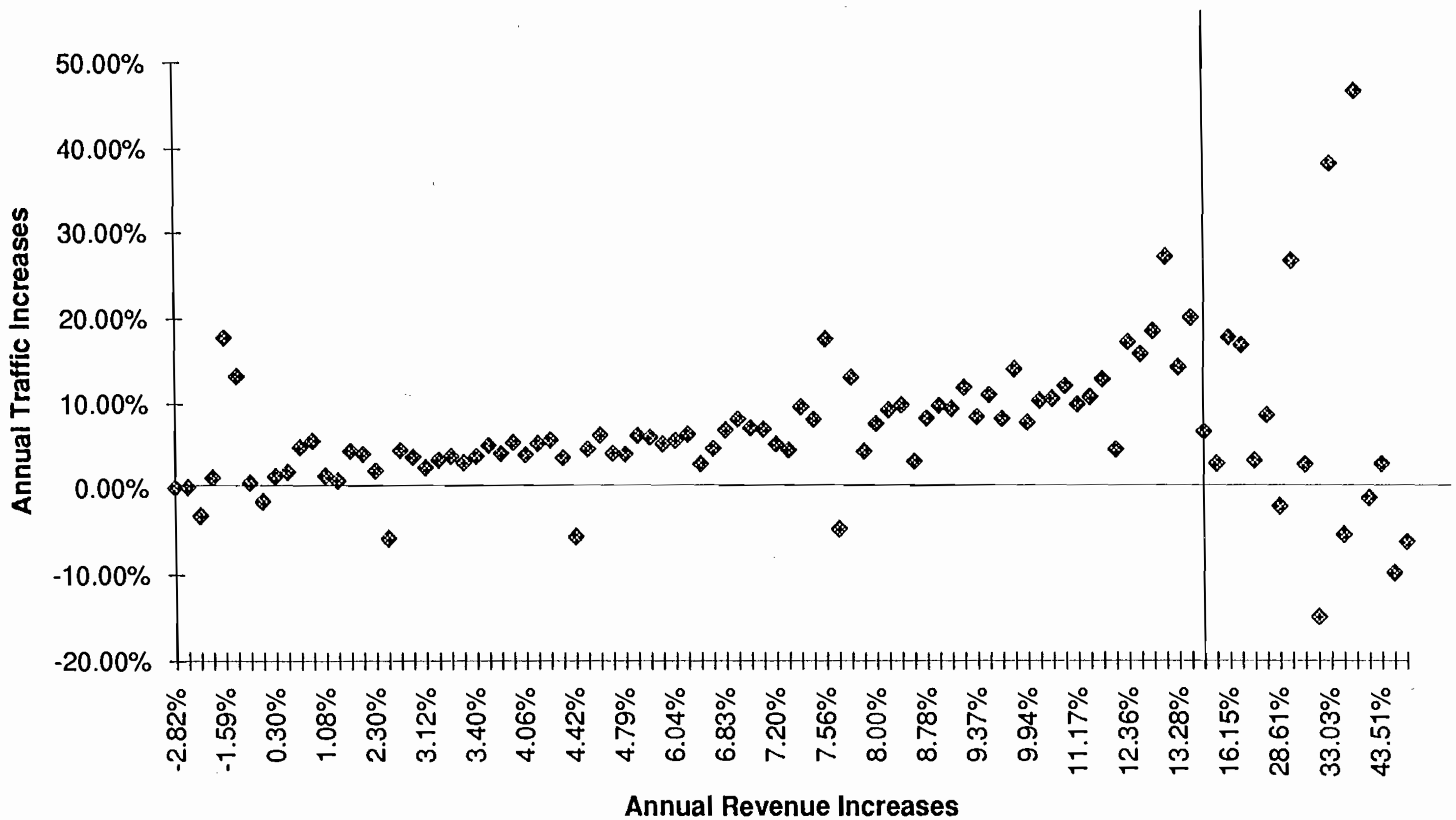
In order to better visualize the relationships between annual revenue, traffic, and cost increases, it was perceived that simple scatter plots of A.R.I. vs. A.T.I., A.R.I. vs. A.C.I., and A.T.I. vs. A.C.I. would be useful. Without using any sophisticated statistical tools for this initial analysis, a simple examination of the three scatter plots, which are shown as Figures 3 - 5 on the following pages, yields some interesting findings.

Figure 3 compares the annual revenue and traffic increase data from the Appendix. The figure shows a steadily increasing trend of annual traffic increases from approximately 0 to 10 percent corresponding to annual revenue increases ranging from -2.82 percent to about 15 percent. This can be interpreted as a fairly strong correlation between revenue and traffic increases.

However, at about 15 percent, a shift in the correlation becomes apparent. It seems as if the trend suddenly splits into two directions, with one direction continuing to indicate a strong positive correlation between the two annual increases, and the other indicating a negative correlation between A.R.I. and A.T.I. How are these two simultaneous trends possible?

They are possible, and actually make sense, because they explain two different phenomena. A large increase in the annual revenue occurs for one of two reasons: a toll rate increase or the opening of additional mileage on the toll road network. The first type of increase is perceived negatively by

Figure 3



50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
-10.00%
-20.00%
Annual Traffic Increases
-2.82%
-1.59%
0.30%
1.08%
2.30%
3.12%
3.40%
4.06%
4.42%
4.79%
6.04%
6.83%
7.20%
7.56%
8.00%
8.78%
9.37%
9.94%
11.17%
12.36%
13.28%
16.15%
28.61%
33.03%
43.51%
Annual Revenue Increases

the traveling public and results in a decrease in the traffic volume. The opening of a new extension, however, is usually perceived positively by the public, and thus the high increase in traffic leads to a corresponding high increase in revenues. The data collected for the toll authorities in Florida, New Jersey, and Texas demonstrate these characteristics quite well.

Figure 4 depicts **Annual Revenue Increases** plotted against **Annual Cost Increases**. It is apparent that there exists a slightly increasing trend, indicating that the annual costs escalate with increases in annual revenue. Except for five data values, all annual cost increases shown in the Appendix were positive, which is what we expected. The five negative values all occurred at the low end of the revenue increases range, indicating that those authorities were probably cutting back on new projects and/or maintenance during a low earnings period. The lowest and highest cost increase values on the scatter plot occur in this spectrum. They are both attributed to West Virginia Parkways, Economic Development and Tourism Authority, which had a cost decrease of 19 percent in 1990 and then a cost increase of 33 percent in 1991. Both these years show a corresponding large (relatively speaking) annual revenue decrease. Although there are no notes associated with this authority, it may be reasonable to assume that 1990 and 1991 were tumultuous years in West Virginia, with various state highway agency budgets being trimmed one year, perhaps, and funded with substantial financial assistance the next.

The last figure, Figure 5, depicts **Annual Traffic Increases** versus **Annual Cost Increases**. Figure 5 is very similar to Figure 4, providing the

Figure 4

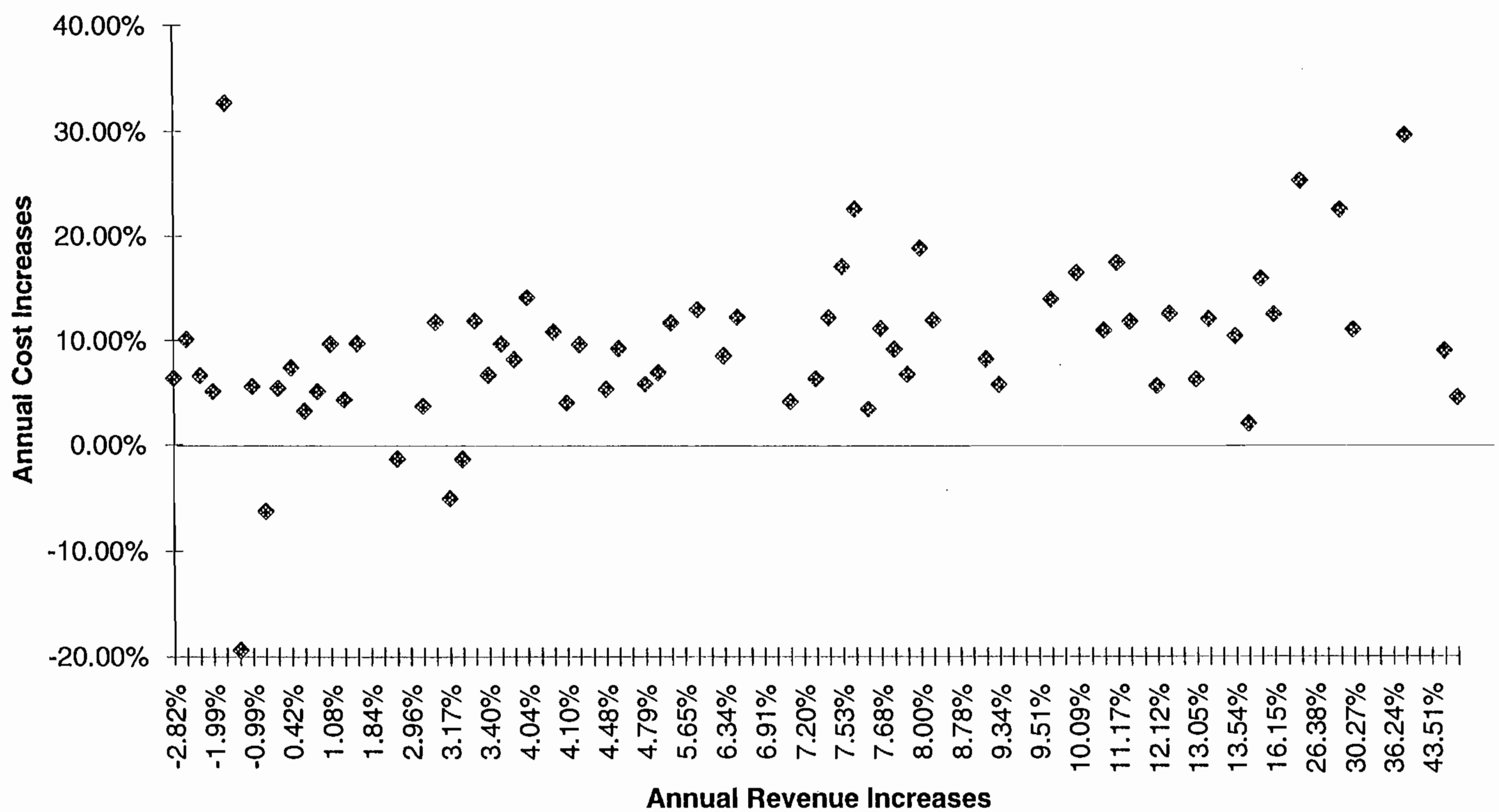
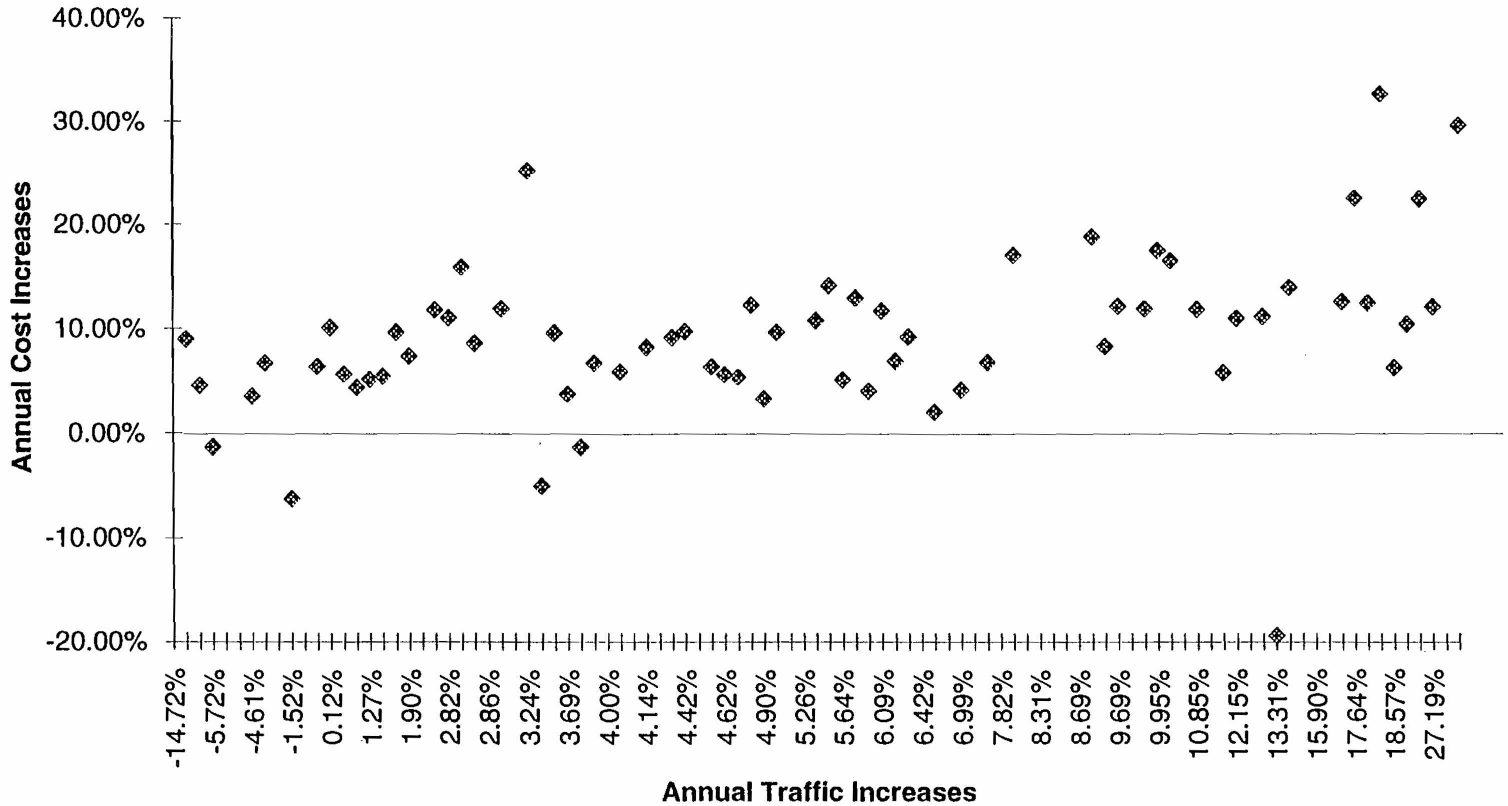

40.00%
30.00%
20.00%
10.00%
0.00%
-10.00%
-20.00%
Annual Cost Increases
-2.82%
-1.99%
-0.99%
0.42%
1.08%
1.84%
2.96%
3.17%
3.40%
4.04%
4.10%
4.48%
4.79%
5.65%
6.34%
6.91%
7.20%
7.53%
7.68%
8.00%
8.78%
9.34%
9.51%
10.09%
11.17%
12.12%
13.05%
13.54%
16.15%
26.38%
30.27%
36.24%
43.51%
Annual Revenue Increases

Figure 5


40.00%
30.00%
20.00%
10.00%
0.00%
-10.00%
-20.00%
Annual Cost Increases
-14.72%
-5.72%
-4.61%
-1.52%
0.12%
1.27%
1.90%
2.82%
2.86%
3.24%
3.69%
4.00%
4.14%
4.42%
4.62%
4.90%
5.26%
5.64%
6.09%
6.42%
6.99%
7.82%
8.31%
8.69%
9.69%
9.95%
10.85%
12.15%
13.31%
15.90%
17.64%
18.57%
27.19%
Annual Traffic Increases

reader with little additional knowledge. One data value that may be an outlier is located at 13.31 percent on the horizontal axis. It has a corresponding annual cost decrease of 19.43 percent. Not surprisingly, this data point also belongs to West Virginia during the year 1990. One is persuaded that the reasoning behind the outliers in Figure 4 is applicable to those in Figure 5 as well. Once again, more information about what occurred that year in West Virginia would be useful.

3.2.5 Revenue Deviation Column (Table 3)

Returning to Table 3, we notice that **Revenue Deviations** has an extremely low average aggregate deviation of 0.64%. At first glance, this may seem to indicate that the toll authorities have wonderful forecasting tools, allowing them to accurately predict the revenues in forthcoming years. It is necessary, however, to examine this deviation more carefully. Regrettably, the collected data contains Revenue Deviation numbers from only five authorities -- and only two of the five actually provide a full ten years' compilation of data. Figures 6 and 7 show the Actual Annual Revenues plotted against the Revenue Deviation for these two authorities. The values for Ohio ranged from -5.57% to 4.08%, whereas the values for Texas ranged from -3.71% to 25.88%. This significantly high latter value occurred in 1987, which is the year that the Dallas North Tollway Extension opened. The Texas Turnpike Authority had predicted that a large increase in traffic would increase their revenue by 68.57% over the previous year. However, their revenue increased by only 37.19%, about half of what was

Figure 6 - Ohio Revenues

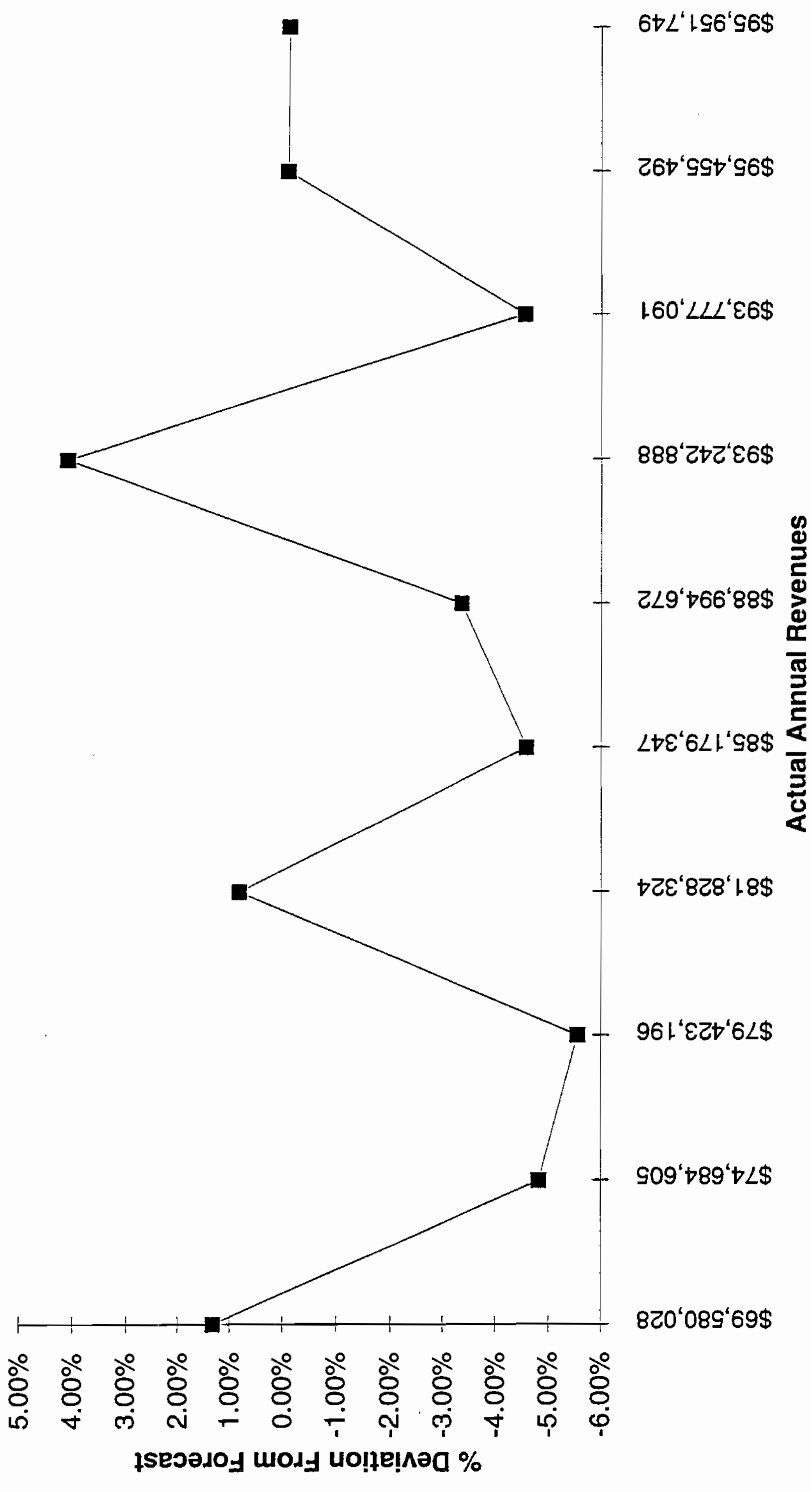
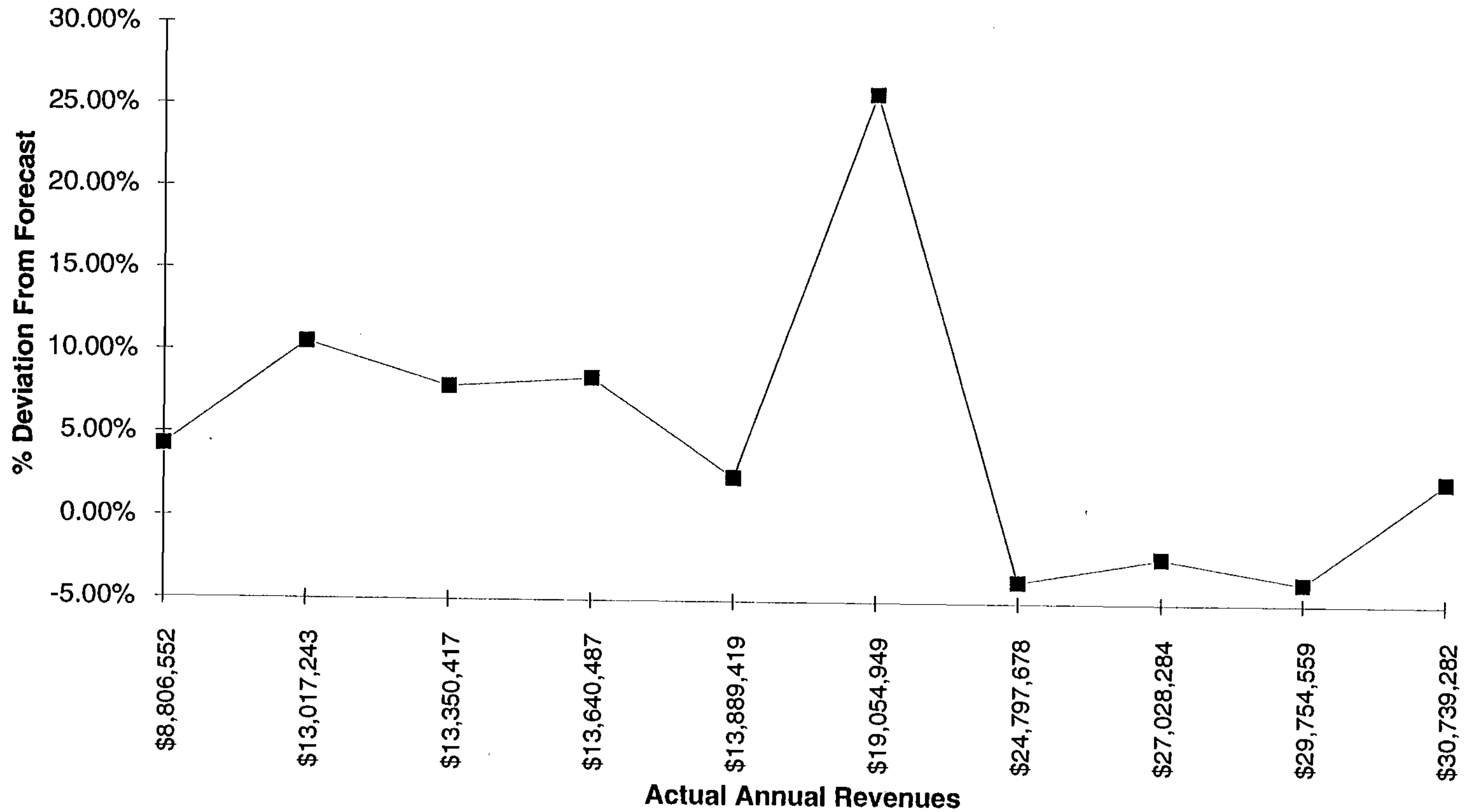


Figure 7 - Texas Revenues

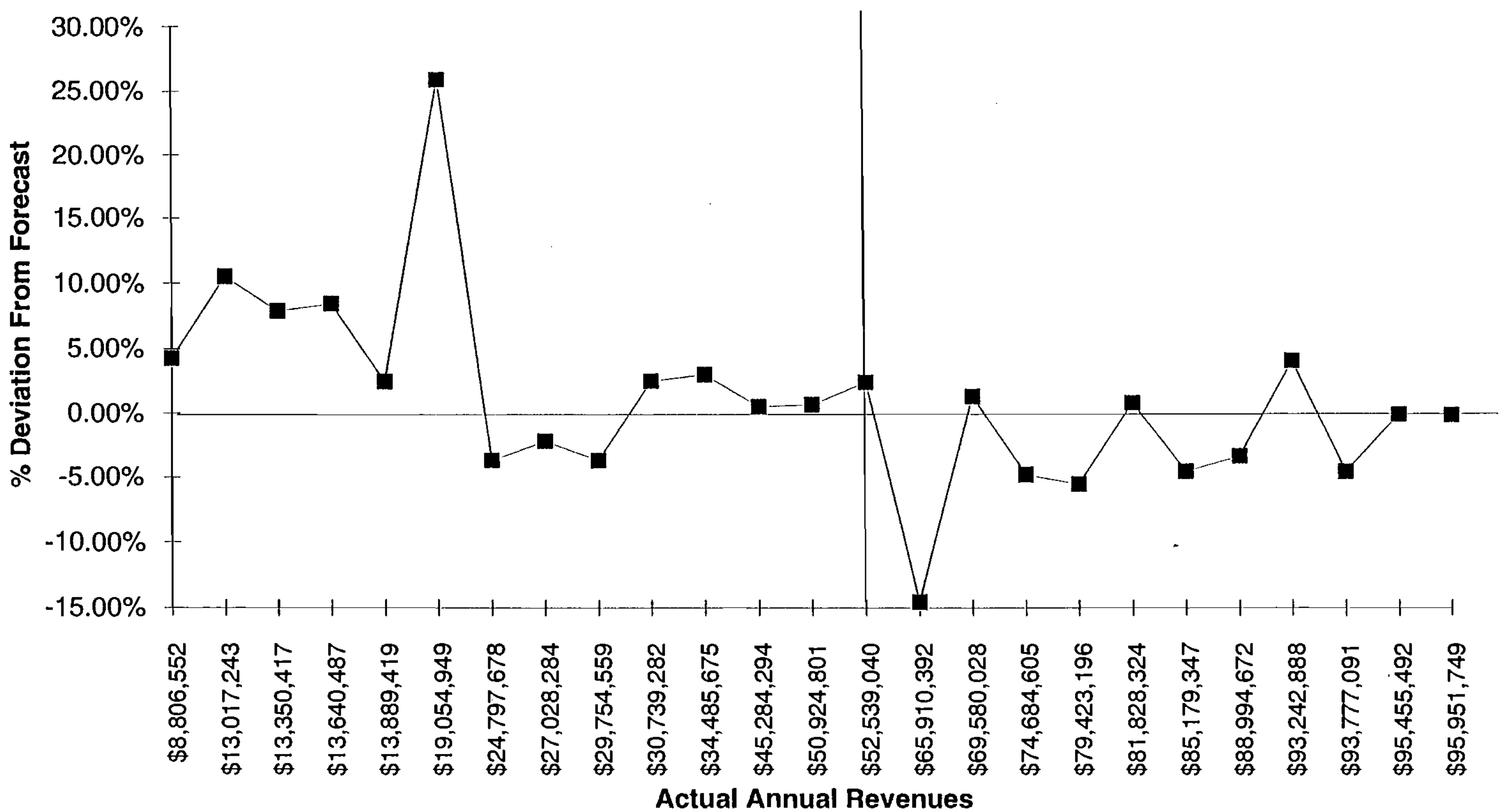


anticipated. Note that the Texas Turnpike Authority reacted to this over-prediction by underpredicting the following three years.

Figure 8 shows how the **Revenue Deviation** varies with the magnitude of the **Actual Annual Revenues**. This figure incorporates all available Revenue Deviation data, including those from Ohio and Texas. The horizontal axis displays a range between $8,805,552 and $95,951,749. The two outlier points located at 25% and -15% revenue deviation represent Texas and Oklahoma, respectively. The reason behind Texas' high deviation has already been explained in the previous paragraph. Oklahoma's large negative deviation is attributed to the 30% toll increase implemented on January 1, 1991, for all cash toll users. The Authority predicted only a minor increase in toll revenue, since officials believed that the traffic volume would decline slightly, thus offsetting the gain from the toll charge increase. To their pleasant surprise, many drivers continued to use the toll roads, but they switched from using cash to the PIKEPASS electronic toll collection system since those prices had not been increased.

If one were to draw a horizontal line on Figure 8 at 0.0% Deviation from Forecast and a vertical line at about $52,000,000, which represent approximately both the mean and the median of the Actual Annual Revenues, an interesting picture is created. To the left of the vertical line, the majority of data points lie above 0.0%. To the right, the majority of points lie below 0.0%. From this picture, we can surmise that the authorities that earn smaller annual revenues, such as Texas, tend to overpredict in their revenue forecasts, while authorities like Ohio, which are on the high end of the revenue spectrum, tend to underpredict in their revenue forecasts. This

Figure 8 - Revenues



picture also helps explain why the aggregate revenue deviation is only 0.64%; the overprediction and underprediction tend to cancel one another. Why does this over- and under-forecasting occur?

Some comments about the toll roads studied in this report may lead to an understanding of this underprediction and overprediction. Newer toll roads are usually shorter, carry less traffic, and therefore earn less revenue, but the toll authorities operating them may be more optimistic than they are about those with higher annual revenues. New toll roads are usually located in developing areas of large suburbs, and a probable increase in development will most likely lead to a build-up of traffic which increases the revenues, thereby justifying this optimism. On the other hand, authorities with higher revenues, who appear to be underpredicting, are not necessarily pessimistic. Since they are fairly large state agencies, they may be hesitant to predict large increases in revenue for fear that elected officials might start clamoring for toll rate decreases. It is interesting to note that the Ohio Turnpike, the authority with the largest revenues studied in this report, was supposed to have been converted to a free interstate in 1991 since all construction debt obligations had been repaid. However, through some deft political maneuverings, the Ohio Turnpike Commission has managed to ensure that the Turnpike remains tolled for at least the next few years.

3.2.6 Cost Deviations Column (Table 3)

The aggregate average of **Cost Deviations** showed an overprediction of operating expenses of 5.59%. With the exception of 1986 data from Ohio, all cost deviations were positive, indicating a consistent overprediction of expenses across all authorities. At this time, we have no background information on why 1986 was an abnormal year for the Ohio Turnpike Commission. Figures 9 - 11 detail **Actual Annual Expenses** versus **Cost Deviation** for the toll authorities in Maine, Ohio, and Texas, respectively. The Texas Turnpike Authority had the highest average overprediction with a 13.16% Cost Deviation -- more than double that of the next highest authority.

Figure 12 combines all eleven authorities' expenses and displays them plotted against their cost deviations. From a careful examination of this figure, it seems as if the annual expense range between $9,500,000 and $29,000,000 is fairly close to an accurate prediction of expenses (0.0% deviation from forecast). The only outlying point in this section belongs to Oklahoma, with a 17.32% cost deviation in 1987. Following this large deviation, Oklahoma improved its forecasting ability to such an extent that the average deviation for 1988 - 1991 turned out to be just 0.02%. Information regarding why 1987 was unusual for the Oklahoma Turnpike Authority is not currently available.

Returning to Figure 12, it seems as if the low operating expense authorities ($2,500,000 - $9,500,000) and the high operating expense authorities ($29,000,000 - $50,000,000) both have average cost deviations significantly above 0.0%. Given the lack of detailed information concerning expenses, it is difficult to explain this phenomenon. It would be wise to collect more data to see whether this graph is truly representative of the cost

Figure 9 - Maine Expenses

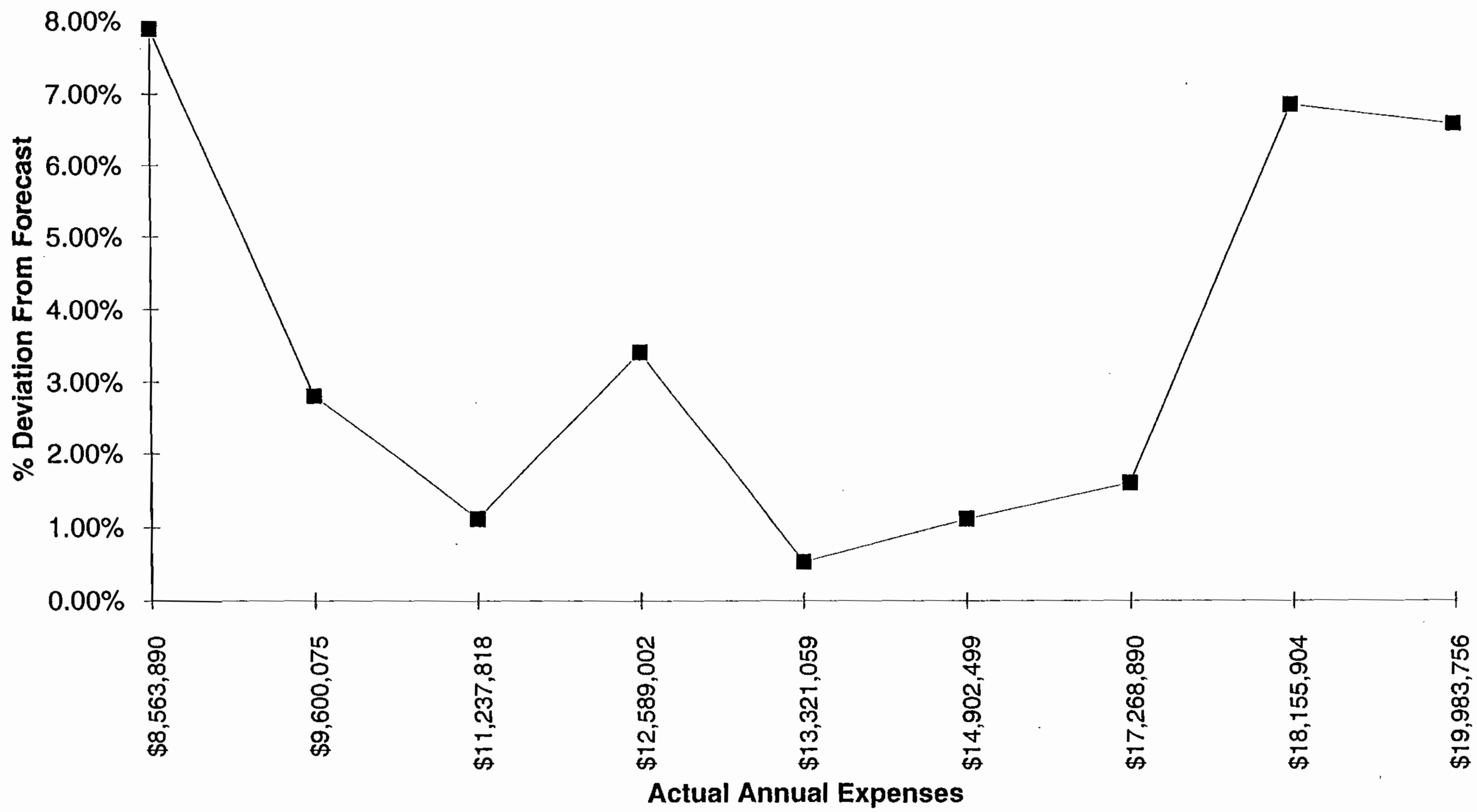


Figure 10 - Ohio Expenses

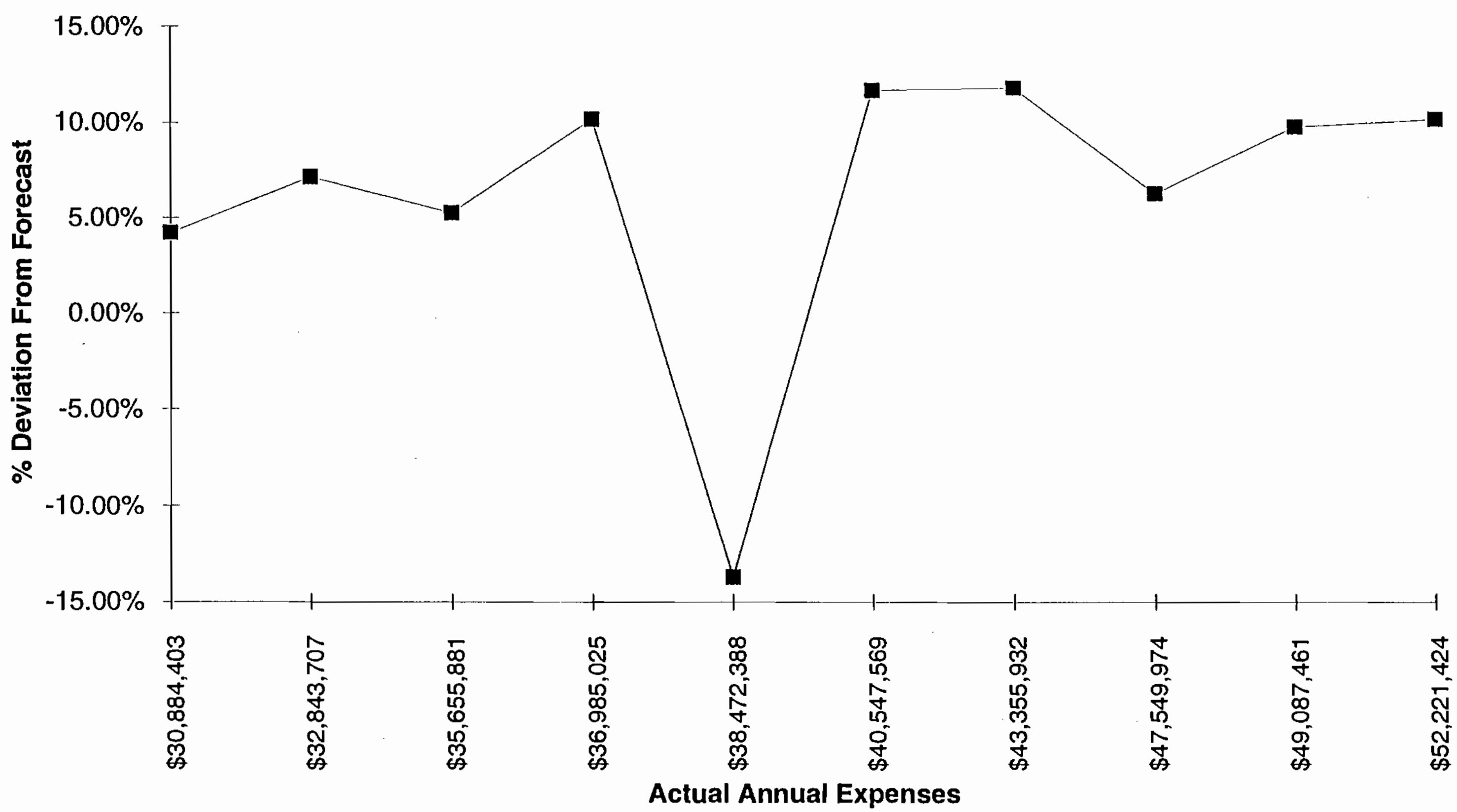


Figure 11 - Texas Expenses

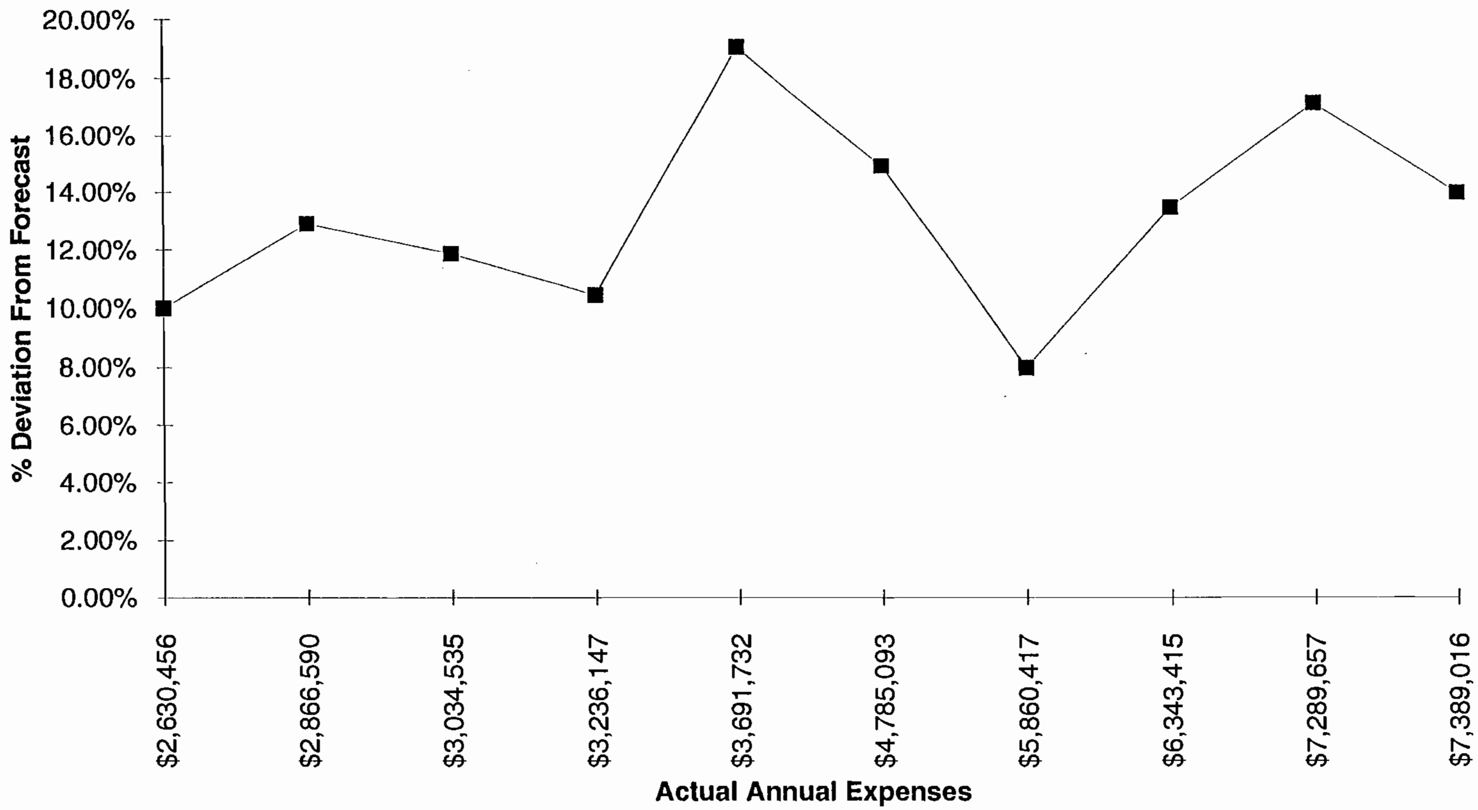
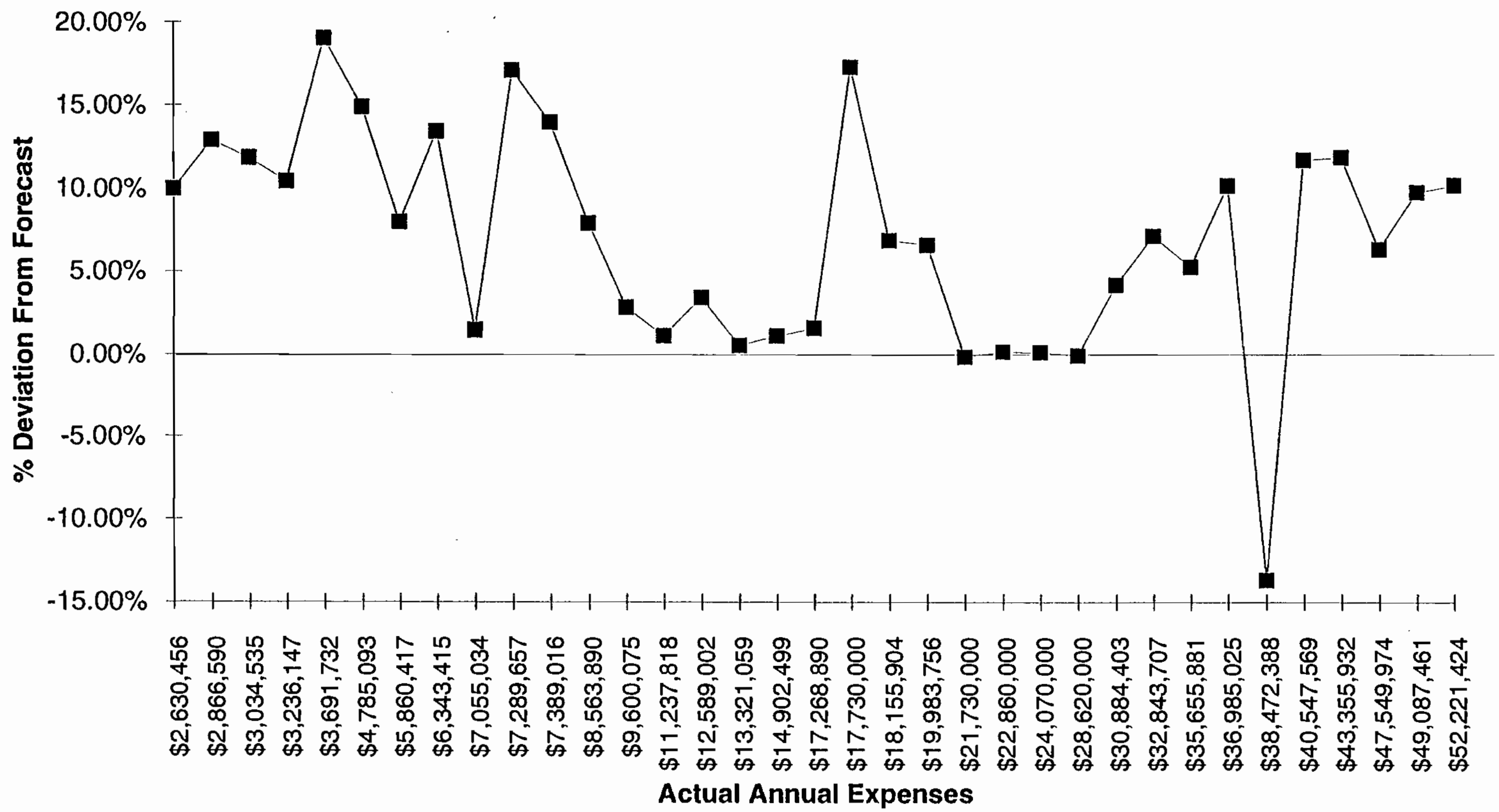


Figure 12



% Deviation From Forecast
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
$2,630,456
$2,866,590
$3,034,535
$3,236,147
$3,691,732
$4,785,093
$5,860,417
$6,343,415
$7,055,034
$7,289,657
$7,389,016
$8,563,890
$9,600,075
$11,237,818
$12,589,002
$13,321,059
$14,902,499
$17,268,890
$17,730,000
$18,155,904
$19,983,756
$21,730,000
$22,860,000
$24,070,000
$28,620,000
$30,884,403
$32,843,707
$35,655,881
$36,985,025
$38,472,388
$40,547,569
$43,355,932
$47,549,974
$49,087,461
$52,221,424
Actual Annual Expenses

deviations across the range of annual expenses for all toll road authorities and not just for our sample of eleven.

3.2.7 Columns Six, Seven, and Eight (Table 3)

Columns Six and Seven in Table 3 do not hold much apparent meaning except for comparisons with Columns Three and One, respectively. The forecast annual increases in toll revenues and operating expenses closely match the actual increases in revenues and expenses. This is not surprising, since most authorities tend to use the current year's increase in revenue or expenses to predict the following year's increase. This practice is known as trend extrapolation.

Finally, the last column in Table 3 cannot possibly be representative of deviation of forecast from actual traffic counts for toll roads in the United States, since it describes only two years of Texas Turnpike Authority data. The lack of forecast toll traffic data limited the analysis of deviations, because traffic is one of the essential components in the Revenue-Traffic-Toll Charges diagrams.

3.3 Statistical Analysis of Data

The second step in the analysis of data was to compute statistics based on what we have observed during the examination of the scatter plots. Figures 3, 4, 5, 8, and 12 were scrutinized using a regression software package (Statworks©). Table 4 displays the results of the regression analyses. The units of each regression model are percentages of the listed variables. Also, for analyzing 20 or more data points, a t-statistic exceeding

TABLE 4 – Statistical Analysis Summary

Equation Number	Regression Model	Correlation Coefficient (r)	t-Statistic for Constant	t-Statistic for Variable(s)	Corresponding Figure
1	A.T.I.* = 6.11 + 0.08(A.R.I.)	0.11	5.29	1.06	3
2	A.T.I. = 1.96 + 0.78(A.R.I.)	0.60	2.27	6.74	3 (truncated)
3	A.C.I. = 7.27 + 0.23(A.R.I.)	0.32	6.36	2.72	4
4	A.C.I. = 6.15 + 0.44(A.T.I.)	0.48	5.76	4.50	5
5	R.D. = 7.10 - 1.15 x 10^{-7} (A.R.)	0.50	2.78	-2.73	8
6	C.D. = 9.07 - 1.03 x 10^{-7} (A.C.)	0.24	4.91	-1.39	12 (simple)
7	C.D. = 15.1 - 9.21 x 10^{-7} (A.C.) + 1.65 x 10^{-14} $(A.C.)^2$	0.54	6.17	-3.59 3.29	12 (polynomial)

*A.T.I. = Annual Traffic Increase
A.C.I. = Annual Cost Increase
R.D. = Revenue Deviation
C.D. = Cost Deviation
A.C. = Annual Cost
A.R. = Annual Revenue
A.R.I. = Annual Revenue Increase

1.96 in absolute value usually means that the coefficient is statistically significantly different from zero with 95% confidence limits.

Most of the regression equations shown in this table are simple bivariate equations that correspond directly to the data used in plotting the associated scatter plots. Equations 3 - 5 follow this pattern, with the corresponding correlations of coefficient ranging from 0.32 to 0.50. All of the equation coefficients are statistically significant with 95% confidence limits. Equation 3 indicates that for every 5% gain in the annual revenue, the annual cost increases by approximately 1%. Similarly, Equation 4 states that for every 2.5% gain in annual traffic, the annual cost increases by approximately 1%. Equation 5, which corresponds to Figure 8, shows that the revenue deviation of the actual from the forecast revenue decreases by approximately 1% for every $8,700,000 increase in actual annual revenues.

Regression Equations 1 and 6, corresponding to Figures 3 and 12 respectively, did not have statistically significant variable coefficients, and the correlation coefficients were rather poor. However, with closer examination of the scatter plots, better regression equations soon became apparent.

As discussed in Section 3.2.4, the scatter plot (Figure 3) shows a straight line trend pattern up to about 15%, when suddenly two patterns seem to materialize. The objective of the statistical analysis was to derive a relationship between revenue and traffic that mathematically explains this scatter plot. Since a regression line is, by definition, one and not two lines, Equation 1 did not provide a good fit for all of the data points. In order to obtain a better fit, Equation 2 was created by ignoring all annual revenue increases greater than 15.38% (i.e., by considering them as outliers). As noted in Table 4, this second truncated equation gives a much higher correlation coefficient and statistically significant variable coefficients. The equation basically states that a 3% increase in annual traffic is brought about by approximately a 4% increase in annual revenues -- almost a one-to-one relationship, which is what we expected. For those revenue increases greater than 15.38%, no statistics were computed, since there were not very many of those values and a regression equation would have provided us with strongly biased results.

The data values in Figure 12, described in Section 3.2.6, produced a low coefficient of correlation and an insignificant variable coefficient in Equation 6. The reason for the poor fit is that a straight line has difficulty resembling the U-shaped pattern traced by the data points in Figure 12. A better regression equation was found to be a polynomial expression of the second degree. This provided a much tighter fit, and both the actual cost and squared actual cost terms are statistically significant. Equation 7 can be interpreted as stating that the cost deviation percentage decreases by approximately 1% for every $1,000,000 increase in annual expenses and, simultaneously, increases by 1% for every $(\$8{,}000{,}000)^2$ increase in annual expenses. This second term is more significant for the authorities with large annual increases in expenditures.

3.4 Elasticity of the Collected Data

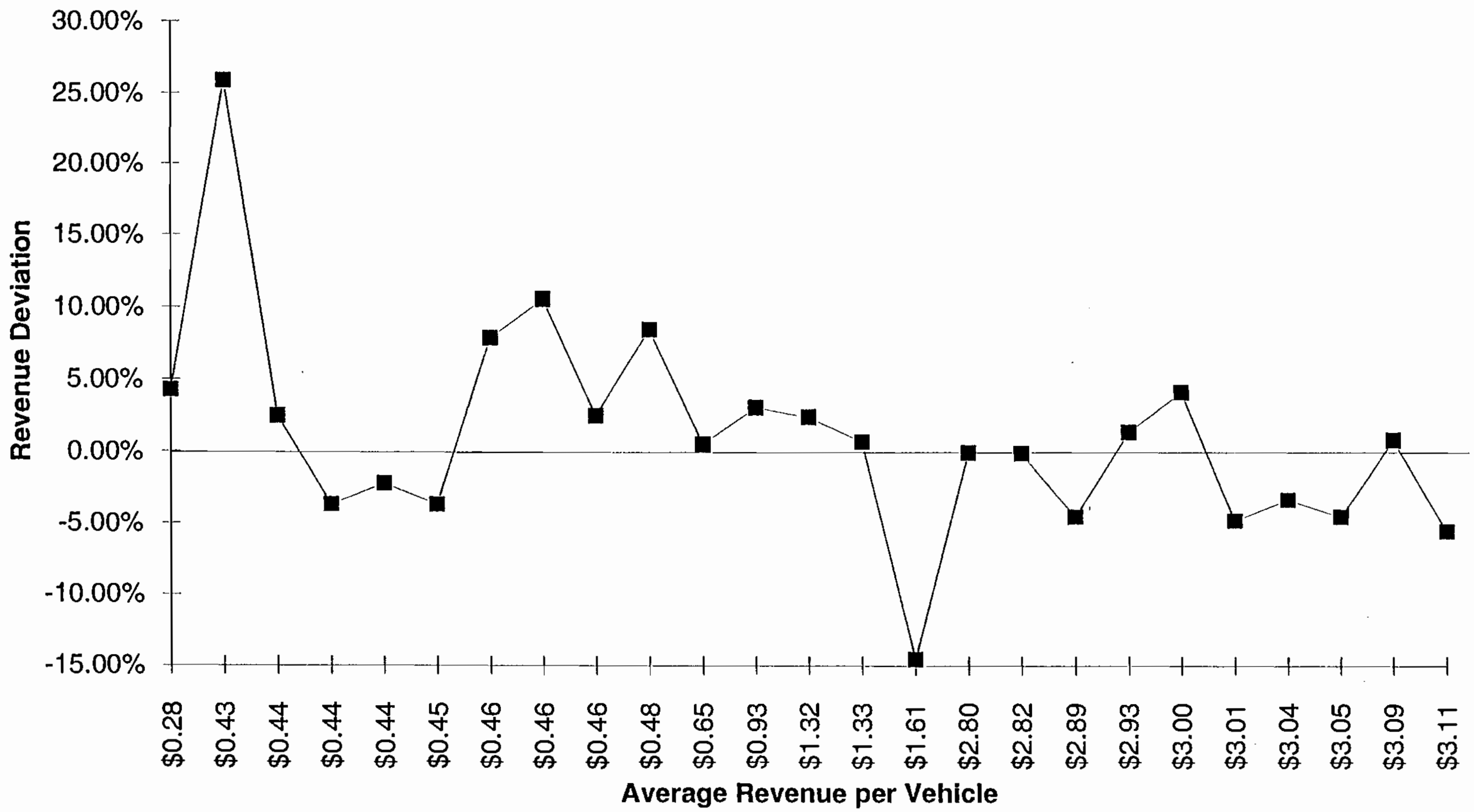
Although we cannot compute elasticities from the **Forecast** data, we may be able to extract some valuable information from the **Actual** data. In order to do so, we need to return to the Appendix and examine the **Annual Revenue Per Vehicle** column. This column was omitted earlier in

Section 3.2. The Revenue Per Vehicle values were computed simply by dividing the **Actual Toll Revenues** by the **Actual Toll Traffic.** Admittedly, this is a gross measurement, since revenue includes monies other than toll receipts and traffic includes mixtures of both passenger and commercial vehicles. Nevertheless, this measure is useful, especially when comparing agencies against one another and against their own revenue deviations.

The Revenues Per Vehicle were rather stable over the ten-year period across all authorities. A sudden upturn was usually due to a toll rate increase. The stability gives further evidence of the strong positive correlation between toll traffic and toll revenues. The ten-year average annual revenue per vehicle ranged from $0.38 in Florida to $2.97 in Ohio. Remember that Ohio also has the highest percentage of commercial vehicles of the toll roads studied, which may explain the high revenue-to-traffic ratio. Florida's facilities are primarily commuting toll roads which are used mostly by inexpensively tolled passenger vehicles.

Figure 13 depicts the **Average Revenue Per Vehicle** versus **Revenue Deviation**. This graph is remarkably similar to Figure 8 described earlier in this chapter. Even the two outliers are the same. The trend line slopes downward as it traverses from low average revenues per vehicle to high average revenues per vehicle. Again, we notice an overprediction in forecasting revenues on the left side of approximately $2.00 and

Figure 13



30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
Revenue Deviation
$0.28
$0.43
$0.44
$0.44
$0.44
$0.45
$0.46
$0.46
$0.46
$0.48
$0.65
$0.93
$1.32
$1.33
$1.61
$2.80
$2.82
$2.89
$2.93
$3.00
$3.01
$3.04
$3.05
$3.09
$3.11
Average Revenue per Vehicle

an underprediction on the right side. If we exclude the two outliers, the entire range of deviation from forecast is approximately -5% to +10% of the actual revenues.

Once again we used our statistical package to derive a regression equation for the data corresponding to Figure 13. This equation is remarkably similar to Equation 5 in Table 4. The values in the parentheses represent the t-statistics.

$$\underset{}{R.D.} = \underset{(2.26)}{5.23} - \underset{(-2.22)}{2.59}(A.R.V.) \qquad r = .42$$

The revenue deviation decreases by approximately 2.5% for every $1 increase in the average revenue per vehicle. The equation verifies our premise that the revenue deviations obtained for average revenues of approximately $2.00 per vehicle are very close to 0.0%. For average revenues smaller than $2.00 and greater than $2.00 per vehicle, the forecast revenue is overpredicted and underpredicted, respectively.

3.5 Inputs for an Error Forecasting Model

In Section 2.2, we mention that a key objective in writing this report is to formulate a set of inputs that can subsequently be utilized in developing an Error Forecasting Computer Model. It was hoped that the contacted toll road authorities would provide enough aggregate information in order to create this input set. Unfortunately, the amount of data collected, although informative in its own sense, does not provide enough material to produce a detailed input list. Nonetheless, an attempt is made here to extract a general description of inputs deemed necessary for any such computer model.

The first item is to establish the relationship between revenues, traffic, and expenses, both actual and forecast, as we have done earlier in the chapter. These relationships should begin at aggregate levels (annually) and then be disaggregated into monthly, weekly, and perhaps even hourly values. Regression equations can then be formulated which explain the trend patterns observed in scatter plots.

Next, the elasticity of traffic to toll rates should be explored. This can be done by using the regression equations along with the actual toll rates for the toll road in question. It is important to mention that elasticities should begin at a very detailed disaggregate level and then should be aggregated into more general elasticities. This process is in contrast to the revenue and traffic relationship analysis proposed above. This is because the inputs used in computing direct elasticities come from individual vehicles reacting to changes in the toll road price structure. Such a pricing mechanism is geared towards a multiple-vehicle classification system. Of course, indirect or cross-elasticity adds another dimension to this problem, since it considers variables which are only subtly related to traffic volume or revenue.

After regression equations and elasticity figures have been derived for different levels of aggregation, they can then be programmed into a computer model. This model can take as inputs the current revenues, traffic, and elasticity of traffic demand, all of which are at the <u>same</u> aggregation level. The only other input required is the future year for which an error forecast is desirable. The error forecast, for that specific year, is ideally the output from the computer model.

In the previous section, we have mentioned that certain authorities over- or underpredicted in their various forecasts. The list below should provide the reader with a helpful guide to all possible forecast errors for any type of prediction (Ref 21).

e1 = Overestimation of an increase
e2 = Underestimation of an increase
e3 = Predicted decrease but actual increase
e4 = Overestimation of a decrease
e5 = Underestimation of a decrease
e6 = Predicted increase but actual decrease

This list is a reminder that an error prediction model must give not only accurate values of forecast deviation but also correct signs for these deviations. Finally, the reader should keep in mind that even though forecast deviations can be quite small, there is zero probability that forecast revenue or traffic will exactly match actual revenues or traffic.

Although this report stops far short of establishing a desirable computer model, it has laid the groundwork for this concept by explaining through simple statistical analysis how the different facets of a toll road facility are interrelated. With the collection of more data, one could easily begin developing such an error forecasting computer model.

3.6 Summary

This chapter has examined in some detail all the collected data. Many figures and tables are incorporated to explain what each data value means, either by itself or in conjunction with others. The key conclusions that can be drawn from this chapter are that (1) toll revenues and toll traffic are strongly and positively correlated, and that (2) toll authorities earning below the aggregate average revenue tend to overpredict their revenue while the toll authorities earning more than the aggregate average revenue tend to underpredict.

While these are important conclusions, it is important that more data be gathered in order to validate or refute these conclusions. Especially interesting would be a verification of the mid-range area where the predicted values basically match the actual values. With more data, perhaps, mathematical models can eventually be utilized to help a toll agency calculate its toll rates so as to minimize the deviation between forecast and actual revenue.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the entire report, with primary emphasis given to the results of the data analysis performed in the previous chapter. The second section proceeds to discuss the myriad of considerations involved in the building of toll facilities. Finally, in the last section, recommendations are made as to how the results of this report can be implemented in a useful fashion in order to simplify the process of determining toll road financial feasibility.

4.1 Results of Analysis

In Chapter Three, we performed an analysis of the data which we had collected. Based on this analysis, we were able to propose a foundation for developing a computerized error forecasting model. As we mentioned earlier, the most important inputs required are regression equations relating traffic volumes and toll revenues, along with the corresponding demand elasticities for the different vehicle classifications — all of which are measured at the same aggregation level. There are numerous different — and good — forecasting models in use today, but many of them are not widely used since they are wrongly perceived as producing deviations from actual values. The blame for errors in forecasting rests much more with the quality of the input data than with the forecasting model itself. Many transportation agencies rely upon other local agencies to prepare part or all of the projections of inputs. The reliability of the input data, however, diminishes with the number of local agencies involved; it is always better to collect the data first-hand.

Of all the inputs that are needed for a forecasting model, the most important one, and the one most difficult to obtain accurately, is the projection of future land use for the corridor area under consideration. Land use changes form the major basis for determining the shape of the annual growth curve, and, thus, travel forecasting can never be more accurate than the land use forecasts upon which the travel forecast depends. In a majority of states, the Metropolitan Planning Organizations and/or the local governments provide the land use and related socio-economic data for input to the forecasting process. This, unfortunately, means that many land use forecasting activities are performed using a vast amount of professional judgment and with minimal reliance on any standardized procedures (Refs 9, 19). The development of an error forecast model as suggested by this report would be a small but important step towards establishing some semblance of standardization in the forecasting process.

The author of one of the cited references (Ref 3), Yataro Fujii, has defined a rather robust equation which relates the setting of toll rates to the demand function for a toll road. He bases his equation on public toll roads, but it is equally valid for private facilities.

$$\sum_{t=1}^{n} PD_t(P)(1+i)^{n-t} = C(1+i)^n + \sum_{t=1}^{n} O_t(1+i)^{n-t}$$

where
P = toll rate,
D = demand function for period t,
i = interest rate,
C = construction cost,
O = maintenance cost for period t,
n = period of redemption of bonds (in years), and
t = year.

In the initial period of road use, demand for the toll road will be small and price elasticity will be high. Demand will increase with time, resulting in lower elasticities. In sum, Fujii states that toll rates should be fixed at a relatively low level during the early years of operation, while higher rates should be adopted for later years. For a private facility, it is necessary to add one more term on the right side of the equation. This term is the return on investment (i.e., the profit factor). This model can be incorporated into the envisioned error forecast model and used to determine the setting of optimal toll rates (P). Fujii's model is a general equation since it does not specify the demand function for any period. This allows either a public or a private toll road authority to input specific demand elasticity functions for its roads and thus have a more accurate forecast model.

4.2 Private and Public Partnerships

Although we have mentioned private toll facilities throughout this report, in reality only minor roads can be completely private. A major toll road usually has some mixture of both private and public influence. A few types of public-private partnerships include:

(a) Total financing and operation by a private firm but under public oversight,
(b) Build-operate-transfer,
(c) Build-transfer-operate,
(d) Buy and operate after improvements, and
(e) Temporary arrangement for expansion and repair.

Such partnerships are claimed by some privatization experts as leading the way in exploring new technologies and techniques. These technologies and techniques include congestion pricing and the use of Automatic Vehicle Identification (AVI) to impose and collect toll charges. Congestion pricing theories have been available for some time; however, it is the innovativeness of the private facilities that will allow this technology to be implemented on a non-experimental basis. AVI is almost a mandatory requirement nowadays on all new toll roads, since the removal of toll plaza queuing delays is believed to be the single greatest incentive for drivers to use the facility.

Private toll roads are unlikely ever to be a significant portion of the high-performance highway system in the United States in terms of either mileage or dollar investment. The most important limitation is the sheer size of the existing U.S. road system, which means that many of the potential opportunities for profitable toll roads have already been pre-empted. Instead, private toll roads may serve as a laboratory for identifying and testing new concepts that, when successful, might be emulated by the much larger public highway system.

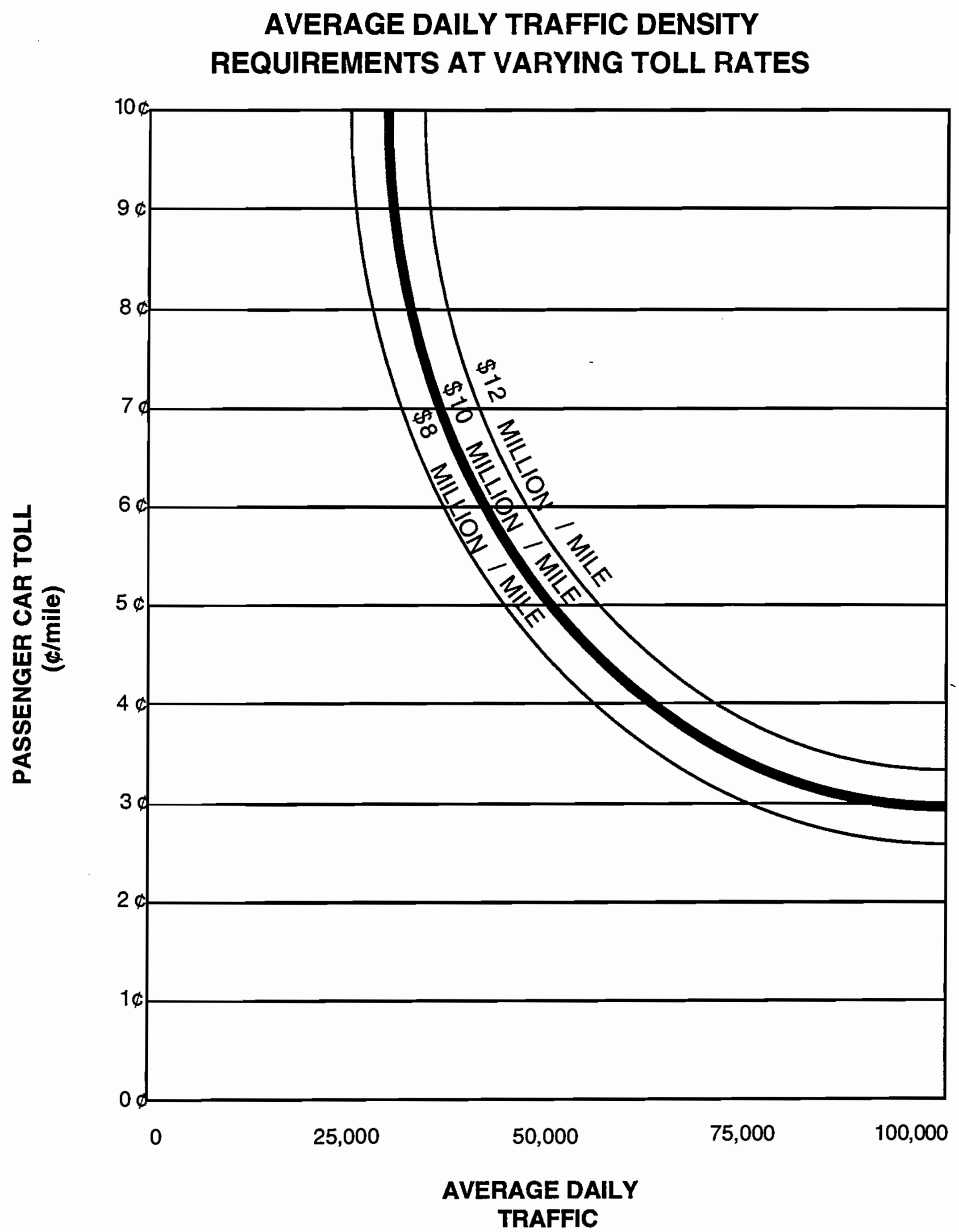
4.3 Other Financing Issues

As we have noted in previous sections, a toll road usually cannot survive on toll receipts alone, especially a road that traverses a lightly traveled route or a short road that acts only as a connector route. Many toll facilities, in order to raise enough revenue to be financially feasible, would either have to charge exorbitantly high rates on very few vehicles or charge acceptable rates on many vehicles. But the volume of traffic required to meet the financial requirements may turn out to exceed the physical capacity of the toll facility. Figure 14, developed by Vollmer Associates, provides a general relationship between traffic and vehicle toll rates.

This relationship makes one realize the close link between toll charges and traffic. Because of the obvious inability of toll receipts to cover all construction, operating, and maintenance costs, other sources of funds need to be established, especially for non-commuter toll facilities. Thus, in addition to tolls and federal aid, a toll road should also receive traditional state highway funds, local government funds, property donations of right-of-way, and tax diversions (Ref 4).

The bottom line in any committed participation by private-sector financiers is the project profitability. The most contentious factor in the profit equation is the forecast of revenue, which is linked to forecasts of traffic.

Figure 14 - Traffic vs. Vehicle Toll Rates



$ 12 MILLION / MILE = $ 7.5 MILLION / KM

$ 10 MILLION / MILE = $ 6.2 MILLION / KM

$ 8 MILLION / MILE = $ 5.0 MILLION / KM

1 cent per mile = 0.6 cent per kilometer

Travel demand forecasts are prominent in any toll road risk assessment. The private sector will increasingly look to the public sector and to consultants to provide better data and advice on such important items as direct and cross-elasticities of travel demand (toll charges, perceived costs, levels of service), traffic levels throughout the day (not just the AM peak), and values of travel time savings (Ref 2).

4.4 Summary

As this report draws to a close, it is hoped that the reader comes away with a better understanding of the complexity of issues involved in the building and operation of both private and public toll roads. Although most of the data analysis focused on public toll roads, private toll roads would probably have provided much of the same information. Similarities abound between the two types of roads: both serve the same purpose; both have varying elasticity of demand for different classifications of vehicles and for different times of the day; and both follow the Revenue-Traffic-Toll Charges diagram to some extent. The key difference is in the financing mechanism. But even here, similarities exist. A necessary input to determining revenues is an accurate traffic prediction. This report has measured, in a general sense, how good a job state toll authorities are doing in the forecasting business. Using this analysis, the report has focused on developing the groundwork for a computer model that not only forecasts traffic and revenues for some future year, but one that also measures the accuracy of that forecast. With this model, financial institutions that are interested in investing in toll roads can assess and compare different projects on a standard basis and then support the most feasible projects.

APPENDIX

FORECAST DATA SPREADSHEETS

TABLE A1

State	Authority	Toll Roads	Notes
Delaware	Delaware Transportation Authority	Delaware Turnpike	Tolls were increased on July 1, 1983. Tolls were adjusted on Oct. 1, 1989.
Florida	Orlando-Orange County Expressway Authority	Bee Line Expressway East-West Expressway Eastern Beltway	Airport Interchange opened in 1984. Tolls increased on January 1, 1987. North Section of Eastern Beltway opened in January 1989. Eastern Extension opened in July 1989. Tolls were increased on July 1, 1990. The Western Extension opened in October 1990. South Section of Eastern Beltway opened in July 1990.

TABLE A2

Year	Forecast Toll Revenues	Actual Toll Revenues	Revenue Deviation	Annual Revenue Increase	Annual Revenue Forecast Increase
1982		$12,400,000			
1983		$13,100,000		5.65%	
1984		$18,800,000		43.51%	
1985		$19,700,000		4.79%	
1986		$20,500,000		4.06%	
1987		$22,300,000		8.78%	
1988		$24,600,000		10.31%	
1989		$26,100,000		6.10%	
1990		$28,316,116		8.49%	
1991		$28,966,814		2.30%	
1992		$29,500,000		1.84%	
1982		$8,403,974			
1983		$9,489,730		12.92%	
1984		$12,624,422		33.03%	
1985		$13,879,651		9.94%	
1986		$15,199,141		9.51%	
1987		$21,791,544		43.37%	
1988		$28,025,883		28.61%	
1989		$31,748,729		13.28%	
1990		$37,498,267		18.11%	
1991		$49,749,499		32.67%	

TABLE A3

Year	Forecast Toll Traffic	Actual Toll Traffic	Traffic Deviation	Annual Traffic Increase	Annual Revenue Per Vehicle
1982		13,300,000			$0.93
1983		14,000,000		5.26%	$0.94
1984		14,400,000		2.86%	$1.31
1985		15,000,000		4.17%	$1.31
1986		15,600,000		4.00%	$1.31
1987		16,900,000		8.33%	$1.32
1988		18,700,000		10.65%	$1.32
1989		19,900,000		6.42%	$1.31
1990		20,526,342		3.15%	$1.38
1991		20,949,732		2.06%	$1.38
1992		21,800,000		4.06%	$1.35
1982		32,305,975			$0.26
1983		37,443,776		15.90%	$0.25
1984		51,723,337		38.14%	$0.24
1985		55,767,717		7.82%	$0.25
1986		60,399,659		8.31%	$0.25
1987		59,786,058		-1.02%	$0.36
1988		58,573,107		-2.03%	$0.48
1989		66,990,395		14.37%	$0.47
1990		78,336,132		16.94%	$0.48
1991		66,802,854		-14.72%	$0.74

TABLE A4

Year	Forecast Operating Expenses	Actual Operating Expenses	Cost Deviation	Annual Cost Increase	Annual Forecast Cost Increase
1982					
1983					
1984					
1985					
1986					
1987					
1988					
1989					
1990					
1991	$7,158,400	$7,055,034	1.47%		
1992					
1982					
1983					
1984					
1985					
1986					
1987					
1988					
1989					
1990					
1991					

TABLE B1

State	Authority	Toll Roads	Notes
Kansas	Kansas Turnpike Authority	Kansas Turnpike	
Maine	Maine Turnpike Authority	Maine Turnpike	Effective February 1, 1982 tolls were increased 40% for passenger cars and 50% for commercial vehicles. The actual traffic for 1982 to 1985 does not include commuter ticket traffic. Effective January 1, 1989 tolls were increased 15% for all classes of vehicles except commuter fares.

TABLE B2

Year	Forecast Toll Revenues	Actual Toll Revenues	Revenue Deviation	Annual Revenue Increase	Annual Revenue Forecast Increase
1981		$23,325,070			
1982		$24,117,610		3.40%	
1983		$24,938,729		3.40%	
1984		$26,445,909		6.04%	
1985		$26,710,402		1.00%	
1986		$29,947,857		12.12%	
1987		$32,096,753		7.18%	
1988		$34,663,558		8.00%	
1989		$36,569,464		5.50%	
1990		$38,282,710		4.68%	
1991		$39,879,283		4.17%	
1982		$17,686,922			
1983		$20,235,943		14.41%	
1984		$21,750,669		7.49%	
1985		$23,388,380		7.53%	
1986		$26,459,069		13.13%	
1987		$28,930,471		9.34%	
1988		$31,249,646		8.02%	
1989		$36,057,232		15.38%	
1990		$35,340,235		-1.99%	
1991	$35,528,000	$34,485,675	3.02%	-2.42%	
1992	$37,583,000				

TABLE B3

Year	Forecast Toll Traffic	Actual Toll Traffic	Traffic Deviation	Annual Traffic Increase	Annual Revenue Per Vehicle
1981		12,210,980			$1.91
1982		12,577,847		3.00%	$1.92
1983		13,055,228		3.80%	$1.91
1984		13,802,769		5.73%	$1.92
1985		14,580,849		5.64%	$1.83
1986		15,254,193		4.62%	$1.96
1987		16,319,724		6.99%	$1.97
1988		17,569,053		7.66%	$1.97
1989		18,638,572		6.09%	$1.96
1990		19,825,348		6.37%	$1.93
1991		20,543,038		3.62%	$1.94
1982		17,882,739			$0.99
1983		19,088,885		6.74%	$1.06
1984		20,939,430		9.69%	$1.04
1985		22,649,533		8.17%	$1.03
1986		28,807,000		27.19%	$0.92
1987		32,252,000		11.96%	$0.90
1988		35,444,000		9.90%	$0.88
1989		36,452,000		2.84%	$0.99
1990		36,916,000		1.27%	$0.96
1991		36,959,977		0.12%	$0.93
1992					

TABLE B4

Year	Forecast Operating Expenses	Actual Operating Expenses	Cost Deviation	Annual Cost Increase	Annual Forecast Cost Increase
1981		$9,632,489			
1982		$10,773,213		11.84%	
1983		$11,496,963		6.72%	
1984		$12,981,174		12.91%	
1985		$13,648,170		5.14%	
1986		$14,418,720		5.65%	
1987		$15,017,046		4.15%	
1988		$16,035,685		6.78%	
1989		$17,903,097		11.65%	
1990		$19,554,764		9.23%	
1991		$21,421,149		9.54%	
1982		$8,396,167			
1983	$9,239,380	$8,563,890	7.89%	2.00%	
1984	$9,869,740	$9,600,075	2.81%	12.10%	6.82%
1985	$11,363,020	$11,237,818	1.11%	17.06%	15.13%
1986	$13,018,264	$12,589,002	3.41%	12.02%	14.57%
1987	$13,391,630	$13,321,059	0.53%	5.82%	2.87%
1988	$15,068,310	$14,902,499	1.11%	11.87%	12.52%
1989	$17,543,765	$17,268,890	1.59%	15.88%	16.43%
1990	$19,400,000	$18,155,904	6.85%	5.14%	10.58%
1991	$21,300,000	$19,983,756	6.59%	10.07%	9.79%
1992	$22,700,000				6.57%

TABLE C1

State	Authority	Toll Roads	Notes
New Hampshire	Department of Transportation Bureau of Turnpikes	Central Turnpike (F.E. Everett Turnpike) Spaulding Turnpike (Eastern Turnpike) Blue Star Turnpike (Eastern Turnpike)	Two toll plazas (out of six existing) raised their rates to $.25 on April 15, 1987. One mainline toll rate was increased to $.75 on July 1, 1987, reduced to $.50 on October 28, 1987, and increased to $.75 on January 1, 1988. Another mainline toll rate was increased to $.40 on July 1, 1987 and reduced to $.25 on October 28, 1987. All passenger car tolls at each toll plaza were increased by $.25 on October 16, 1989. Commercial rates were higher and varied by class and toll plaza.

TABLE C2

Year	Forecast Toll Revenues	Actual Toll Revenues	Revenue Deviation	Annual Revenue Increase	Annual Revenue Forecast Increase
1981		$13,126,877			
1982		$14,749,693		12.36%	
1983		$15,929,853		8.00%	
1984		$17,689,870		11.05%	
1985		$19,244,579		8.79%	
1986		$21,463,244		11.53%	
1987		$23,494,286		9.46%	
1988		$29,690,994		26.38%	
1989		$31,830,111		7.20%	
1990		$43,365,808		36.24%	
1991	$45,510,000	$45,284,294	0.50%	4.42%	
1992	$45,550,893				

TABLE C3

Year	Forecast Toll Traffic	Actual Toll Traffic	Traffic Deviation	Annual Traffic Increase	Annual Revenue Per Vehicle
1981		34,280,722			$0.38
1982		40,201,990		17.27%	$0.37
1983		43,936,202		9.29%	$0.36
1984		49,272,474		12.15%	$0.36
1985		54,129,380		9.86%	$0.36
1986		61,146,936		12.96%	$0.35
1987		67,948,715		11.12%	$0.35
1988		73,856,042		8.69%	$0.40
1989		77,742,045		5.26%	$0.41
1990		73,642,422		-5.27%	$0.59
1991		69,605,913		-5.48%	$0.65
1992	71,106,891				

TABLE C4

Year	Forecast Operating Expenses	Actual Operating Expenses	Cost Deviation	Annual Cost Increase	Annual Forecast Cost Increase
1981		$13,475,952			
1982		$15,162,901		12.52%	
1983		$18,013,398		18.80%	
1984		$19,983,188		10.94%	
1985					
1986					
1987					
1988					
1989					
1990					
1991	$14,972,127				
1992	$18,382,057				

TABLE D1

State	Authority	Toll Roads	Notes
New Jersey	New Jersey Turnpike Authority	New Jersey Turnpike	Tolls were increased on March 17, 1991. Previous to that, the tolls were raised on April 1, 1980. During the last increase, two additional commuter bus classes were added. During the decade between 1990 - 2000, the Turnpike Authority is planning to spend $701,068,501.99 on various highway projects. The toll increase in 1991 raised tolls by 70% for cars, 0% for commuter buses, and 100% for trucks and non-commuter buses.
New York	New York State Thruway Authority	New York State Thruway	A toll increase was implemented on April 17, 1988 and on April 17, 1991. The latter increase was only for passenger cars at one barrier toll plaza.

TABLE D2

Year	Forecast Toll Revenues	Actual Toll Revenues	Revenue Deviation	Annual Revenue Increase	Annual Revenue Forecast Increase
1981		$126,188,012			
1982		$129,922,144		2.96%	
1983		$138,894,904		6.91%	
1984		$151,913,410		9.37%	
1985		$162,449,170		6.94%	
1986		$173,546,512		6.83%	
1987		$178,969,813		3.12%	
1988		$185,930,888		3.89%	
1989		$187,932,292		1.08%	
1990		$188,730,002		0.42%	
1991		$285,638,471		51.35%	
1992					
1987		$206,679,744			
1988		$269,243,253		30.27%	
1989		$289,859,797		7.66%	
1990		$290,717,487		0.30%	
1991		$287,851,358		-0.99%	

TABLE D3

Year	Forecast Toll Traffic	Actual Toll Traffic	Traffic Deviation	Annual Traffic Increase	Annual Revenue Per Vehicle
1981		127,211,999			$0.99
1982		132,932,001		4.50%	$0.98
1983		143,854,884		8.22%	$0.97
1984		156,029,218		8.46%	$0.97
1985		167,179,166		7.15%	$0.97
1986		178,838,750		6.97%	$0.97
1987		183,166,154		2.42%	$0.98
1988		190,740,162		4.14%	$0.97
1989		193,498,385		1.45%	$0.97
1990		197,167,048		1.90%	$0.96
1991		185,193,140		-6.07%	$1.54
1992					
1987		207,787,968			$0.99
1988		213,654,044		2.82%	$1.26
1989		203,805,254		-4.61%	$1.42
1990		206,565,431		1.35%	$1.41
1991		207,878,903		0.64%	$1.38

TABLE D4

Year	Forecast Operating Expenses	Actual Operating Expenses	Cost Deviation	Annual Cost Increase	Annual Forecast Cost Increase
1981					
1982					
1983					
1984					
1985					
1986		$102,093,000			
1987		$114,047,000		11.71%	
1988		$123,380,000		8.18%	
1989		$135,266,000		9.63%	
1990		$145,235,000		7.37%	
1991		$151,756,860		4.49%	
1992	$159,991,800				
1987		$121,619,947			
1988		$135,003,077		11.00%	
1989		$139,629,821		3.43%	
1990		$147,227,152		5.44%	
1991		$155,459,774		5.59%	

TABLE E1

State	Authority	Toll Roads	Notes
Ohio	Ohio Turnpike Commission	James W. Shocknessy Ohio Turnpike	The last toll increase went into effect on February 1, 1982. The increase averaged 40% for passenger cars and 50% for commercial vehicles.
Oklahoma	Oklahoma Turnpike Authority	Turner Turnpike H.E. Bailey Turnpike Will Rogers Turnpike Indian Nation Turnpike Cimarron Turnpike Muskogee Turnpike John Kilpatrick Turnpike Cherokee Turnpike Chickasaw Turnpike Creek Turnpike	There was a 30% toll increase on January 1, 1991.

TABLE E2

Year	Forecast Toll Revenues	Actual Toll Revenues	Revenue Deviation	Annual Revenue Increase	Annual Revenue Forecast Increase
1982	$70,500,000	$69,580,028	1.32%		
1983	$71,081,000	$74,684,605	-4.83%	7.34%	0.82%
1984	$75,000,000	$79,423,196	-5.57%	6.34%	5.51%
1985	$82,500,000	$81,828,324	0.82%	3.03%	10.00%
1986	$81,278,000	$85,179,347	-4.58%	4.10%	-1.48%
1987	$86,000,000	$88,994,672	-3.37%	4.48%	5.81%
1988	$89,500,000	$93,777,091	-4.56%	5.37%	4.07%
1989	$95,350,000	$95,455,492	-0.11%	1.79%	6.54%
1990	$95,825,000	$95,951,749	-0.13%	0.52%	0.50%
1991	$97,050,000	$93,242,888	4.08%	-2.82%	1.28%
1982		$39,500,217			
1983		$39,416,081		-0.21%	
1984		$42,073,962		6.74%	
1985		$42,650,059		1.37%	
1986		$44,302,459		3.87%	
1987		$45,494,393		2.69%	
1988		$48,933,043		7.56%	
1989	$51,259,000	$50,924,801	0.66%	4.07%	
1990	$53,788,000	$52,539,040	2.38%	3.17%	
1991	$56,305,000	$65,910,392	-14.57%	25.45%	
1992					

TABLE E3

Year	Forecast Toll Traffic	Actual Toll Traffic	Traffic Deviation	Annual Traffic Increase	Annual Revenue Per Vehicle
1982		23,724,506			$2.93
1983		24,793,586		4.51%	$3.01
1984		25,500,993		2.85%	$3.11
1985		26,442,420		3.69%	$3.09
1986		27,968,495		5.77%	$3.05
1987		29,267,915		4.65%	$3.04
1988		31,094,750		6.24%	$3.00
1989		32,467,990		4.42%	$2.89
1990		34,058,283		4.90%	$2.80
1991		34,080,680		0.07%	$2.82
1982		30,071,414			$1.31
1983		29,615,649		-1.52%	$1.33
1984		31,009,287		4.71%	$1.36
1985		31,280,332		0.87%	$1.36
1986		32,865,544		5.07%	$1.35
1987		30,984,017		-5.72%	$1.47
1988		36,450,042		17.64%	$1.34
1989		38,387,864		5.32%	$1.33
1990		39,654,329		3.30%	$1.32
1991		40,937,458		3.24%	$1.61
1992					

TABLE E4

Year	Forecast Operating Expenses	Actual Operating Expenses	Cost Deviation	Annual Cost Increase	Annual Forecast Cost Increase
1982	$32,177,155	$30,884,403	4.19%		
1983	$35,188,836	$32,843,707	7.14%	6.34%	9.36%
1984	$37,534,312	$35,655,881	5.27%	8.56%	6.67%
1985	$40,750,000	$36,985,025	10.18%	3.73%	8.57%
1986	$33,200,685	$38,472,388	-13.70%	4.02%	-18.53%
1987	$45,297,892	$40,547,569	11.72%	5.39%	36.44%
1988	$48,502,150	$43,355,932	11.87%	6.93%	7.07%
1989	$50,542,215	$47,549,974	6.29%	9.67%	4.21%
1990	$53,893,461	$49,087,461	9.79%	3.23%	6.63%
1991	$57,548,253	$52,221,424	10.20%	6.38%	6.78%
1982		$14,930,000			
1983		$14,000,000		-6.23%	
1984		$15,710,000		12.21%	
1985		$16,390,000		4.33%	
1986		$17,970,000		9.64%	
1987	$20,800,000	$17,730,000	17.32%	-1.34%	
1988	$21,700,000	$21,730,000	-0.14%	22.56%	4.33%
1989	$24,100,000	$24,070,000	0.12%	10.77%	11.06%
1990	$22,900,000	$22,860,000	0.17%	-5.03%	-4.98%
1991	$28,600,000	$28,620,000	-0.07%	25.20%	24.89%
1992	$27,700,000				-3.15%

TABLE F1

State	Authority	Toll Roads	Notes
Texas	Texas Turnpike Authority	Dallas North Tollway	Last toll increase became effective on October 1, 1982. Dallas North Tollway Extension opened in stages in 1986 and 1987.
West Virginia	West Virginia Parkways, Economic Development and Tourism Authority	West Virginia Turnpike	

TABLE F2

Year	Forecast Toll Revenues	Actual Toll Revenues	Revenue Deviation	Annual Revenue Increase	Annual Revenue Forecast Increase
1982	$9,181,000	$8,806,552	4.25%		
1983	$14,387,000	$13,017,243	10.52%	47.81%	56.70%
1984	$14,789,000	$13,640,487	8.42%	4.79%	2.79%
1985	$14,401,000	$13,350,417	7.87%	-2.13%	-2.62%
1986	$14,229,000	$13,889,419	2.44%	4.04%	-1.19%
1987	$23,986,000	$19,054,949	25.88%	37.19%	68.57%
1988	$23,878,000	$24,797,678	-3.71%	30.14%	-0.45%
1989	$26,424,000	$27,028,284	-2.24%	9.00%	10.66%
1990	$28,652,000	$29,754,559	-3.71%	10.09%	8.43%
1991	$31,500,000	$30,739,282	2.47%	3.31%	9.94%
1992	$33,894,000				7.60%
1981		$16,633,000			
1982		$18,491,000		11.17%	
1983		$19,912,000		7.68%	
1984		$22,608,000		13.54%	
1985		$24,830,000		9.83%	
1986		$28,070,000		13.05%	
1987		$31,227,000		11.25%	
1988		$36,270,000		16.15%	
1989		$39,131,000		7.89%	
1990		$38,656,000		-1.21%	
1991		$38,043,000		-1.59%	

TABLE F3

Year	Forecast Toll Traffic	Actual Toll Traffic	Traffic Deviation	Annual Traffic Increase	Annual Revenue Per Vehicle
1982		31,210,197			$0.28
1983		28,171,360		-9.74%	$0.46
1984		29,304,746		4.02%	$0.46
1985		28,396,621		-3.10%	$0.48
1986		29,951,012		5.47%	$0.46
1987		43,943,386		46.72%	$0.43
1988		55,681,612		26.71%	$0.45
1989		60,934,081		9.43%	$0.44
1990	65,931,000	67,281,576	-2.01%	10.42%	$0.44
1991	69,290,000	69,797,550	-0.73%	3.74%	$0.44
1992	77,726,000				
1981		5,808,000			$2.86
1982		6,386,000		9.95%	$2.90
1983		7,228,000		13.19%	$2.75
1984		8,683,000		20.13%	$2.60
1985		9,910,000		14.13%	$2.51
1986		11,750,000		18.57%	$2.39
1987		13,025,000		10.85%	$2.40
1988		15,350,000		17.85%	$2.36
1989		16,015,000		4.33%	$2.44
1990		18,147,000		13.31%	$2.13
1991		21,387,000		17.85%	$1.78

TABLE F4

Year	Forecast Operating Expenses	Actual Operating Expenses	Cost Deviation	Annual Cost Increase	Annual Forecast Cost Increase
1982	$2,893,110	$2,630,456	9.99%		
1983	$3,236,340	$2,866,590	12.90%	8.98%	11.86%
1984	$3,394,180	$3,034,535	11.85%	5.86%	4.88%
1985	$3,573,930	$3,236,147	10.44%	6.64%	5.30%
1986	$4,394,670	$3,691,732	19.04%	14.08%	22.96%
1987	$5,498,540	$4,785,093	14.91%	29.62%	25.12%
1988	$6,327,980	$5,860,417	7.98%	22.47%	15.08%
1989	$7,196,170	$6,343,415	13.44%	8.24%	13.72%
1990	$8,420,480	$7,389,016	13.96%	16.48%	17.01%
1991	$8,537,010	$7,289,657	17.11%	-1.34%	1.38%
1992	$8,654,290				1.37%
1981		$7,091,000			
1982		$8,328,000		17.44%	
1983		$9,254,000		11.12%	
1984		$10,213,000		10.36%	
1985		$11,631,000		13.88%	
1986		$12,363,000		6.29%	
1987		$13,820,000		11.79%	
1988		$15,537,000		12.42%	
1989		$16,955,000		9.13%	
1990		$13,666,000		-19.40%	
1991		$18,136,000		32.71%	

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