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of the requirements for

DOCTOR OF PHILOSOPHY degree in ECONOMICS

Major professor

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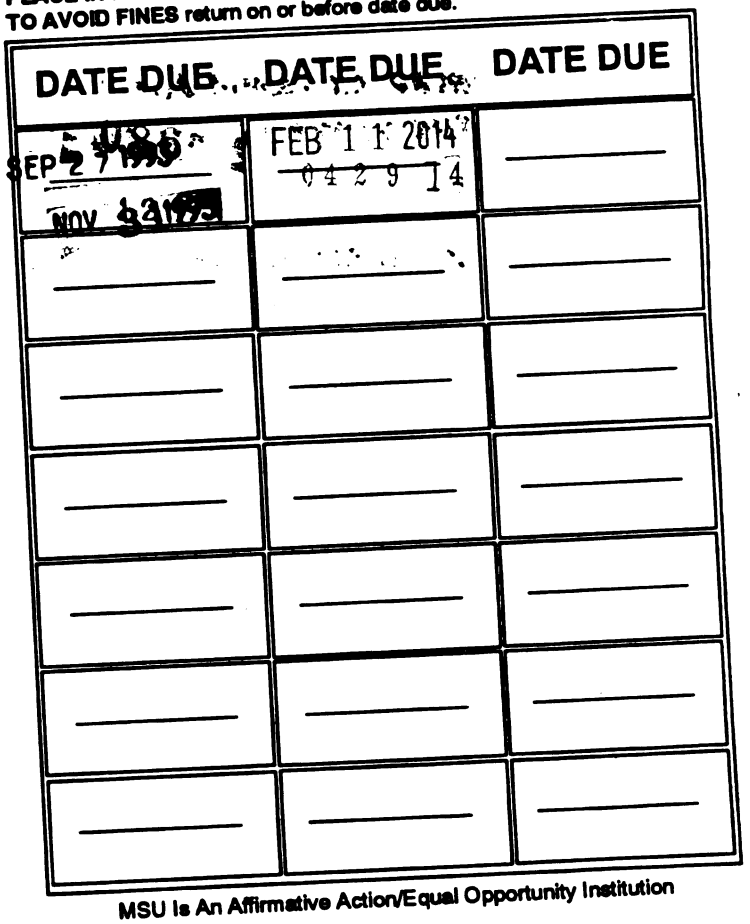

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A MONTHLY UPDATED REVENUE FORECASTING MODEL

FOR THE STATE OF MICHIGAN
Volume I

By

David Patrick Comyn Kelly

A DISSERTATION

Submitted to
Michigan State University
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ABSTRACT

A MONTHLY UPDATED REVENUE FORECASTING MODEL FOR THE STATE OF MICHIGAN

By

David Patrick Comyn Kelly

The monthly updated revenue forecasting (MURF) equations developed in this dissertation provide the State of Michigan with an improved means of both tracking revenue performance and refining estimates of revenue over the two-year budget forecast horizon.

Prior to the development of MURF, the econometric input into revenue forecasts was based solely on the output of a quarterly econometric model, SQEM, run by the Research Seminar in Quantitative Economics at the University of Michigan. The MURF equations use the forecasts of economic variables from this model.

However, the MURF equations for the most important taxes have a monthly frequency. This has both econometric and administrative advantages. From an econometric point of view the use of monthly data greatly expands the number of observations on the independent variables and so improves the accuracy with which the relationship between revenues and economic variables can be measured.

From an administrative point of view, the use of monthly forecasting models allows for an earlier recognition of trends in revenues which should allow for a smoother functioning of the budget process.

The MURF tax equations are shown to out-perform the SQEM tax equations in the 1987-1988 period. In addition the MURF equations generally outperform both individual auto-regressive moving-average (ARMA) equations and a vector autoregressive (VAR) model of a group of these taxes.

MURF also contains some entirely new features. For the first time an econometric model is used to forecast ticket sales for the state lottery. In addition, a model is developed to predict income tax refunds. These two innovations add about $1.5 billion to the scope of econometrically forecast General Fund-General Purpose and School Aid Fund Revenues.

ACKNOWLEDGMENTS

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I addition, I am also very grateful to the staff of the Office of Revenue and Tax Analysis in the Michigan Department of Management and Budget. In particular, I must thank Doug Drake both for his patience with my seemingly unending stream of questions concerning the Michigan tax system and his encouragement throughout. This dissertation would not have been possible without his help.

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CHAPTER I

INTRODUCTION

> "The governor shall submit to the legislature at a time fixed by law, a budget for the ensuing fiscal period setting forth in detail, for all operating funds, the proposed expenditures and estimated revenue of the state. Proposed expenditures shall not exceed the estimated revenue thereof...."[1]

Such is the formal language which sets out the constitutional requirement for a balanced budget in the State of Michigan. The constitution also requires that the budget be balanced as passed by the legislature, (Art.IV,Sec.31), and be kept in balance in the year of its operation, (Art.V,Sec.20).[2]

This requirement has, until recently, left the executive branch with a certain amount of leeway, since there has, in the past, been some flexability regarding the fiscal year to which some revenues and expenditures should be accrued. However, House Bill No. 5179, passed in 1984, required the state to move to generally accepted accounting principals (GAAP) in its budget process. In addition, the

1. Art. V, Sec. 18., Constitution of the State of Michigan See: "Michigan Statutes Annotated", Vol. 1A, Norbert Kamowski, ed., Callaghan & Co., 1983.

2. The state fiscal year runs from October 1st of the prior year to September 30th.

requirements to maintain GAAP certification have tightened over the years. As a result, the state government has less room to maneuver in dealing with impending deficits than in the past.

It is still, in theory, possible to run a deficit. One method is to simply ignore the constitution. The state constitution prohibits running a deficit but, slightly inconsistently, requires that any deficit run, become the first obligation of the next fiscal year, (Art.V, Sec.18). There is no legal penalty attached to running a deficit but the political consequences, as a notable recent example illustrates, can be painful.[3]

As an alternative, the state might decide to repeal the law which requires that the budget be balanced according to GAAP. It is possible to argue that GAAP is inconsistent and so should be abandoned.[4] However, pressing such a claim would also carry a political price.

Consequently, in the real world of Michigan in the late 1980's, if revenues are greatly overestimated, cuts in spending or increases in taxation become inevitable. Clearly then, there is a very high cost involved in inaccurate forecasts of revenues at the time of the passage

3. The deficit in Massachusetts proved to be an embarassment to its Governor in the Presidential election campaign of 1988.

4. Most notable among these inconsistencies is the requirement that income tax refunds paid out next year, based on economic activity in this year, be regarded as a liability of this fiscal year but that annual payments not be regarded as an asset of this fiscal year.

of the budget. There is also vital need to track revenues carefully in the course of the fiscal year. A revenue shortfall discovered in March is much easier to remedy than one noticed in August.[5]

Given the importance of correctly forecasting revenues, a brief look at how revenues have been forecast in the past seems in order.[6] The first serious attempt to produce an econometric model of the State of Michigan was D.B. Suits' 1966 model, which he produced at the University of Michigan.[7] This model was an annual model using data from 1949 to 1964. It contained 58 independently estimated OLS equations along with 20 non-stochastic or definitional equations. However, the state government did not use the output of this model to forecast revenues.

Prior to 1971, individual econometric equations were used to forecast revenues but no simultaneous equations model of the state economy was employed. Forecasts of the U.S. economy were derived from various sources including meetings with the economists of each of the major auto

5. Strictly speaking, the dollar magnitude of changes in taxation or spending might be the same in either case. However, the negative political and economic results of a one percent rise in the state income tax rate over six months would, in fact, be far less than that resulting from a three percent rise over two months.

6. The following history is based, for the most part, on converations with Tom Clay, Doug Drake and Dan Kitchel, all of whom work for the Department of Management and Budget.

7. See "Econometric Model of Michigan", Daniel B. Suits, State Resource Planning Program Technical Report No. 3, Lansing, Michigan, 1966.

firms.

Edward Robb, a graduate student at Michigan State University, constructed an econometric model of Michigan as his doctoral dissertation in 1971.[8] This model was estimated simultaneously, but did not include specific tax equations. For a while, Robb worked for the state and his model contributed to forecasts of Michigan economic variables, although other methods were used as well. At this time the budget function was performed by the Bureau of Programs and Budget in the governor's office. Robb left in the early 1970's at around the time of the creation of the Department of Management and Budget. At this time, revenue forecasts were still ground out using income projections and elasticity analysis.

In 1973, Saul Hymans and Harold Shapiro of the Research Seminar in Quantitative Economics, (RSQE), estimated a recursive model of the Michigan economy.[9] This was in response to both a perceived need to update and expand Suit's earlier work, and requests from the Senate and House fiscal agencies for an econometric model to use in evaluating the Executive branch's forecasts. This model was revamped and expanded into a fully simultaneous model in

8. See "A Quarterly Econometric Model of Michigan", Edward H. Robb, Thesis for the degree of Ph.D., Michigan State University, 1971.

9. See "The Michigan Economy in 1973", Saul H. Hymans and Harold T. Shapiro, The Economic Outlook for 1973 (Ann Arbor, Michigan: Twentieth Anniverary Conference on the Economic Outlook, November 16-17, 1972).

Joan Marcia Weisses' 1976 dissertation.[10]

In 1978, Julius Chiang, who had been doing much of the econometric work involved in revenue forecasting for Management and Budget, left to work in Washington. The Executive branch, after failing to find someone suitable to replace Chiang, agreed to use RSQE's model if the tax section was expanded, which it was. This model, after some modification became RSQE's current model of the Michigan economy, SQEM.[11]

At present, RSQE publishes forecasts of the U.S. economy six times a year, using its U.S. macroeconomic model, MQEM. Four times a year, output from this model is fed into SQEM. This model currently consists of 30 economic equations and 18 tax equations. The model is partly block-recursive and apart from feedback from the income-tax withholding equation to disposable income, none of the tax equations feed back into the economic equations. The output from these equations have, for the last decade, formed the principal basis for revenue forecasts.

There are a number of drawbacks, however, associated with this heavy dependence on SQEM. SQEM forecasts of the Michigan economy and revenues are only made four times a year, usually in March, June, September and November.

10. See "An Econometric Forecasting Model of the Michigan Economy", Joan Marcia Weiss, Dissertation for the degree of Ph.D., University of Michigan, 1976.

11. An outline of SQEM can be found in "A Regional Econometric Forecasting System", Harold T. Shapiro and George A. Fulton, University of Michigan Press, 1985.

Moreover, the June forecast only uses tax data from up to the end of the first quarter, the September forecast stops with tax data from the second quarter, etc.

The net result of this is that in August, the latest tax information being used in formal estimates of state revenues is the tax receipts of April. By August, for practical purposes, only three months of revenues which are relevent to the fiscal year budget remain unknown, those of August, September and October.[12] Yet the formal modeling procedure is missing seven months of tax information.

Partly in response to this problem, various ad hoc methods have been used to predict the month-to-month cash-flow associated with quarterly revenue forecasts.[13]

All of these methods, however, suffered from the drawback that, even if an unusually strong month of revenues could be identified as such, there was no good way of measuring the size of the state's good fortune or incorporating this information into forecasts of revenues. Perhaps more importantly, the converse was also true, so

12. This is only approximately true as, for some taxes, cash receipts from November and later months are accrued back to the old fiscal year.

13. One method has been to multiply the previous year's revenue for each month by the ratio of the forecast of this fiscal year's total revenue to the previous fiscal year's total revenue. An alternative method, which is only slightly more sophisticated, is to multiply the projected fiscal year total by the median fraction of annual revenue received in any one month over the previous decade. A regression method which estimates monthly revenues based on quarterly forecast totals and normalizes the forecast values to add up to the fiscal year forecast total has also been recently utilized.

that gauging the magnitude of an impending deficit was exceptionally difficult.

Another problem with an exclusive reliance on SQEM is the lack of any formal econometric models of income tax refunds and lottery revenues. These are perhaps the two of the most difficult parts of the state budget to forecast econometrically. However, as they summed to more than $1.4 billion in fiscal 1988, there is a clear need for the application of more, rather than less, science in these areas.

A third problem with the SQEM model concerns the accrual of revenues. For most of the major taxes, the revenues received in October are accrued back to the old fiscal year. For these taxes, SQEM measures the third quarter as running from August to October. However, for some taxes such as cigarette tax and oil and gas severance tax some revenues due in October are not actually recorded until November. Consequently, forecasts of accrued revenues are less accurate than they could be.

More seriously, SQEM estimates single business tax (SBT) revenues using calendar quarters and leaves the job of accruing revenues to the Department of Mangagement and Budget. However, forecasting the amount of the accrual for SBT is by no means a simple task. All of the estimated payments that were <u>due</u> at the end of October are accrued back to the previous fiscal year along with two-thirds of the estimated payments that were <u>due</u> at the end of November.

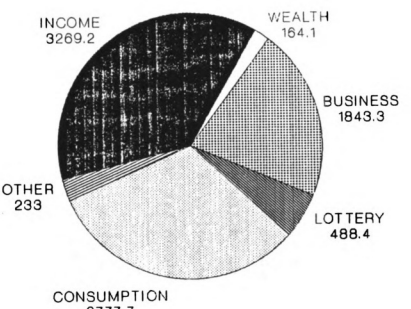
Crude methods of estimating this accrual, such as using the same fraction as last year of projected fourth quarter revenue, can lead to errors which are financially significant.

A fourth problem with using SQEM to forecast revenues, does not so much involve the specification of the model as its operation. The fit period for most of the equations in SQEM ends in the fourth quarter of 1983. Sets of adjustment constants are used to try to keep the model on track and for forecasts.

This is a sub-optimal procedure. First, the costs of mistakes are now so large relative to computational difficulty of reestimating SQEM, that at least an annual reestimation should be considered. Second, although recent income data may not be of sufficient quality to risk contamination of estimated coefficients, the same cannot be said of tax data. There is a very strong argument for at least updating the fit period for the tax equations. Third, a procedure of frequently reexamining tax equations increases the likelihood that advantageous changes in specification will be recognized and implemented.

The monthly updated revenue forecasting (MURF) system grew out of a need to deal with these problems and thereby provide more accurate forecasts of GFGP/SAF revenues over the two-year budget horizon. MURF now consists of 27 OLS equations used to explain and forecast the major General Fund and School Aid Fund revenue sources for the State of

FIGURE 1.1: GFGP/SAF REVENUE
FISCAL 1988, MILLIONS OF DOLLARS



SOURCE: MONTHLY FINANCIAL REPORT, JANUARY 1989

Michigan, shown in Figure 1.1. For the most important taxes, these equations use monthly observations on tax receipts, although MURF includes one semi-weekly, three weekly, six quarterly and eight annual models. All of these models are re-estimated on a monthly basis since, even for the annual models, there is usually some information gained in the course of a month.

There are a number of links among the equations in MURF. Disposable income, which is used in models of consumption taxes, is endogenous to MURF, since it is partly dependent on state income tax withholding. Both property taxes and the over-65 population are assumed to affect the number of state 1040 forms filed which, in turn, is used as an explanatory variable in the equations which generate the components of income tax refunds and annual payments. The equation for annual single business tax revenues uses an annual sum of lagged estimated payments as a regressor. The forecasts of intangibles and inheritance taxes depend, in part, on lagged values of income tax estimated payments. Finally, in the lottery models, Lotto sales feed into the model of Daily game sales and both are found to have an influence on Instant game sales.

However, the overall structure of these models still allows the use of ordinary least squares because all of these links are recursive.

In general, there are probably more differences than similarities between the individual MURF equations and their

SQEM counterparts. These differences are dealt with on a case-by-case basis in the chapters that follow. There are, however, a number of crucial differences that should be mentioned at the outset.

First, the fit periods for all but one of the MURF models are substantially shorter than their SQEM counterparts. The monthly frequency of the most important of the MURF models, however, allows them more degrees of freedom, as can be seen in Tables 1.1 and 1.2.

Table 1.1: Fit Periods, Observations & Independent Variables for Tax Equations in SQEM

SQEM Dependent Variable	Fit Period	# of Obs.	# of Ind. Vars.	Degrees of Freedom
Income Tax, Withholding	67.4 - 83.4	65	2	63
Income Tax, Quarterly	69.3 - 83.4	58	8	50
Income Tax, Annual	69.1 - 83.4	60	12	48
Sales Tax, Real Autos	57.3 - 83.4	106	14	92
Sales Tax, Nominal Others	57.2 - 83.4	107	10	97
Use Tax	56.2 - 83.4	111	6	105
Cigarette Tax	57.2 - 83.4	106	6	100
Beer And Wine Taxes	56.1 - 83.4	112	6	106
Utility Property Tax	58.4 - 83.4	101	4	97
Gross Single Business Tax	78.1 - 83.4	24	6	18
Inheritance Tax	68.1 - 83.4	64	6	58
Liquor Tax	68.1 - 83.4	64	6	58
Value of Oil Production	73.1 - 83.4	44	6	38
Value of Gas Production	72.4 - 83.4	45	6	39
Horse Tax	1957 - 1983	27	6	21
Intangibles Tax	1977 - 1983	7	1	6

Table 1.2: Fit Periods, Observations & Independent Variables for Tax Equations in MURF

MURF Dependent Variable	Fit Period	# of Obs.	# of Ind. Vars.	Degrees of Freedom
Income Tax, Withholding	76.09 - 88.12	148	24	124
Income Tax, Quarterly	77.1 - 88.4	48	9	39
Population over 65	1974 - 1987	14	3	11
State Equalized Valuation	1961 - 1988	28	5	23
MI 1040 Filers	1975 - 1987	13	4	9
General Prop. Tax Credits	1977 - 1987	11	4	7
Senior Prop. Tax Credits	1975 - 1987	11	4	7
Overwithholding	1975 - 1987	11	5	6
Income Tax, Annual	1975 - 1987	13	4	9
Sales Tax	76.03 - 88.12	154	29	125
Use Tax	76.03 - 88.12	154	28	126
Cigarette Tax	80.09 - 88.12	100	24	76
Beer And Wine Taxes	80.12 - 88.12	97	17	80
Liquor Tax	80.12 - 88.12	85	12	73
SBT, Quarterly, I	80.2 - 88.4	35	6	29
SBT, Quarterly, II	80.1 - 88.4	36	4	32
SBT, Quarterly, III	80.1 - 88.4	36	5	31
SBT, Annual	81.01 - 88.12	96	16	80
SBT, Refunds	81.06 - 88.12	96	21	75
Utility Property Tax	77.3 - 88.4	24	13	11
Oil and Gas Severance	80.02 - 88.12	107	22	85
Inheritance Tax	76.1 - 88.4	53	6	47
Intangibles Tax	1977 - 1988	12	3	9
Lotto Sales by Draw	05\09\87 - 02\11\89	185	5	180
Lottery, Lotto	04\28\86 - 02\13\89	147	17	130
Lottery, Daily Game	09\02\85 - 02\13\89	181	17	164
Lottery, Instant Game	11\17\86 - 02\13\89	118	13	105

Second, new data sets have been constructed for three of the taxes, SBT, cigarette tax, and oil and gas severance tax. These new data sets run from the middle of one month to the middle of the next. This both reduces the level of "noise" in these equations, allowing for more precise estimates of coefficients and allows for a more accurate forecast of final accrued fiscal year totals.

Finally, MURF includes models of both income tax refunds and sales from the state lottery. This latter model is, so far as I know, the only formal econometric model used by any state to forecast what is probably the fastest growing source of state revenues nationwide.

CHAPTER II

SOME ECONOMETRIC ISSUES

2.1 Introduction

There are a number of econometric issues involved in the construction of MURF which merit special attention at the outset. These issues are common to some or all of the equations and so it would be repetitive to deal with them in each chapter.

The question of the appropriate frequency for the dependent variable is addressed in the next section. The issue of how best to deal with serially correlated errors is considered in section 2.3. Section 2.4 reviews the use of dummy variables in MURF. The criteria used for various model specification decisions are reviewed in section 2.5. Section 2.6 considers the various specification and performance tests applied to the MURF models. Finally in section 2.7, I examine the question of how best to interpolate monthly income data from quarterly flows.

2.2 The Frequency of the Dependent Variable

The MURF model of GFGP/SAF revenues consists of eight annual equations, six quarterly equations, nine monthly equations, three weekly equations and one semi-weekly

equation. One of the basic differences between MURF and SQEM lies in MURF's use of monthly models to predict revenues from the most important taxes.

The decision to use monthly equations seems more efficient in these cases, quite apart from any administrative advantages in monitoring or forecasting cash-flow. The key theoretical question is this: Are monthly models inherently more efficient than quarterly models even if based, for the most part, on quarterly observations on economic variables?

One approach to this question is to look at three possible models. In model A, all information, both tax and economic, is only available in a quarterly form. It would still be possible to construct a monthly model by using some interpolation of quarterly data. Clearly, such an exercise would be pointless, since no information is gained by moving to monthly models. However, provided the interpolations within quarters reflected the pattern of the data between quarters, the estimated coefficients should be much the same as in the corresponding quarterly model, and the actual precision of these estimates, regardless of calculated t-statistics, should also be the same for both models.

Consider the other extreme. In model B, all variables, both dependent and independent are originally measured in monthly form. Using a quarterly model would remove two-thirds of the available observations. This, without any doubt, reduces the efficiency of the estimating procedure.

A monthly MURF model, model C, falls between these two extremes. Some of the independent variables are only measured quarterly and so an interpolation is required to generate monthly values. Some care is taken with this process, as is discussed in section 2.7. However, all of the dependent variables are measured on a monthly basis. There is clearly more information in this model than in the first extreme. The only circumstance which could make a quarterly model superior, is if adding different tax data and some independent variables which are measured monthly, generated more noise than information.

There are a number of reasons to believe that this is not the case. First, for the major taxes, revenues do not flow in smoothly throughout a calendar quarter. Rather they are clustered around specific payment dates in each month. Thus each quarter contains three distinct batches of information for each of these taxes and aggregating will almost certainly smooth out more information than noise.

Second, all but one of the monthly MURF equations employ either an AR or MA term or both. Thus revenue data from this month are useful as predictors of future revenues.

Third, the effects of any change in tax rates which occur in mid-quarter can be measured with more precision in monthly models.

Fourth, any unusual quarterly observations can usually be traced to an unusual occurance in a particular month. Dealing with such an outlier will thus cause the sacrifice

of a smaller fraction of the total fit period in a monthly model.

Fifth, unusual observations due to accounting or other errors are easier to recognize in a monthly model than a quarterly model. This reduces the danger that true outliers will go unnoticed.

Except under some very restrictive assumptions, it is probably not possible to verify the above argument with a mathematical proof and I have not attempted to do so.[1]

Apart from the use of monthly models there are other questions of frequency to deal with. The model for annual payments on income tax uses an annual frequency since inter-month or even inter-quarter variation in revenues is caused by factors which cannot easily be exploited in an econometric model. This is also the case for the intangibles tax.

The utility property tax is levied in two payments and so the model used is perhaps best described as a semi-annual model, although regressed over just the last two quarters of each year.

The model for estimated payments on single business tax

1. Kmenta (1971) proves the inefficiency of grouping individual observations on both dependent and independent variables, when individual observations on both are available. See "Elements of Econometrics" by Jan Kmenta, The MacMillan Company, 1971, pp. 324-325, for details. However, it is not possible to prove the same result when one or more of the variables is only available in grouped form, since any general proof should require some assumptions about the within group variation of the grouped variable which is, in this case, unobserved.

consists of three quarterly equations which use data from the first, second and third months of each quarter respectively. This method is used to exploit the fact that the same group of taxpayers make payments in the same month in each quarter. It also helps avoid the severe heteroskedasticity problem caused by using data on large payment months and small payment months in the same monthly equation. These equations also avoid the loss of efficiency in aggregating monthly data into quarterly totals. At the same time, however, they do not benefit from the extra degrees of freedom afforded by purely monthly models.

The equations for inheritance tax and quarterly payments on income tax are expressed as more orthodox quarterly models. In both cases it was felt that aggregation reduced the noise in the data more than the information.

The equation used to construct a distribution of Lotto jackpots is measured on a per-draw basis as this allows the greatest precision in estimating the effect of the guaranteed jackpot on sales.

The other lottery equations are measured on a weekly basis. This is mainly due to the availability of weekly data over a four year period, as well as the need to use a period of at least this length to measure the income elasticity with any accuracy.

It should be emphasized, however, that the choice of model frequency is for the most part a matter of judgement.

The judgements made on this, as well as in a host of other decisions in specifying MURF, stand or fall based on the forecast performance of these models.

2.3 Serial Correlation

Serial correlation presents both a problem and an opportunity for the forecaster. On the one hand, it is an admission of failure. It implies that there is some trend in the data that either has not, or can not, be modeled by some respecification. The corrections using lagged dependent variables, AR, or MA terms clearly represent second best alternatives.

The best solution to a problem of serial correlation is to directly remove the cause of the affliction. There are many possible causes including the incorrect omission of relevent regressors, the use of an incorrect functional form, the inability to deal with more complicated forms of seasonal variation and trended measurement error.

Attempts have been made to deal with all of these problems in the MURF models of state revenues. Nevertheless, some correlation remained among residuals from different periods in most of the regressions. Moreover, given the high degree of explanation in most of the equations without corrections for serial correlation, this problem becomes more noticeable.

Consequently, when all other avenues had been closed, AR and MA terms have been used as regressors.[2]

2.4 The Use of Dummy Variables

There are four general types of dummy variables in MURF models of state revenues.

First, there are single month dummies. B8203 takes a value of unity in March of 1982 and zero elsewhere. This dummy, in most cases, ensures that data on the dependent variable for March of 1982 will have no effect on the estimated coefficients for all other variables.

This is only approximately true in models using AR terms as the dummy is used to model both its own and the following residual in the case of AR(1) transformations. However, from a practical standpoint, the error caused in AR models tends to be very small.

The use of zero-one dummies, such as B8305, to exclude the effects of outliers is convenient in that it easily identifies the offending observation. It also allows the use of AR and MA terms which TSP, the regression package with which MURF is estimated, will not allow with split samples, an alternative means of excluding outliers. It should be noted, however, that individual outlier dummies have the effect of artificially inflating the estimated R^2. This is not a serious problem unless R^2 is being used as a

2. It is worth noting that although these terms help in the context of short-run forecasting such as the two-year horizon over which revenues are normally forecast, they are by no means recommended for longer-run models of revenues. With the passage of time it becomes increasingly likely that the underlying specification problem, which is temporarily solved by the use of these terms, will return to haunt the forecaster.

principal measure of model performance, which is probably unwise even in the absence of this problem.

Second, there are seasonal dummies such as TR1, the dummy variable for January. This shows the estimated deviation of January revenues from December revenues, given the values of all the other independent variables. The coefficient on TR1 is chosen to minimize the sum of the squared residuals of January observations. In the MURF model of annual payments and refunds on single business tax, these dummies are multiplied by a time trend to allow for a changing pattern of seasonal variation over time.

Third, there are variables such as JAN1F in the withholding equation and INCENT in the sales tax equation. As an example, JAN1F is used in a year in which January 1st falls on a Friday. When this occurs, paychecks which would normally have been handed out in January, are handed out on the last day of December. As employers are forced to pay withholding on the 15th of January, for all wages paid in December, this has the effect of inflating January withholding revenues and reducing those of February.

Consequently, JAN1F takes a value of one in January and minus one in February in a year in which January 1st falls on a Friday. This restricts the estimated adjustment in January to have the same absolute level and the opposite sign in February. This situation occurs twice in the fit period for the withholding equation, with the absolute level of the adjustment being determined by the minimization of

the sum of the squared residuals in the four affected months.

It is important to note that these dummies are being used to model the amount of inter-month movement in revenues rather than to eliminate the effect of the residuals in these months on the estimated coefficients. The advantage of this procedure is that it allows the model to estimate this effect when it occurs again.

Fourth, there are dummies such as BAFT76 in the state equalized valuation (SEV) equation. This variable is used to model the effect on SEV of the exclusion of business inventories and takes a value of zero for observations up to 1975 and one for observations after that. This is used in a log equation so that its effect rises with the overall level of SEV.

Dummy variables are like corrections for serial correlation, in that they represent a second best alternative. Attempts should and have been made to replace them with the information which they proxy. Importantly, wherever it has been possible to adjust a series for known changes or unusual events, this has been done. However, as is emphasized in the next section, the focus of MURF is clearly on providing the best short-term forecast of revenues rather than proving beyond a reasonable doubt, the validity of all specification choices.

2.5 Specification Criteria for Including Regressors and Excluding Outliers

In all choices regarding the specification of MURF models of state revenues, I have quite deliberately used a fairly liberal set of criteria. It is, I believe, crucially important to recognize the distinction between a purely academic economic model, whose primary purpose is to prove a relationship, and a forecasting model.

In the former type of model, and indeed, throughout statistics, a sharp distinction is drawn between a type I error and a type II error. An example of a type I error would be the inclusion an irrelevant regressor. A type II error would be to wrongly exclude a relevant regressor. A type I error is judged to be a much more serious mistake than a type II error and consequently a t-statistic of two or more is normally called for to justify the inclusion of a regressor. Under ideal conditions, this is equivalent to reducing the chance of a type I error to one in twenty.

In a model which is explicitly used for forecasting, such a stringent criterion for including a variable does not seem to be justified. If we are 90 percent sure that including a variable will improve the ability of the equation to forecast, then it seems logical to include it. The reverence in which a t-statistics are normally held obscures the fact that ultimately it is the loss function of the analyst that should determine the inclusion or exclusion of independent variables. If including a variable will most

likely perceptably increase the accuracy of forecasts then that variable should be included.

A very similar issue is how to deal with outliers. In a purely academic paper on what is the "true" money demand function, an analyst could very rightly be criticized for excluding observations that did not agree with his/her theoretical view of the world. It could be said quite fairly that the analyst had failed to explain the demand for money if the most remarkable observations are ignored.

The criteria applied to a model specifically designed for forecasting should necessarily be slightly different. If the cause of an outlying observation is known, and is unlikely to recur, then it is probably wisest to omit this observation. For example, the months immediately surrounding changes in the cigarette tax rate tend to be unusual, due to individuals and retailers stocking up in advance of the increase. These observations will tend to distort the regression line, and provided no change in the tax rate is in the forecast horizon, they should be dropped.[3]

A more difficult decision is to drop outlying observations where the reason for the unusual observation is not clear. There is no clear decision rule to follow here.

3. A fairly basic point with regard to outliers should always be borne in mind. Least squares, as its name implies, weights observations by the square of their residuals. Consequently, outlying observations which are retained in the fit period have a much more than proportional effect on the values of estimated coefficients.

However, it should be safer to drop such observations if they occur early in the fit period. The question that the analyst needs to consider is whether this observation is more likely to be due to some institutional factor that is unlikely to recur, or some economic trend which should not be ignored for forecasts.[4]

As in many of these issues, the question of the exclusion of outliers is ultimately a judgement call. However, it should be stressed that the judgement used should and has been influenced by a recognition of the ultimate goals of MURF as a forecasting model.

2.6 Performance and Specification Tests

The main test of the performance of all MURF models is a series of post-sample, dynamic forecast simulations. In most cases, this has involved forecasting the 24 monthly observations between January 1987 and December 1988. These forecasts are then compared with actual values, forecasts

4. An example of the former occured in February and March of 1989, when a total of about $30 million in estimated SBT payments were incorrectly put in the annual payments account. This error was apparently due the vacation of the individual who normally records these numbers. Although this error was corrected, it is likely that the data sets for all the major taxes contain errors of this type.

On the other hand, January withholding revenues have been above fitted levels for the last three years. One hypothesis advanced for this phenomenon is an increase in year-end bonuses. Although it has not yet been possible to verify this theory or alternative theories, it is probable that without some correction, the current model will underestimate January revenues in 1990. Clearly, this is a case where it would be a great mistake to omit observations with large residuals.

generated by a simulation of the SQEM equations and forecasts generated by both ARMA and VAR models.

There are a number of respects in which these comparisons could be criticized. First, the forecast performance of any model depends both on quality of the model specification and the ability to forecast the independent variables. Whereas this has been a constant concern in the construction of MURF models, no adjustment is made to allow for this second factor in the dynamic simulations, since all values of independent variables used are historical values.[5]

A second problem with simulations over this period is that the specification of MURF models was necessarily somewhat influenced by actual tax data from this period. The day-to-day operation of MURF requires that the most recent data be used in constructing forecasts. As a result, it was impossible not to examine the performance of the MURF models when regressed over this period. Consciously or sub-consciously, variables have been included, outliers have been excluded and changes in functional form have been considered, partly in light of the data in the simulation period.[6]

It should be emphasised, however, that coefficients used in dynamic simulations were all estimated using fit

5. It should be noted that the root mean squared errors (RMSE) of ARMA and VAR models tested somewhat understates their relative performance, since they do not rely on the accuracy of forecasts of exogenous variables.

periods that ended prior to the simulation period. Moreover, even given these problems in comparison, the relative performance of the MURF models over this period is, I believe, fairly convincing.

Apart from simulations, three formal tests were conducted on most of the MURF models, a likelihood ratio test for structural change, a likelihood ratio test for the significance of seasonal dummies, and a Box-Pierce test for white noise residuals[7]. In addition to the normal statistical output, an adjusted R-squared was calculated to measure the usefulness of variables other than time-series variables and seasonal dummies.

The first likelihood ratio test for was used to determine if the hypothesized relationship between taxes and economic variables was constant over time. The test compared the log of the likelihood function generated by running the regression over the second half of the sample period with the same statistic evaluated by setting all the coefficients for the second half of the regression period equal to their fitted values over the entire sample range. Failure of this test could also be interpreted as a sign of

6. Because of this, the performance of MURF relative to SQEM maybe somewhat overstated. However, one of the basic tenets of the operation of MURF is that equations should be reestimated and the specification reexamined every month in light of new data. Consequently, I do not feel too guilty about the advantage given to MURF over SQEM, whose fit period for most taxes ends in 1983.

7. See "Econometric Models and Economic Forecasts", by R.S. Pindyck & D.L. Rubinfeld, McGraw-Hill, 1976, pp. 490-492, for details.

significant measurement error in economic variables, in particular, state personal income. The null hypothesis was that of structural stability and this was tested at the five percent level.

The likelihood ratio test for the significance of seasonal dummies was used to determine if seasonal dummies collectively contributed to the overall fit of the regression.[8] In this case, the null hypothesis was that of no seasonal variation and this was also tested at the five percent level.

The Box-Pierce test for white noise residuals was used in preference to the Durbin-Watson test for auto-correlation for two main reasons. First, tables of the Durbin-Watson statistic for more than 100 observations or more than five independent variables are rare. Second, and more importantly, the Box-Pierce test allows the analyst to check for more subtle forms of inter-temporal relationships between residuals than the Durbin-Watson test. The null hypothesis is that of white-noise residuals and this is tested at the five percent level.

8. One option considered was including only those individual seasonal dummies which appeared to be significant. This approach was rejected, however, for two main reasons. First, there is no shortage of degrees of freedom in most of the MURF models, which considerably reduces the cost of including irrelevent regressors. Second, in most cases, there is a strong theoretical prior that if seasonality is present in some months then it is also present in others. If this is the case, then including seasonal dummies, even with very low t-statistics, will probably marginally improve forecast performance.

The results of all simulations and tests are discussed on an individual basis in the text.

2.7 Interpolating Income within Quarters

In building monthly revenue models using quarterly economic data, some decision needs to be made on a method for constructing monthly observations on the economic data. The crudest method possible would be to repeat each observation three times. Thus, for example, January wage and salary income, AVWSM1, could be calculated as:

(2.1) $AVWSM1_{January} = WSM_{qtr1}$

The error caused by doing this might not be too large, so long as the pattern of growth through the first quarter repeated itself each year, since the seasonal dummies in the tax equation would allow for a constant growth in revenues relative to income throughout the first quarter. However, in so far as the actual growth in income in the first quarter of one year differed from the growth in the first quarter of another year, error would be introduced.

An acceptable alternative for most purposes is to use a simple, three-month linear interpolation, to generate a monthly income series.[9] Using this, January income is calculated as:

(2.2) $AVWSM2_{January} = ((WSM_{qtr4})+(WSM_{qtr1})+(WSM_{qtr1}))/3$

February income is calculated as:

(2.3) $AVWSM2_{February} = ((WSM_{qtr1})+(WSM_{qtr1})+(WSM_{qtr1}))/3$

and March income is calculated as:

(2.4) $AVWSM2_{March} = ((WSM_{qtr1})+(WSM_{qtr1})+(WSM_{qtr2}))/3$

This pattern is shown in Figure 2.1 for the period September 1979 to December 1980. This period was chosen as it is one of the few periods in the last fifteen years in which contains a noticeable decline in nominal wage and salary income.

There are three basic problems with this method. First, it is normally assumed that nominal income grows in a geometric rather than arithmetic progression. In other words, it might be more accurate to assume growth at a constant rate throughout a quarter rather than growth of equal nominal amounts between months. One solution to this problem is to calculate January, February and March income as in equations (2.5), (2.6) and (2.7) below:

(2.5) $AVWSM3_{January} = ((WSM_{qtr4})*(WSM_{qtr1})*(WSM_{qtr1}))^{1/3}$

(2.6) $AVWSM3_{February} = ((WSM_{qtr1})*(WSM_{qtr1})*(WSM_{qtr1}))^{1/3}$

(2.7) $AVWSM3_{March} = ((WSM_{qtr1})*(WSM_{qtr1})*(WSM_{qtr2}))^{1/3}$

This pattern is shown in Figure 2.2.

9. It should perhaps be noted that although I describe this as a "three-month" linear interpolation, the monthly values which are being interpolated are identical within each quarter. This is, I believe, fairly obvious both in the text and in the algebra and this description has been retained as I have been unable to come up with a more precise term which is not a considerably more cumbersome.

FIGURE 2.1: INTERPOLATIONS OF WSM

(QUARTERLY VALUES & THREE-MONTH LINEAR INTERPOLATION)

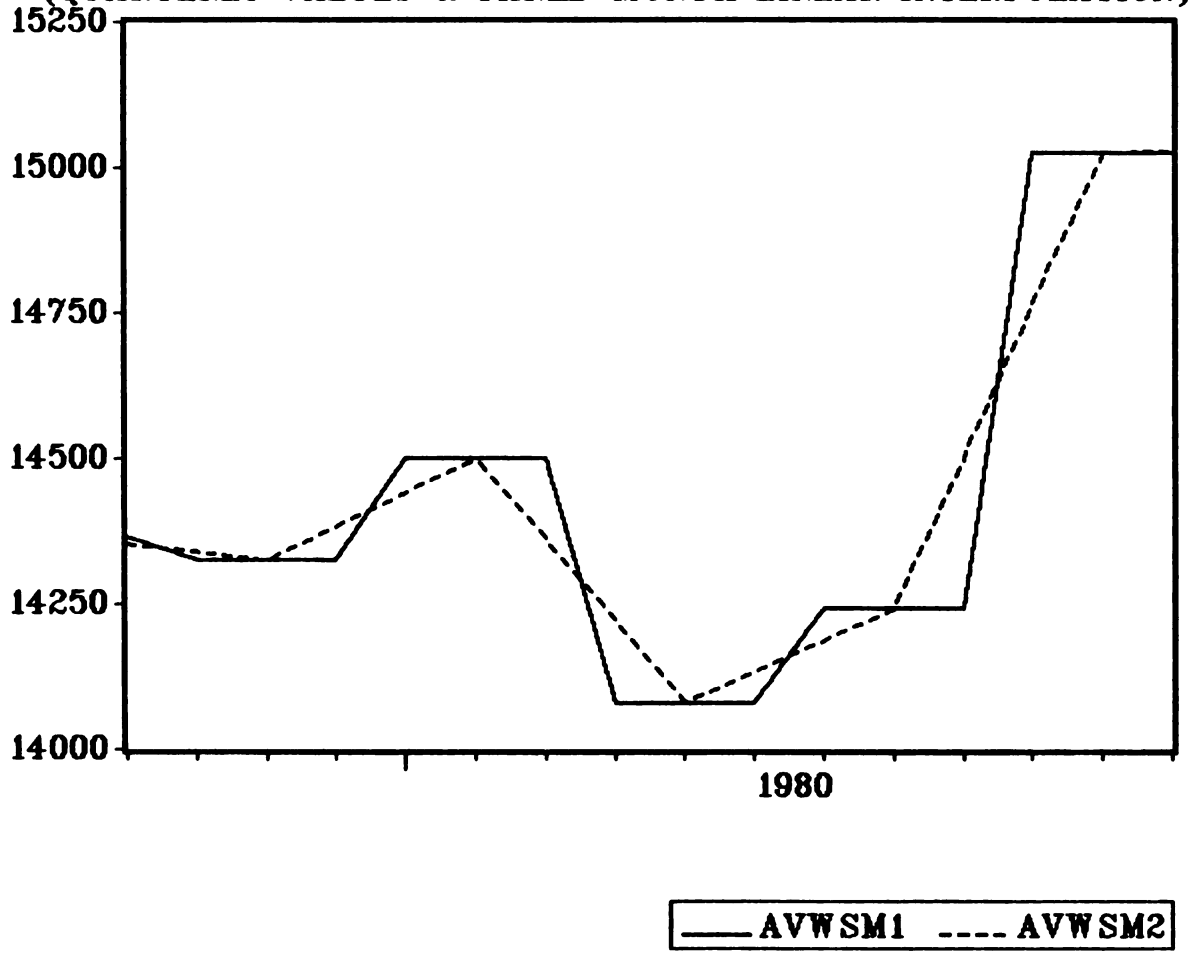
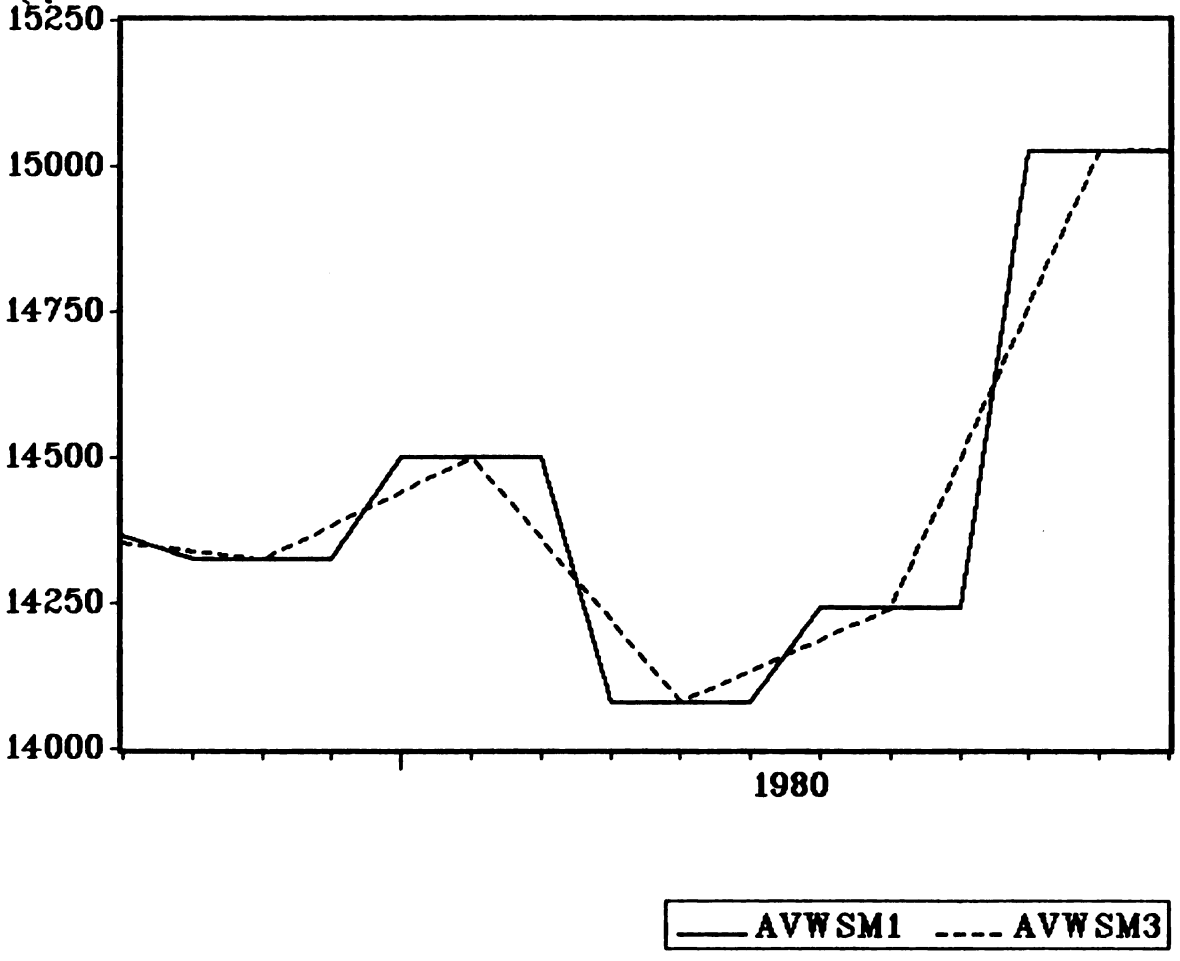


FIGURE 2.2: INTERPOLATIONS OF WSM

(QUARTERLY VALUES & THREE-MONTH GEOMETRIC INTERPOLATION)



A second problem with either of these methods is that they both place turning points in the middle of the quarter. For example, if income rises from the fourth quarter to the first quarter but then falls from the first quarter to the second quarter, both of these methods will show a peak in February. If the fall between the first and second quarters is much larger than the rise between the fourth and the first, then we might expect income to peak in January rather than in February. A solution to this is to use a five-month geometric interpolation, which is shown in Figure 2.3. Thus we have:

(2.8) $$AVWSM4_{January} = ((WSM_{qtr4})*(WSM_{qtr4})*(WSM_{qtr1})*(WSM_{qtr1})*(WSM_{qtr1}))^{1/5}$$

and similarly:

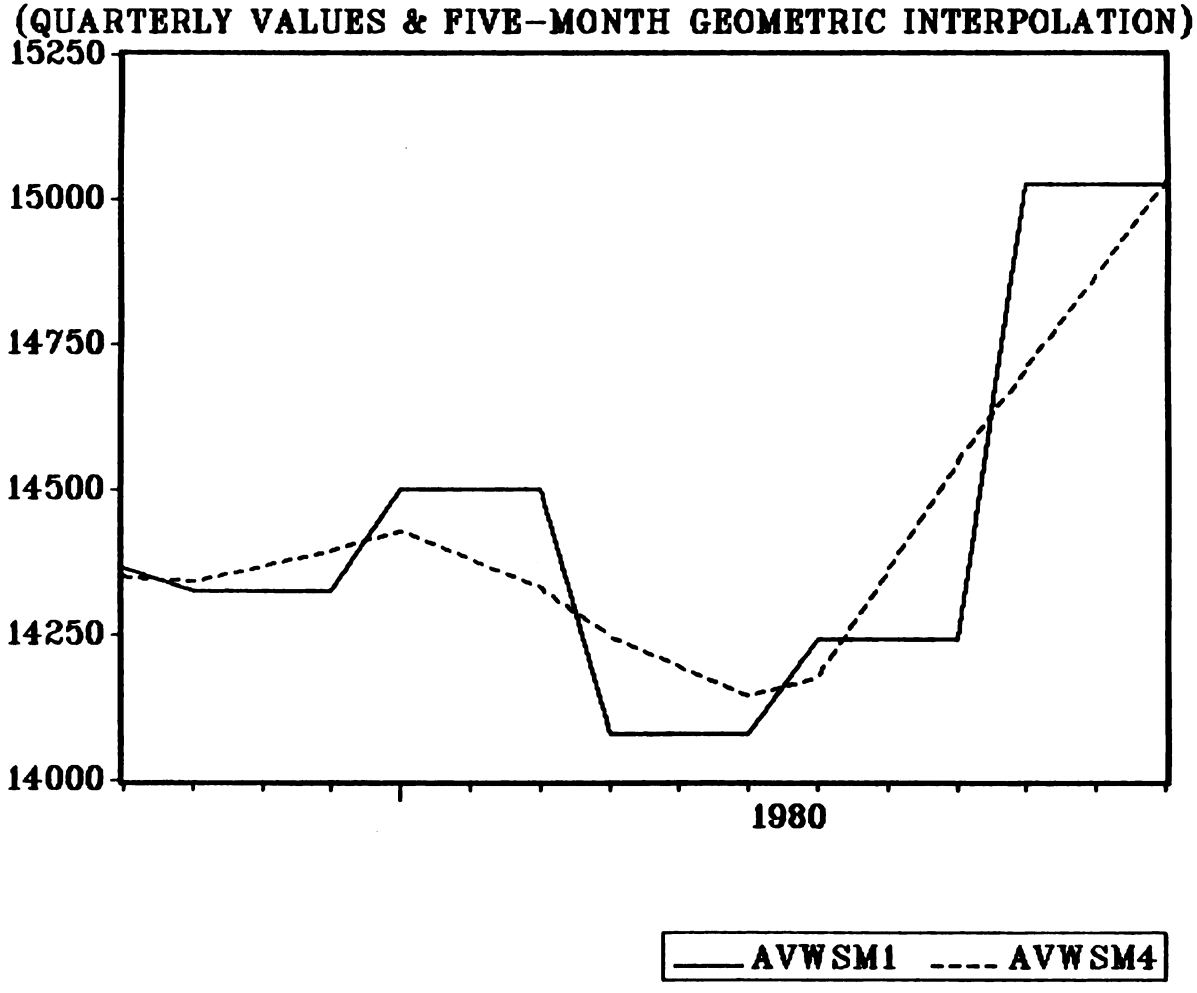
(2.9) $$AVWSM4_{February} = ((WSM_{qtr4})*(WSM_{qtr1})*(WSM_{qtr1})*(WSM_{qtr1})*(WSM_{qtr2}))^{1/5}$$

and,

(2.10) $$AVWSM4_{March} = ((WSM_{qtr1})*(WSM_{qtr1})*(WSM_{qtr1})*(WSM_{qtr2})*(WSM_{qtr2}))^{1/5}$$

A final problem that remains is that none of the methods outlined above guarantees that the average of January, February and March equal the average for the 1st quarter. A solution to this is to multiply AVWSM4 by WSM

FIGURE 2.3: INTERPOLATIONS OF WSM



for the quarter and then divide by the average of calculated values of AVWSM4 over the quarter. This is shown in Figure 2.4 and calculated according to equations (2.11), (2.12) and (2.13) below:

$$(2.11)\qquad AVWSM5_{January} = (AVWSM4_{January})^{*}\frac{(WSM_{next})}{((AVWSM4_{January})+(AVWSM4_{February})+(AVWSM4_{March}))/3}$$

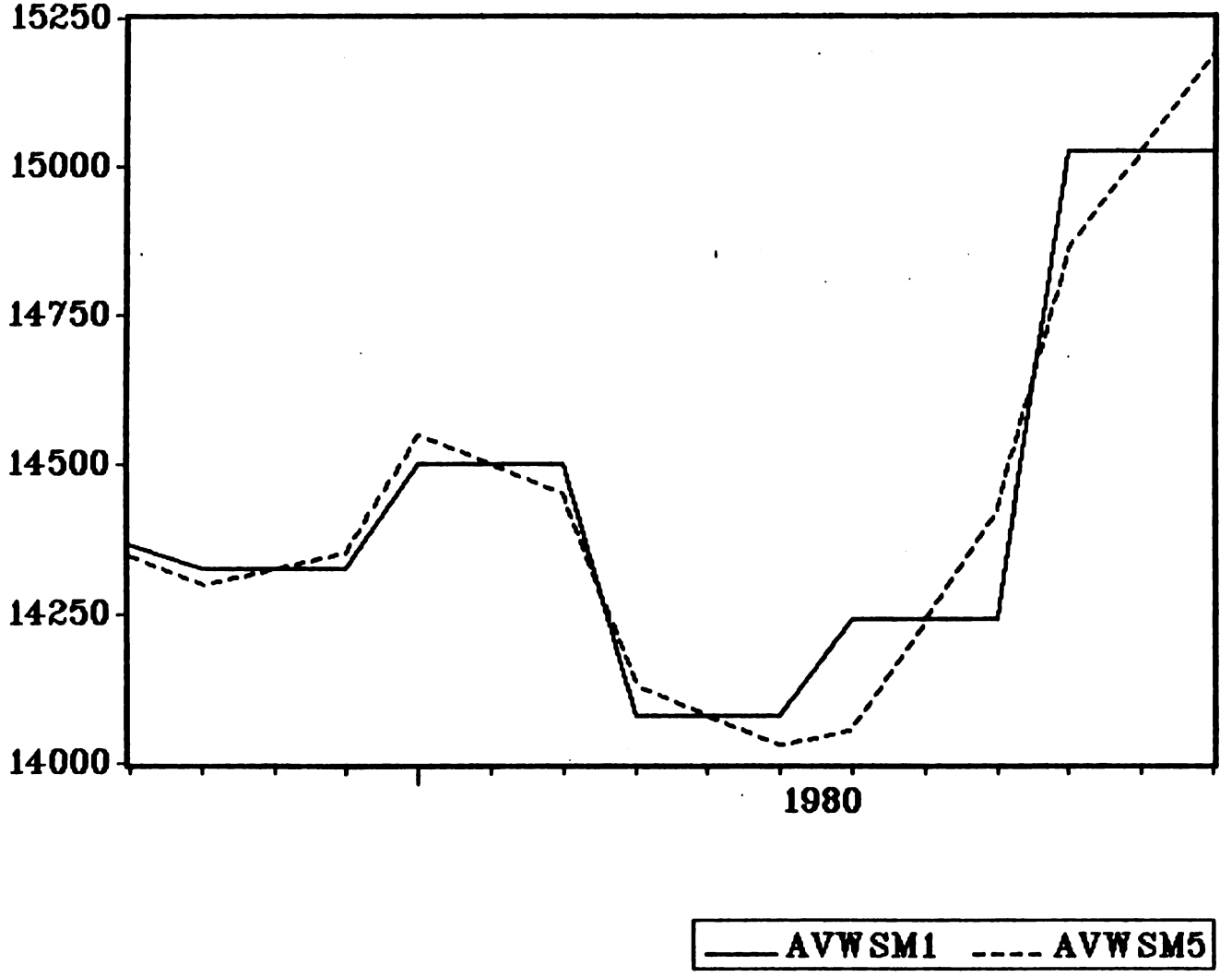
$$(2.12)\qquad AVWSM5_{February} = (AVWSM4_{February})^{*}\frac{(WSM_{next})}{((AVWSM4_{January})+(AVWSM4_{February})+(AVWSM4_{March}))/3}$$

$$(2.13)\qquad AVWSM5_{March} = (AVWSM4_{March})^{*}\frac{(WSM_{next})}{((AVWSM4_{January})+(AVWSM4_{February})+(AVWSM4_{March}))/3}$$

In light of the efforts required to arrive at this interpolation, it is a little disappointing that it does not perform noticeably better than the others. In fact, as measured by R-squared, the model using the five-month, geometric normalized interpolation, AVWSM5, fits slightly worse than AVWSM1. It should be stressed that the highest R^2 achieved using any of these interpolations was .996241 whereas the lowest was .996067. Because of this and because of its reasonable theoretical underpinnings, I have used the last of these interpolations to generate observations on income variables in most cases. Like all variables in MURF, however, this is retained on a strictly probationary basis.

FIGURE 2.4: INTERPOLATIONS OF WSM

(QUARTERLY VALUES & FIVE-MONTH NORMALIZED GEOMETRIC INTERPOLATION)



CHAPTER III

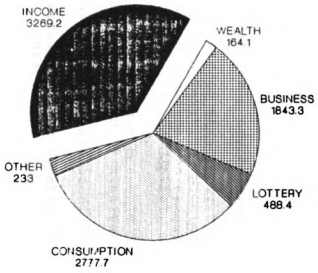
INDIVIDUAL INCOME TAX

3.1 Introduction

The Michigan personal income tax is the biggest single contributor to GFGP/SAF[1] revenues, accounting for more than 37% of total revenues in fiscal 1988. In fact, as is shown in Figure 3.1, gross general fund collections from income tax amounted to $4,519.7 million in 1988, although this total was reduced by more than $1 billion by income tax refunds and payments to units of local government. This chapter is divided into five sections. In the next section, the history of the state income tax is briefly reviewed. In section 3.3 the MURF model for income tax withholding is outlined. The model for estimated (quarterly) payments on income tax is explained in section 3.4. Finally, section 3.5 contains the models for both income tax refunds and annual payments.

1. GFGP stands for general fund - general purpose. SAF is the acronym for the school aid fund.

FIGURE 3.1: INCOME TAX COMPONENTS
FISCAL 1988, MILLIONS OF DOLLARS



Withholding	3,816.0
Annual Payments	326.6
Quarterly Payments	377.1
Gross Collections	4,519.7
Less: Refunds	945.8
Campaign Fund	1.5
Net Income Tax	3,572.4
Less: Revenue Sharing	303.2
Net Income Tax to GFGP	3,269.2

SOURCE: MONTHLY FINANCIAL REPORT, JANUARY 1989

3.2 A Short History of the Individual Income Tax[2]

The Michigan personal income tax was introduced in 1967 to counteract a record operating deficit of $156 million caused, in part, by a recession in the auto industry. It was hoped that an income tax would provide the state with an elastic and reliable source of funds. It was also felt that an income tax would improve the equity of the overall system of state taxes. The base for the tax was, and still is, adjusted gross income (AGI) as defined for federal income tax purposes. The tax was originally levied at a flat rate of 2.6% with a personal exemption of $1,200.[3]

In fiscal 1970-1971 a national recession and a UAW strike resulted in a smaller than expected increase in state revenues. In response, the income tax rate was increased to 3.9% in August of 1971.

2. There are four basic sources for this history. They are:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, Michigan, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.
(iii) "Executive Budget, State of Michigan", various editions, 1970 - 1988.
(iv) "Budget Message of the Governor", various editions, 1970 - 1988.

3. Under Article 9, Section 7 of the state constitution, the state and any of its subdivisions are barred from imposing an income tax which is graduated as to rate or base. Since 1967 the voters have on three occasions rejected attempts to change this provision. Nevertheless, the combination of a flat rate and a personal exemption is mildly progressive.

Due to stronger economic growth, the introduction of the state lottery and the enactment of federal revenue sharing, the state was able to adopt a tax relief measure by 1973. The personal exemption was increased from $1,200 to $1,500 and a general homestead property tax credit was introduced to compensate those with relatively high property taxes, given their adjusted gross income.

On May 1, 1975, in order to replace revenues lost from exempting food and drugs from the sales tax, the income tax rate was increased to 4.6%. It was scheduled to be rolled back to a rate of 4.4% in July of 1977, but this plan was abandoned in the face of further budgetary constraints.

On May 17th, 1982, in response to budgetary problems caused by the 1982 recession, the income tax rate was increased to 5.6% for a six month period starting, retroactively, on April 1st. Some of this revenue was received in higher annual payments and lower refunds in 1983, as May revenues reflected none of the increase and June revenues reflected approximately half the increase.[4]

Continued budgetary problems in 1983 resulted in an increase in the rate to 6.35% on April 1st, backdated to January 1st. Employers were instructed to use a withholding rate of 6.92% for the rest of that year to recover the extra revenue from the first quarter of the year.[5] In

4. May 17th, 1982 fell on a Monday. By then, two Thursdays and two Fridays had elapsed in May and two Thursdays and two Fridays remained. For the purposes of the MURF withholding model the effective tax rate for May is assumed to be 5.1% (=(4.6%+5.6%)/2).

January 1984 the rate was reduced to 6.10% and in September it was further reduced to 5.35%. In January of 1986 the rate was reduced to 5.1% and in April of that year the rate was returned to 4.6% backdated to January. However, as withholding was maintained at 4.6% for the remainder of the year, an additional liability of $93.2 million was created for refunds in 1987.[6]

Since 1987, the income tax rate has been maintained at 4.6%. However, in order to compensate taxpayers for the broadening of the tax base caused by federal tax reform and the state's adherence to federally defined AGI, a schedule of increases in the personal exemption was announced late in 1987. This schedule set the level of the personal exemption at $1,600 (retroactively) for 1987, $1,800 for 1988, $2,000 for 1989 and $2,100 for 1990. In addition, certain unemployed individuals were granted an extra partial exemption for the first time. At the same time, individuals earning more than $1,500 were no longer allowed both to claim a personal exemption and be claimed as a dependent on someone else's tax return.[7]

At the end of 1988, part of the exemption that was

5. Again the timing of the tax increase is important. April 1st, 1983 fell on a Friday. Consequently, even if a rate of 6.92% had been applied for the rest of the month, revenues would be below expectations for withholding at 6.92%. In view of this, for the purposes of the withholding model, I treat May 1983 receipts as an outlier.

6. $950.6 million was withheld at 5.1% from paychecks in January, February and March. At 4.6% only $857.4 would have been withheld, leaving overwithholding of $93.2 million.

granted to earning dependents prior to 1987 was restored. This exemption was set at $500 for 1988 and $1,000 for 1989 and succeeding years. At the same time, lottery winnings were made subject to the state income tax. The net effect on state revenues of tax reform and the changes in exemptions are expected to be positive in 1988 and 1989, but negative from 1990 on out.

3.3 Withholding

The MURF withholding model is constructed in two stages. First, a regression model is used to forecast withholding in the absence of the changes in exemptions introduced at the end of 1987. Then adjustments are made to allow for both a rise in the level of the personal exemption and a fall in the number of allowable exemptions.

The dependent variable used, LNAJWITH, is the natural log of monthly receipts from withholding at 4.6%[8], before withholding refunds, as reported in the Monthly Research and Statistical Bulletin (MRSB). It is adjusted for changes in personal exemptions since January 1988, as is outlined later in this section.

The natural log of a five-month normalized geometric interpolation of wage and salary income in Michigan, LNAVWSM, is used as the income term in the regression.[9] Other income is subject to the state income tax, but is not

7. Since the new exemption schedule was signed into law on December 27th, it is assumed that no effect on withholding revenues was felt until February.

normally subject to withholding. LNAVWSM is expressed in log form so that a one percent increase in wage and salary income is assumed to have the same percentage effect on withholding at different levels of income.

The monthly model also includes monthly dummy variables. These take a value of one in the relevant month and zero elsewhere. This allows the positive dollar effect on withholding, caused by the fact that the month happens to be January, to increase over time with the overall level of withholding. The monthly dummies are expressed as TR1, TR2 etc.

The month following a month with an above average number of paydays will tend to yield extra revenue. Thus a dummy variable called FRIS5 is used which takes a value of one when there are five Fridays in a month and zero otherwise. A similar variable called THURS5 is used for five Thursdays. Again this implies that the positive dollar effect on withholding, caused by the fact that the previous month happened to contain five Fridays, will increase with the overall level of withholding.

8. This gives the value of withholding revenues if the rate had remained at 4.6% throughout the fit period. The withholding number is based on a history of gross withholding. There is a small item called withholding refunds (not income tax refunds) which needs to be subtracted from this figure to give net withholding. Withholding refunds are paid to employers who have incorrectly overwithheld taxes from their employees and forwarded these to the state.

9. The rationale behind this interpolation is discussed in Section 2.7

If the first of January is a Friday, then a large number of workers who would otherwise have been paid on Friday will be paid on Thursday, December 31st. This will tend to increase withholding revenues in January and reduce them in February. A similar, though smaller, effect occurs when January 1st falls on a Thursday. To model this, dummy variables are introduced with a value of one in January and minus one in February. The variable for Friday, January 1st is called JAN1F and the variable for Thursday, January 1st is called JAN1T. Likewise when Good Friday falls on April 1st some people that would normally have been paid on April 1st are paid on March 30th instead. This has the effect of raising revenues in April and lowering them in May. This occurs in 1983, 1988 and 1994. A dummy variable which takes a value of one in April and minus one in May is used to model this effect. This dummy variable is named GDFRI.

A variable called WEEKDY, which gives the number of weekdays in a month, is also used as an explanatory variable. Even after including the number of Thursdays and the number of Fridays as explanatory variables, a month following a month with an above average number of weekdays tends to have high withholding receipts. WEEKDY is also expressed in level form.

The effective state income tax rate changed seven times in the course of the 1980's, as is shown in Table 3.14 at the end of this chapter. Withholding revenues have been multiplied by (4.6%/the effective rate) to give the amount

that would have been withheld, ceteris paribus, had the tax rate been at its current 4.6%. However, even given this adjustment, some slight reduction in the tax base may have occured as the income tax rate rose. To measure this, a variable called RATE is used, which is just the effective income tax rate for each month. This too is entered in level form.

It should be noted that LNAVWSM, FRIS5, THURS5, WEEKDY, and RATE are all lagged by one month in the regression equation because withholding receipts represent the money withheld from paychecks in the previous month.

Two observations in the early 1980's are treated as outliers, those of 82.03, and 83.05. These observations may be outliers due to problems in the income data or problems with the introduction of higher tax rates. The notation for these outliers is B8203 and B8305.

In addition to the variables above, AR terms at lags of three and six months and an MA term at a lag of six months are introduced to deal with an autocorrelation problem. This problem probably is due to the fact that some employers with very small wage bills are allowed to pay withholding to the state on a quarterly basis.

Although this model allows us to project withholding over the course of the next two years, it fails to deal with the changes in the tax law due to tax reform. First, it is necessary to make an adjustment for the fall in the number of exemptions used. A fall in the number of children being

claimed as dependents should be only partially offset by an increase in the number of exemptions being claimed by the unemployed. Overall, according to unofficial Treasury department estimates, the original loss of exemptions by earning dependents should have been about 500,000 exemptions. However, there should also have been an increase in exemptions used by the unemployed of about 50,000 leaving a net reduction in total exemptions of 450,000. Since the new law should have affected paychecks in January 1988, it should have been reflected in an increase in revenues starting in February 1988. To estimate the addition to revenues from this source, 450,000 is multiplied by $1,500 and then by .046. This amounts to $37,950,000 in a full year.

Second, the estimate of revenues needs to be reduced to reflect a rise in the level of the personal exemption. In the absence of tax reform, unofficial Treasury estimates suggest that about 8,100,000 exemptions would have been claimed in 1988. As the exemptions for seniors and the handicapped, which constitute about 750,000 of the total, have not been increased and the overall number of exemptions has fallen by 450,000, a total of 6,900,000 exemptions should have been affected by the increase in the level of the exemption.

From January 1988 to December 1988, the exemption was $1,800, a rise of $300. This should have resulted in a loss in revenues of $300 times .046 times 6,900,000, or

$95,220,000 in total from February 1988 to January 1989. From February 1989 to January 1990, the increase in the personal exemption to $2,000 should reduce revenues by an additional $63,480,000. From February 1990 to January 1991, increasing the personal exemption to $2,100 should cost a further $31,740,000.

In order to get a smooth series on the dependent variable, an adjustment is made to LNAJWITH throughout 1988. This adjustment adds back a net $64,170,000 to revenues in that year with the adjustment in each month being proportional to the amount of revenue received in that month. This gives a measure of withholding in the absence of changes in exemptions.

The increases in the exemption in 1989 and 1990 are included explicitly in the forecasts, with the annual cost being distributed among the months in proportion to the unadjusted revenues received in that month.[10]

Thus the MURF withholding equation is given by equation (3.1) below:

$$
\begin{aligned}
(3.1)\quad \text{LNAJWITH} &= a_1 + a_2*\text{TR1} + \ldots + a_{12}*\text{TR11} \\
&+ a_{13}*\text{LNAVWSM}(-1) + a_{14}*\text{FRIS5}(-1) + a_{15}*\text{THURS5}(-1) \\
&+ a_{16}*\text{JAN1F} + a_{17}*\text{JAN1T} + a_{18}*\text{WEEKDY}(-1) \\
&+ a_{19}*\text{GDFR1} + a_{20}*\text{B8203} + a_{21}*\text{B8305} + a_{22}*\text{RATE}(-1) \\
&+ a_{23}*\text{MA}(6) + a_{24}*\text{AR}(3) + a_{25}*\text{AR}(6)
\end{aligned}
$$

Performance Review

The results of regressing the MURF withholding equation are shown in Table 3.1. The R^2 is .996, and except for some of the seasonal dummies, all of the explanatory varibles are significant at the 90% confidence level. The partial R^2 given outlier dummies, seasonal dummies and AR and MA terms was found to be .891.

A likelihood ratio test on the significance of the seasonal dummies as a group was conducted, yielding a Chi-square of 196.13 with 11 degrees of freedom. This allows the rejection of the null hypothesis of insignificant seasonal dummies at the five percent level.

A likelihood ratio test for structural stability was also conducted by splitting the data set at its midpoint, October 1982. The log of the likelihood function was evaluated in the second half of the sample period for both the unconstrained equation and for the equation where all coefficients were restricted to take the values found by regressing over the entire data set. Doubling the difference between the unconstrained and constrained likelihood functions yielded a Chi-square of 22.22 with 22 degrees of freedom, insufficient to reject the null

10. The forecast through 1990 is adjusted in a similar way to allow for the partial restoration of the earning dependent exemption and the tax on lottery winnings. The former should reduce withholding by $10.4 million in fiscal 1989 and $24 million in fiscal 1990. The latter should generate only an additional $2.5 million in fiscal 1989 and $3.5 million in fiscal 1990, in the form of withholding.

Table 3.1: Statistical Output from the MURF
Income Tax Withholding Equation.

LS // Dependent Variable is LNAJWITH
SMPL range: 1976.09 - 1988.12
Number of observations: 148
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2.3962709	0.4393947	5.4535727	0.000
TR1	0.1443726	0.0219618	6.5737973	0.000
TR2	0.0602022	0.0217703	2.7653330	0.006
TR3	-0.0034409	0.0093069	-0.3697172	0.712
TR4	0.0676229	0.0218385	3.0964973	0.002
TR5	-0.0020876	0.0216855	-0.0962662	0.923
TR6	0.0117572	0.0044675	2.6317053	0.008
TR7	0.0987113	0.0218786	4.5117775	0.000
TR8	-0.0055925	0.0216744	-0.2580220	0.796
TR9	-0.0399504	0.0088639	-4.5070870	0.000
TR10	0.0500369	0.0216786	2.3081256	0.021
TR11	0.0111184	0.0215032	0.5170603	0.605
LNAVWSM(-1)	1.0084825	0.0440426	22.897869	0.000
FRIS5(-1)	0.0837452	0.0033940	24.674314	0.000
THURS5(-1)	0.0284866	0.0041326	6.8931950	0.000
JAN1F	0.0509918	0.0087337	5.8385287	0.000
JAN1T	0.0380775	0.0086453	4.4044127	0.000
WEEKDY(-1)	0.0053675	0.0024948	2.1514558	0.031
GDFR1	0.0581911	0.0094836	6.1359413	0.000
B8203	0.0509290	0.0152936	3.3300890	0.001
B8305	-0.0566205	0.0173363	-3.2660183	0.001
RATE(-1)	-0.0086003	0.0031870	-2.6985479	0.007
MA(6)	-0.3557595	0.1312254	-2.7110560	0.007
AR(3)	0.2095762	0.0900555	2.3271887	0.020
AR(6)	0.6208139	0.0988738	6.2788499	0.000

R-squared	0.996096	Mean of dependent var	12.30731
Adjusted R-squared	0.995335	S.D. of dependent var	0.251140
S.E. of regression	0.017154	Sum of squared resid	0.036194
Durbin-Watson stat	1.666918	F-statistic	1307.705
Log likelihood	405.3866		

hypothesis of structural stability at the five percent level.

The Box-Pierce test for white noise residuals was also employed. Given 21 degrees of freedom this yields a Chi-square of 26.45, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

Clearly one of the main purposes behind the construction of MURF models is to provide more accurate forecasting equations than those of SQEM. The SQEM model of withholding is given in equation (3.2), where TYWM represents seasonally adjusted withholding revenues, RTYWM is the tax rate, WSM is wage and salary income, TEXEMPT give the value of the personal tax exemption and MPOP is the Michigan population.

$$(3.2) \qquad TYWM = \frac{RTYWM}{100} * \left[a_1 + a_2 * WSM + a_3 * \frac{TEXEMPT}{4} * \frac{MPOP}{1000} \right]$$

TYWMNS, quarterly withholding revenues, are found by deseasonalizing the forecast of TYWM. In SQEM, this equation is regressed between the fourth quarters of 1967 and 1983 which gives an R^2 of .999.[11]

As a test of the relative dynamic forecast performance of the MURF and SQEM models of withholding, two post-sample dynamic forecast simulations were run from the first quarter of 1987 to the last quarter of 1988. The results of the

11. This may no longer be the case as the income data used in this equation has been changed several times since the equation was first estimated.

simulations are illustrated in Figure 3.2 and outlined in Table 3.2.[12] It should be noted that the fit period for the MURF model is 1976.03 to 1987.01 and that the forecast period for both models is February 1987 to January 1989.

Table 3.2: Income Tax Withholding (Relative Performance of MURF & SQEM Forecasts, 1987-1988)

		MURF		SQEM	
	ACTUAL	EST	ERROR	EST	ERROR
1987					
I	891.9	888.2	-3.7	917.5	25.6
II	895.0	901.7	6.6	923.6	28.6
III	872.6	885.9	13.4	913.6	41.1
IV	971.0	981.9	11.0	990.4	19.5
1988					
I	969.6	957.9	-11.7	970.4	0.9
II	937.4	947.0	9.6	987.0	49.6
III	973.4	1007.5	34.1	1007.1	33.8
IV	1069.7	1083.3	13.6	1120.1	50.4
RMSE			15.5		34.8

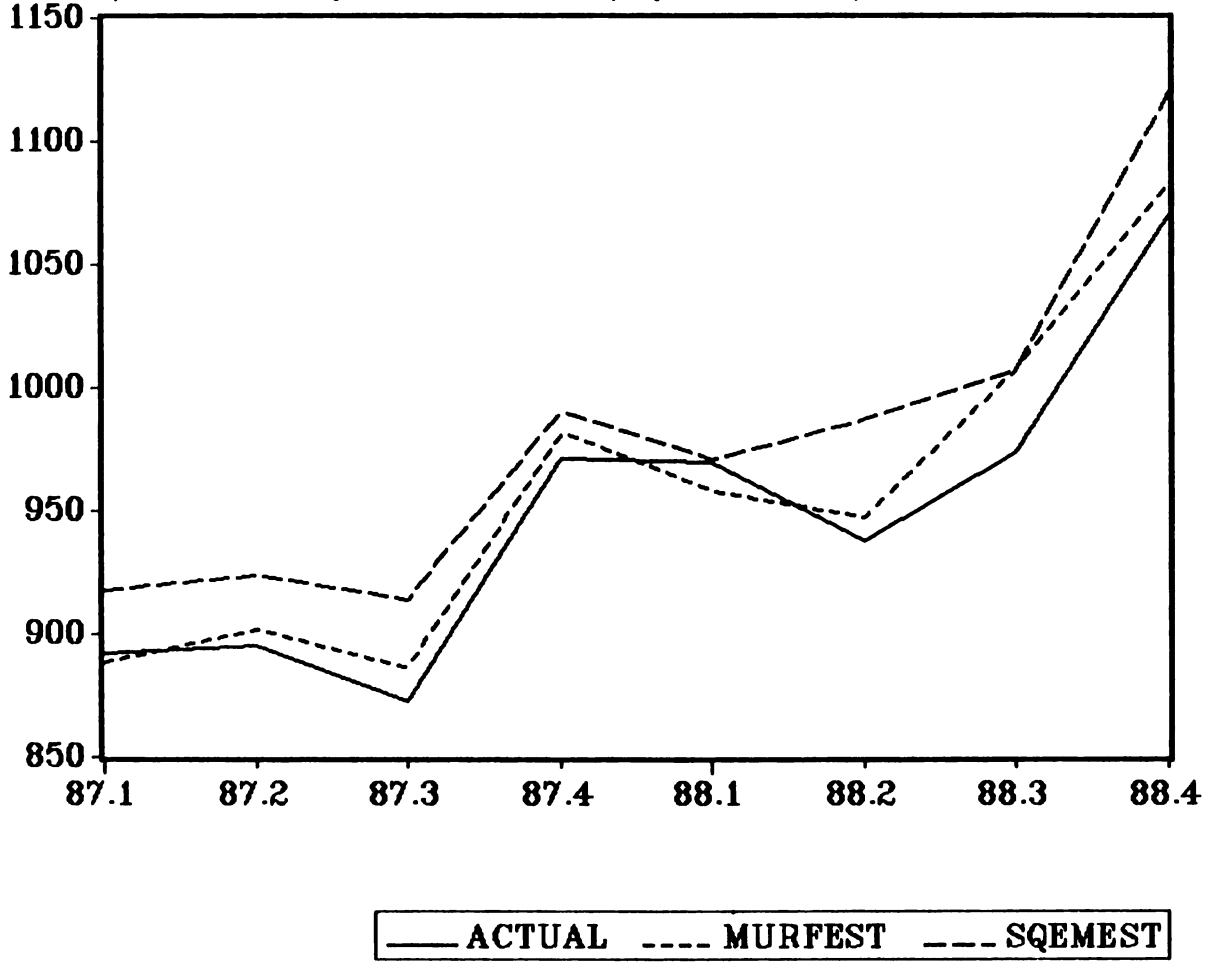
Overall, the results are very encouraging. The Root Mean Squared Error of the MURF model was less than half that of the SQEM version.

As a further test of forecast performance, the results of a dynamic post-sample forecast for MURF were compared with those of a Vector Auto Regression (VAR) model and an

12. Three points should be borne in mind concerning this table. First, for both models, the quarters contain the revenues accrued to that quarter rather than the cash received in that quarter. Second, the forecast variable is withholding, net of withholding refunds. The RSQE model uses this as its dependent variable and an estimate of $342,000 per month has been subtracted from the MURF model to account for withholding refunds. Third, the actual values used for comparison have been adjusted to represent the revenues that would have been received in the absense of the changes in exemptions enacted at the end of 1987.

FIGURE 3.2: INCOME TAX WITHHOLDING

(ACTUAL, MURF & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



Auto Regressive Moving Average (ARMA) model. For the purposes of this simulation the MURF model forecasts were generated by a the MURF withholding equation estimated over the period January 1981 and December 1986, which was also the fit period for the VAR and ARMA models.

The VAR model regressed LNAJWITH on lagged values of itself and eight other monthly tax series. The lags were set at one month and two months. In addition, 11 seasonal dummies were used as regressors in the VAR model. The ARMA model used moving average terms at lags of one, two, three and five months and auto-regressive terms at one and three months along with 11 seasonal dummies. The estimated coefficients for both ARMA and VAR models are shown in Appendix C. The results of the simulations are illustrated in Figures 3.3, 3.4 and 3.5 and shown in Table 3.3.

Again, the results of these simulations are very encouraging. The RMSE for the MURF model at $10.3 million is just over half that of the VAR model and just over a third that of the ARMA model.

FIGURE 3.3: INCOME TAX WITHHOLDING

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

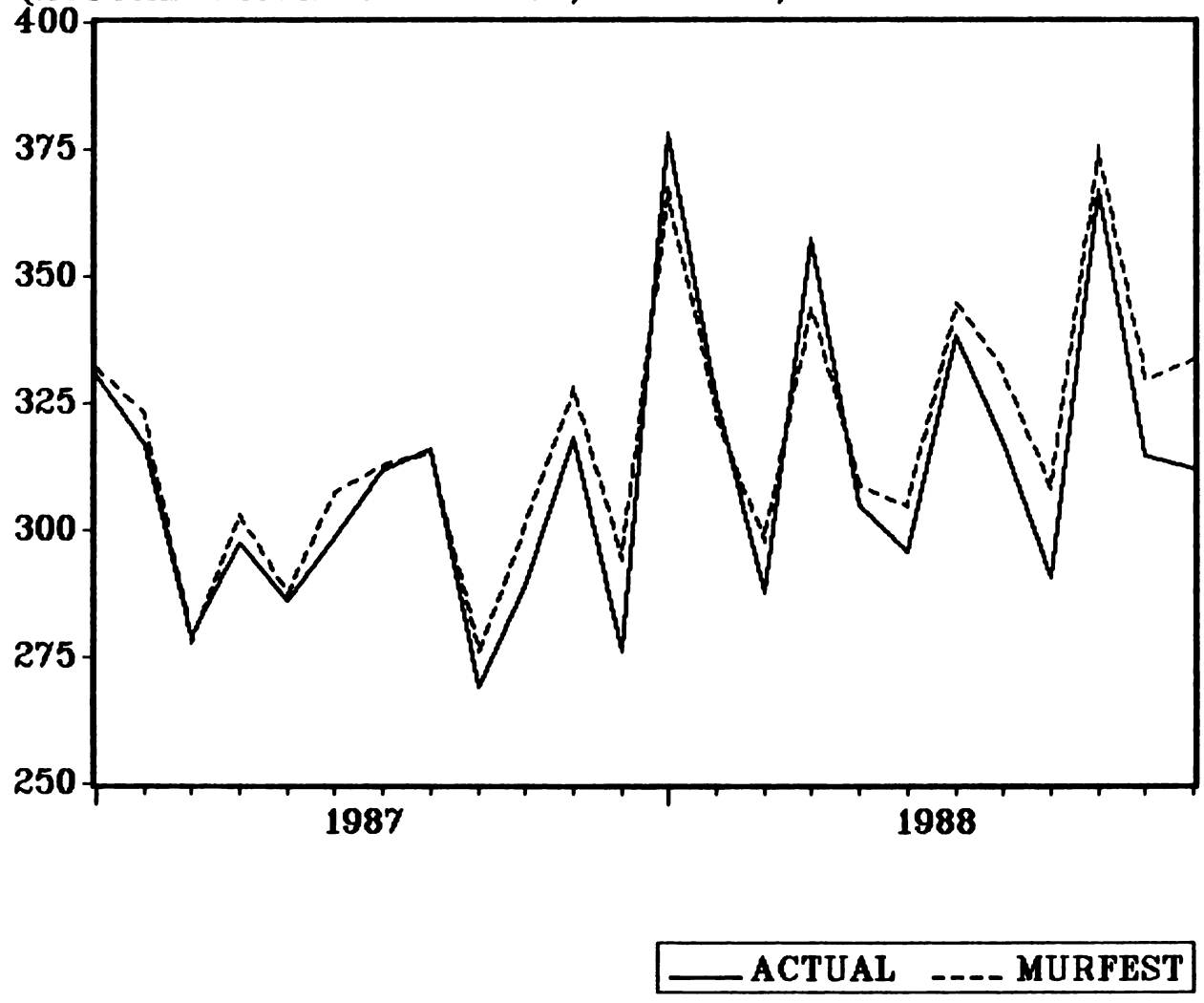


FIGURE 3.4: INCOME TAX WITHHOLDING

(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

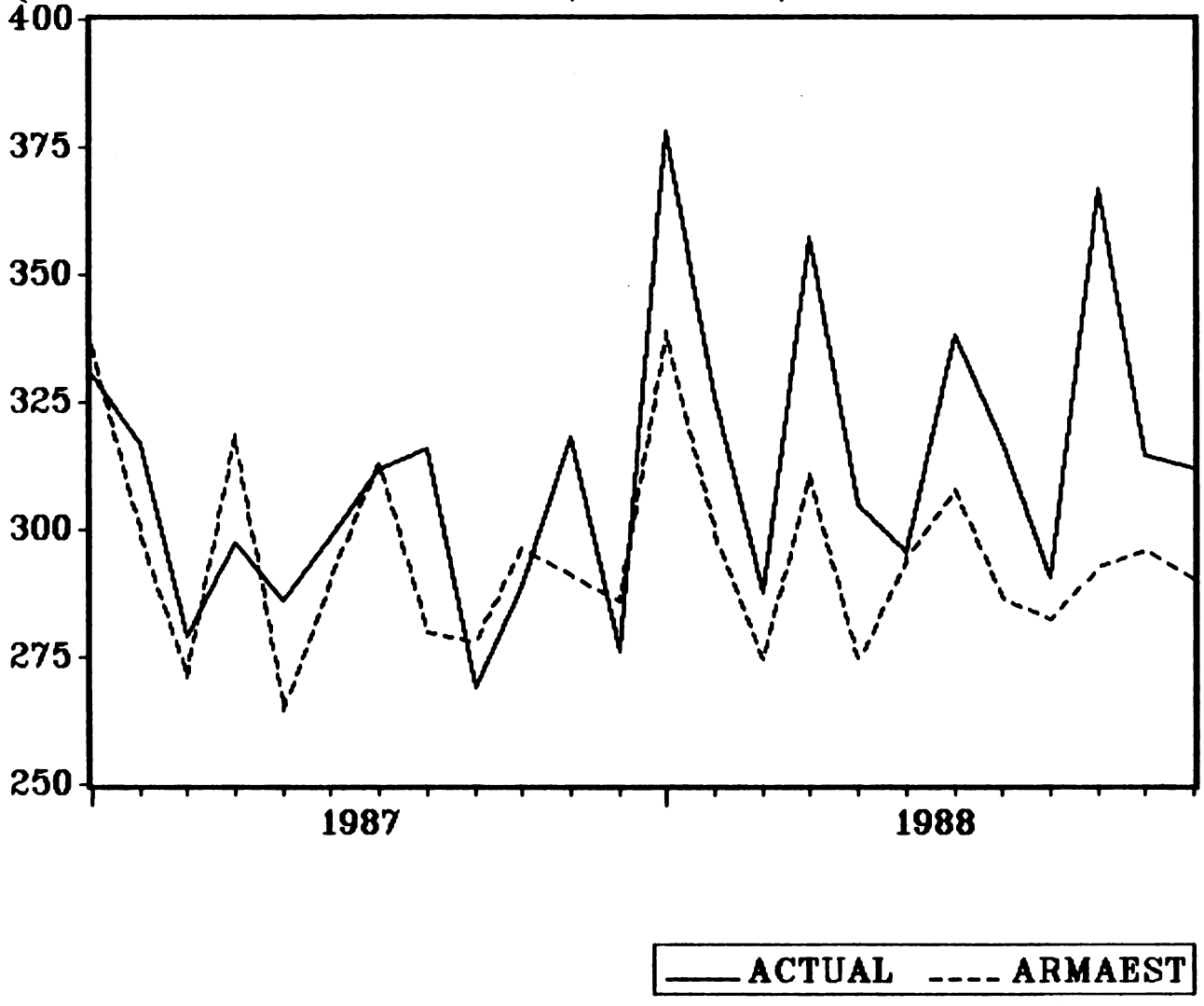


FIGURE 3.5: INCOME TAX WITHHOLDING

(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

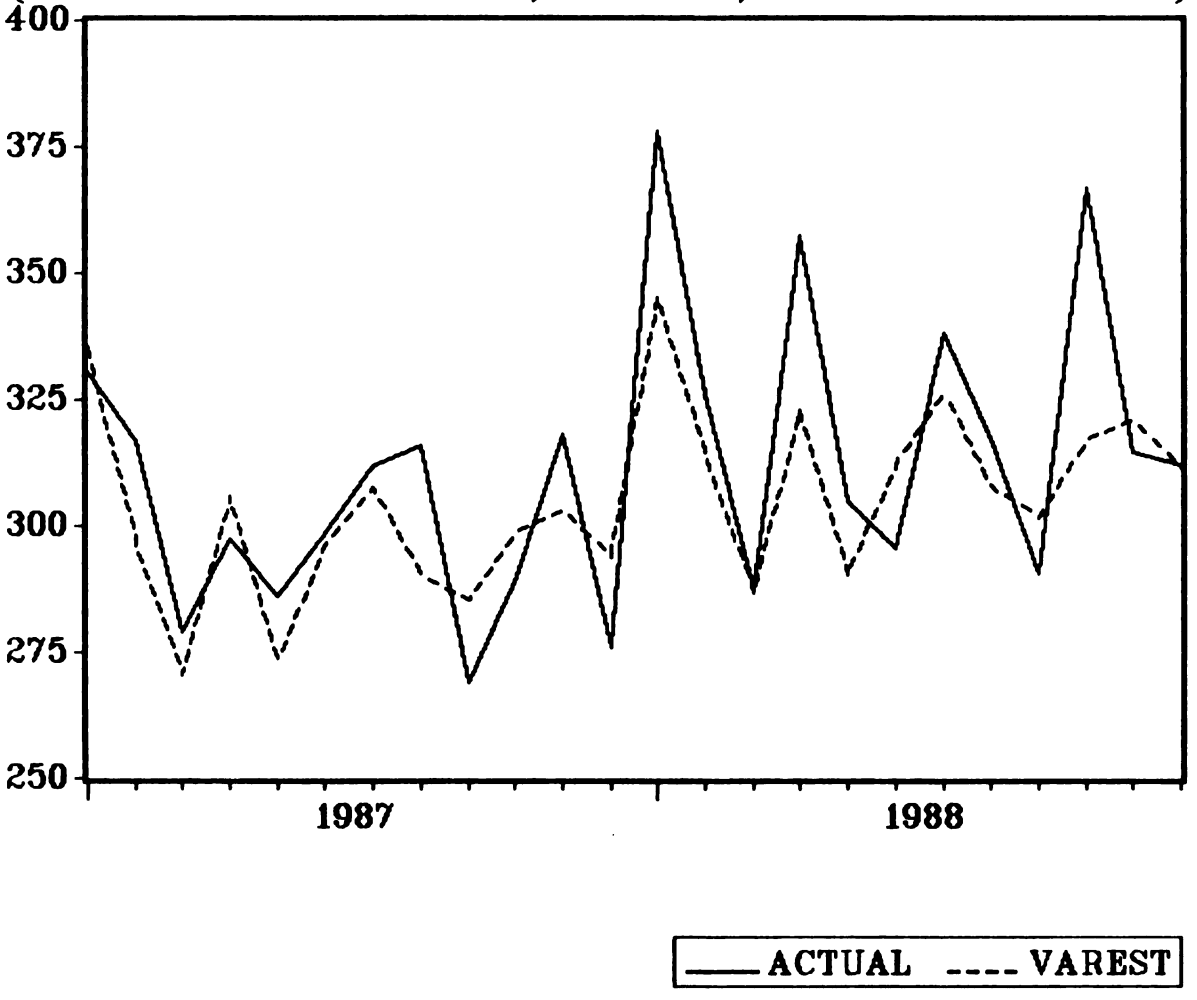


Table 3.3: Income Tax Withholding (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	330.3	331.8	1.5	335.9	5.6	335.2	4.9
FEB.	316.6	322.6	6.0	299.1	-17.5	296.8	-19.9
MAR.	279.1	277.6	-1.4	270.7	-8.4	270.3	-8.7
APR.	297.2	303.0	5.8	318.9	21.7	305.9	8.7
MAY.	286.0	287.1	1.2	264.4	-21.6	272.4	-13.5
JUN.	298.3	307.4	9.1	289.9	-8.3	296.0	-2.2
JUL.	311.8	312.8	0.9	313.5	1.7	307.8	-4.0
AUG.	315.8	315.1	-0.6	279.7	-36.0	290.2	-25.6
SEP.	269.0	275.7	6.7	277.8	8.8	285.0	16.0
OCT.	288.8	301.1	12.3	296.2	7.4	298.6	9.8
NOV.	318.1	328.2	10.1	290.7	-27.4	303.1	-15.0
DEC.	275.9	293.7	17.8	285.6	9.7	293.8	17.8
1988							
JAN.	377.9	367.3	-10.6	338.7	-39.2	345.6	-32.4
FEB.	325.9	322.7	-3.2	299.2	-26.7	314.2	-11.7
MAR.	287.5	297.5	10.0	273.9	-13.6	286.6	-0.9
APR.	357.2	344.5	-12.7	310.9	-46.3	322.8	-34.4
MAY.	304.8	308.7	3.9	273.4	-31.4	290.2	-14.6
JUN.	295.6	304.3	8.8	294.2	-1.4	312.0	16.5
JUL.	338.0	344.7	6.7	307.9	-30.1	326.8	-11.2
AUG.	317.2	331.2	14.0	286.5	-30.7	307.9	-9.4
SEP.	290.4	307.5	17.1	282.1	-8.3	301.6	11.2
OCT.	366.8	375.6	8.8	292.6	-74.2	317.0	-49.7
NOV.	314.4	329.4	14.9	295.9	-18.6	321.0	6.6
DEC.	312.0	333.6	21.6	290.0	-22.0	311.4	-0.6
RMSE			10.3		27.0		18.3

3.4 Quarterly Payments

Quarterly payments on income tax are made four times a year, on April 15th, June 15th, September 15th, and January 15th, for individuals whose fiscal year corresponds to the calendar year. The payment on each of these dates is an estimate and so may be based on the liability for the previous tax year. Thus the payment in April 1987 might be based on tax liability for all of 1986, the tax payment in June might be based on payments for all of 1986 etc. As an alternative, individuals may simply pay the same amount as they did last year with something added on for growth. This second alternative seems to be more likely as quarterly payments have shown a very strong tendency to increase during the year.

Instead of making a fourth quarterly payment in January, individuals have the option of making an annual payment (reconciliation) at this point. An increase in the number of individuals making this reconciliation should cause a decrease in the number of quarterly payments, since these payments are then counted as annual rather than quarterly payments. However, given the growth in payments during the year, it is unlikely that many taxpayers would make annual payments in January if they could avoid doing so until April.

Although there is an accurate monthly series on quarterly payments on income tax going back over 10 years, a quarterly model was employed to forecast revenues in this

case. There are two main reasons for this. First, unlike SBT quarterly payments, money received in one of the smaller revenue months is, for the most part, a spillover from the larger months. In other words, most of the money received in July is not from individuals who use some special fiscal year but rather represents payments which should have been received in June. In such a case, much of the argument for monthly models loses its validity.

Second, the extreme seasonal variation in the estimated payments equation confounds efforts to estimate the coefficients on either the key independent variables or the seasonal dummies. In a levels equation, the coefficients on income variables will tend to be underestimated for the large months and overestimated for the small months. In addition, using 11 seasonal dummies in a levels equation will tend to underestimate seasonality towards the end of the sample, since dollar seasonal variation will tend to increase with the overall level of revenue.

On the other hand, in an equation with a dependent variable expressed in logs, as much importance is attached to a $3 million dollar error in July, when revenues average about $5 million, as a $60 million dollar error in January when revenues amount to $100 million.

A partial solution to this dilemma can be found by letting the seasonal dummies interact with other independent variables. However, this solution is further complicated by the effects of Federal tax reform, which seem to have

permanently increased the tax base starting late in 1986.

Consequently, a quarterly model is employed. The dependent variable, LAJQUARQ, is the natural log of quarterly payments on income tax at a constant tax rate of 4.6 percent. The income variable used is YQ, a measure of personal income from dividends, interest and rent along with proprietors income. This is expressed in log form and lagged by one quarter. The tax rate, RATE, is also among the independent variables. This is expected to have a negative coefficient as rising tax rates presumably have some negative impact on the tax base.

The model includes three seasonal dummies to model the increase in the size of quarterly payments between April and January each year. A dummy variable called BAFT863 is also employed to take account of the positive effects of the 1986 tax reform act on the base for quarterly income tax payments. BAFT863 takes a value of zero in all quarters up to and including the third quarter of 1986 and a value of one thereafter.

Finally, an MA term at a lag of one quarter and an AR term at a lag of four quarters are introduced to deal with some remaining correlation between residuals. Thus the final MURF quarterly payments equation is given by:

$$(3.3) \quad LAJQUARQ = a_1 + a_2*TR1 + a_3*TR2 + a_4*TR3 + a_5*LNYQ(-1) + a_6*RATE + a_7*BAFT863 + a_8*MA(1) + a_9*AR(4)$$

Performance Review

The MURF model of quarterly payments was regressed over the period 1977.1 to 1988.4 and the results are show in Table 3.4. Overall, the model seems to have a high degree of explanatory power, as shown by an R^2 of .981. However, the partial R^2 given seasonal dummies and AR and MA terms is only .35. This suggests that an ARMA model with seasonal dummies could do a fairly good job of estimating revenues from this tax.

Table 3.4: Statistical Output from the MURF Income Tax Estimated Payments Equation.

LS // Dependent Variable is LAJQUARQ
SMPL range: 1977.1 - 1988.4
Number of observations: 48
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-0.7130355	1.1942656	-0.5970493	0.554
TR1	1.1014284	0.0956604	11.513943	0.000
TR2	1.4351691	0.1002525	14.315551	0.000
TR3	0.9791441	0.0983186	9.9588923	0.000
LNYQ(-1)	1.2632355	0.1400778	9.0180966	0.000
RATE	-0.0688504	0.0342042	-2.0129195	0.051
BAFT863	0.1654652	0.0660956	2.5034214	0.017
MA(1)	0.3186036	0.1619003	1.9679000	0.056
AR(4)	0.5231548	0.1221241	4.2837954	0.000

R-squared	0.980783	Mean of dependent var	10.62390
Adjusted R-squared	0.976841	S.D. of dependent var	0.708382
S.E. of regression	0.107803	Sum of squared resid	0.453237
Durbin-Watson stat	1.986163	F-statistic	248.8022
Log likelihood	43.79191		

A Box-Pierce Q-statistic was calculated to check for remaining intertemporal correlation among the residuals.

This yielded a Chi-square of 4.029, which given 6 degrees of freedom, is not sufficient to reject the null hypothesis of white noise residuals at the 5 percent level.

A likelihood ratio test for structural stability was conducted by splitting the sample range at its midpoint, 82.4. This also yielded a Chi-square below the critical value of 15.51 at the five percent level of significance given eight degrees of freedom.

Finally, a likelihood ratio test for the significance of the three seasonal dummies generated a Chi-square of 26.2, well above the critical value of 7.81 given three degrees of freedom. Thus, the null hypothesis of insignificant seasonal dummies was rejected.

The SQEM model of estimated income tax payments is fairly complicated. It is given by equation (3.4) below, where TYQMNS represents estimated payments on income tax, DSEAS1 takes a value of one in the first quarter and minus one in the fourth quarter, D1 takes a value of one in the first quarter and zero elsewhere, RTYQM is the effective income tax rate for quarterly payments, RTYAM is the effective income tax rate for annual payments and YQ is the sum of proprietor's income, dividends, personal interest income and rental income.

$$(3.4) \quad TYQMNS = a_1 + a_2*DSEAS1 + a_3*DSEAS2 + a_4*DSEAS3 + a_5*D1*\frac{RTYQM_{-1}}{100}*\sum_{i=5}^{8} YQ_{-i}$$

$$+ a_6 * D1 * \left[\frac{RTYAM}{100} * \sum_{i=1}^{4} YQ_{-i} - \frac{RTYQM_{-2}}{100} * \sum_{i=5}^{8} YQ_{-i} \right]$$

$$+ a_7 * D2 * \frac{RTYQM}{100} * \sum_{i=2}^{5} YQ_{-i}$$

$$+ a_8 * D3 * \frac{RTYQM_{-1}}{100} * \sum_{i=3}^{6} YQ_{-i}$$

$$+ a_9 * D4 * \frac{RTYQM_{-2}}{100} * \sum_{i=4}^{7} YQ_{-i}$$

The logic behind this equation can best be explored in terms of the determinants of revenue in each individual quarter. In the first quarter of 1987, revenues depend upon (i) a seasonal dummy, (ii) the effective income tax rate for quarterly payments in the second quarter of 1986 times total YQ for 1985 and (iii) the current effective rate for annual payments times total YQ for 1986 less (ii).

In the second quarter of 1987, revenues depend upon (i) a seasonal dummy and (ii) the current effective income tax rate for quarterly payments times total YQ for 1986.

In the third quarter of 1987, revenues depend upon (i) a seasonal dummy and (ii) the effective income tax rate for quarterly payments in the second quarter of 1987 times total YQ for 1986.

In the fourth quarter of 1987, revenues depend upon the effective income tax rate for quarterly payments in the second quarter times total YQ for 1986.

Some comments can be made about the reasoning behind this particular equation. First, it is not entirely clear

why the effective quarterly income tax rate used is always that of the second quarter. Presumably the correct rate to apply to each quarter is the rate which is in effect in that quarter (see Table 3.14). The MURF model of estimated payments avoids this problem by looking at what revenues would have been had the rate been at its current 4.6%.

Second, the emphasis on the prior year's YQ rather than the income on which the tax will be paid this year suggests that the taxpaying behavior of individuals this year may be determined by their behavior last year. But if this is the case, it seems logical to include a dependent variable lagged four quarters as an explanatory variable.

Third, the inclusion of the annual tax liability for 1986 in the first quarter of 1987 suggests that individuals will tend to make up some of the difference between their liability for the previous year and their payments with their last quarterly payment. But again, actual lagged quarterly payments are not included as explanatory variables. Rather the actual liability in the previous year is used.

This is clearly a complicated equation which fits the quarterly data well between 1969.3 and 1983.4. The main problem with this equation is not its suitability for that period, but rather its continued use after tax reform when there has clearly been a broadening of the tax base for quarterly revenues.

Table 3.5 and Figures 3.6, 3.7 and 3.8 show the results

FIGURE 3.6: INCOME TAX, ESTIMATED PAYMENTS

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

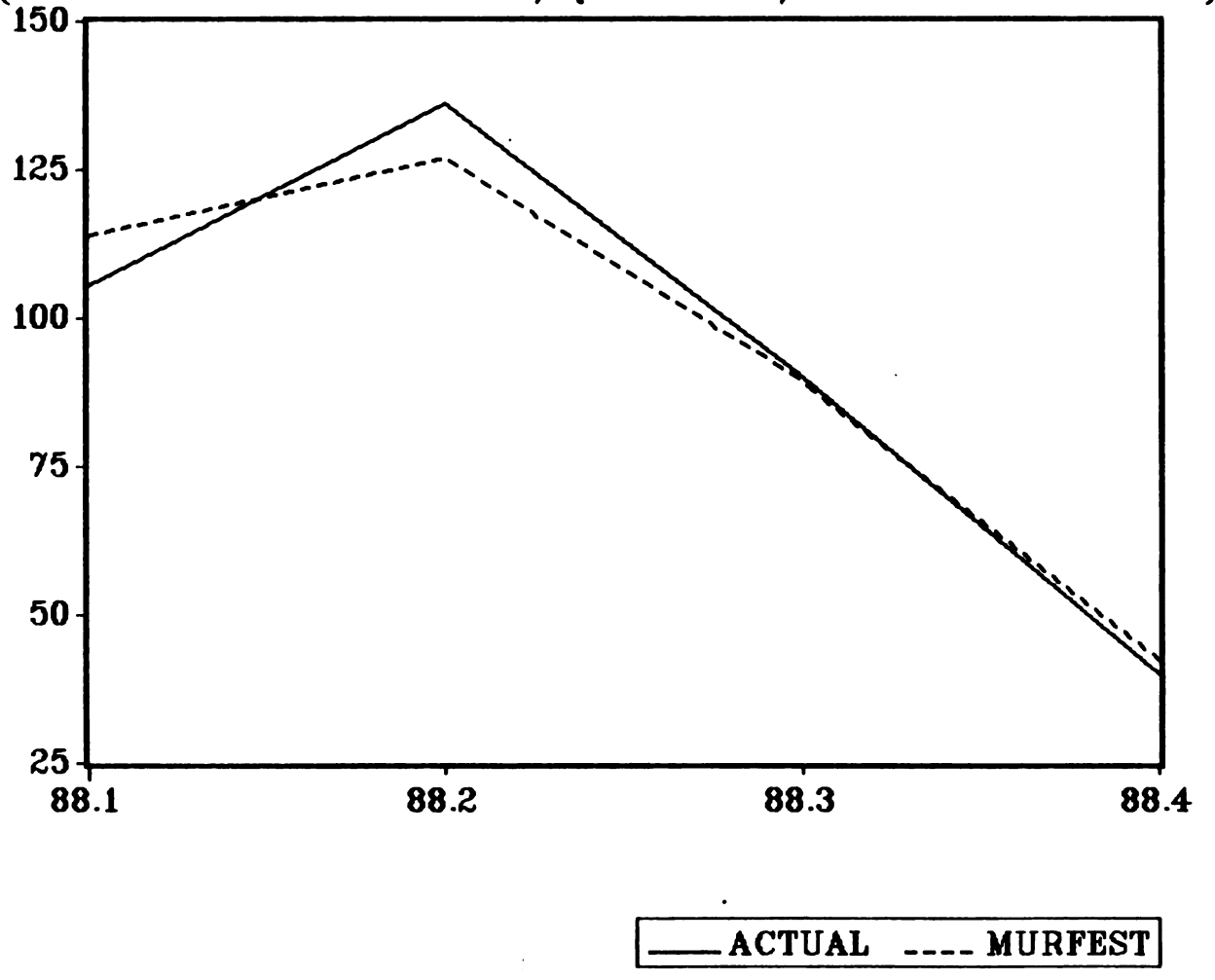


FIGURE 3.7: INCOME TAX, ESTIMATED PAYMENTS

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

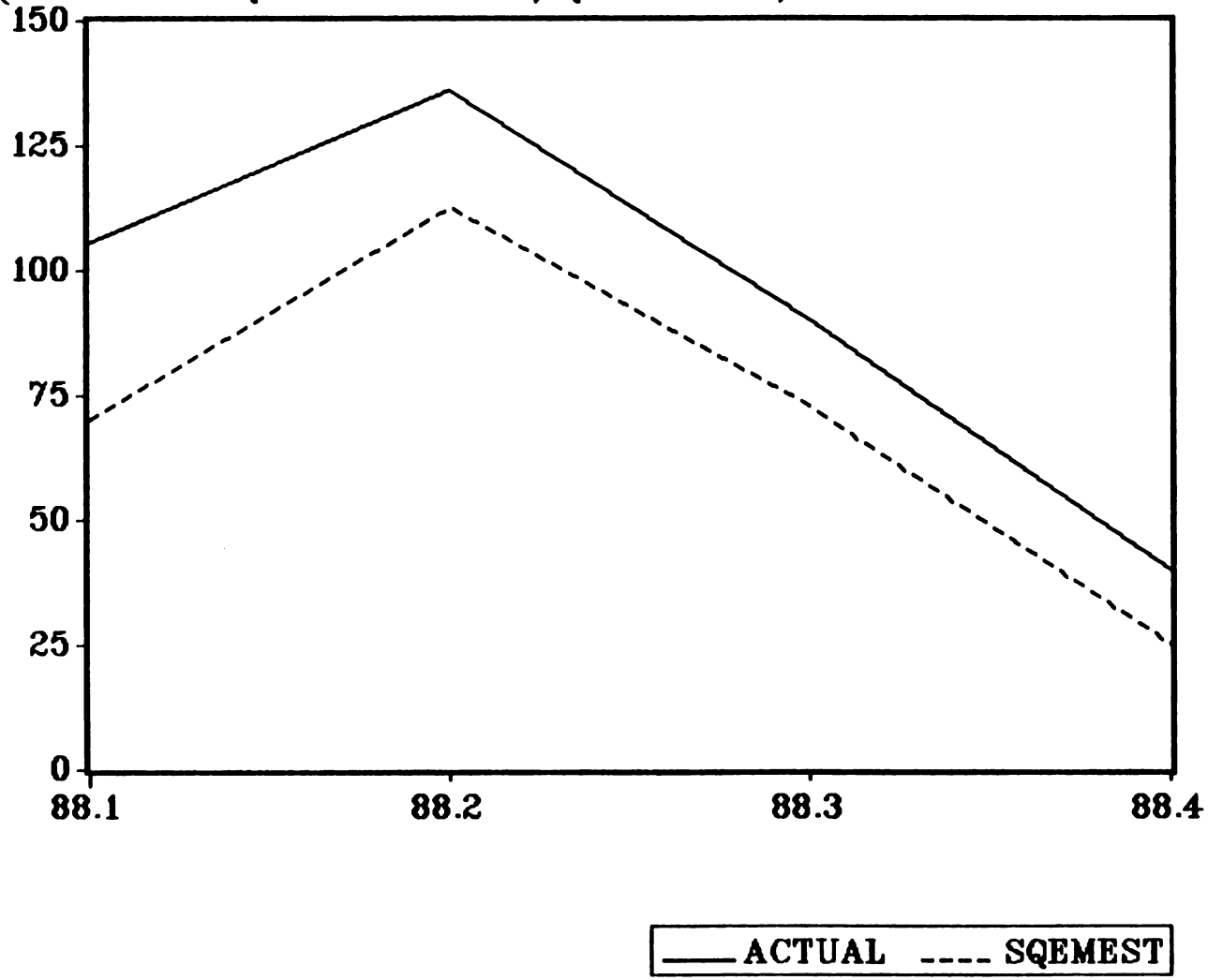
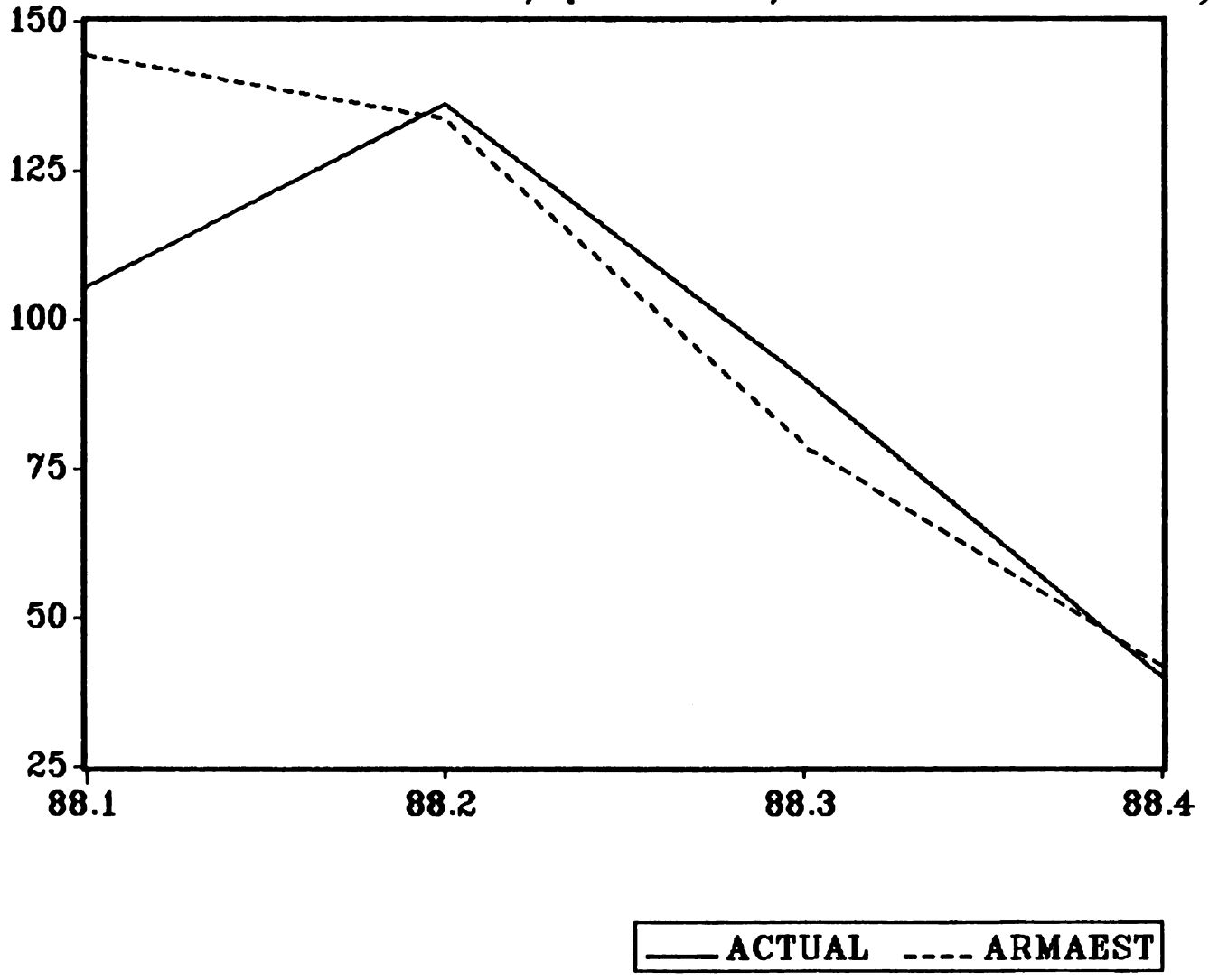


FIGURE 3.8: INCOME TAX ESTIMATED PAYMENTS

(ACTUAL & ARMA FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



of dynamic forecasts using the MURF and SQEM models. In addition, an ARMA model is estimated with AR terms at lags of one and four quarters and an MA term at a lag of five quarters along with three seasonal dummies. Both the MURF and ARMA models use a fit period of 1977.1 to 1987.4. The forecasts generated by each model are over the period 1988.1 to 1988.4 since given the profound effects of tax reform on the revenues from this tax, results generated by fit periods ending prior to 87.4 are not particularily meaningful for either the MURF or ARMA models.

However, even given the limited nature of the simulation, the results are quite encouraging with the RMSE of the MURF model being only a third that of the ARMA model and a quarter that of the SQEM equation.

Table 3.5: Income Tax, Estimated Payments (Relative Performance of MURF, SQEM & ARMA Forecasts, 1988)

		MURF		SQEM		ARMA	
	ACTUAL	EST	ERROR	EST	ERROR	EST	ERROR
1988							
I	105.4	113.9	8.5	70.1	-35.3	144.3	38.9
II	136.1	126.9	-9.2	112.6	-23.5	133.5	-2.6
III	90.1	89.2	-0.9	72.6	-17.5	78.8	-11.3
IV	40.0	42.2	2.2	25.0	-15.0	41.7	1.7
RMSE			6.4		24.1		20.3

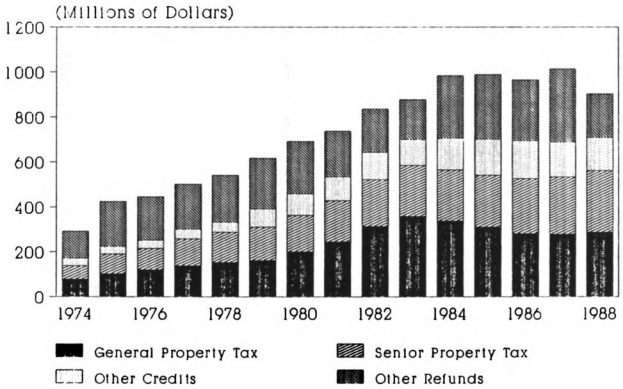
3.5 Refunds and Annual Payments

Refunds and annual payments are particularly hard to estimate for three main reasons. First, unlike withholding for which the receipts for February are determined by economic factors in January, refunds and annual payments are determined by aggregate economic factors for the previous calendar year. Because of this, we really only get one meaningful observation per year on the factors that are supposed to determine refunds and annual payments. Thus the MURF models of the components of refunds have only 11 observations each and the MURF model of annual payments has only 13 observations.

Second, more than two-thirds of dollar refunds in the State of Michigan are the result of various credit programs that the state uses to achieve many social goals. These credits need to be considered when examining both refunds and annual payments since, even if an individual does not qualify for a refund, he can reduce the level of his annual payment by claiming some of these credits. The growth of these credits and total refunds is shown in Figure 3.9. The most important of the credit programs are property tax credits.

In calendar 1988, it is estimated that the state paid out $287.3 million in general property tax credits and $274.8 million in senior credits, claimed for the 1987 tax year. Both credits are designed to compensate individuals whose property tax bill is large relative to their incomes.

FIGURE 3.9: INCOME TAX CREDITS
CALENDAR 1974 - CALENDAR 1988



general credit is 60% of the amount that homestead property taxes exceed 3.5% of adjusted gross income. Renters are allowed estimate property taxes as constituting 17% of their rent.

The property tax credit for seniors equals 100% of the amount that homestead property taxes exceed the percentage of adjusted gross income given in Table 3.6 below.

Table 3.6: Senior Homestead Property Tax Credit, Income Levels & Income Percentage Threshold for Property Tax Credit

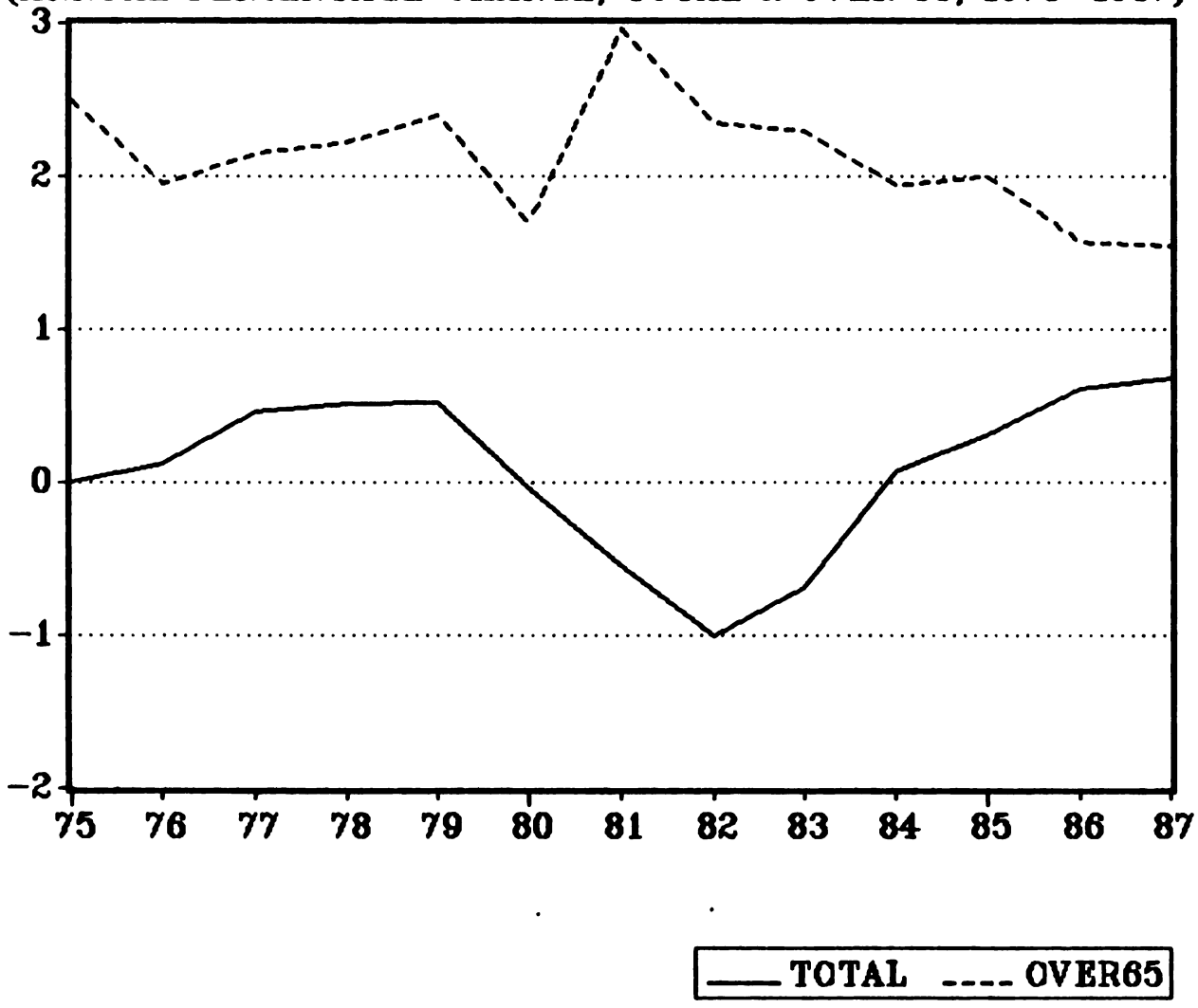
INCOME LEVEL	PERCENTAGE OF INCOME NOT REFUNDABLE
0 - $3,000	0.0%
$3,001 - $4,000	1.0%
$4,001 - $5,000	2.0%
$5,001 - $6,000	3.0%
OVER $6,000	3.5%

These brackets have not been changed since the program was first introduced in 1973 and have obviously suffered serious bracket creep. The dollar amount of refunds should be positively correlated with the size of the population over the age of 65, due to more generous property tax credits for this group. The growth of this segment of the population in the last 15 years is shown in Figure 3.10.

The important point to note about these two property tax credits is that they make overall income tax refunds highly sensitive to relationship between property taxes and income. If, in any given year, an individual's income rises by 5% and property taxes rise by 5%, then his or her property tax credit should rise by 5%, provided the

FIGURE 3.10: MICHIGAN POPULATION GROWTH

(ANNUAL PERCENTAGE CHANGE, TOTAL & OVER 65, 1975–1987)



individual has not reached the income or maximum credit limit.[13] But if property taxes rise more quickly than income, as happened in the late 1970's and early 1980's and as is shown in Figure 3.11, then property tax credits can rise faster than both.

Other credits include solar heating credits, farm property tax credits, home heating credit as well as credits for contributions to higher education and credits for tax paid to other states or cities in Michigan.

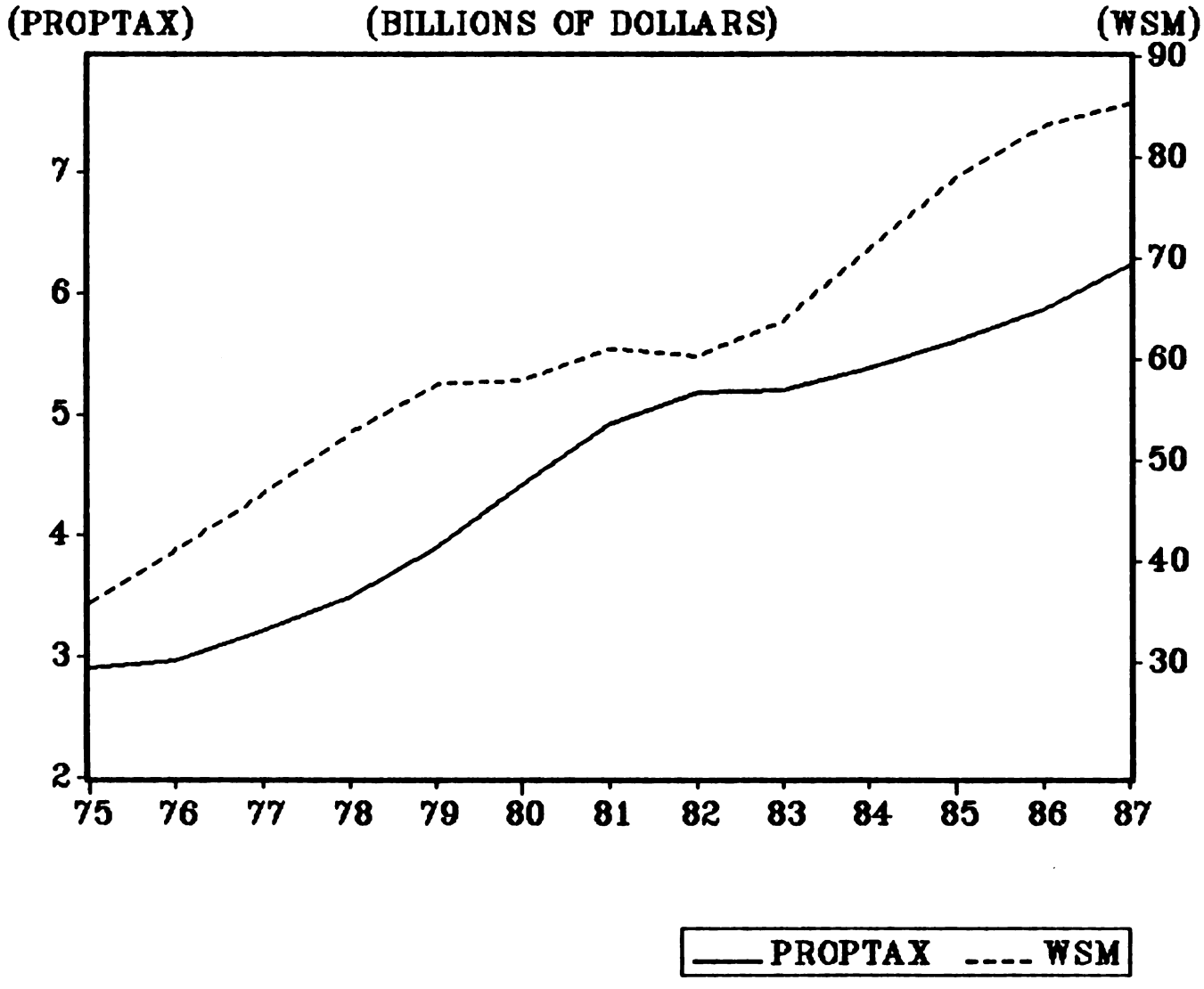
The third major problem in forecasting the behavior of refunds and annual payments is the effect of the 1986 federal tax reform act. At the end of 1986, a large number of investors realized long term capital gains, in order to avoid paying a higher tax rate on these gains under the tax reform act. This had the effect of increasing annual payments and reducing refunds in 1987. Further confusion was caused by overwithholding in early 1986 which, in the absence of this effect, would have cost the state about $93.2 million.

The model of refunds and annual payments consists of seven equations. Three variables need to be forecast before proceeding to forecast either refunds or annual payments.

First, demographic data is used to predict the number of people over the age of 65 in a given calender year. The dependent variable, OLDPOP, is regressed on the total

13. Property tax credits are reduced by 10 percent for every $1,000 by which household income exceeds $73,650. The maximum credit is $1,200.

FIGURE 3.11 PROPERTY TAXES & WSM



population of Michigan, TOTPOP, and a time trend, TIME. Forecasts for total population are based on internal projections. This equation is shown as equation (3.5) below:

(3.5) $OLDPOP = a_1 + a_2*TOTPOP + a_3*TIME$

The results of regressing this equation between 1974 and 1987 are shown in Table 3.7. The very high R^2 could be the result of a very stable pattern of growth in the elderly population in Michigan. A less optimistic interpretation would be that the reason for smoothness in the series was beacuse of some fairly crude interpolations on the dependent variable between census years. Nevertheless, the data are the best available.

Table 3.7: Statistical Output from the MURF Senior Population Equation

LS // Dependent Variable is OLDPOP
SMPL range: 1974 - 1987
Number of observations: 14

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	1195.1105	65.589665	18.221019	0.000
TOTPOP	-0.0452700	0.0071508	-6.3308024	0.000
TIME	19.776434	0.1178825	167.76389	0.000

R-squared	0.999621	Mean of dependent var	929.0000
Adjusted R-squared	0.999552	S.D. of dependent var	83.22444
S.E. of regression	1.761842	Sum of squared resid	34.14496
Durbin-Watson stat	2.411002	F-statistic	14498.28
Log likelihood	-26.10604		

A Box-Pierce test for white noise residuals was also

employed. Given 2 degrees of freedom this yields a Chi-square of .861, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

Second, the total value of property on which property taxes are paid (SEV) is forecast. The dependent variable, LNSEV, is expressed in logs since the relatively long estimation period, 1961 to 1988, results in heteroskedastic disturbances in level-form equations. The independent variables include the log of Michigan population, LNTOTPOP and the log of the Detroit CPI, LNPCPID.

A dummy variable, BAFT76 is introduced to deal with a fall in business SEV associated with the introduction of the Single Business Tax. This variable takes a value of zero from 1961 to 1976 and one thereafter. A first-order Cochrane-Orcutt correction was used to deal with a problem of serially correlated errors. The MURF SEV equation is shown as equation (3.6):

$$(3.6) \quad LNSEV = a_1 + a_2*LNPCPID + a_3*LNTOTPOP + a_4*BAFT76 + a_5*AR(1)$$

Overall, this equation, whose results are shown in Table 3.8 achieves a remarkably good fit as is indicated by an R^2 of .999. However, given the limited number of observations these results need to be interpreted with a degree of caution.

The Box-Pierce test for white noise residuals yielded a Chi-square of 4.872 with two degrees of freedom,

insufficient to reject the null hypothesis of white noise residuals at the five percent level. The forecasts generated by this equation along with internal estimates of average property tax rates combine to generate a forecast of total property taxes paid in Michigan, ESTTAX.

Table 3.8: Statistical Output from the MURF State Equalized Valuation Equation

LS // Dependent Variable is LNSEV
SMPL range: 1961 - 1988
Number of observations: 28
Convergence achieved after 2 iterations

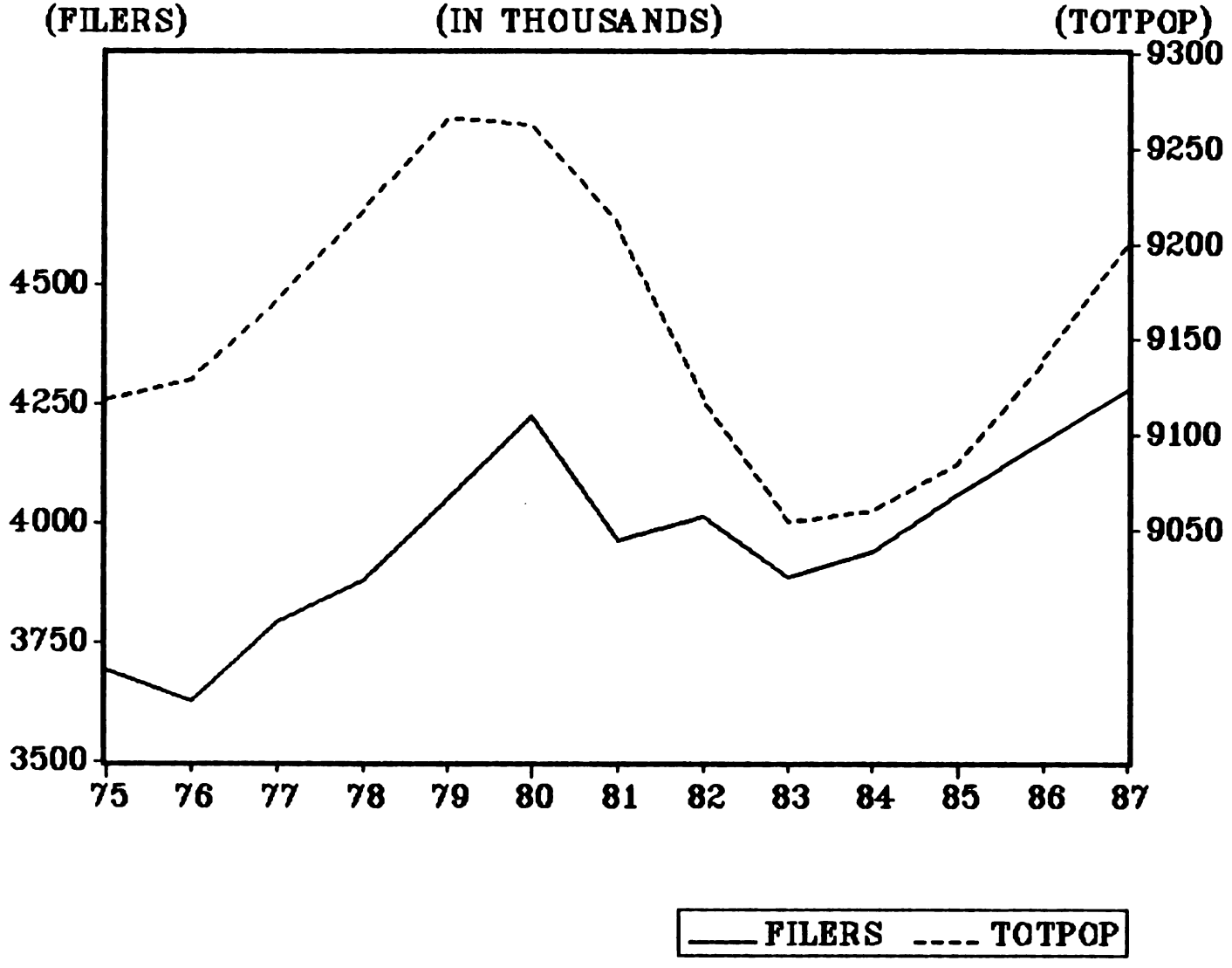
VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-6.2447336	3.7417739	-1.6689233	0.109
LNPCPID	1.0568407	0.0366316	28.850540	0.000
LNTOTPOP	1.4208237	0.4199392	3.3834036	0.003
BAFT76	-0.0789317	0.0204756	-3.8549204	0.001
AR(1)	0.7145638	0.1436552	4.9741604	0.000

R-squared	0.999028	Mean of dependent var	10.87644
Adjusted R-squared	0.998859	S.D. of dependent var	0.539583
S.E. of regression	0.018227	Sum of squared resid	0.007641
Durbin-Watson stat	1.268188	F-statistic	5909.764
Log likelihood	75.15958		

The third input into the refund and annual payments equations is the total number of 1040's filed, FILERS. This is predicted using an equation which includes as explanatory variables, the rate of unemployment in Michigan, UEMPMI, the total population of Michigan, TOTPOP, and average U.S. household size, HOUSESIZE.

Clearly, there is a strong relationship between TOTPOP and the number of 1040s filed, as is shown in Figure 3.12. A rise in unemployment in the previous year will reduce the

FIGURE 3.12: 1040S & POPULATION (1975–1987)



number of people who need to file MI1040s. However, the secular reduction in average household size in the US and Michigan is probably responsible for an increasing ratio of MI1040s to TOTPOP over the last 15 years. The equation for the total number of filers is given by equation (3.7) below:

$$(3.7) \quad FILERS = a_1 + a_2*TOTPOP(-1) + a_3*UEMPMI(-1) + a_4*HOUSESIZE(-1)$$

The results of regressing this equation are shown in the next page. All the variables are significant and have their expected signs. A test for white noise residuals yielded a Chi-square of 4.214 with 2 degrees of freedom, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

Table 3.9: Statistical Output from the MURF
MI 1040 Filers Equation

LS // Dependent Variable is FILERS
SMPL range: 1975 - 1987
Number of observations: 13

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	1594.6661	1757.1624	0.9075235	0.388
TOTPOP(-1)	0.7968188	0.1824293	4.3678230	0.002
UEMPMI(-1)	-34.569701	4.9804048	-6.9411428	0.000
HOUSSIZE(-1)	-1642.2079	132.06468	-12.434876	0.000

R-squared	0.958045	Mean of dependent var	3942.692
Adjusted R-squared	0.944060	S.D. of dependent var	176.5481
S.E. of regression	41.75638	Sum of squared resid	15692.36
Durbin-Watson stat	2.094251	F-statistic	68.50566
Log likelihood	-64.57007		

For the purposes of estimation, total income tax refunds

are divided into four categories. These are general property tax credits, senior property tax credits, overwithholding and other credits. The first three of these are forecast econometrically, whereas other credits are projected on the based in a more ad hoc manner, as the time series for these credits is too untidy to allow useful econometric analysis.

The equation for general property tax credits is expressed in level form with the dependent variable, GENERAL, representing the annual value of general property tax credits paid. The total value of property taxes paid, ESTTAX and total personal income, YPM, are among the list of regressors. Given the nature of the property tax credit there is a strong theoretical prior that credits will rise with ESTTAX and fall with YPM. Both these variables are lagged by one year since the credit is claimed based on income and property taxes paid in the previous calendar year. The total number of filers of MI 1040s, FILERS, is also included as a regressor.

Thus, the MURF equation for general property tax credits is given by equation (3.8) below and the regression results obtained for the period 1977 to 1987 are shown in Table 3.10.

$$(3.8) \quad GENERAL = a_1 + a_2*YPM(-1) + a_3*ESTTAX(-1) + a_4*FILERS$$

Both YPM and ESTTAX are significant and have their

predicted signs. FILERS has a positive coefficient which is in line with expectations. However, this coefficient is found to be statistically insignificant.

A Box-Pierce Test for white noise residuals yielded a Chi-square of 1.487, which was too low to reject the null hypothesis of white noise residuals at the five percent level, given two degrees of freedom.

Table 3.10: Statistical Output from the MURF General Property Tax Equation

LS // Dependent Variable is GENERAL
SMPL range: 1977 - 1987
Number of observations: 11

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-196.70987	160.97145	-1.2220171	0.261
YPM(-1)	-0.0067838	0.0009467	-7.1658326	0.000
ESTTAX(-1)	0.0002115	1.955E-05	10.819295	0.000
FILERS	0.0396927	0.0418936	0.9474654	0.375

R-squared	0.985235	Mean of dependent var	252.8364
Adjusted R-squared	0.978908	S.D. of dependent var	78.50544
S.E. of regression	11.40148	Sum of squared resid	909.9556
Durbin-Watson stat	1.583299	F-statistic	155.7027
Log likelihood	-39.89358		

The equation for senior property tax credits is also expressed in level form with the dependent variable, SENIOR, representing the annual value of senior property tax credits paid. ESTTAX and YPM, both lagged by one quarter are both used as explanatory variables. In addition, the total Michigan population over age 65, OLDPOP, is employed as a regressor. The MURF equation for senior property tax credits is given by equation (3.9):

(3.9) $SENIOR = a_1 + a_2*YPM(-1) + a_3*ESTTAX(-1) + a_4*OLDPOP(-1)$

The output from this regression, which is displayed in Table 3.11, shows each of the explanatory variables to be significant with their expected signs. The R^2 of .997 should not be taken too seriously, however, in light of the small number of observations used. A Box-Pierce test for white-noise residuals generated a Chi-square of 3.776, well below the critical value required to reject the null hypothesis of white-noise residuals at the five percent level given two degrees of freedom.

Table 3.11: Statistical Output from the MURF
Senior Property Tax Equation

LS // Dependent Variable is SENIOR
SMPL range: 1977 - 1987
Number of observations: 11

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-232.77555	71.829924	-3.2406487	0.014
YPM(-1)	-0.0005514	0.0002583	-2.1350010	0.070
ESTTAX(-1)	3.574E-05	4.441E-06	8.0478464	0.000
OLDPOP(-1)	0.3397330	0.1127699	3.0126221	0.020

R-squared	0.997566	Mean of dependent var	194.1545
Adjusted R-squared	0.996522	S.D. of dependent var	47.13842
S.E. of regression	2.779878	Sum of squared resid	54.09403
Durbin-Watson stat	2.204246	F-statistic	956.1344
Log likelihood	-24.36888		

The equation for net overwithholding is again expressed in level form. The dependent variable, OVERWITH, is regressed on total personal income, YPM, the income tax

rate, TAXRATE and the unemployment rate, UEMPMI, all lagged by a year. Overwithholding is assumed to rise with YPM and TAXRATE and to fall with UEMPMI, since although unemployment benefits are taxable, state income tax is not normally withheld from these benefits.

In addition to these variables, a dummy variable, B87, is introduced to deal with 1987 which is an outlier due to the retroactive lowering of the income tax rate in 1986. The MURF overwithholding equation is shown in equation (3.10) below:

$$(3.10) \quad OVERWITH = a_1 + a_2*YPM(-1) + a_3*TAXRATE(-1) + a_4*UEMPMI(-1) + a_5*B87$$

Table 3.12: Statistical Output from the MURF Senior Property Tax Equation

LS // Dependent Variable is OVERWITH
SMPL range: 1977 - 1987
Number of observations: 11

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-9.5703076	25.146218	-0.3805864	0.717
YPM(-1)	0.0006550	0.0002175	3.0111722	0.024
TAXRATE(-1)	55.174872	6.9888771	7.8946691	0.000
UEMPMI(-1)	-9.5627602	1.3125156	-7.2858257	0.000
B87	76.579198	14.931793	5.1286002	0.002

R-squared	0.976165	Mean of dependent var	235.8496
Adjusted R-squared	0.960276	S.D. of dependent var	47.25650
S.E. of regression	9.418681	Sum of squared resid	532.2694
Durbin-Watson stat	1.927626	F-statistic	61.43364
Log likelihood	-36.94422		

The results of regressing equation (3.10) from 1977 to 1987 are shown in Table 3.12. The regressors all have their

expected signs and are significant. The null hypothesis of white noise residuals was rejected since the Box-Pierce Q statistic with two degrees of freedom was 6.451, just above the five percent critical value. No remedy for this was applied, however, due to the lack of degrees of freedom.

The annual payments model uses YQ as its main income variable. YQ consists of dividends, interest, rental income and proprietor income. This income variable, is used in preferance to a more general income variable as it is felt that a large fraction of annual payments are generated by the fact that tax is not withheld from non-wage income. Lack of degress of freedom along with problems of multicollinearity preclude the use of more than one income variable.

In addition to YQ, ESTTAX is again used as an explanatory variable. The coefficient on this variable should be negative as high property tax credits can be used to offset annual payments. The income tax rate is also employed as a regressor. All three of the independent variables are lagged by a year. The MURF annual payments equation is shown as equation (3.11) below:

$$(3.11) \quad ANNDOL = a_1 + a_2*ESTTAX(-1) + a_3*YQ(-1) + a_4*TAXRATE(-1)$$

The annual payments model, whose results are shown in Table 3.13, appears to work well, at least in terms of the expected signs on the coefficients. The R^2 is .99, although

this statistic should be interpreted with caution given the limited number of degrees of freedom in the model. A Chi-square test for white noise residuals yielded a value of .979 with 2 degrees of freedom, insufficient to reject the null hypothesis.

Table 3.13: Statistical Output from the MURF Income Tax Annual Payments Equation

LS // Dependent Variable is ANNDOL
SMPL range: 1975 - 1987
Number of observations: 13

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-125560.12	18584.505	-6.7561721	0.000
ESTTAX(-1)	-0.0181933	0.0101983	-1.7839590	0.108
YQ(-1)	12.427969	1.8377376	6.7626459	0.000
TAXRATE(-1)	28768.586	4670.0947	6.1601719	0.000

R-squared	0.990052	Mean of dependent var	155364.4
Adjusted R-squared	0.986736	S.D. of dependent var	68745.83
S.E. of regression	7917.335	Sum of squared resid	5.64E+08
Durbin-Watson stat	2.234832	F-statistic	298.5745
Log likelihood	-132.7545		

Since there is no refund equation in SQEM it is impossible to compare the relative performance of the MURF model with the SQEM model. However, the SQEM model of annual payments is given by equation (3.12). TYAMNS represents annual payments on income tax, D1 takes a value of one in the first quarter and zero elsewhere, TYCRM, is the level of tax credits, D74.2 is a dummy variable which takes a value of zero prior to the second quarter of 1972 and one thereafter, and YA is an income construct which consists of the difference between quarterly payments on

income tax and the effective annual income tax rate times adjusted personal income.

$$(3.12)\quad TYAMNS = a_1 + a_2*D1*YA + a_3*D2*YA_{-1} + a_4*D3*YA_{-2} + a_5*D4*YA_{-3} + a_6*D74.2 + a_7*TYCRM + D81.1*(a_8 + a_9*D1*YA + a_{10}*D2*YA_{-1} + a_{11}*D3*YA_{-2} + a_{12}*D4*YA_{-3} + a_{13}*D74.2 + a_{14}*TYCRM)$$

There are two major problems with this equation. First, a quarterly model is used although the distribution of revenues throughout the year is almost entirely determined by the behavior of the Treasury department in processing 1040s and the behavior of the public in filing them. In other words, the use of a quarterly model only serves to distribute a fixed total of annual payments throughout the year.

Second, there is the problem of how to predict TYCRM. At present the SQEM model uses a Department of Management and Budget estimate of TYCRM in its forecasts. This leaves only errors in withholding and quarterly payments to be explained in the SQEM model. The MURF model has the advantage of looking at the economic variables which determine TYCRM.

I have not compared the abilities of the SQEM and MURF models in forecasting annual payments, partly because this would necessitate shortening an already too short fit period, but also partly because these models are not

directly comparable since the SQEM model takes tax credits as given whereas the MURF model attempts to predict these.

TABLE 3.14

EFFECTIVE INCOME TAX RATES
(1982 - 1987)

WITHHOLDING

	1982	1983	1984	1985	1986	1987
JANUARY	4.60	4.60	6.92	5.35	5.10	4.60
FEBRUARY	4.60	4.60	6.10	5.35	5.10	4.60
MARCH	4.60	4.60	6.10	5.35	5.10	4.60
APRIL	4.60	4.60	6.10	5.35	5.10	4.60
MAY	5.60	6.92	6.10	5.35	4.60	4.60
JUNE	5.60	6.92	6.10	5.35	4.60	4.60
JULY	5.60	6.92	6.10	5.35	4.60	4.60
AUGUST	5.60	6.92	6.10	5.35	4.60	4.60
SEPTEMBER	5.60	6.92	6.10	5.35	4.60	4.60
OCTOBER	5.60	6.92	5.35	5.35	4.60	4.60
NOVEMBER	4.60	6.92	5.35	5.35	4.60	4.60
DECEMBER	4.60	6.92	5.35	5.35	4.60	4.60

TABLE 3.14 (cont'd.)

QUARTERLY PAYMENTS

	1982	1983	1984	1985	1986	1987
JANUARY	4.60	4.60	6.35	5.35	5.27	4.60
FEBRUARY	4.60	4.60	6.35	5.35	5.27	4.60
MARCH	4.60	4.60	6.35	5.35	5.27	4.60
APRIL	4.60	6.35	6.10	5.35	4.60	4.60
MAY	4.60	6.35	6.10	5.35	4.60	4.60
JUNE	4.60	6.35	6.10	5.35	4.60	4.60
JULY	5.60	6.35	6.10	5.35	4.60	4.60
AUGUST	5.60	6.35	6.10	5.35	4.60	4.60
SEPTEMBER	5.60	6.35	6.10	5.35	4.60	4.60
OCTOBER	5.60	6.35	5.85	5.35	4.60	4.60
NOVEMBER	5.60	6.35	5.85	5.35	4.60	4.60
DECEMBER	5.60	6.35	5.85	5.35	4.60	4.60

ANNUAL PAYMENTS

	1982	1983	1984	1985	1986	1987
JANUARY	4.60	5.10	6.35	5.85	5.33	4.60
FEBRUARY	4.60	5.10	6.35	5.85	5.33	4.60
MARCH	4.60	5.10	6.35	5.85	5.33	4.60
APRIL	4.60	5.10	6.35	5.85	5.33	4.60
MAY	4.60	5.10	6.35	5.85	5.33	4.60
JUNE	4.60	5.10	6.35	5.85	5.33	4.60
JULY	4.60	5.10	6.35	5.85	5.33	4.60
AUGUST	4.60	5.10	6.35	5.85	5.33	4.60
SEPTEMBER	4.60	5.10	6.35	5.85	5.33	4.60
OCTOBER	4.60	5.10	6.35	5.85	5.33	4.60
NOVEMBER	4.60	5.10	6.35	5.85	5.33	4.60
DECEMBER	4.60	5.10	6.35	5.85	5.33	4.60

CHAPTER IV

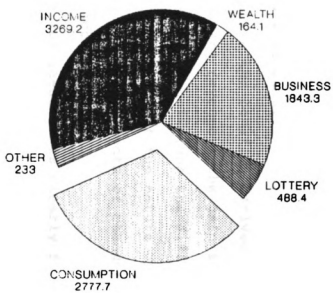
CONSUMPTION TAXES

4.1 Introduction

Consumption taxes in Michigan are the second largest source of GFGP/SAF revenues. They accounted for 31.6% of total revenues, or $2,777.7 million, in fiscal 1988, as can be seen in Figure 4.1.

This chapter is divided into five sections, including this introduction. The question of feedback from taxes to economic variables in Michigan is considered first by using results of the income tax withholding model to endogenize disposable income. The MURF models of sales and use taxes are discussed in section 4.3. The cigarette tax is examined in section 4.4. The Liquor Control Commission and the main alcohol taxes in Michigan are looked at in section 4.5. Each section consists of a short history of the tax(es) in question, the MURF model of the tax(es) and a review of the performance of the MURF model both in absolute terms and relative to the SQEM model.

FIGURE 4.1 GFGP/SAF CONSUMPTION TAXES
FISCAL 1988, MILLIONS OF DOLLARS



Sales Tax	**2,054.2**
Use Tax	**399.7**
Cigarette Tax	**230.7**
Beer and Wine Taxes	**53.3**
4% Liquor Taxes	**39.8**
Total Consumption Taxes	**2,777.7**

SOURCE: MONTHLY FINANCIAL REPORT, JANUARY 1989

4.2 Endogenizing Disposable Income

For the most part the tax equations in MURF and SQEM can be considered to be block recursive with respect to the economic variables that generate them. This obviously represents an approximation of the truth, but there are at least two ways to justify this approximation.

First, it can be argued that a state is much like a small open economy, where domestic fiscal actions are not as important in determining the demand for domestic products as in a closed economy.

Second, the approximation in assuming no feedback from taxes to economic behavior is not as important in an environment where tax rates are not expected to change as in an environment where such changes are expected and must be incorporated in forecasts.

However, given the benefits derived from more accurate forecasting of state revenues, the gain from considering some feedback probably outweighs the difficulties in specifying it. Moreover, if the nature of the feedback can be well defined then the effects of changes in tax rates can be gauged more accurately.

One avenue for feedback is clearly from income tax withholding to disposable income and thence to consumption taxes. SQEM deals with this by the use of an identity:

(4.1) YDM = YPM - TYWM - TRESM

where YDM is defined as disposable personal income, YPM is personal income, TYWM represents state withholding revenues and TRESM denotes other direct taxes.[1]

In the SQEM model, TRESM is exogenous with respect to Michigan taxes. Using equation (4.1) allows MURF to solve for consumption taxes recursively and so permits the continued use of OLS. Accordingly, MURF forecasts of sales, use, cigarette, and liquor taxes, along with forecasts of lottery revenues are constructed using a forecast of YDM generated by equation (4.1), with the MURF withholding model determining the forecast value of TYWM.

One problem with this approach should be noted, however. Figures on tax revenue are released before income figures so that the last month's tax data is compared with a forecast of income. Suppose withholding revenues exceed expectations in a given month. A natural interpretation would be that the economy is growing more strongly than expected and that forecasts of both wage and salary income

1. TRESM is defined by an identity in SQEM:

$$TRESM = \frac{TP-TPSL}{YP+TSIP-GTROF-GTRSL-YUNB} * YPADJM$$

where

TP = U.S. personal tax and nontax payments.
TPSL = U.S. State and Local personal tax and nontax payments.
YP = U.S. personal income.
TSIP = U.S. personal contributions for social insurance.
GTROF = U.S. Federal government transfer payments to persons excluding unemployment benefits.
GTRSL = U.S. State and Local transfer payments to persons.
YUNB = U.S. Unemployment benefits.
YPADJM = Adjusted personal income in Michigan.

and disposable income are underestimates.

Unfortunately, adjusting the forecast of disposable income for the unexpectedly high level of withholding using equation (4.1) actually requires a downward revision in disposable income.

Consequently, the values of YDM are only revised when a new forecast is made for YPM and are not revised each month in light of new withholding receipts data.

4.3 Sales and Use Taxes

A Short History of the Michigan Sales and Use Taxes[2]

The Michigan sales tax was first adopted in 1933 at a rate of 3% as a replacement for the state property tax. This rate increased to 4% in 1961 and has remained at that level since. The sales tax was originally levied against retailers for the privilege of selling at retail. Sales of services have always been exempted from the sales tax, at an estimated 1987 cost of $962 million.

Over the years, various items have been removed from the tax base. Between 1935 and 1970, some purchases by non-

2. There are three basic sources for this history. They are:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, Michigan, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.
(iii) "Analysis of Michigan's Sales Tax", Taxation and Economic Policy Office, Department of Treasury, October 1988.

profit organizations and radio and television stations were excluded as well as newspapers, periodicals, movies, new motor vehicles purchased in Michigan for use outside the state and components of air and water pollution control devices.

In 1974, food and prescription drugs purchased for home consumption were removed from the tax base, at an estimated 1987 revenue loss of $413 million and in 1978, various categories of medical equipment were exempted at an additional 1987 cost of $10 million.

The recession of 1980 prompted a 50% reduction in the sales tax on new cars for the month of July in an effort to promote car sales. Car sales surged in July but fell sharply in August, indicating that the tax cut may have had a greater effect on the timing of purchases than on their overall level.

Starting on January 1st, 1984, individuals were allowed deduct the sales tax on the difference between the value of the trade-in on a used car and the cost of a new car.[3] This program expired prematurely on March 1st, in part because used car dealers protested the ruinous effect of this program on their sales.

The Michigan use tax was adopted in 1937 at a 3% rate to complement the sales tax. The use tax is levied on non-retail types of transactions such as the sale of used automobiles by individuals plus the services of intra-state telephone and telegraph equipment. It is also levied on

goods bought outside of Michigan, for use in Michigan. One purpose of the tax is to discourage purchases outside the state made to avoid paying Michigan sales tax. This has the dual benefit of enhancing the tax base and helping Michigan retailers compete with out-of-state stores.

In 1961, the use tax rate was raised to its current 4%. There are important differences between the sales and the use tax for budget policy purposes. First, all use tax revenues are deposited into the general fund whereas most of the sales tax is earmarked for the school aid fund. Second, the use tax rate, unlike the sales tax rate, can be changed without a constitutional amendment.

The MURF Model of Sales Tax

In specifying the form of the MURF sales tax model, the first decision made was to express the dependent variable and the independent income variables in log form. There is considerable seasonal variation in the Michigan sales tax, the dollar amount of which has increased over time with the overall level of revenues from the tax. Simply regressing

3. Previously if you bought a new car worth $10,000 and traded in your old car for $4,000, you would have to pay 4% sales tax on the whole purchase price of the new car. That is you would have paid $10,000 X .04 = $400. Under this short-lived scheme you could deduct the trade-in value of your old car when figuring the sales tax. In the above example your sales tax would have been ($10,000 - $4,000) X .04 = $240. After the scheme was introduced, Act 32 of 1984 set a cash limit on the total amount of revenue the state could lose through this scheme. This limit was exceeded by March 1st of 1984, at which time the scheme expired prematurely (relative to the legislature's original intent).

the amount of sales tax receipts on eleven seasonal dummies and other independent variables would restrict the equation to choosing a fixed dollar amount of seasonal variation for each month. By contrast, a log linear form of the equation restricts the equation to a fixed percentage amount of seasonal variation for each month and so allows the dollar amount of variation to increase with the overall level of the tax.

The MURF model of the sales tax starts with disposable income. In earlier versions of the MURF sales tax model, a permanent income variable, LNAVYPRM, was included. This is a linear interpolation of a five-quarter lagged weighted average of Michigan disposable income, expressed in natural log form.[4]

The problem with using LNAVYPRM as the lone income variable is that the sales tax base is heavily weighted towards consumer durables which tend to be more responsive to changes transitory income than overall consumption. Thus it seemed appropriate to add a transitory income variable to the regression. Unfortunately, expressing such a variable in log form is impossible, since this would involve taking the log of a negative number. As an alternative, the log of

4. The weights used are those used in the SQEM permanent income variable, that is, .271 in the current quarter, .217 in t-1, .173 in t-2, .139 in t-3, .111 in t-4, and .089 in t-5. These weights are designed to sum to one and to be 80% of the weight of the previous quarter. Although this variable is no longer used in the MURF sales tax equation, it is used in the 4% liquor tax equation, expressed in constant 1982 dollars.

a linear interpolation of total disposable income, LNAVYDM, is used as a regressor.

However, when both LNAVYDM and LNAVYPRM were included in the same regression the t-statistics on both fell, indicating a possible problem of multicollinearity. Consequently, it was finally decided to include LNAVYDM only among the set of regressors.

This model includes the Detroit CPI as a regressor. This variable, which is expressed in log form as LNAPCPID, is included along with disposable income variables because sales tax receipts may be more responsive to rises in real disposable income than nominal disposable income.

Over time, the fraction of consumption spending on services, which are exempt from the sales tax, has tended to rise. This secular movement in the economy is proxied by the variable ESMSHARE, which is the service sector's fraction of total wage and salary employment.

A variable called DIFF, which is the difference between RAAA, a triple-A rated corporate bond rate, and RCPCD, the rate on four to six month paper, is included as a regressor. The rationale behind the use of this variable is that a large value for DIFF implies a steep yield curve and suggests that investors expect interest rates to rise. If this is the case, they may wish to buy now before interest rates rise. In addition, RAAA is included as a regressor on its own to model the depressing effect on sales of high interest rates.

RUMICH, the Michigan unemployment rate is also included among the set of regressors to capture the negative effect of a rise in the jobless rate on consumer sentiment and thus consumer spending.

Another oft-quoted determinant of consumer spending is the weather. It is sometimes alledged that warm weather tends to cause an increase in retail sales, as more consumers take to the malls and car lots. Although, the effects of weather on consumption are probably more complicated than this, the monthly average temperature in Detroit, Metro, TEMP, was included as a regressor with the a priori belief that it would yield a positive coefficient. Forecasts of this variable are a 28-year average of monthly values for this variable.

There is an extreme seasonal pattern to sales tax receipts. Eleven monthly seasonal dummies have been included in the set of regressors to model this seasonality.

A variable called INCENT has also been included to model the higher sales tax receipts in October of 1985 and 1986 and in September and November of 1987, due to the introduction of more aggressive sales incentives for automobiles. This dummy variable takes a value of one in the month after the incentives and minus one in the month following that, to reflect first increased sales due to incentives and then a falloff in sales when incentives are dropped. The form of this dummy variable implicitly assumes that incentives only affect the timing of purchases rather

than their overall level.

Finally, a variable called WEEKDY is used. This variable gives the number of weekdays in a month with the expectation that sales tax receipts will be higher in a month after a month with an above average number of weekdays.

It should be noted that LNAVYDM, LNAPCPID, RAAA, DIFF, RUMICH, ESMSHARE, WEEKDY and TEMP, all enter the equation lagged by one month, because sales tax receipts are paid to the state on the 15th of the month following the sale of goods.

Six observations are treated as outliers in the current model.[5] Sales tax receipts were below normal in July, August, September, and October of 1980 due to a 50% reduction in sales tax for cars sold between June 27 and August 1, 1980. Thus dummy variables have been entered for July, August, September and October 1980. In addition, sales tax receipts were unusually low in May of 1979. This was probably, partly the result of a teamster's strike in April of that year as well as a fall in auto sales in response to a gasoline shortage. Consequently, a dummy variable, B7905 has been entered for this month.

Finally, sales tax receipts were unusually low in February 1987. This was probably the result of individuals

5. Much of the information on outliers in this and other MURF models is gleaned from the Monthly Financial Report to the Legislature which is published by the Department of Management and Budget, usually within 30 days of the end of the month.

bringing forward their purchases of "big-ticket" items into 1986 to take advantage of sales tax deductability which was eliminated, starting January 1987, under the 1986 federal tax reform act. A dummy variable, B8702 has been entered into the MURF model for this month.

In addition, to the above variables, MA terms at lags of one and 12 months were included among the set of regressors to take account of some remaining correlation and seasonality among the residuals.

The MURF sales tax equation is shown below:

$$
\begin{aligned}
(4.2)\quad LNSALETX = {} & a_1 + a_2*TR1 + \ldots + a_{12}*TR11 \\
& + a_{13}*LNAVYDM(-1) + a_{14}*LNAPCPID(-1) + a_{15}*RAAA(-1) \\
& + a_{16}*DIFF(-1) + a_{17}*RUMICH(-1) + a_{18}*ESMSHARE(-1) \\
& + a_{19}*WEEKDY(-1) + a_{20}*TEMP(-1) + a_{21}*INCENT \\
& + a_{22}*B7905 + a_{23}*B8007 + a_{24}*B8008 + a_{25}*B8009 \\
& + a_{26}*B8010 + a_{27}*B8702 + a_{28}*MA(1) + a_{29}*MA(12)
\end{aligned}
$$

Performance Review

The results of regressing the MURF model of sales tax on data from March 1976 to December 1988 are shown in Table 4.1. The R^2 is .993 and all but one of the economic variables were found to be significant at least at the 5 percent level. A partial R^2 for the economic variables given outlier and seasonal dummies and MA terms was calculated to be .973.

Table 4.1: Statistical Output from the
MURF Sales Tax Equation

LS // Dependent Variable is LNSALETX
SMPL range: 1976.03 - 1988.12
Number of observations: 154
Convergence achieved after 3 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2.3312885	0.8375199	2.7835618	0.005
TR1	0.2206613	0.0119293	18.497391	0.000
TR2	-0.0615602	0.0151858	-4.0538105	0.000
TR3	-0.1273420	0.0129412	-9.8400401	0.000
TR4	-0.0063427	0.0098134	-0.6463242	0.518
TR5	0.0026488	0.0107019	0.2475046	0.805
TR6	0.0235268	0.0149009	1.5788825	0.114
TR7	0.0651966	0.0191773	3.3996815	0.001
TR8	-0.0146057	0.0220814	-0.6614462	0.508
TR9	-0.0104965	0.0208987	-0.5022559	0.615
TR10	0.0311176	0.0172092	1.8081969	0.071
TR11	-0.0186424	0.0109460	-1.7031199	0.089
LNAVYDM(-1)	0.7465191	0.1455038	5.1305813	0.000
LNAPCPID(-1)	0.6915371	0.1692386	4.0861655	0.000
RAAA(-1)	-0.0058416	0.0027323	-2.1380027	0.033
DIFF(-1)	0.0138211	0.0023566	5.8647646	0.000
RUMICH(-1)	-0.0138498	0.0033046	-4.1910697	0.000
ESMSHARE(-1)	-5.4520335	1.1074592	-4.9230109	0.000
WEEKDY(-1)	0.0077571	0.0025846	3.0012943	0.003
TEMP(-1)	0.0009337	0.0006025	1.5498539	0.121
INCENT	0.0326850	0.0086389	3.7834615	0.000
B7905	-0.0463924	0.0255320	-1.8170275	0.069
B8007	-0.0645110	0.0251999	-2.5599747	0.010
B8008	-0.0689375	0.0253104	-2.7236768	0.006
B8009	-0.0367985	0.0255565	-1.4398872	0.150
B8010	-0.0461262	0.0249698	-1.8472805	0.065
B8702	-0.0793660	0.0254347	-3.1203863	0.002
MA(1)	0.3303897	0.0919194	3.5943415	0.000
MA(12)	0.2761613	0.0996263	2.7719723	0.006

R-squared	0.993295	Mean of dependent var	11.87049
Adjusted R-squared	0.991793	S.D. of dependent var	0.258740
S.E. of regression	0.023440	Sum of squared resid	0.068680
Durbin-Watson stat	1.981271	F-statistic	661.3319
Log likelihood	375.5577		

The Box-Pierce Q-statistic with 22 degrees of freedom was found to be 22.97, well under the 5 percent critical level for Chi-square of 31.41. This failed to reject the null hypothesis of white noise residuals. A likelihood ratio test on the significance of seasonal dummies yielded a Chi-square of 278.56, easily exceeding the critical value of 19.68 given 11 degrees of freedom, and thus allowing rejection of the null hypothesis of insignificant seasonal dummies. Finally, a likelihood ratio test for structural change generated a Chi-square of 31.4, just below the critical value for a Chi-square with 24 degrees of freedom of 36.42. This failed to reject the null hypothesis of a structurally stable equation.

The SQEM model of the sales tax consists of two econometric equations and two identities. First there is an equation which explains the level of real sales tax receipts on automotive products, TRSAMN82:

$$
\begin{aligned}
(4.3)\qquad \text{TRSAMN82} &= a_1 + a_2*\text{YTM67} + a_3*\text{YPERM67} \\
&+ a_4*\sum_{i=1}^{3}\left[\frac{(\text{RAAA}-\text{RCPCD})_{-i}}{3}\right] + a_5*\frac{\text{PCDA}*\text{DAUTO}}{\text{PC}_{-1}} \\
&+ a_6*\text{DASTRIKE} + a_7*\text{DASTRIKE}_{-1} + a_8*\text{TRSAMN82}_{-1} \\
&+ a_9*(\text{TRSAMN82}_{-1}-\text{TRSAMN82}_2) + a_{10}*\text{DSEAS1} + a_{11}*\text{DSEAS2} \\
&+ a_{12}*\text{DSEAS3} + a_{13}*\text{D5769}*\text{DSEAS1} + a_{14}*\text{D5769}*\text{DSEAS1} \\
&+ a_{15}*\text{D5769}*\text{DSEAS1}
\end{aligned}
$$

YTM67 and YPERM67 are real transitory and permanant income respectively. RAAA is a AAA-rated corporate bond

rate and RCPCD is the four- to six- month commercial paper rate. The difference between these acts as a proxy for the slope of the yield curve and so gives some idea of investors' interest rate expectations. A large gap suggests the expectation of rising interest rates which would encourage individuals to buy now while rates are still relatively low.

PC is the implicit price deflator for consumption expenditures and PCDA is the implicit price deflator for the motor vehicles and parts component of consumption expenditures. DAUTO is described as a dummy variable which takes a value of .9 in 74.2 and 74.3, .95 in 75.1 and 75.2 and 1.0 otherwise. This is used to reflect auto rebates and the reaction to higher auto price in the mid 1970's. In fact the values of this variable were chosen based on auto sales and so this should not be regarded as a dummy variable strictly speaking. DASTRIKE is a dummy variable used to measure the effect of strikes in the auto industry. The values of DASTRIKE are given in Table 4.2.

Table 4.2: Values of DASTRIKE in SQEM

1964.4	-2.0	1971.2	1.2
1965.1	1.2	1973.4	-0.5
1965.2	0.8	1974.1	0.375
1967.4	-1.0	1974.2	0.125
1968.1	0.75	1976.4	-1.0
1968.2	0.25	1977.1	0.75
1970.4	-3.6	1977.2	0.25

Again this is not, strictly speaking, a dummy variable.

Each strike causes a loss of production and income in the strike quarter with 75 percent of the backlog in production made up in the following quarter and the final 25 percent made up in the next quarter. The relative magnitudes of the strikes are based on manhours lost.

A lagged dependent variable is included, presumably to eliminate serially correlated errors.

The seasonal dummy DSEAS1 takes a value of one in the first quarter, minus one in the fourth quarter and zero otherwise. The term D5769 takes a value of one between 1957 and 1969 and zero otherwise. This is to take account of a changed seasonal pattern in automotive sales tax receipts after 1969, probably due to the 1970 General Motors strike.

There is no term included to measure the effect on revenues of the 1961 rise in the sales tax rate from 3% to 4%. The data prior to that date are multiplied by 4/3 to get an adjusted sales tax series. This does not, however, allow for the effects of the sales tax increase on overall retail sales.

Second, there is an equation which attempts to explain the level of nominal sales tax receipts for other goods, TRSOMNS:

$$
\begin{aligned}
(4.4) \quad \text{TRSOMNS} &= a_1 + a_2 * \text{D80.2} + a_3 * (\text{YDM} - \text{YPERM}) \\
&+ (a_4 + a_5 * \text{DFOOD} + a_6 * \text{DTSALES}) * \text{YPERM} \\
&+ a_7 * \text{D75.1} + a_8 * \text{TRSOAMNS}_{-1} + a_9 * \text{DSEAS1} * \text{DTIME} \\
&+ a_{10} * \text{DSEAS2} * \text{DTIME} + a_{11} * \text{DSEAS3} * \text{DTIME}
\end{aligned}
$$

D80.2 takes a value of zero between 1957.2 and 1980.1 and one otherwise. YDM-YPERM is nominal transitory income. DFOOD and DTSALES are both used to reflect changes in sales tax coverage starting in 1974.4 and 1970.2 respectively. D75.1 is a dummy variable which takes a value of 1 in the first quarter of 1975 and zero elsewhere, effectively to deal with the outlier of the first quarter of the sales tax exemption for food.

$TRSOAMNS_{-1}$ is also included, presumably because of some unexplained remaining trend in sales tax receipts. DSEAS1 is multiplied by TIME to allow for a changing seasonal pattern of receipts over time.

Third, there is an identity which generates nominal automotive related sales tax from real automotive related sales tax:

(4.5) TRSAMNS = TRSAMN82*(PCDA/100)

Last, total sales tax is given by:

(4.6) TRSMNS = TRSOMNS + TRSAMNS

As a test of the relative performance of the MURF and SQEM models of sales tax receipts, two simulations were run from the first quarter of 1987 to the last quarter of 1988. The results of the simulations are illustrated in Figure 4.2 and outlined in Table 4.3. It should be noted that, for both models, the quarters contain the revenues accrued to that quarter rather than the cash received in that quarter.

FIGURE 4.2: NET SALES TAX

(ACTUAL, MURF & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

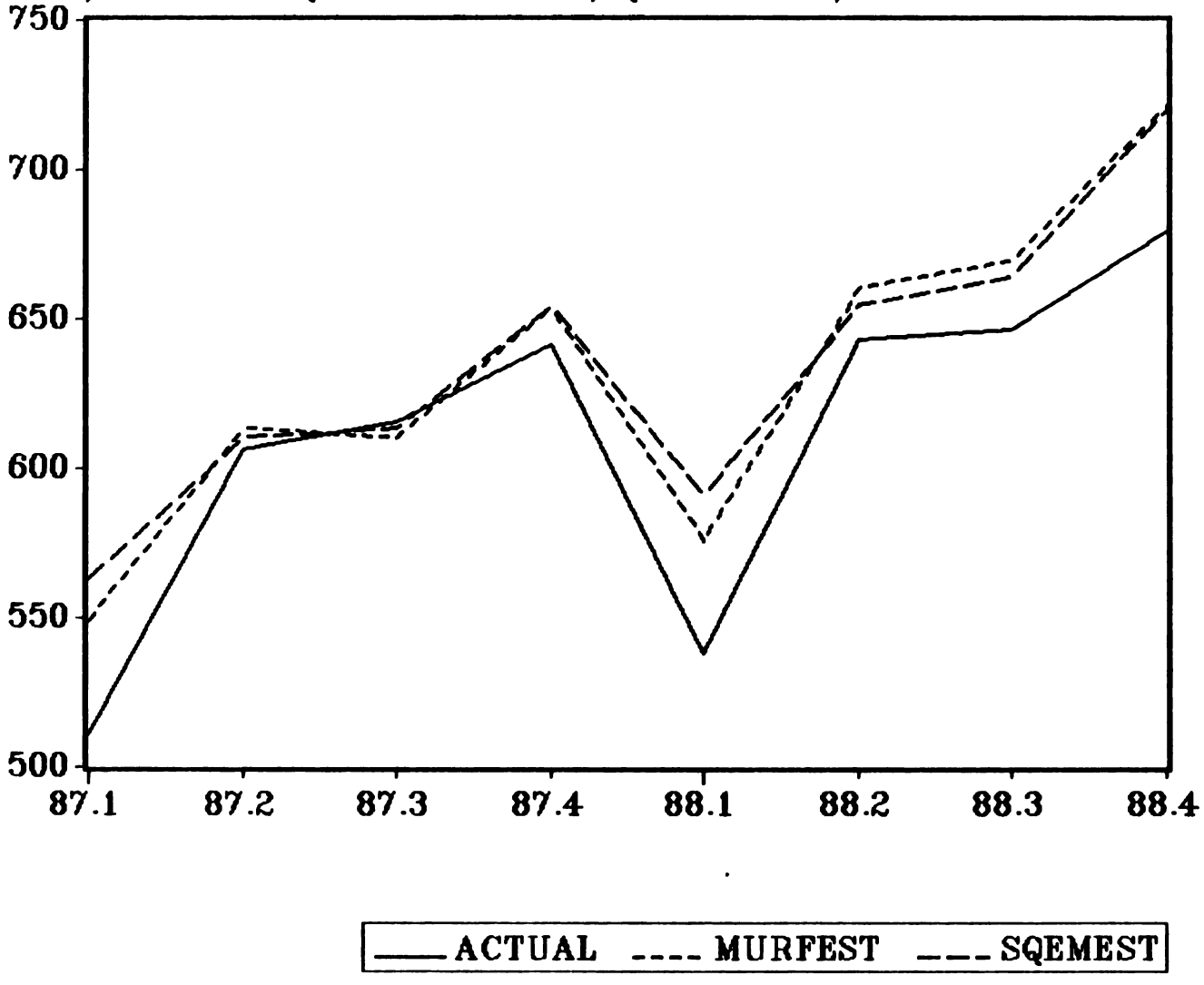


TABLE 4.3: Sales Tax (Relative Performance of MURF & SQEM Forecasts, 1987-1988)

	ACTUAL	MURF EST	MURF ERROR	SQEM EST	SQEM ERROR
1987					
I	511.0	548.8	37.8	562.8	51.8
II	606.2	613.5	7.3	610.2	4.0
III	615.4	610.0	-5.4	613.2	-2.2
IV	641.3	653.9	12.6	654.6	13.3
1988					
I	537.9	575.6	37.7	590.6	52.7
II	643.1	660.2	17.1	654.5	11.4
III	646.4	669.4	23.0	663.9	17.5
IV	679.0	721.5	42.5	720.4	41.4
RMSE			26.8		31.2

Two main conclusions can be drawn from Table 4.3. First, within the forecast period the MURF model of net sales tax performed marginally better that the SQEM model. Second, both models significantly overestimated net sales tax. This is probably due to more cautious behavior by consumers as evidenced by the recent rising personal savings rate nationally. Despite some innovations in the MURF model to try to pick up on changes in consumer sentiment, its forecast performance in this period is not particularily impressive.

As a further test of forecast performance the results of a dynamic post-sample forecast simulation for MURF were compared with those of a Vector Auto Regression (VAR) model shown in Appendix C and an Auto Regressive Moving Average (ARMA) model. The ARMA model used both an auto regressive term and a moving average terms at a lag of one month along with 11 seasonal dummies. For the purposes of this

simulation all three models were fitted over the period 1981.01 to 1986.12. The results of these simulations are illustrated in Figures 4.3, 4.4 and 4.5 and are shown in Table 4.4.

The results of these simulations are a little disappointing. The MURF model consistently overestimated revenues throughout 1987 and 1988 and was outperformed by both ARMA and VAR forecasts. The reason for the poor performance of the MURF model is presumably its inability to deal with a period of robust growth in disposable income in Michigan in which sales grew much more sluggishly. I am, however, not yet ready to abandon a model driven by economic variables at this time in favor of a pure time series model.

FIGURE 4.3: NET SALES TAX

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

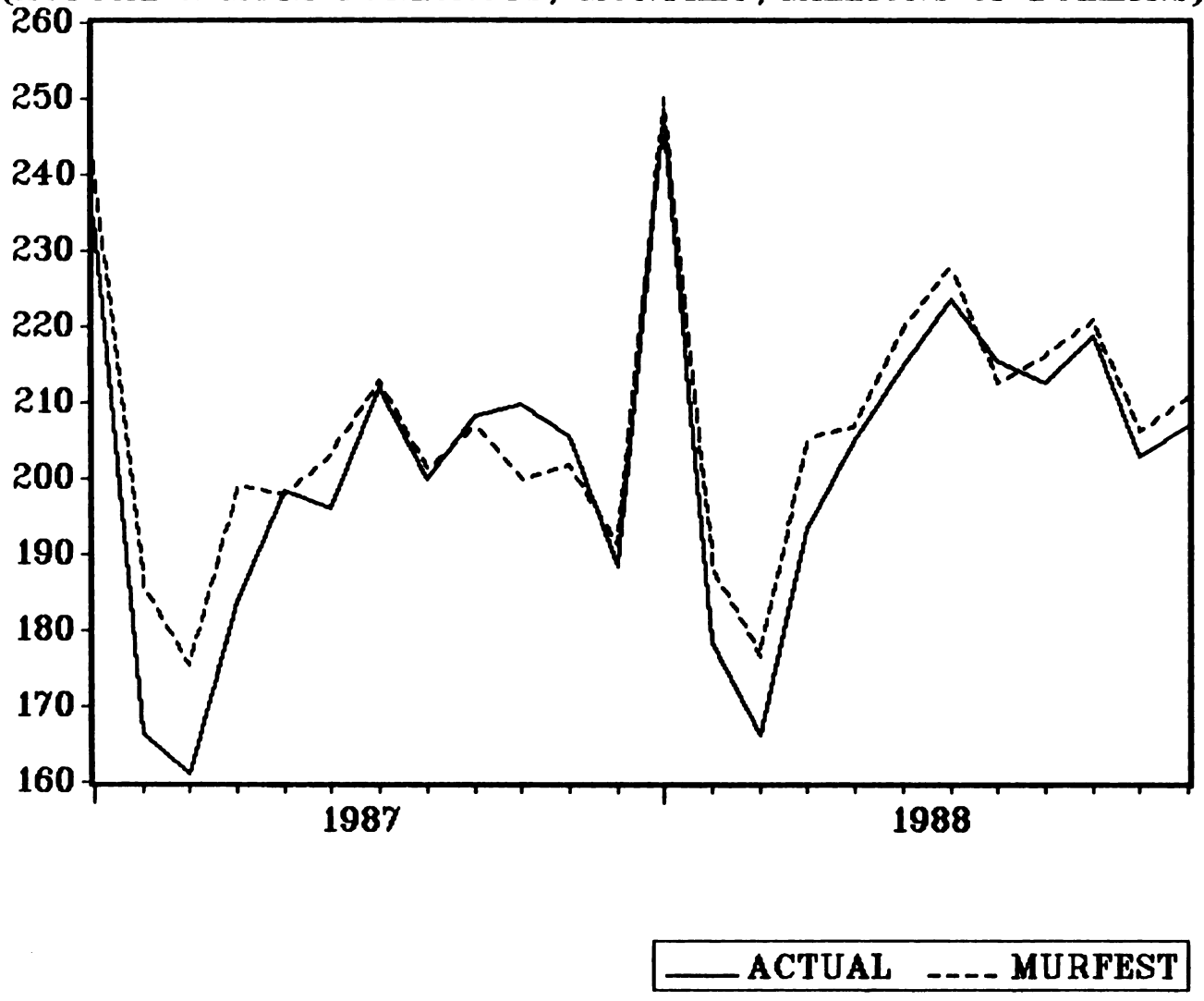
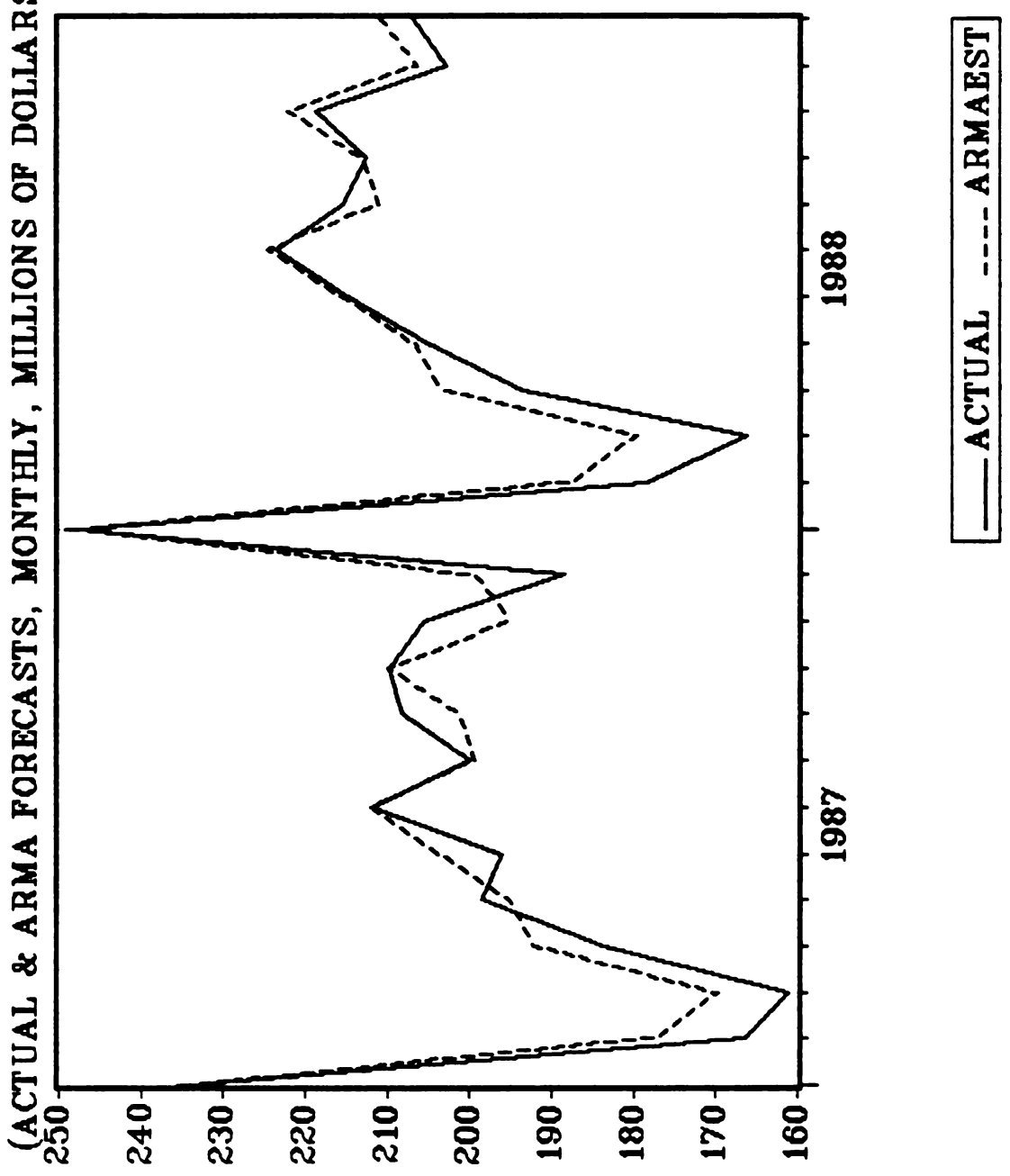


FIGURE 4.4: NET SALES TAX

(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)



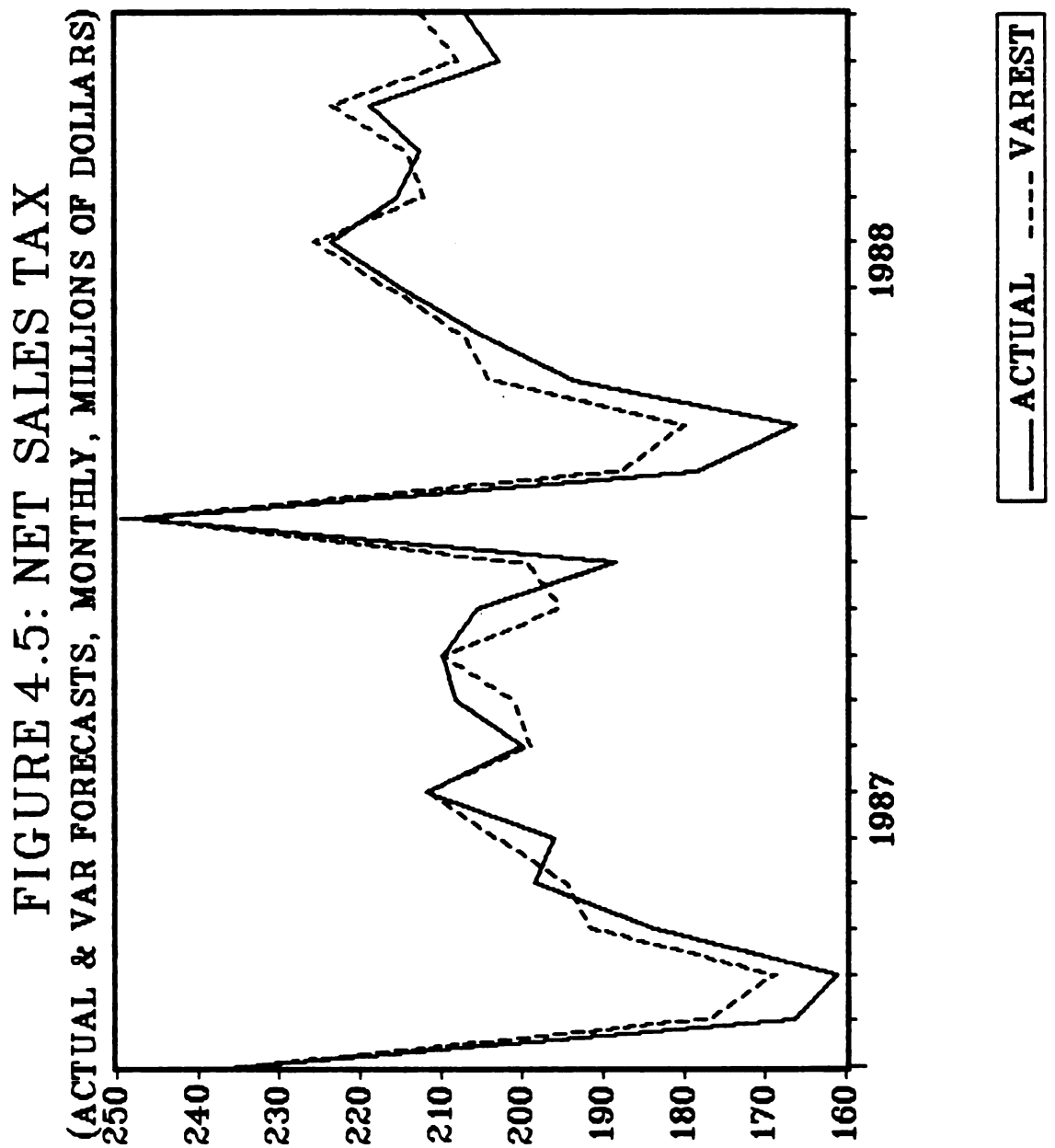


FIGURE 4.5: NET SALES TAX
(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)
250
240
230
220
210
200
190
180
170
160
1987
1988
ACTUAL
VAREST

TABLE 4.4: Sales Tax (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	234.1	241.7	7.6	235.4	1.3	235.2	1.1
FEB.	166.3	186.0	19.6	177.3	10.9	177.0	10.7
MAR.	161.1	175.2	14.1	169.5	8.5	168.6	7.5
APR.	183.6	199.1	15.4	192.1	8.5	191.5	7.8
MAY	198.3	197.8	-0.6	195.2	-3.1	194.6	-3.7
JUN.	196.0	203.1	7.1	203.7	7.7	203.1	7.1
JUL.	211.8	213.0	1.2	212.2	0.4	211.9	0.1
AUG.	199.9	201.0	1.1	199.3	-0.6	198.9	-1.0
SEP.	208.1	207.0	-1.1	201.2	-6.9	201.0	-7.1
OCT.	209.7	199.8	-9.8	209.9	0.3	209.9	0.2
NOV.	205.5	201.7	-3.7	194.9	-10.6	194.9	-10.5
DEC.	188.3	191.0	2.7	199.3	11.0	199.5	11.2
1988							
JAN.	247.6	250.1	2.5	249.2	1.7	249.5	1.9
FEB.	178.3	188.6	10.2	187.7	9.3	187.7	9.4
MAR.	166.2	176.6	10.4	179.5	13.3	179.7	13.6
APR.	193.4	205.3	11.9	203.4	10.0	203.9	10.5
MAY	204.9	206.8	1.9	206.7	1.7	207.3	2.3
JUN.	214.7	219.6	4.8	215.6	0.9	216.4	1.7
JUL.	223.5	228.0	4.6	224.6	1.2	225.6	2.2
AUG.	215.3	212.5	-2.9	210.9	-4.4	211.9	-3.4
SEP.	212.5	216.2	3.7	213.0	0.4	214.2	1.6
OCT.	218.6	220.8	2.2	222.2	3.6	223.6	5.0
NOV.	202.8	206.0	3.2	206.2	3.5	207.7	4.9
DEC.	206.8	210.7	3.9	210.9	4.1	212.5	5.7
RMSE			7.9		6.6		6.7

The MURF Model of the Use Tax

The MURF model of the use tax employs, for the most part, the same basic set of regressors as the sales tax equation. However, three variables which were included in the sales tax equation, RAAA, TEMP and INCENT, are excluded from the use tax equation as they were found to be insignificant.

One of the major problems in modeling use tax revenues is that the series on the dependent variable contains a large number of outliers, going back over ten years. This is mainly due to the fact that a few large taxpayers, particularily telephone companies, have tended to distort the series in the settlement of tax disputes.

Consequently, ten observations of the 154 observations on the use tax are treated as outliers in the current model. Revenues were unusually high in September 1978 due to a multi-year audit payment from a large company. Revenues in March 1980 were unusually high for unknown reasons. Revenues in September 1983 were high due in part to the collection of revenues that would normally be received in other months. B8403 is included to deal with large use tax revenues associated with the removal of sales tax on the difference between the purchase price of a new car and the sale price of a used car. B8412, B8501, B8502, B8503, and B8504 are used to exclude the revenues from these months from the equation. These months had particularily low revenues due to litigation over the taxable status of the

instate portion of interstate long-distance telephone calls. Finally, B8804 is included to deal with unusually high payments in April 1988, for reasons which are not yet clear.

The MURF use tax equation is shown as equation (4.7) on the next page:

$$
\begin{aligned}
(4.7)\quad \text{LNUSETAX} &= a_1 + a_2*\text{TR1} + \ldots + a_{12}*\text{TR11} \\
&+ a_{13}*\text{LNAVYDM}(-1) + a_{14}*\text{LNAPCPID}(-1) + a_{15}*\text{DIFF}(-1) \\
&+ a_{16}*\text{WEEKDY}(-1) + a_{17}*\text{RUMICH}(-1) + a_{18}*\text{ESMSHARE}(-1) \\
&+ a_{19}*\text{B7809} + a_{20}*\text{B8003} + a_{21}*\text{B8309} + a_{22}*\text{B8403} \\
&+ a_{23}*\text{B8412} + a_{24}*\text{B8501} + a_{25}*\text{B8502} + a_{26}*\text{B8503} \\
&+ a_{27}*\text{B8504} + a_{27}*\text{B8804}
\end{aligned}
$$

Performance Review

The results of regressing the MURF model of use tax on data from March 1976 to December 1988 are shown on the next page. The R^2 is .985 and all the economic variables are significant at the 5% level of significance. A partial R^2 for the contribution of the economic variables, given the seasonal and outlier dummies was calculated to be .982.

A Chi-square statistic was calculated to test the null hypothesis of white noise residuals. This hypothesis could not be rejected as the estimated Chi-square of 19.14 was well below the five percent critical value of 36.42 given 24 degrees of freedom.

Table 4.5: Statistical Output from the MURF Use Tax Equation

LS // Dependent Variable is LNUSETAX
SMPL range: 1976.03 - 1988.12
Number of observations: 154

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-2.8441243	1.2587194	-2.2595380	0.024
TR1	0.0389143	0.0178549	2.1794725	0.029
TR2	-0.1025499	0.0174785	-5.8671960	0.000
TR3	-0.1226372	0.0188361	-6.5107491	0.000
TR4	0.0207550	0.0178627	1.1619226	0.245
TR5	0.0355489	0.0167906	2.1171852	0.034
TR6	0.0562365	0.0169646	3.3149244	0.001
TR7	0.1343294	0.0167304	8.0290805	0.000
TR8	0.0562531	0.0170302	3.3031361	0.001
TR9	0.0677268	0.0176415	3.8390596	0.000
TR10	0.1246206	0.0166663	7.4773780	0.000
TR11	0.0296309	0.0168384	1.7597160	0.078
LNAVYDM(-1)	1.1295014	0.2107309	5.3599241	0.000
LNAPCPID(-1)	0.5800208	0.2485634	2.3334926	0.020
DIFF(-1)	0.0225487	0.0046626	4.8360342	0.000
WEEKDY(-1)	0.0180367	0.0046318	3.8940671	0.000
RUMICH(-1)	-0.0141198	0.0055569	-2.5409656	0.011
ESMSHARE(-1)	-6.8122759	1.9510089	-3.4916683	0.000
B7809	0.1423064	0.0440965	3.2271567	0.001
B8003	0.1515270	0.0445447	3.4016827	0.001
B8309	0.1327643	0.0439760	3.0190186	0.003
B8403	0.2755959	0.0442052	6.2344730	0.000
B8412	-0.1561316	0.0441562	-3.5358927	0.000
B8501	-0.2331680	0.0449635	-5.1857143	0.000
B8502	-0.1170669	0.0452085	-2.5894857	0.010
B8503	-0.1431214	0.0456901	-3.1324402	0.002
B8504	-0.1180940	0.0453532	-2.6038746	0.009
B8804	0.1406461	0.0441373	3.1865563	0.001

R-squared	0.985034	Mean of dependent var	10.03683
Adjusted R-squared	0.981827	S.D. of dependent var	0.307297
S.E. of regression	0.041426	Sum of squared resid	0.216234
Durbin-Watson stat	1.861874	F-statistic	307.1443
Log likelihood	287.2461		

A test for structural change was conducted by evaluating the log likelihood function from 1982.08 to 1988.12 both in unconstrained form and using the coefficients evaluated over the entire fit period. This test yielded a Chi-square of 17.44 which was less than half of the five percent critical level for Chi-square given 26 degrees of freedom.

Finally, a likelihood ratio test was conducted to test the null hypothesis of insignificant seasonal dummies. Given 11 degrees of freedom, the calculated test statistic of 219.2 was more than ten times the maximum value that would have prevented rejection of this hypothesis.

The SQEM model of the use tax consists of equation (4.8) below:

$$
\begin{aligned}
(4.8) \qquad \text{TUSEMNS} &= a_1 + a_2 * \text{YDM} + a_3 * \text{TUSEMNS}_{-1} \\
&+ a_4 * \text{DSEAS1} * \text{DTIME} + a_5 * \text{DSEAS2} * \text{DTIME} + a_6 * \text{DSEAS3} * \text{DTIME} \\
&+ a_7 * \text{D79.4}
\end{aligned}
$$

In this equation TUSEMNS represents quarterly use tax revenues, YDM is disposable income in Michigan, D79.4 takes a value of one in the fourth quarter of 1979 and zero elsewhere, DTIME is a time trend, and DSEAS1 is a seasonal dummy.

One interesting point to note is that no adjustment is made in this equation for the increase in the use tax rate from 3% to 4% in 1960. I have notified RSQE of this error which, in itself, is of no theoretical significance.

However, in practical terms it does underline one of the problems involved in using early observations, that is, that the further back you go, the more likely it is that some piece of information which is important to the model will be forgotten.

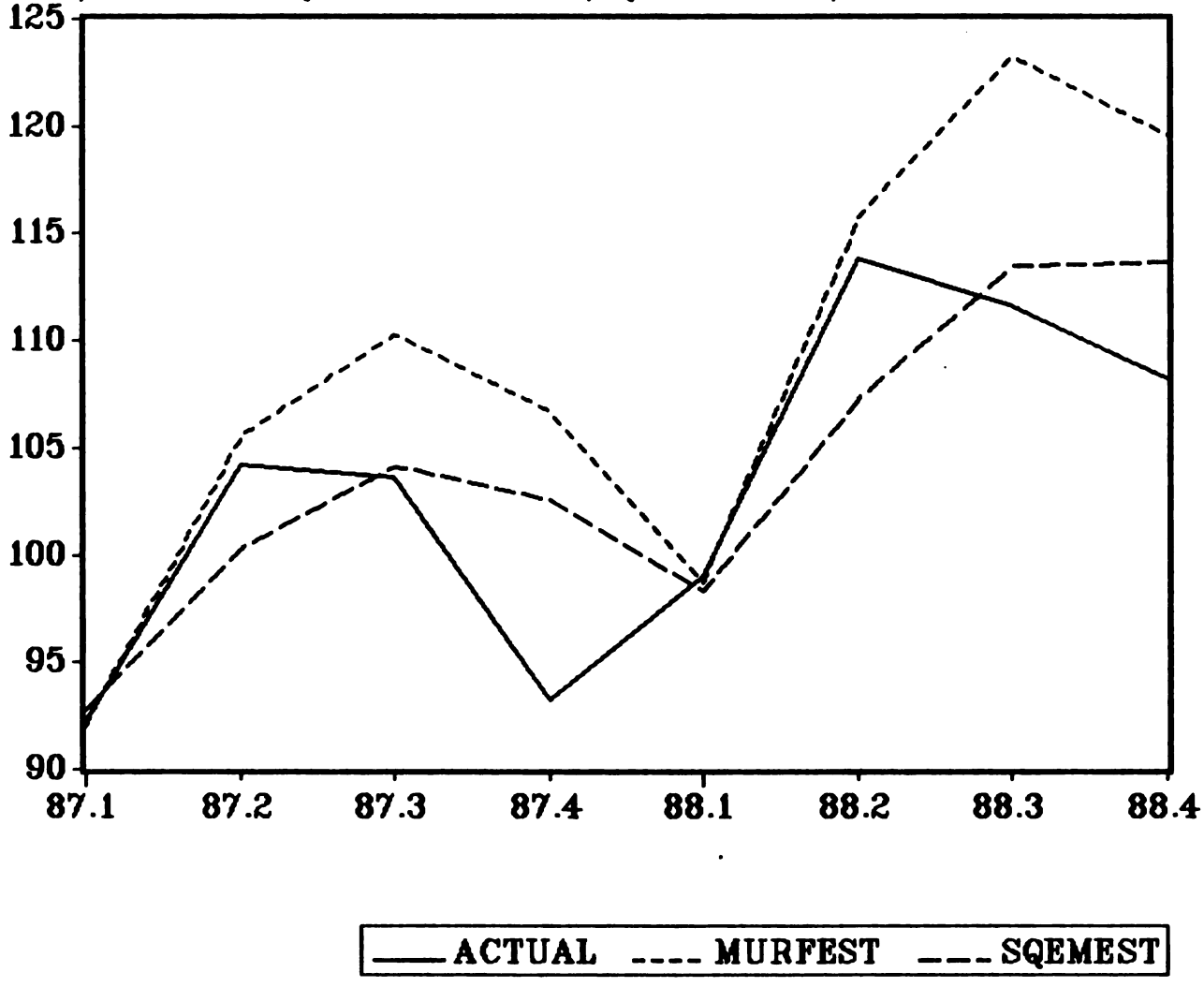
As a test of the relative performance of the MURF and SQEM models of use tax revenues, two simulations were run from the first quarter of 1987 to the last quarter of 1988. The results of the simulations are illustrated in Figure 4.6 and outlined in Table 4.6. It should be noted that, for both models, the quarters contain the revenues accrued to that quarter rather than the cash received in that quarter. It should also be noted that this is a forecast of net use tax revenue so that $564,000 is subtracted from the MURF forecast of gross use tax revenues in each quarter for use tax refunds.[6]

In some ways Table 4.6 is disappointing. The MURF model failed to outperform a fairly crude SQEM model of the use tax. However, the data is distorted by a $7 million refund in December of 1987 and a fall in payments from the communications sector. It probably also suffers from the same problem as the MURF sales tax equation in this period

6. The number $564,000 is derived from a monthly average level of use tax refunds in calendar 1987 and 1988 of $188,000. These amounts tend to fluctuate somewhat from month to month, but are not large enough to warrent great concern. A constant amount is subtracted in the forecast rather than the actual amount as to do otherwise would slightly bias the forecast comparison in favor of the MURF model.

FIGURE 4.6: NET USE TAX

(ACTUAL, MURF & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



in not picking up a fall in the average propensity to consume in Michigan in this period.

TABLE 4.6: Use Tax (Relative Performance of MURF & SQEM Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	SQEM EST	ERROR
1987					
I	92.2	92.0	-0.2	92.8	0.6
II	104.2	105.5	1.3	100.3	-3.9
III	103.6	110.3	6.7	104.1	0.5
IV	93.2	106.6	13.4	102.5	9.3
1988					
I	99.0	98.7	-0.3	98.2	-0.8
II	113.8	115.7	1.9	107.2	-6.6
III	111.6	123.2	11.6	113.4	1.8
IV	108.2	119.5	11.3	113.6	5.4
RMSE			7.9		4.7

A second test of the relative performance of the MURF model is a little more encouraging. As can be seen in Table 4.7 below, and as is displayed in Figures 4.7, 4.8, and 4.9, the MURF model clearly performed better on a monthly basis than either the VAR model or an ARMA model with an MA terms at lags of one and four months and AR terms at lags of one month along with 11 seasonal dummies. For the purposes of this simulation all models were fitted over the period 1981.01 to 1986.12.

TABLE 4.7: Use Tax (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	36.8	33.3	-3.6	30.3	-6.6	31.2	-5.7
FEB.	30.9	29.5	-1.4	27.4	-3.5	28.0	-2.9
MAR.	27.8	28.4	0.6	27.4	-0.4	27.7	-0.1
APR.	33.7	32.6	-1.1	30.7	-3.0	30.9	-2.8
MAY	35.3	32.9	-2.4	32.1	-3.2	32.3	-2.9
JUN.	32.6	34.0	1.4	34.0	1.4	34.1	1.6
JUL.	37.4	37.1	-0.3	36.6	-0.8	36.6	-0.8
AUG.	35.8	35.5	-0.2	35.0	-0.8	34.9	-0.9
SEP.	33.2	35.4	2.2	36.3	3.2	36.2	3.0
OCT.	36.3	38.3	2.0	38.0	1.7	37.7	1.4
NOV.	34.1	35.0	0.9	35.3	1.2	35.0	0.9
DEC.	32.8	32.1	-0.7	32.0	-0.8	31.6	-1.2
1988							
JAN.	34.0	35.4	1.4	33.0	-1.0	33.4	-0.7
FEB.	29.5	30.7	1.1	29.5	-0.0	29.9	0.3
MAR.	28.6	30.4	1.9	29.4	0.8	29.9	1.3
APR.	41.3	35.3	-6.0	32.6	-8.7	33.3	-8.0
MAY	35.8	34.9	-1.0	34.1	-1.7	34.7	-1.1
JUN.	36.3	37.6	1.3	36.1	-0.2	36.7	0.4
JUL.	42.0	40.4	-1.6	38.9	-3.2	39.3	-2.7
AUG.	36.4	37.7	1.4	37.1	0.8	37.5	1.1
SEP.	37.2	39.8	2.6	38.6	1.4	38.9	1.6
OCT.	38.6	42.0	3.4	40.4	1.7	40.5	1.9
NOV.	34.8	37.9	3.1	37.5	2.7	37.6	2.8
DEC.	36.5	35.6	-0.9	34.0	-2.5	34.0	-2.5
RMSE			2.2		2.9		2.7

FIGURE 4.7: GROSS USE TAX

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

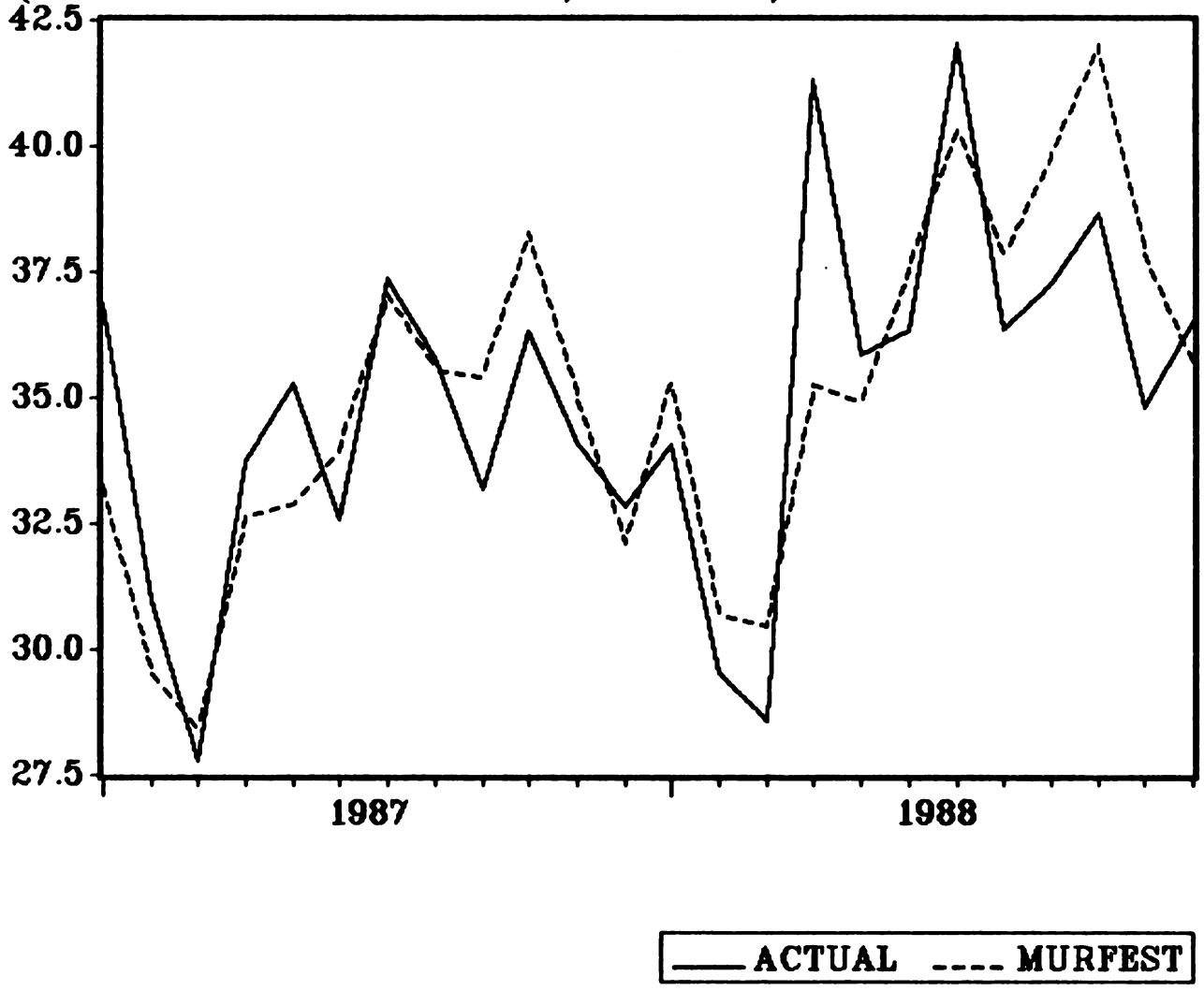


FIGURE 4.8: GROSS USE TAX

(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

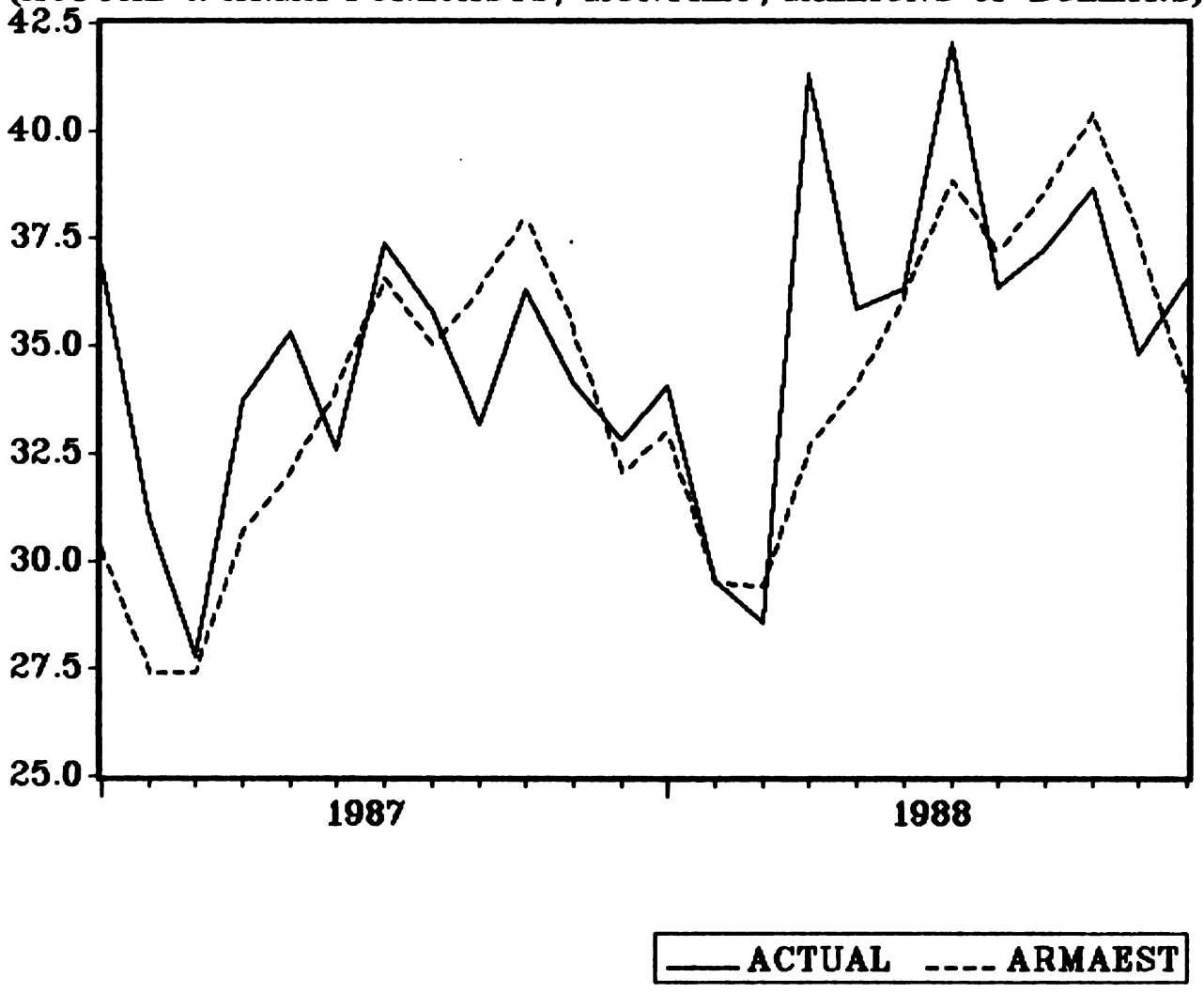
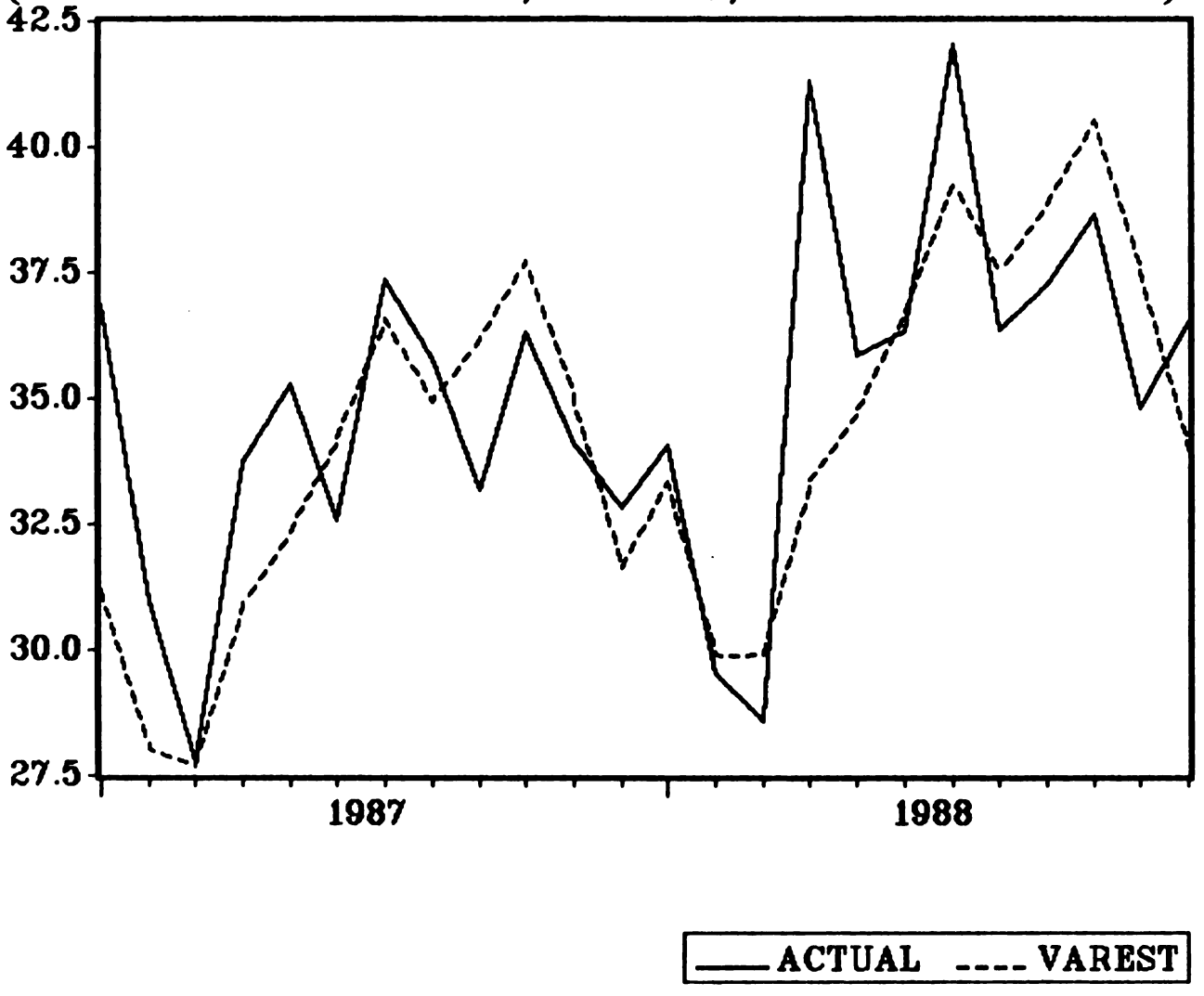


FIGURE 4.9: GROSS USE TAX

(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)



4.4 Cigarette Tax

A Short History of the Michigan Cigarette Tax[7]

The Michigan cigarette tax was first imposed in 1947 at a rate of 3 cents per pack of 20 cigarettes. In 1957, the rate was raised to 5 cents, with the additional 2 cents being earmarked to the school aid fund. In 1959, the rate was raised to 6 cents as part of a package to deal with a deficit. In 1961, the rate was reduced to 5 cents again.

In 1962, the rate was increased to 7 cents and in 1970, it was increased to 11 cents. In 1982, again in response to fiscal problems, the rate was raised to 21 cents with the additional 10 cents being dedicated to the working capital reserve account (WCRA). WCRA expired at the end of fiscal 1986. However, the tax remained at 21 cents and was increased to 25 cents in 1988 as part of the Wayne county bailout package. All of the additional 4 cents was dedicated to Wayne county for the remainder of fiscal 1988. After September 1988, one cent of the increase is dedicated to indigent care with the rest going to Wayne and other county units.

7. There are two basic sources for this history. They are:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, Michigan, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.

The MURF Model of the Michigan Cigarette Tax

The MURF model of the Michigan cigarette tax is constructed in light of three important facts. First, the cigarette tax is a specific tax, that is, it is levied on a per pack basis rather than according to the price of a pack.[8] Second, the tax rate has risen fairly dramatically in recent years which seems to have had a depressing effect upon consumption. Third, the payment date is on the 20th of the month and, as a result, revenues for one month frequently get recorded in the following month.

The dependent variable, LAJC25TX, is the natural log of monthly cigarette tax revenues, adjusted to a rate of 25 cents per pack. The adjustment is made by multiplying revenues before May 1982 by 25/11, and multiplying revenues from May 1982 to January 1988 inclusive, by 25/21. Monthly revenues are defined as the revenue that comes in between the 11th of one month and the 10th of the next month.

The income variable used, LYDM82, is the log of a geometric interpolation of a quarterly series on Michigan real disposable income.

There should also be a seasonal pattern to cigarette tax receipts, both due to different numbers of days in different months and, perhaps, some seasonality in cigarette consumption. Eleven monthly seasonal dummies have been included in the set of regressors to deal with this

8. Strictly speaking the tax is currently levied at a rate of 1.25 cents per cigarette.

seasonality.

A variable called LRELPCIG is also used as a regressor. This is the natural log of the the ratio of PRICE, a price index of tobacco products in the CPI-U, to PCPID, the Detroit CPI for all items. This variable is fairly smooth over time with the exception of a jump in 1983, due to a doubling of the federal tax on tobacco products.

LRATE is the natural log of the state tax rate. Because LAJC25TX is being used as the dependent variable and because the U.S. price of tobacco products is essentially independent of Michigan taxes, a negative relationship should be observed between the Michigan tax rate and revenues at 25 cents. LYDM82, LRELPCIG and LRATE are all lagged one month as cigarette tax collections are generated by the sales in the previous month.

The Michigan tax rate changed twice over the course of the sample period and the U.S. tax rate changed once. Just before and after changes in the tax rate, revenues are unusually volatile as consumers stock up in advance of a tax rise. Consequently, dummy variables are introduced for some of these months, so that they do not influence the estimated regression line. In addition, a dummy variable is included for July 1988, in which revenues were unusually high for reasons that are not yet clear.

A variable called WEEKDY is also employed as a regressor with a lag of one month. This variable gives the number of weekdays in the current month. A larger than

normal number of weekdays in the previous month may increase retail sales of tobacco products and so increase revenues.

Finally a moving average term is introduced with a lag of one month to deal with some remaining serial correlation among residuals.

Thus the MURF cigarette tax equation is given by equation (4.9) below:

$$(4.9) \quad LAJC25TX = a_1 + a_2*TR1 + \ldots + a_{12}*TR11 + a_{13}*LYDM82(-1) + a_{14}*WEEKDY(-1) + a_{15}*LRELPCIG(-1) + a_{16}*LRATE(-1) + a_{17}*B8205 + a_{18}*B8206 + a_{19}*B8212 + a_{20}*B8301 + a_{21}*B8302 + a_{23}*B8303 + a_{24}B8807 + a_{25}*MA(1)$$

Performance Review

The MURF cigarette tax model, whose results are outlined in Table 4.8, explains only 91.8 percent of the variation in cigarette tax revenues. However, it is important to note that the total sum of squared residuals with the adjusted data is 25 percent lower than in a model regressed over the same period using the same independent variables but data on the dependent variable recorded by calendar month. All the explanatory variables have their predicted signs but the real income variable appears to be profoundly insignificant.

There are at least three possible explanations for this result. First, it is possible that cigarette consumption is highly inelastic with respect to changes in income, although

this does not seem entirely compatable with its apparent sensitivity to the tax rate as evidenced by the fall-off in consumption after May 1982.[9]

Second, given the relatively short fit period, it may be that changes in real disposable income have not been sufficient to induce a measurable effect.

Third, and perhaps most likely, it may be that a positive real income effect is being masked by an increase in health consciousness among the public which has caused a trend downwards in cigarette consumption nationwide. As yet, I have not found a way to measure this trend explicitly.

In addition to the statistics generated by the regression program, a partial R^2 was calculated to measure the explanatory power of the economic variables, given the seasonal and outlier dummies and the MA term. This was found to be .744. Two likelihood ratio tests were performed. In the first, a Chi-square was estimated to test the null hypothesis of structural stability and was found to be 27.7, just under the 28.9 critical value for Chi-square at the five percent level, given 18 degrees of freedom. The sample period was split at its midpoint for this test. In the second, the null hypothesis of insignificant seasonal dummies was rejected as the calculated Chi-square amounted to 123.28 compared to a critical value of 19.68.

9. It is possible that part of the falloff in collections may be related to an increase in smuggling and out-of-state purchases after the 10 cent tax increase.

Table 4.8: Statistical Output from the
MURF Cigarette Tax Equation

LS // Dependent Variable is LAJC25TX
SMPL range: 1980.09 - 1988.12
Number of observations: 100
Convergence achieved after 4 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	9.4440068	0.5647711	16.721830	0.000
TR1	0.0435648	0.0167606	2.5992305	0.011
TR2	-0.0637829	0.0162656	-3.9213330	0.000
TR3	-0.0550476	0.0162285	-3.3920304	0.001
TR4	-0.0167746	0.0159146	-1.0540330	0.296
TR5	0.0060189	0.0159934	0.3763367	0.708
TR6	0.0285149	0.0162898	1.7504686	0.085
TR7	0.0876338	0.0160936	5.4452539	0.000
TR8	0.0910418	0.0161134	5.6500816	0.000
TR9	0.0697836	0.0152842	4.5657412	0.000
TR10	0.0529904	0.0150793	3.5141050	0.001
TR11	0.0377581	0.0154585	2.4425508	0.017
LYDM82(-1)	0.0238568	0.0521686	0.4573022	0.649
WEEKDY(-1)	0.0289638	0.0042548	6.8073069	0.000
LRELPCIG(-1)	-0.2443286	0.1092876	-2.2356494	0.029
LRATE(-1)	-0.0807723	0.0250846	-3.2199985	0.002
B8205	-0.2019816	0.0334931	-6.0305366	0.000
B8206	-0.1992768	0.0350739	-5.6816272	0.000
B8212	0.0282272	0.0337777	0.8356748	0.406
B8301	0.1372914	0.0335710	4.0895863	0.000
B8302	-0.1561545	0.0338315	-4.6156542	0.000
B8303	-0.1073947	0.0336819	-3.1884991	0.002
B8807	0.1122394	0.0331804	3.3827059	0.001
MA(1)	-0.2372015	0.1157342	-2.0495373	0.044

R-squared	0.918353	Mean of dependent var	10.09097
Adjusted R-squared	0.893645	S.D. of dependent var	0.093624
S.E. of regression	0.030533	Sum of squared resid	0.070851
Durbin-Watson stat	1.976496	F-statistic	37.16702
Log likelihood	220.7237		

The Box-Pierce test for white noise residuals was also employed. Given 23 degrees of freedom this yielded a Chi-square of 20.33, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

The SQEM model of the Cigarette Tax is given by equation (4.10) below:

$$(4.10) \quad \ln TCIGMNS = a_1 + a_2 * \ln TCIGRT + a_3 * \ln YPERM67 + a_4 * \ln TCIGMNS_{-1} + a_5 * DSEAS1 + a_6 * DSEAS2 + a_7 * DSEAS3$$

In this equation, lnTCIGMNS represents the natural log of quarterly values of revenues from the cigarette tax, lnTCIGRT is the natural log of the tax rate, lnYPERM67 is the log of real permanent disposable income, and DSEAS1 etc. are seasonal dummies.

As a test of the relative performance of the MURF and SQEM models of cigarette tax revenues, two simulations were run from the first quarter of 1987 to the last quarter of 1988. The results of the simulations are illustrated in Figures 4.10 and 4.11 and outlined in Table 4.9. It should be noted that, for both models, the quarters contain the revenues accrued to that quarter rather than the cash received in that quarter. It should also be noted that the MURF MRSB series is slightly different from its SQEM counterpart, due to the way MURF measures months of revenue. Finally, forecasts of gross cigarette tax revenue after refunds are used so that $162,000 is subtracted from the

FIGURE 4.10: GROSS CIGARETTE TAX AT 25 CENTS

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

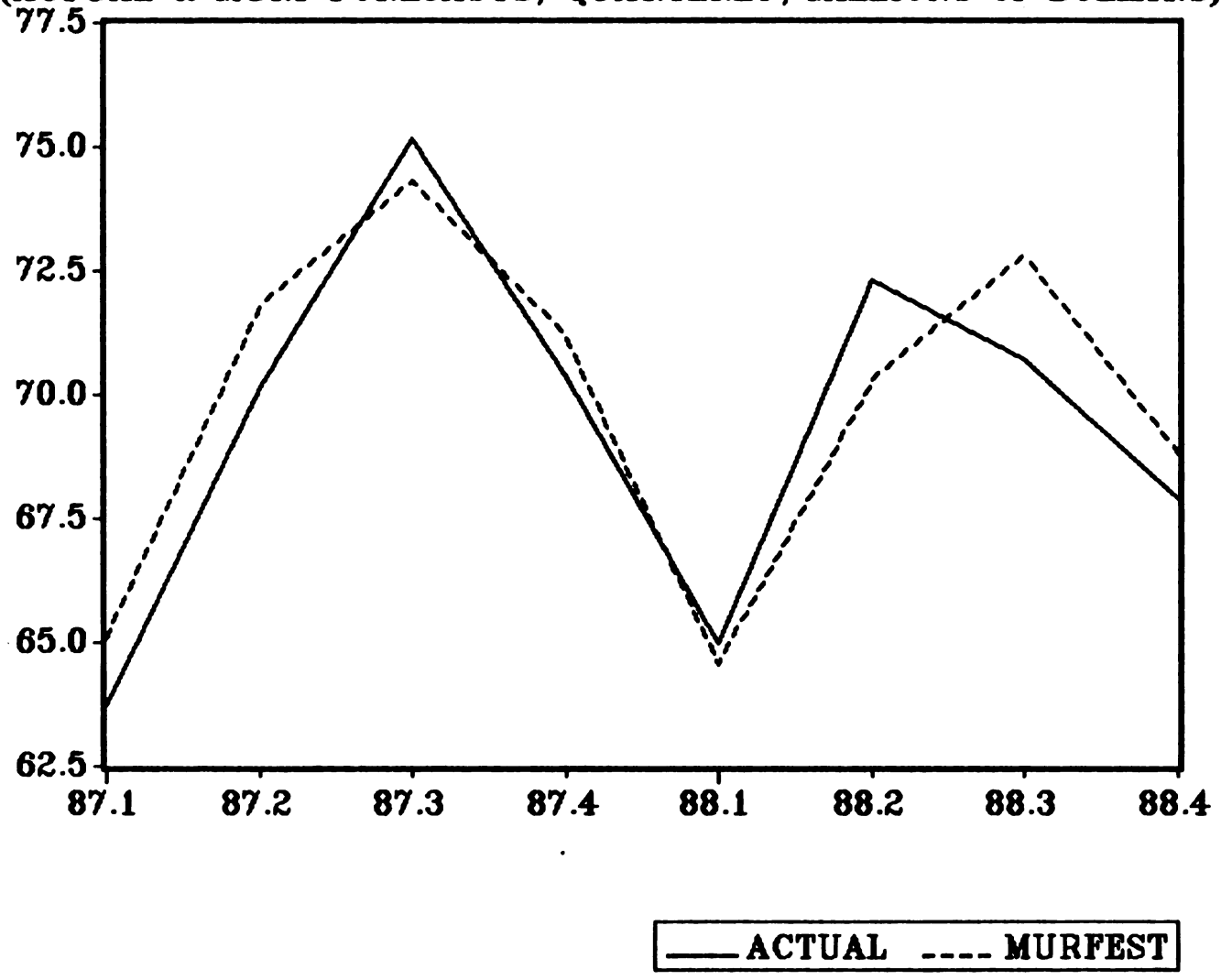
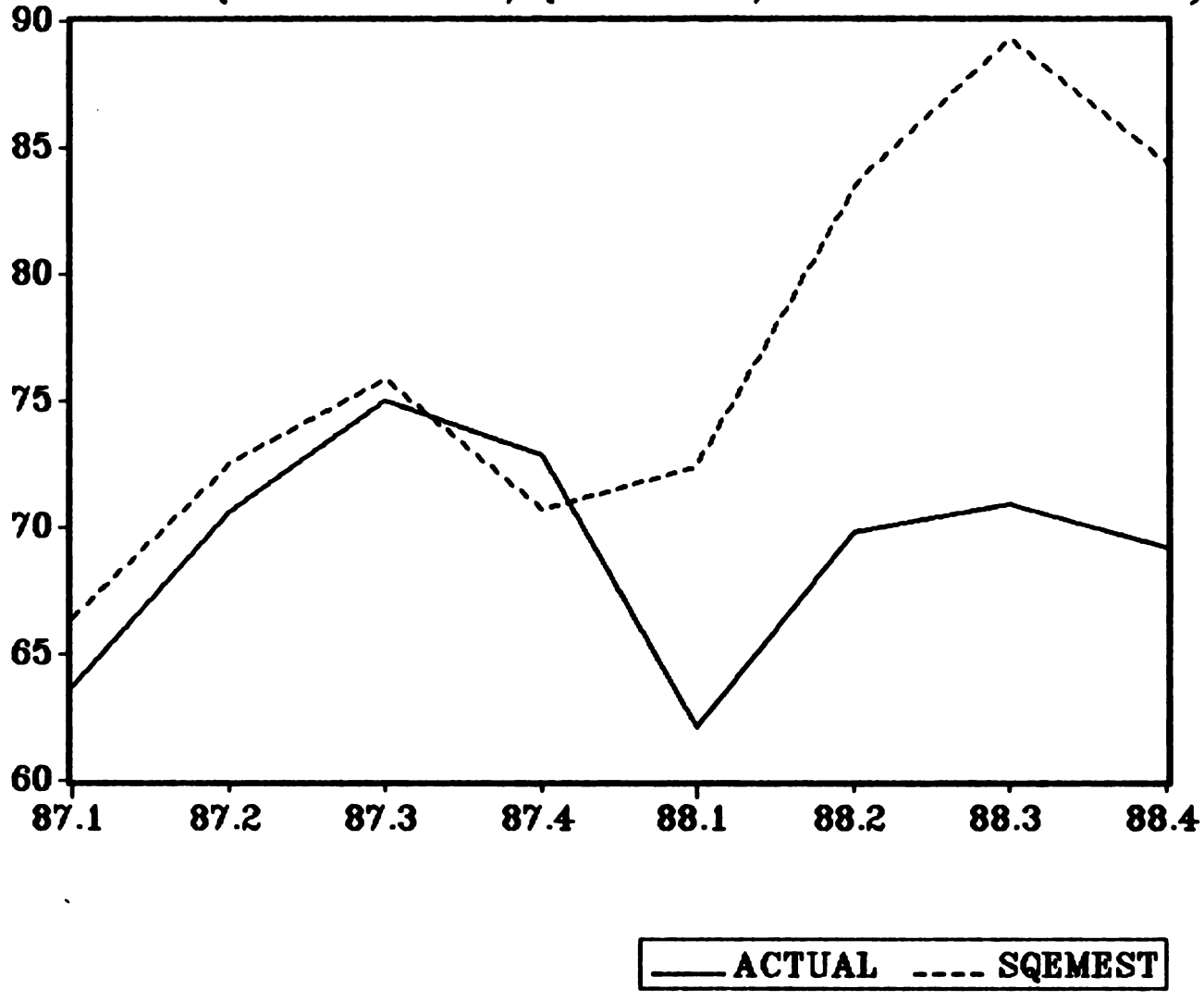


FIGURE 4.11: NET CIGARETTE TAX AT 25 CENTS

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



MURF forecast of gross cigarette tax revenues in each quarter for cigarette tax refunds.[10]

From Table 4.9, it is clear that the MURF model of cigarette tax revenue outperforms its SQEM counterpart in 1987 and 1988. This is not entirely surprising given the relatively unsophisticated SQEM equation and the absence of any variable to take account of changes in the federal tax rate in the SQEM model.

Table 4.9: Cigarette Tax at 25 Cents (Relative Performance of MURF and SQEM Forecasts, 1987-1988)

	MURF ACTUAL	MURF EST	ERROR	SQEM ACTUAL	SQEM EST	ERROR
1987						
I	63.7	65.1	1.4	63.7	66.4	2.7
II	70.1	71.8	1.7	70.6	72.5	1.9
III	75.2	74.3	-0.8	75.0	75.9	0.9
IV	70.3	71.2	0.8	72.9	70.7	-2.2
1988						
I	65.0	64.5	-0.5	62.1	72.4	10.3
II	72.3	70.3	-2.0	69.8	83.5	13.7
III	70.7	72.8	2.1	70.9	89.3	18.4
IV	67.9	68.8	0.9	69.2	84.4	15.2
RMSE			1.4			10.5

As a second test of the relative forecast performance of the MURF model, dynamic simulations were run for the VAR model and an ARMA model from January of 1987 to December of 1988. The VAR model is described in Appendix C whereas the ARMA model had AR terms at one and three months and an MA term at nine months. Both the VAR model and the ARMA model

10. The figure of $162,000 is arrived at by multiplying the average monthly cigarette tax refund in calendar 1987 and 1988 by 3.

used 11th of the month to 10th of the month data and contained 11 seasonal dummies. For the purposes of this simulation all three forecasts were generated using models fitted from 1981.01 to 1986.12. The results of these simulations are displayed in Figures 4.12, 4.13 and 4.14 and in Table 4.10.

The results of these simulations were encouraging with the MURF model outperforming both the VAR model and the ARMA model in the forecast period.

FIGURE 4.12: GROSS CIGARETTE TAX AT 25 CENTS

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

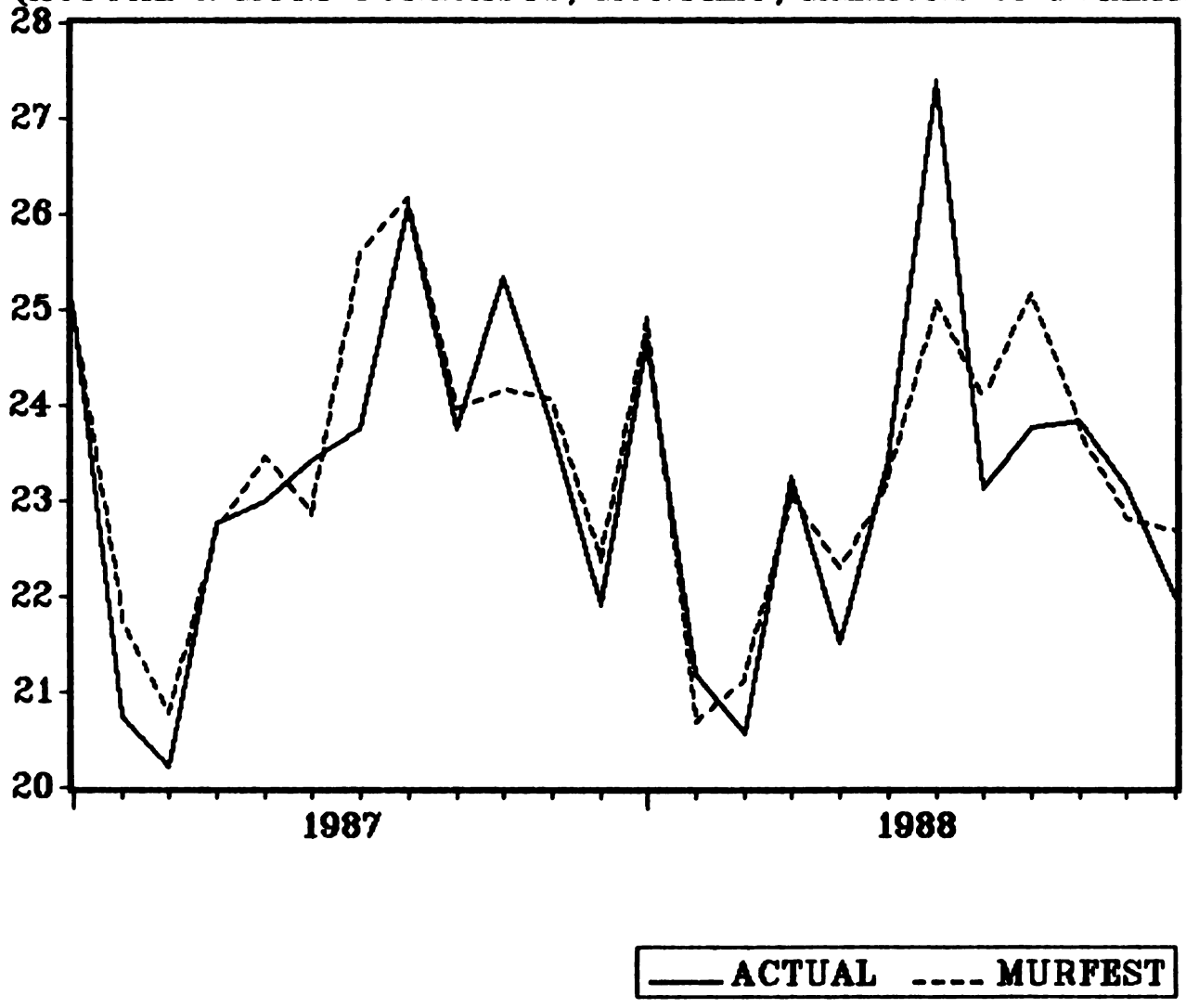


FIGURE 4.13: GROSS CIGARETTE TAX AT 25 CENTS
(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

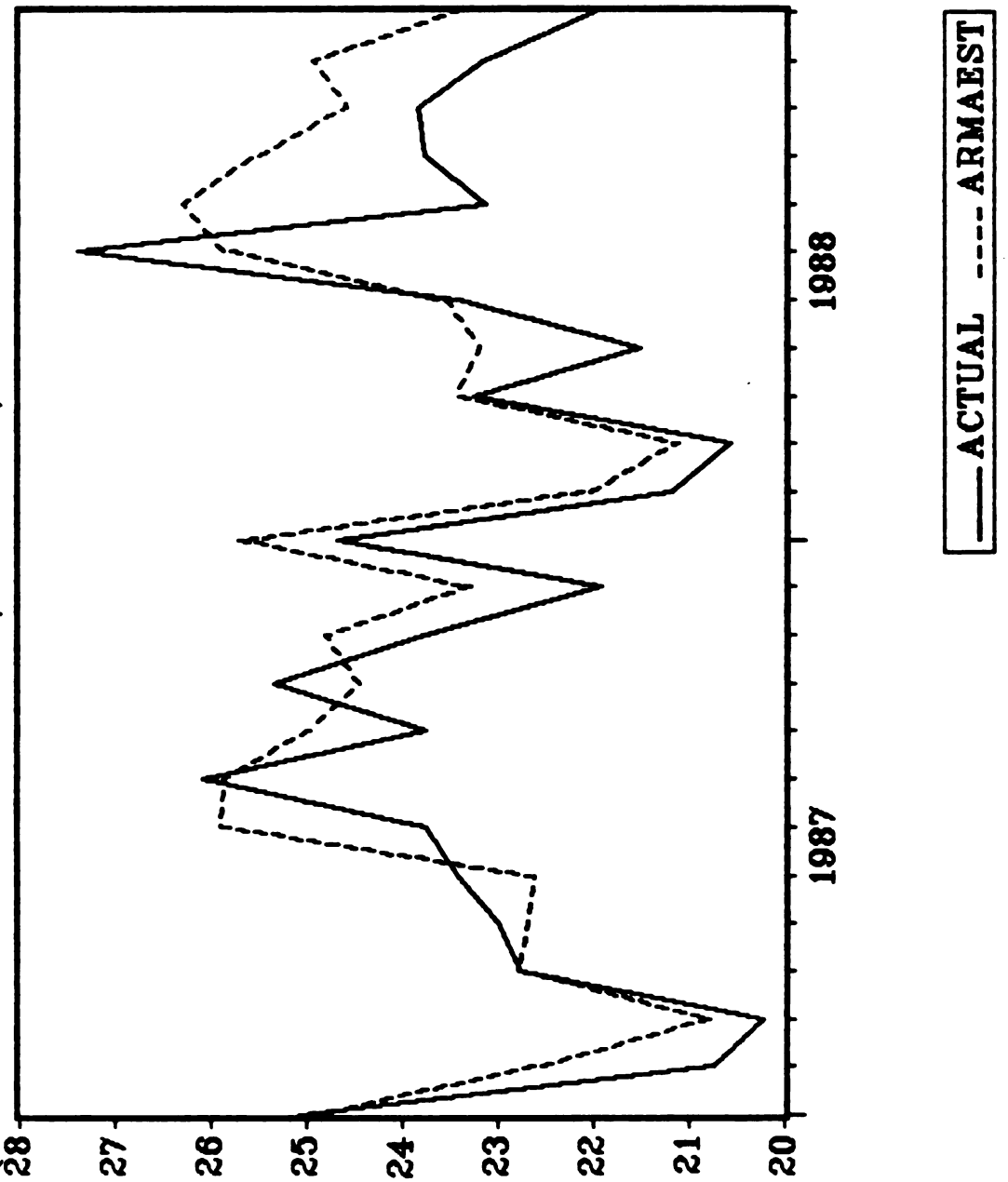


FIGURE 4.14: GROSS CIGARETTE TAX AT 25 CENTS
(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

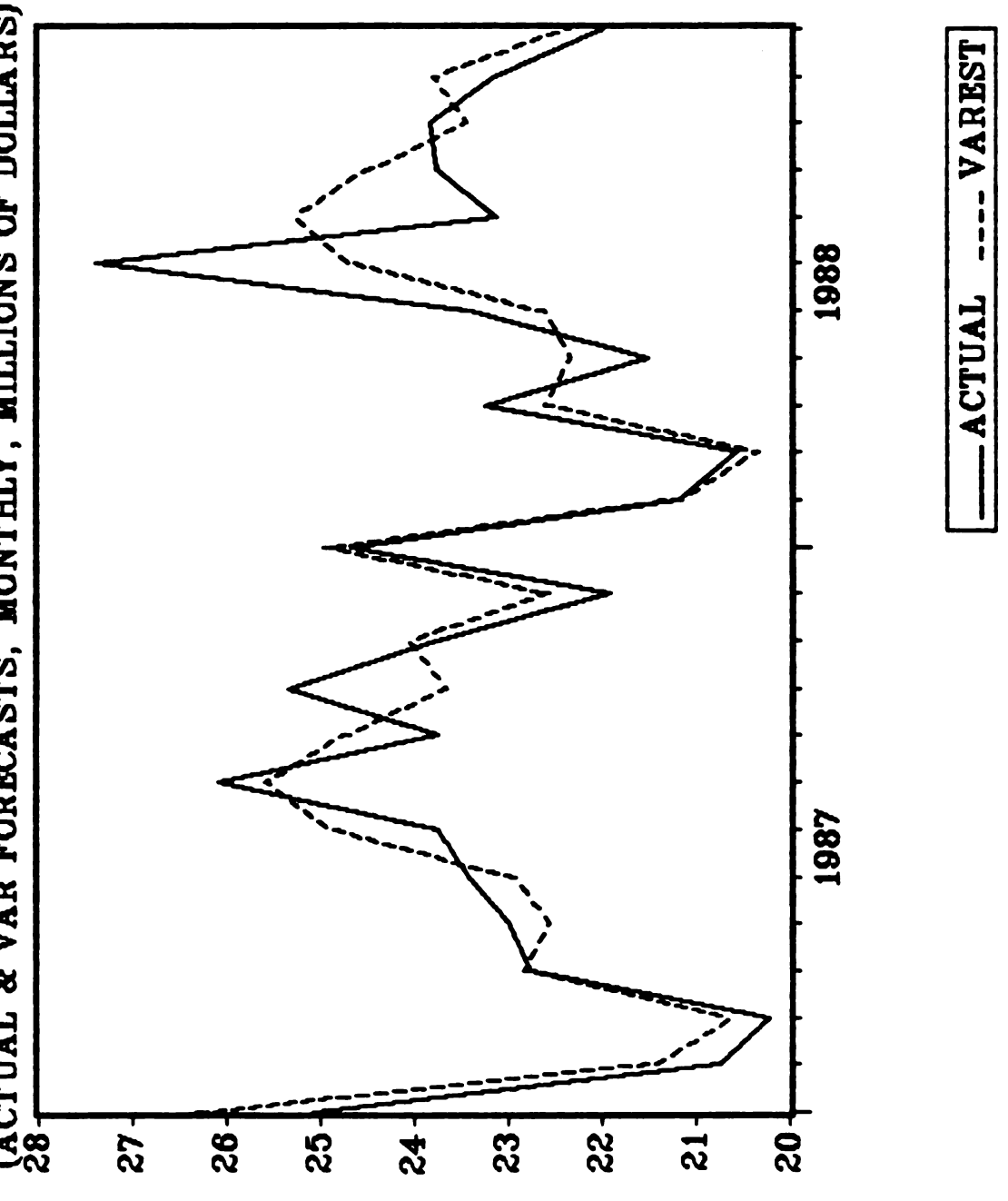


Table 4.10: Cigarette Tax at 25 Cents (Relative Performance of MURF, ARMA and VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	25.1	25.1	-0.0	25.0	-0.1	26.3	1.3
FEB.	20.7	21.8	1.0	22.5	1.8	21.4	0.7
MAR.	20.2	20.8	0.5	20.8	0.5	20.6	0.4
APR.	22.8	22.7	-0.1	22.8	0.0	22.8	0.1
MAY	23.0	23.5	0.5	22.7	-0.3	22.5	-0.4
JUN.	23.4	22.9	-0.6	22.6	-0.8	22.9	-0.5
JUL.	23.7	25.6	1.9	25.9	2.2	24.9	1.2
AUG.	26.1	26.2	0.1	25.9	-0.2	25.6	-0.5
SEP.	23.7	23.9	0.2	25.0	1.2	24.7	1.0
OCT.	25.3	24.2	-1.2	24.4	-0.9	23.6	-1.7
NOV.	23.8	24.1	0.3	24.8	1.0	24.1	0.3
DEC.	21.9	22.4	0.5	23.3	1.4	22.5	0.6
1988							
JAN.	24.7	24.9	0.3	25.7	1.1	25.0	0.3
FEB.	21.2	20.7	-0.5	22.0	0.9	21.2	-0.0
MAR.	20.6	21.1	0.6	21.1	0.5	20.3	-0.2
APR.	23.2	23.1	-0.2	23.4	0.2	22.6	-0.6
MAY	21.5	22.3	0.8	23.2	1.7	22.3	0.8
JUN.	23.4	23.2	-0.2	23.5	0.1	22.6	-0.8
JUL.	27.4	25.1	-2.3	25.9	-1.5	24.7	-2.7
AUG.	23.1	24.1	0.9	26.3	3.2	25.3	2.2
SEP.	23.8	25.2	1.4	25.5	1.7	24.5	0.7
OCT.	23.8	23.7	-0.1	24.6	0.7	23.4	-0.4
NOV.	23.2	22.8	-0.3	24.9	1.8	23.8	0.7
DEC.	22.0	22.7	0.7	23.4	1.4	22.3	0.4
RMSE			0.8		1.3		1.0

4.5 Alcohol Taxes

A Short History of Alcohol Taxes in Michigan[11]

Under Public Act 8 of 1933, the Michigan Liquor Control Commission (LCC) is given the "sole power and duty to control alcoholic beverage traffic in Michigan". The LCC has monopolized the wholesale distribution of liquor since 1933 with the twin, though conflicting, objectives of trying to achieve some moderation in the consumption of alcohol and generating revenue for the state.

The LCC has produced revenue for the state through two basic methods. First, as a monopoly, it has generated monopoly profits through its distribution of alcohol. The LCC imposes a fixed percentage retail markup for liquor over the price that it pays the ultimate suppliers. This markup has changed nine times from 1933 to 1988, ranging from 44% to 55%. Currently the markup is 51%. It then allows a discount of 17% to retailers, so that they may make a profit on the sale of the liquor.

Second, the commission levies various licence fees and taxes. Currently, on liquor, there are two 4% ad valorem

11. There are three basic sources for this history. They are:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, Michigan, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.
(iii) "Estimation of the Demand for Alcoholic Beverages", Mark P. Haas, Unpublished paper, March 1980.

taxes plus a 1.85% ad valorem tax on liquor sold on premises.[12] Beer intended for consumption in Michigan is taxed at a rate of $6.30 per 31-gallon barrel. Wine up to 16% proof is taxed at a rate of 13.5 cents per liter and above 16% proof it is taxed at 20 cents per liter. However, wine made from grapes grown in Michigan is taxed at only one cent per liter. In addition, all alcohol is subject to the 4% sales tax.

The legal drinking age has been changed twice in the state of Michigan in recent years. On February 19th, 1972, it was reduced from 21 to 18 years. On December 3, 1978, it was returned to 21 years.

The MURF Model of Beer and Wine Excise Taxes

The MURF model of revenue from beer and wine excise taxes is the simplest of the models outlined in this chapter. The dependent variable, BEER, gives the combined monthly revenues from the beer and wine excise taxes, as reported by the liquor control commission.

Only two economic variables are employed as explanatory variables. YDM82, is a five-month normalized geometric interpolation of real disposable income. RELPBEER is the ratio of PCPIB, the U.S. CPI for alcoholic beverages for wage earners and clerical workers to PCPID, the Detroit CPI.

There should also be a seasonal pattern to tax receipts

12. An ad valorem tax is based on the dollar value of a transaction rather than the physical quantity sold.

both due to different numbers of days in different months and seasonality in beer and wine consumption. Eleven monthly seasonal dummies have been included in the set of regressors to deal with this seasonality.

Three dummy variables are used to deal with outliers. The first two are used in September and October of 1981. In the years since 1981, September revenues have been much higher than October revenues, due to some of October's cash receipts being accrued back to the previous fiscal year. This apparently did not happen in 1981. A dummy variable is also included for July of 1987 which had unusually high revenues for reasons that are not yet clear.

The MURF beer and wine excise tax equation is given by equation (4.11) below:

$$(4.11) \quad BEER = a_1 + a_2*TR1 + \ldots + a_{12}*TR11 + a_{13}*YDM82(-1) + a_{14}*RELPBEER(-1) + a_{15}*B8109 + a_{16}*B8110 + a_{17}B8707$$

Performance Review

The MURF model of beer and wine excise taxes has an R^2 of .975, although this is almost entirely due to the ability of the seasonal dummies to model the pronounced seasonal variation in revenues. The partial R^2, given seasonal and outlier dummies is only .09. This partly reflects a very low real income elasticity of .038. However, the low root mean squared errors in the forecast simulations shown in Tables 4.12 and 4.13 suggest that this may not indicate a

problem in forecasting revenues from this source. In addition, the standard error of the regression is only $198,000 per month for taxes with annual revenues of more than $50,000,000.

Table 4.11: Statistical Output from the MURF Beer & Wine Excise Tax Equation

LS // Dependent Variable is BEER
SMPL range: 1980.12 - 1988.12
Number of observations: 97

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	973.44237	2235.4134	0.4354641	0.665
TR1	-208.66462	96.834530	-2.1548575	0.035
TR2	-91.518991	97.626184	-0.9374431	0.352
TR3	-85.809348	98.625701	-0.8700506	0.387
TR4	653.56536	98.382303	6.6431191	0.000
TR5	886.86411	98.251639	9.0264561	0.000
TR6	1075.7294	98.021376	10.974437	0.000
TR7	1252.5701	100.80957	12.425111	0.000
TR8	1281.8269	96.966221	13.219314	0.000
TR9	3116.0991	100.54604	30.991763	0.000
TR10	-2125.0855	100.25986	-21.195774	0.000
TR11	404.34264	96.370385	4.1957147	0.000
YDM82(-1)	0.0059416	0.0048248	1.2314736	0.222
RELPBEER(-1)	2458.0506	2137.2009	1.1501262	0.254
B8109	-2391.1797	215.36867	-11.102728	0.000
B8110	2311.8161	214.45180	10.780120	0.000
B8707	946.85569	213.28965	4.4392950	0.000

R-squared	0.975487	Mean of dependent var	4349.228
Adjusted R-squared	0.970584	S.D. of dependent var	1155.298
S.E. of regression	198.1468	Sum of squared resid	3140973.
Durbin-Watson stat	1.969782	F-statistic	198.9695
Log likelihood	-641.3256		

The Chi-square statistic calculated to test the null hypothesis of white-noise residuals is 30.9 which is below the five percent critical level for a Chi-square with 24 degrees of freedom.

The likelihood ratio test for structural stability

yielded a Chi-square of 7.22 which is less than a quarter of the value required to reject the null hypothesis, given 15 degrees of freedom. The sample was split at its midpoint, December 1984, to constuct this test.

Finally, the null hypothesis of insignificant seasonal dummies was rejected as the calculated Chi-square was more than 25 times its critical level.

The SQEM model of beer and wine excise taxes is given by equation (4.12) below:

$$(4.12) \quad \text{lnTBWMNS} = a_1 + a_2*\text{lnTBWRT} + a_3*\ln(\text{PCIB/PCPID}) + a_4*\text{lnYDM67} + a_5*\text{DSEAS1} + a_6*\text{DSEAS2} + a_7*\text{DSEAS3}$$

LnTBWMNS is the natural log of quarterly receipts from the taxes on beer and wine, lnTBWRT is the tax rate on beer, PCIB is the alcoholic beverages component of the consumer price index, adjusted for changes in the Michigan bottle law in 1972, PCPID is the Detroit consumer price index, lnYDM67 is the natural log of real disposable income in Michigan, and DSEAS1 etc. are seasonal dummies.

In order to compare the performance of the MURF and SQEM models, two simulations were run from the first quarter of 1987 to the last quarter of 1988. The results of these simulations are shown in Figures 4.15 and 4.16 and in Table 4.12.

The SQEM model seriously underestimates revenues in this period and has a RMSE which is six times that of the MURF model. It should be noted that RSQE uses a different

FIGURE 4.15: BEER & WINE EXCISE TAXES

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

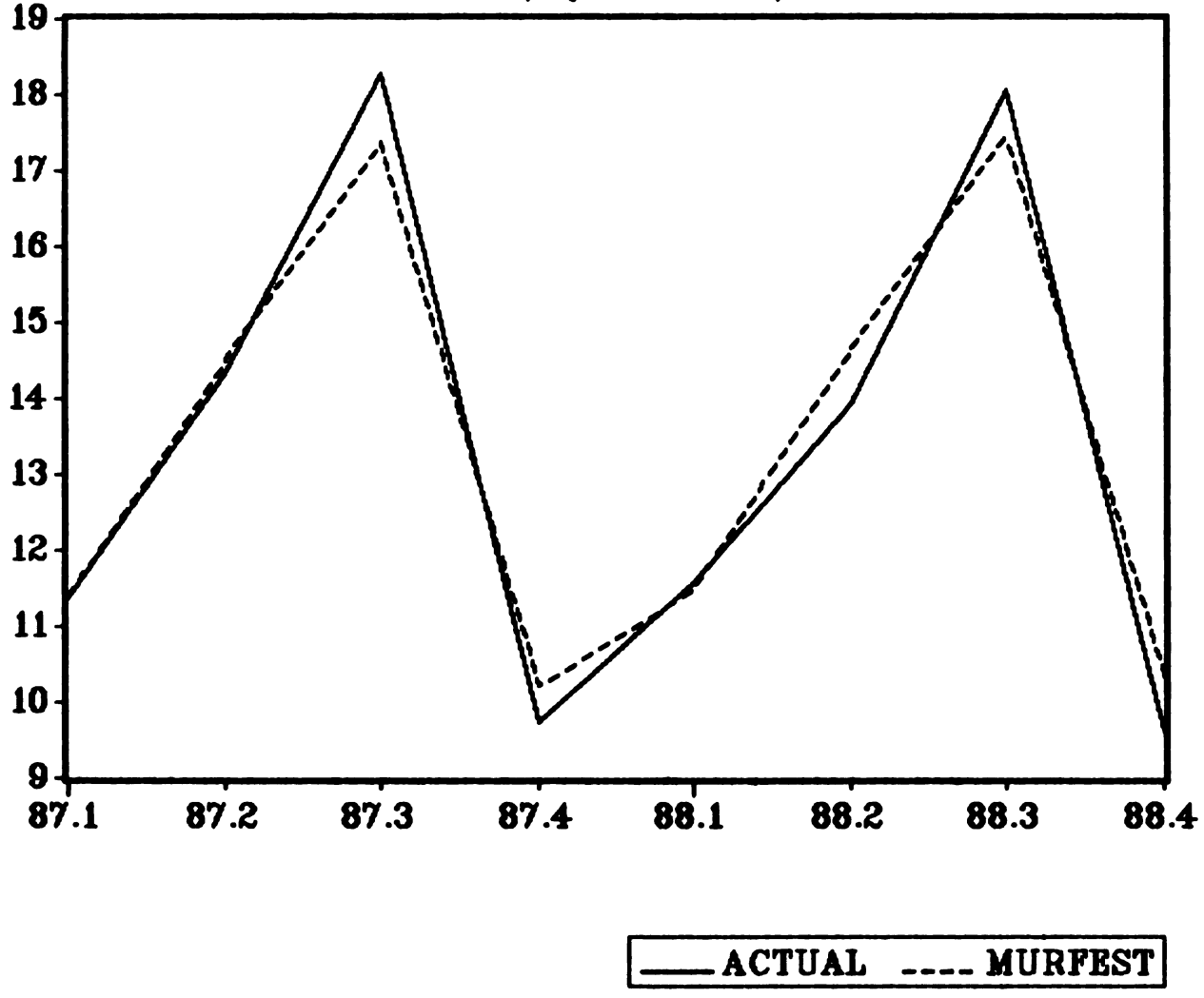
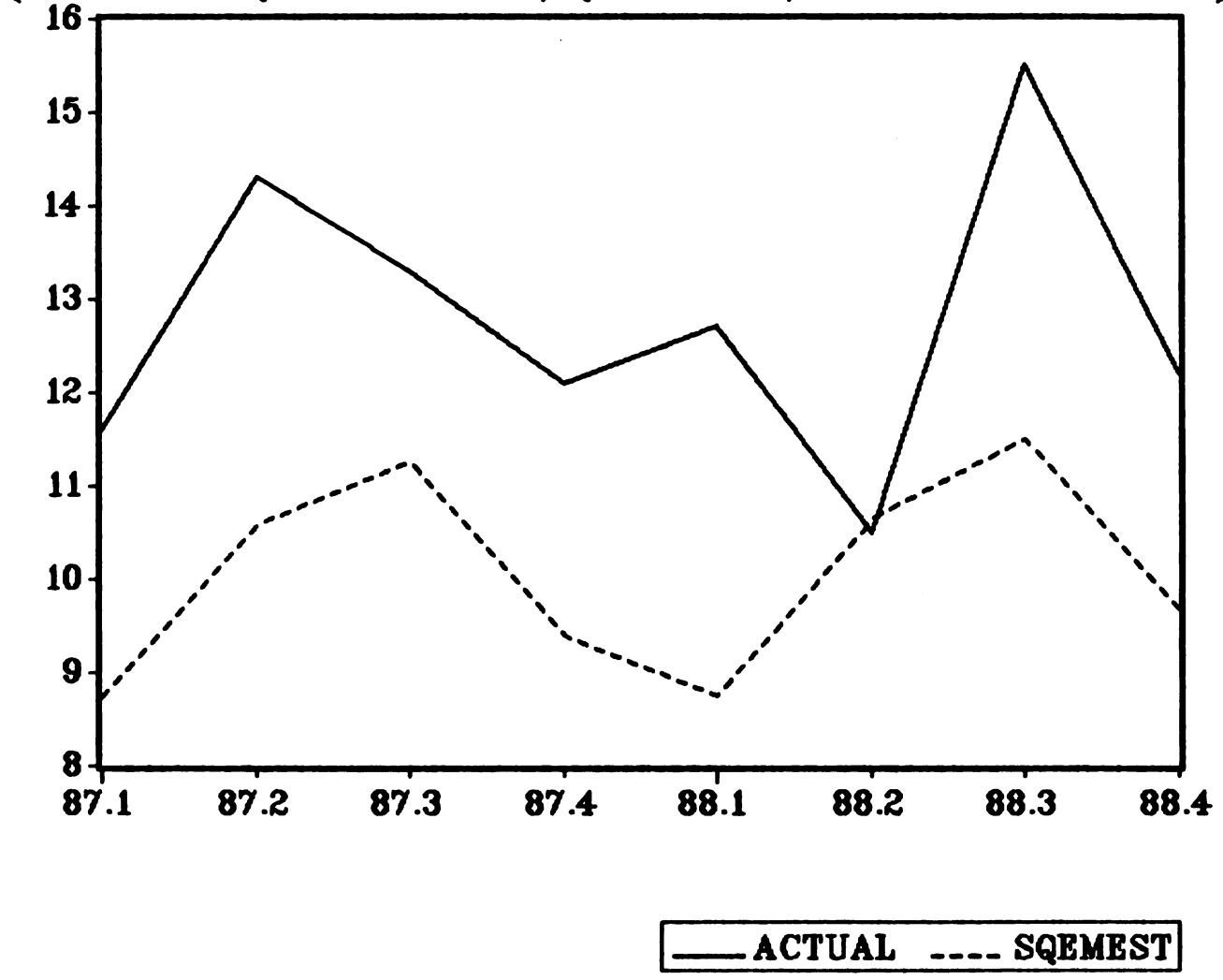


FIGURE 4.16: BEER & WINE EXCISE TAXES

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



data source for their model as their revenues show none of the extreme seasonality of the MURF series which is caused by end-of-year "catching up" on the part of the Liquor Control Commission.

Table 4.12: Beer & Wine Excise Taxes (Relative Performance of MURF & SQEM Forecasts, 1987-1988)

	MURF ACTUAL	MURF EST	ERROR	SQEM ACTUAL	SQEM EST	ERROR
1987						
I	11.4	11.4	-0.0	11.6	8.7	-2.9
II	14.3	14.5	0.2	14.3	10.6	-3.7
III	18.3	17.4	-0.9	13.3	11.3	-2.0
IV	9.7	10.2	0.5	12.1	9.4	-2.7
1988						
I	11.6	11.5	-0.1	12.7	8.7	-4.0
II	13.9	14.7	0.7	10.5	10.6	0.1
III	18.0	17.5	-0.6	15.5	11.5	-4.0
IV	9.6	10.3	0.7	12.2	9.7	-2.5
RMSE			0.5			3.0

As a second test of the relative forecast performance of the MURF model, dynamic simulations were run for the VAR model and an ARMA model from January of 1987 to December of 1988. The VAR model is described in Appendix C. The ARMA model had an MA term at one month in addition to 11 seasonal dummies. Both the ARMA and the VAR model were estimated using a sample period that ran from 1981.01 to 1986.12. The MURF model was forced to use a slightly shorter period as the inclusion of an AR(12) term precluded the use of a sample range which started prior to December 1981.

The results of these simulations, which are displayed in Table 4.13 and in Figures 4.17, 4.18, and 4.19, show both

FIGURE 4.17: BEER & WINE EXCISE TAXES

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

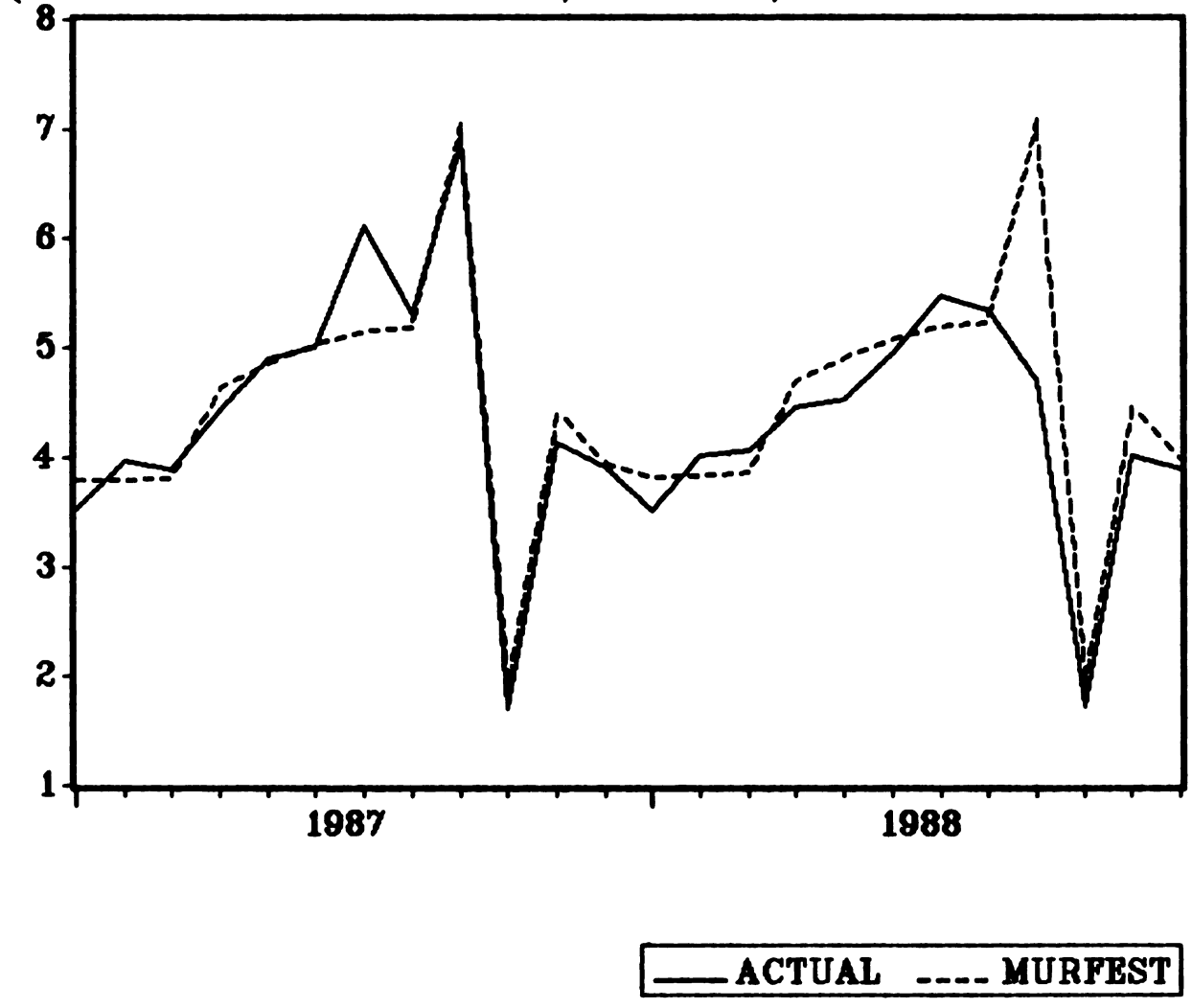


FIGURE 4.18: BEER & WINE EXCISE TAXES
(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

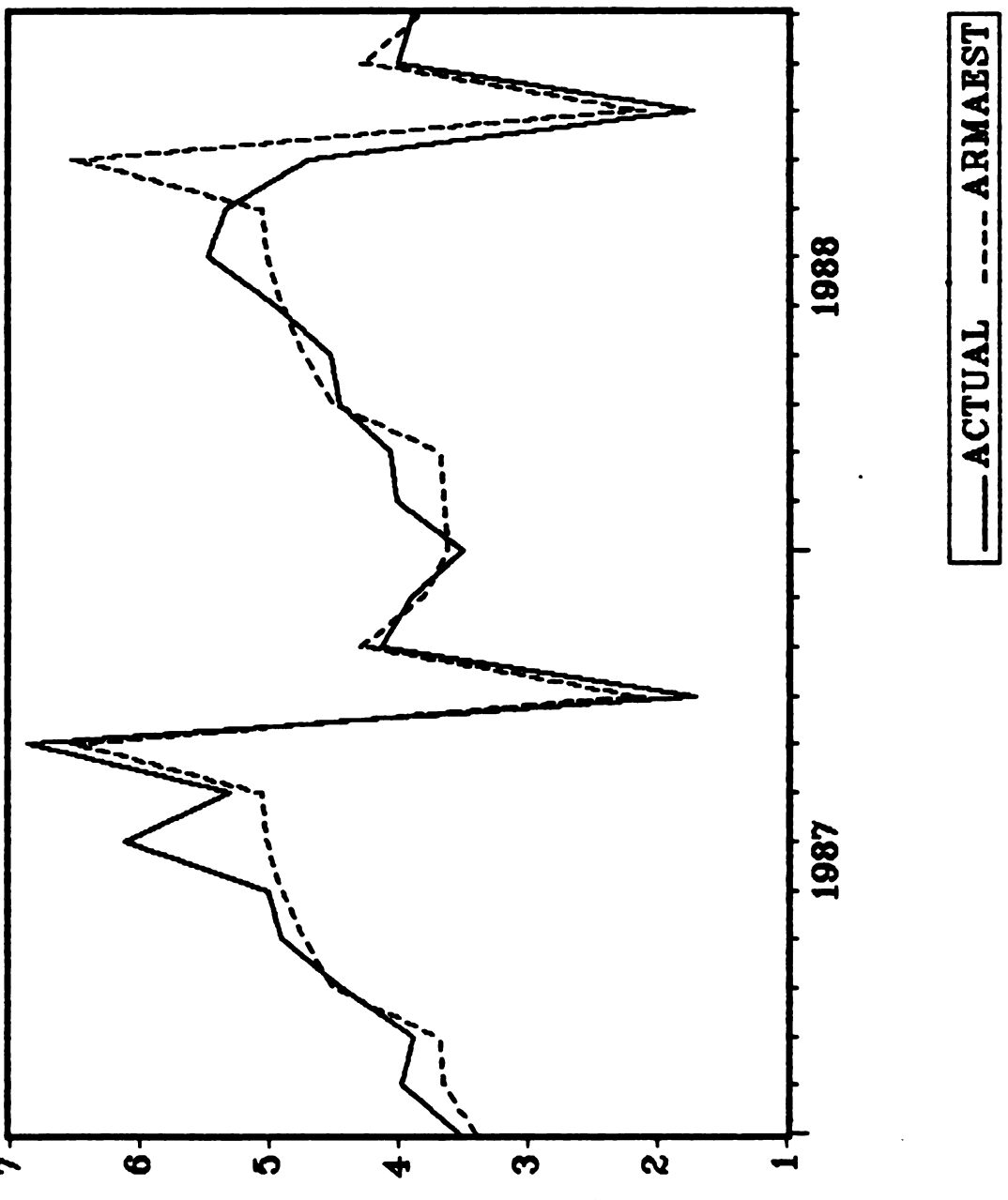


FIGURE 4.19: BEER & WINE EXCISE TAXES
(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

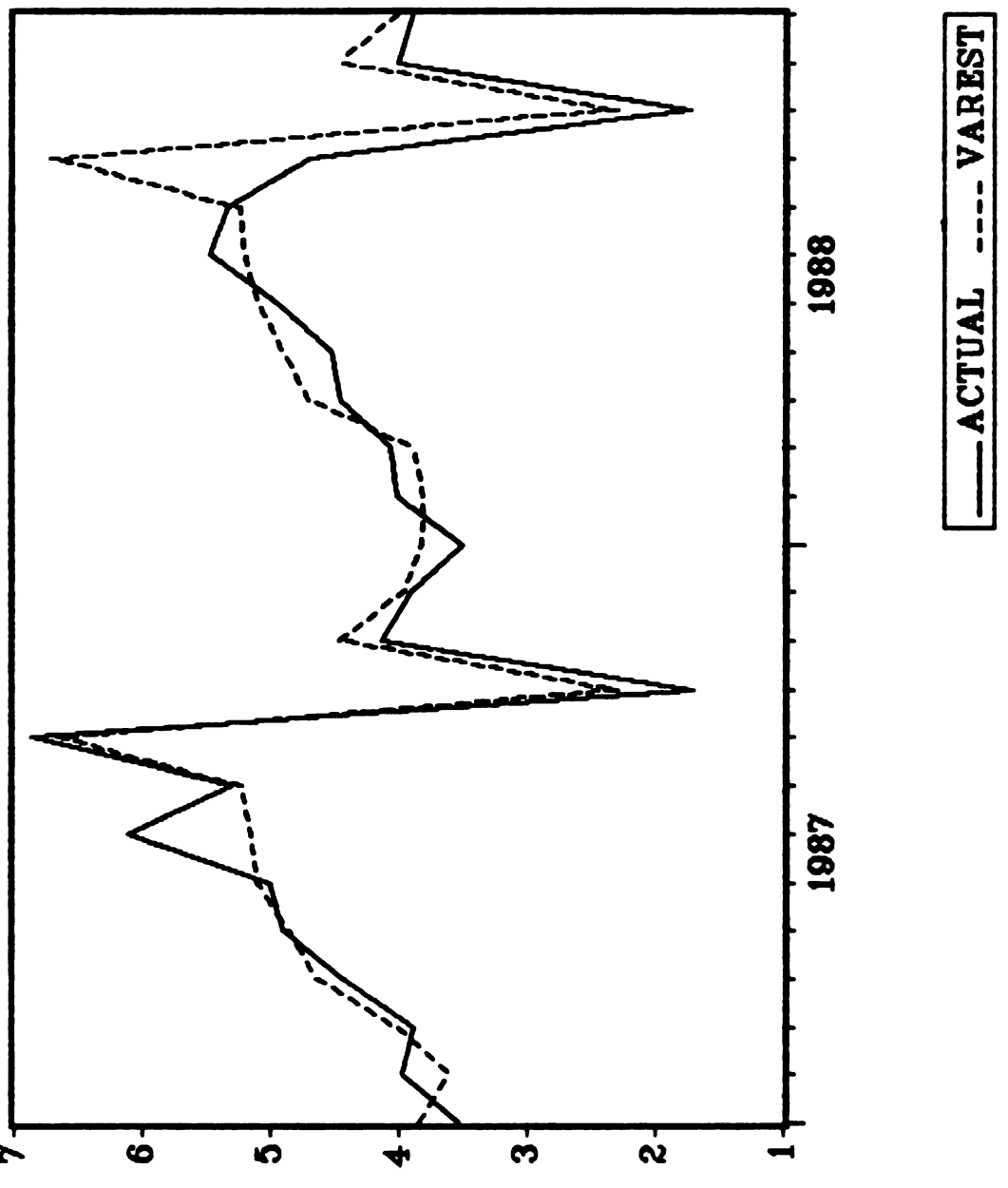


Table 4.13: Beer & Wine Excise Taxes (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	3.5	3.8	0.3	3.4	-0.1	3.8	0.3
FEB.	4.0	3.8	-0.2	3.6	-0.3	3.6	-0.4
MAR.	3.9	3.8	-0.1	3.7	-0.2	4.0	0.1
APR.	4.4	4.6	0.2	4.5	0.1	4.6	0.2
MAY	4.9	4.9	-0.0	4.7	-0.2	4.9	-0.0
JUN.	5.0	5.0	0.0	4.9	-0.1	5.1	0.1
JUL.	6.1	5.1	-1.0	5.0	-1.1	5.2	-1.0
AUG.	5.3	5.2	-0.1	5.0	-0.3	5.2	-0.1
SEP.	6.9	7.0	0.2	6.5	-0.3	6.7	-0.2
OCT.	1.7	1.8	0.1	2.1	0.4	2.3	0.5
NOV.	4.1	4.4	0.3	4.3	0.2	4.5	0.3
DEC.	3.9	3.9	0.0	3.8	-0.1	4.0	0.1
1988							
JAN.	3.5	3.8	0.3	3.6	0.1	3.8	0.3
FEB.	4.0	3.8	-0.2	3.6	-0.4	3.8	-0.2
MAR.	4.1	3.9	-0.2	3.7	-0.4	3.9	-0.2
APR.	4.5	4.7	0.2	4.5	0.0	4.7	0.2
MAY	4.5	4.9	0.4	4.7	0.2	4.9	0.4
JUN.	4.9	5.1	0.1	4.9	-0.0	5.1	0.1
JUL.	5.5	5.2	-0.3	5.0	-0.5	5.2	-0.3
AUG.	5.3	5.2	-0.1	5.0	-0.3	5.2	-0.1
SEP.	4.7	7.1	2.4	6.5	1.8	6.7	2.0
OCT.	1.7	1.9	0.2	2.1	0.4	2.3	0.6
NOV.	4.0	4.5	0.5	4.3	0.3	4.5	0.5
DEC.	3.9	4.0	0.1	3.8	-0.1	4.0	0.1
RMSE			0.6		0.5		0.5

ARMA and VAR models performing slightly better than the MURF model. This is perhaps not too surprising given the dominance of non-economic factors in the MURF equation. All three models, however, have very low root mean square errors, so that the relatively weak forecast performance of the MURF model is not a serious problem for practical purposes.

The MURF Model of the 4% Liquor Taxes

The following is a description of the MURF model of the 4% liquor taxes. It should be noted that there are in fact two 4% taxes levied, one of which goes to the general fund and one of which goes to the school aid fund. Thus the monthly receipts from this tax will turn up twice in any estimate of GFGP/SAF revenues.

As this is an ad valorem tax, the price of liquor has two separate effects on tax revenue. First, there is a direct positive relationship between the price of liquor and revenues, since the tax is levied as a percentage of the gross receipts from the sale of liquor. Second, there is an indirect negative price effect on sales as a rise in the relative price of liquor discourages consumption.

Attempts to use both the relative price of liquor and the absolute price of liquor as regressors led to problems of multicollinearity. Consequently, the MURF equation for liquor tax revenues avoids the direct price effect by using real consumption as the dependent variable.

The dependent variable in this model, LLIQSALE, is constructed to be (LOGLIQTX-LPLIQ) where LOGLIQTX is the natural log of 4% of gross liquor sales and LPLIQ is the natural log of PLIQUOR, the U.S. CPI component for alcoholic beverages for all urban consumers and PCPID is the Detroit CPI. Although 4% of gross liquor sales has tracked actual tax receipts very closely over the last four years, (with a tendency to overestimate actual receipts by only $45,000 in a fiscal year), tax receipts were about $500,000 below the constructed level in the early 1980s. This was due to a change in the way in which the Liquor Control Commission paid its suppliers rather than economic factors so that it was felt that the constructed level of tax receipts was easier to explain than the actual level.

As excise taxes on liquor are consumption taxes and as consumption is allegedly a function of permanent income, the log of real permanent disposable income, LYPERM82 is included as a regressor. In addition, LRLPLIQ is included to measure the price effect upon real consumption. LRLPLIQ is the log of the ratio of PLIQUOR to PCPID.

Five dummy variables are introduced to deal with outliers in October of 1982, 1983, 1984 and 1988 and September of 1985. In the years since 1981, September revenues have been much higher than October revenues due to some of October's cash receipts being accrued back to the previous fiscal year. Some variations in this practice are probably responsible for these outliers.

A variable called WEEKDY is also used. This variable gives the number of weekdays in the previous month with the expectation that receipts will be higher in a month after a month with an above average number of weekdays.

Finally, an MA(1) term is included to help model trends in liquor consumption due to changing public attitudes towards alcohol and AR and MA terms are introduced with lags of 12 months to model seasonal variation in place of seasonal dummies since only one of the latter was found to be significant.

The MURF liquor tax equation is given by equation (4.13) below:

$$\begin{aligned}(4.13)\quad \text{LLIQSALE} = {} & a_1 + a_2*\text{YPERM82}(-1) + a_3*\text{LRLPLIQ}(-1) \\ & + a_4*\text{WEEKDY}(-1) + a_5*\text{B8210} + a_6*\text{B8310} + a_7*\text{B8410} \\ & + a_8*\text{B8509} + a_9*\text{B8810} + a_{10}*\text{MA}(1) + a_{11}*\text{MA}(12) \\ & + a_{12}*\text{AR}(12)\end{aligned}$$

Performance Review

The MURF model of the 4% liquor tax achieves an R^2 of .989 as can be seen in Table 4.14. Moreover, the standard error of the regression is only about $45,000, which must be considered low for a tax with annual receipts of about $20,000,000. The partial R^2 for the economic variables, given outlier dummies and time series terms was found to be .45.

A Q-test for the presence of white noise residuals yielded a Chi-square of 20.50 thus failing to reject

the null hypothesis, given 21 degrees of freedom. In addition, a likelihood ratio test for structural stability which was constructed by splitting the sample range in half, yielded a Chi-square below the level requiring rejection of the null hypothesis of structural stability.

Table 4.14: Statistical Output from the MURF 4% Liquor Taxes Tax Equation

LS // Dependent Variable is LLIQSALE
SMPL range: 1981.12 - 1988.12
Number of observations: 85
Convergence achieved after 16 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-18.126990	8.1116507	-2.2346857	0.029
LYPERM82(-1)	0.9568645	0.1474303	6.4902841	0.000
LRLPLIQ(-1)	0.8775841	0.2277454	3.8533554	0.000
WEEKDY(-1)	0.0115100	0.0035767	3.2180739	0.002
B8210	-0.0810871	0.0245994	-3.2963076	0.002
B8310	-0.1891510	0.0283550	-6.6708247	0.000
B8410	0.1315444	0.0245093	5.3671265	0.000
B8509	0.1598487	0.0204097	7.8319802	0.000
B8810	0.1344740	0.0285474	4.7105550	0.000
MA(1)	0.2667708	0.1250957	2.1325336	0.037
MA(12)	-0.7215427	0.1273121	-5.6675096	0.000
AR(12)	0.9880606	0.0086910	113.68807	0.000

R-squared	0.989357	Mean of dependent var	2.736222
Adjusted R-squared	0.987753	S.D. of dependent var	0.242476
S.E. of regression	0.026834	Sum of squared resid	0.052563
Durbin-Watson stat	1.949252	F-statistic	616.9067
Log likelihood	193.3968		

The SQEM model of the 4% liquor taxes is given by equation (4.14) below:

$$(4.14) \quad \ln TLIQMNS = a_1 + a_2*\ln(PLIQUOR/PCPID) + a_3*\ln YDM67 + a_4*\ln PLIQUOR + a_5*DSEAS1 + a_6*DSEAS2 + a_7*DSEAS3$$

LnTLIQMNS is the natural log of quarterly receipts from the taxes on liquor, PLIQUOR is the alcoholic beverages component of the consumer price index, PCPID is the Detroit consumer price index, lnYDM67 is the natural log of real disposable income in Michigan, and DEAS1 etc. are seasonal dummies.

In order to compare the performance of the MURF and SQEM models, two simulations were run from the first quarter of 1987 to the last quarter of 1988. RSQE appears to use a different data source as although over a fiscal year total revenues are the same, the seasonal variation is slightly different. However, even when this is taken into account, the SQEM equation performs very poorly over the forecast horizon.

Table 4.15: Liquor Taxes at 4% (Relative Performance of MURF & SQEM Forecasts, 1987-1988)

	MURF ACTUAL	MURF EST	ERROR	SQEM ACTUAL	SQEM EST	ERROR
1987						
I	4.5	4.4	-0.1	4.6	2.8	-1.8
II	4.8	4.8	0.0	4.8	3.1	-1.7
III	5.0	5.1	0.1	5.0	3.1	-1.9
IV	5.8	5.9	0.1	5.7	4.1	-1.6
1988						
I	4.3	4.4	0.1	4.4	2.9	-1.5
II	4.7	4.8	0.1	4.7	3.1	-1.6
III	5.1	5.1	0.0	5.1	3.2	-1.9
IV	6.0	6.0	0.0	6.0	4.2	-1.8
RMSE			0.1			1.7

By contrast, although the MURF equation slightly overestimates revenues in this period, the error is not

serious in the overall context of forecasting the budget. The results of these simulations are shown in Table 4.15 and in Figures 4.20 and 4.21.

As a second test of the relative forecast performance of the MURF model, dynamic simulations were run for the VAR model and an ARMA model from January of 1987 to December of 1988. The VAR model is described in Appendix C. The ARMA model had an AR term at a lag of one month and an MA term at a lag of three months. In addition, the ARMA model was equipped with 11 seasonal dummies. Both the ARMA and VAAR models were regressed over the period 1981.01 to 1986.12 for the purposes of this simulation whereas the MURF model had a fit period of 1981.12 to 1986.12. The results of these simulations are shown in Table 4.16 and in Figures 4.22 thru 4.24.

All three models performed exceptionally well over 1987 and 1988 which is probably more of a testament to the stability of drinking patterns in the short-run, than the sophistication of these models.

FIGURE 4.20: LIQUOR TAX AT 4%

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

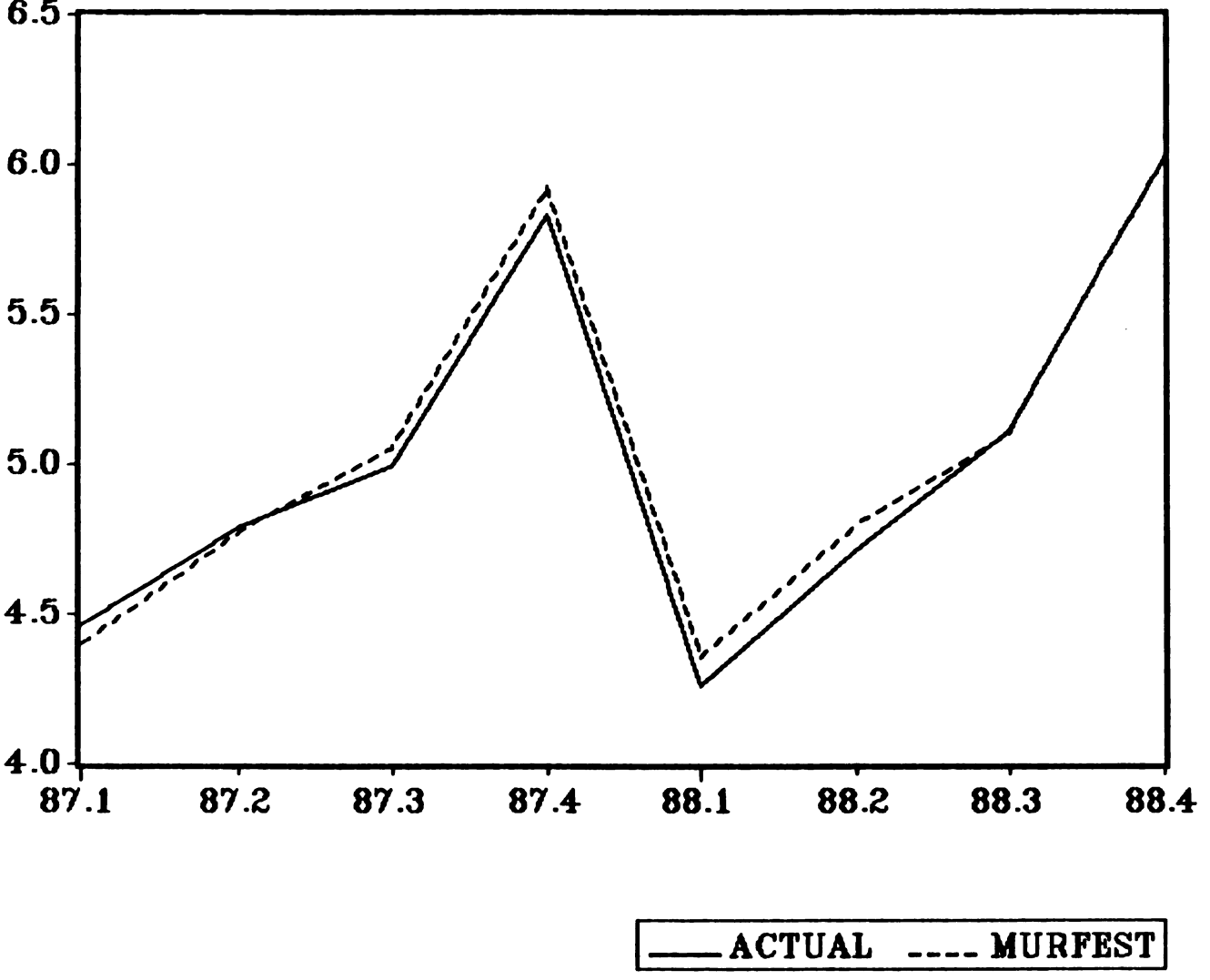


FIGURE 4.21: LIQUOR TAX AT 4%

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

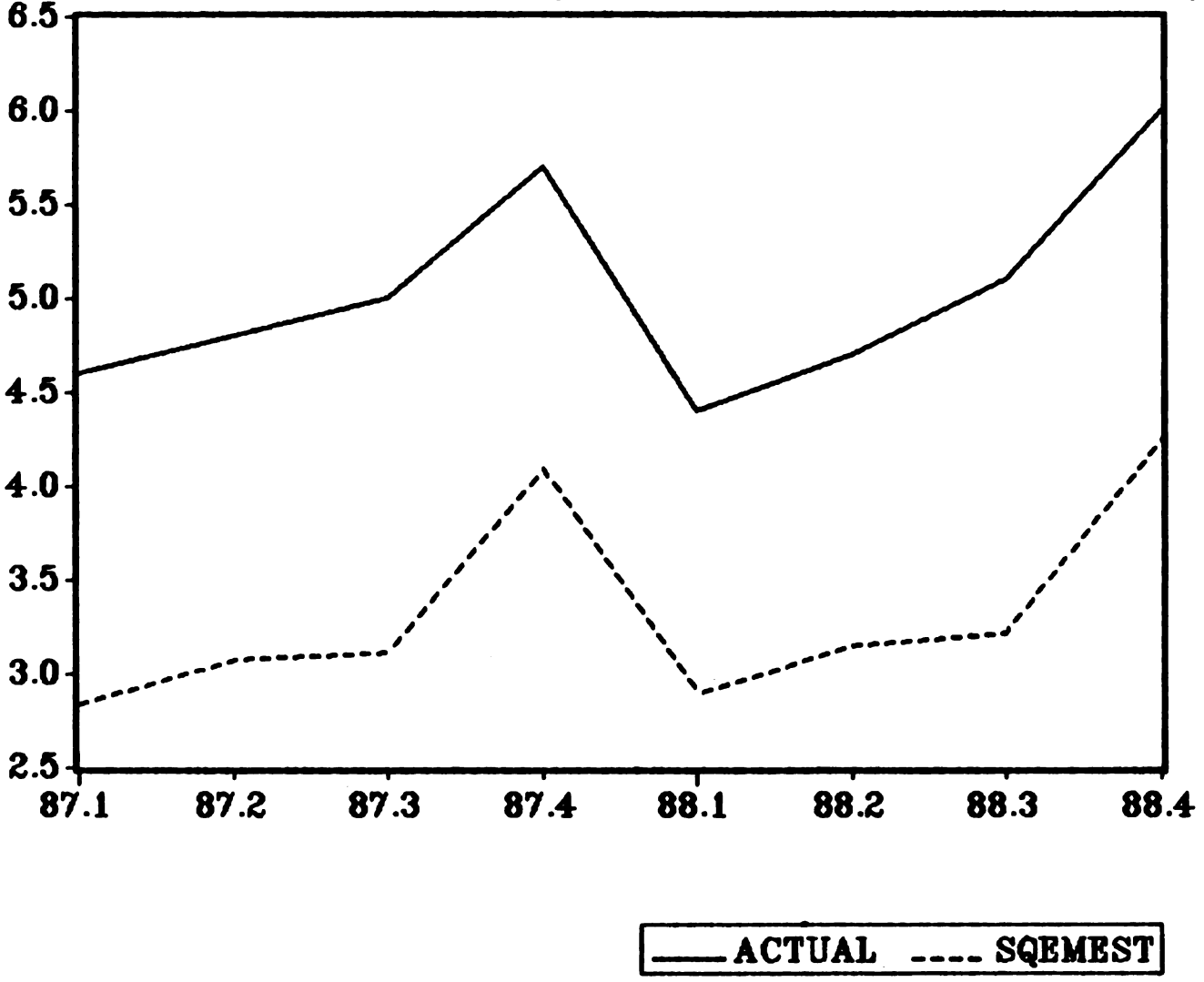


Table 4.15: Liquor Taxes at 4% (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	1.3	1.3	0.0	1.3	0.0	1.4	0.0
FEB.	1.3	1.3	0.0	1.3	-0.0	1.4	0.0
MAR.	1.8	1.7	-0.1	1.8	-0.1	1.8	0.0
APR.	1.5	1.5	0.0	1.4	-0.0	1.5	0.0
MAY	1.5	1.5	0.0	1.4	-0.0	1.5	0.0
JUN.	2.0	1.9	-0.1	1.9	-0.1	2.0	0.0
JUL.	1.5	1.5	0.0	1.5	-0.1	1.6	0.0
AUG.	1.5	1.5	0.0	1.5	-0.0	1.5	0.0
SEP.	2.3	2.1	-0.2	2.2	-0.1	2.3	0.0
OCT.	1.4	1.4	0.0	1.4	-0.0	1.4	0.0
NOV.	1.8	1.7	-0.1	1.8	-0.1	1.8	0.0
DEC.	3.0	2.8	-0.2	2.9	-0.1	3.0	0.0
1988							
JAN.	1.3	1.3	0.0	1.3	-0.0	1.3	0.0
FEB.	1.4	1.3	-0.1	1.3	-0.0	1.4	0.0
MAR.	1.8	1.7	-0.1	1.7	-0.1	1.8	0.0
APR.	1.5	1.5	0.0	1.4	-0.1	1.5	0.0
MAY	1.5	1.5	-0.1	1.4	-0.1	1.5	0.0
JUN.	2.0	1.9	-0.1	1.9	-0.1	2.0	0.0
JUL.	1.6	1.5	0.0	1.5	-0.1	1.6	0.0
AUG.	1.5	1.5	-0.1	1.5	-0.1	1.5	0.0
SEP.	2.3	2.1	-0.2	2.2	-0.1	2.3	0.0
OCT.	1.4	1.4	0.0	1.4	-0.1	1.4	0.0
NOV.	1.9	1.7	-0.1	1.8	-0.1	1.9	0.0
DEC.	3.0	2.9	-0.1	2.9	-0.1	3.0	0.0
RMSE			0.1		0.1		0.0

FIGURE 4.22: LIQUOR TAX AT 4%

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

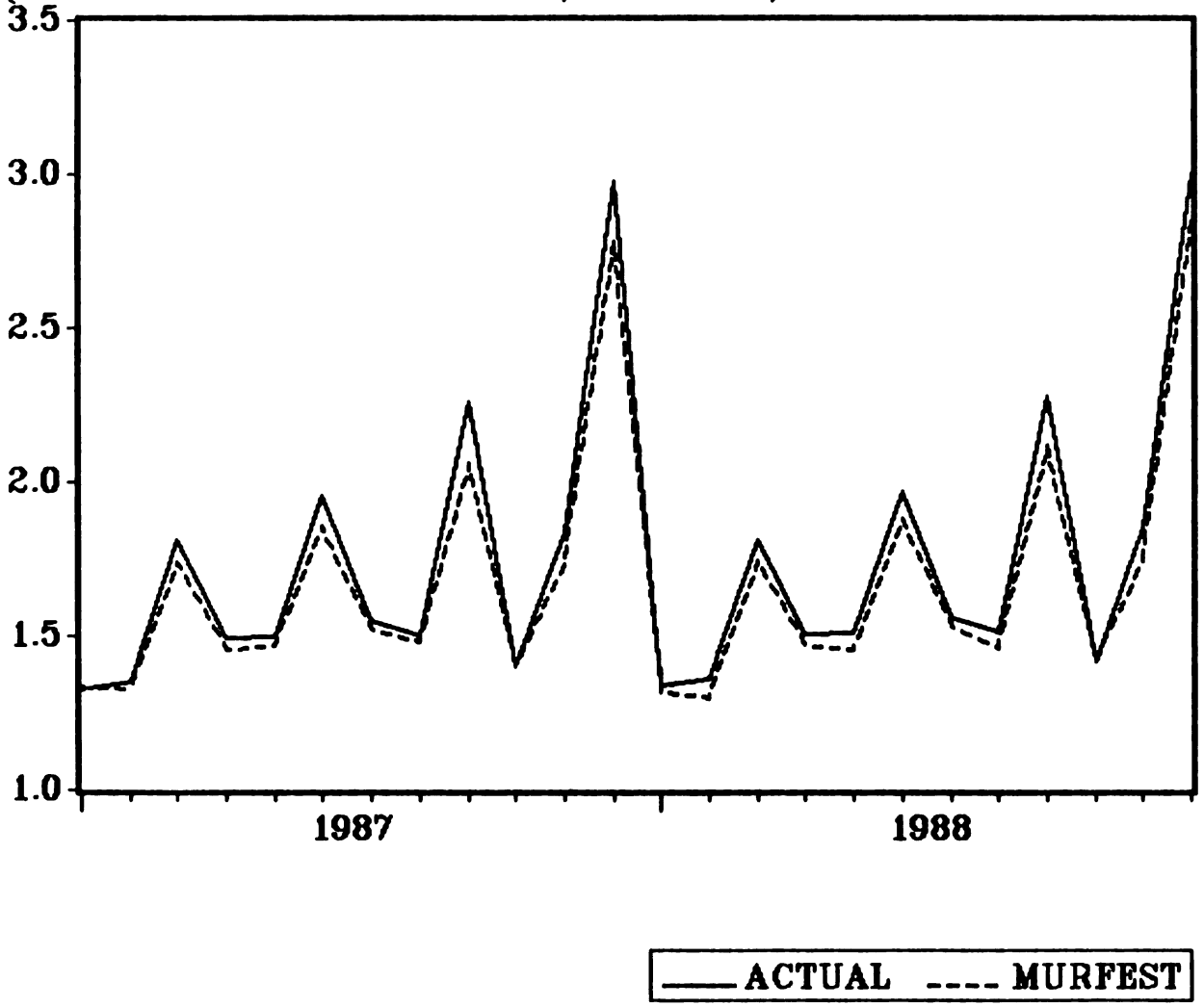
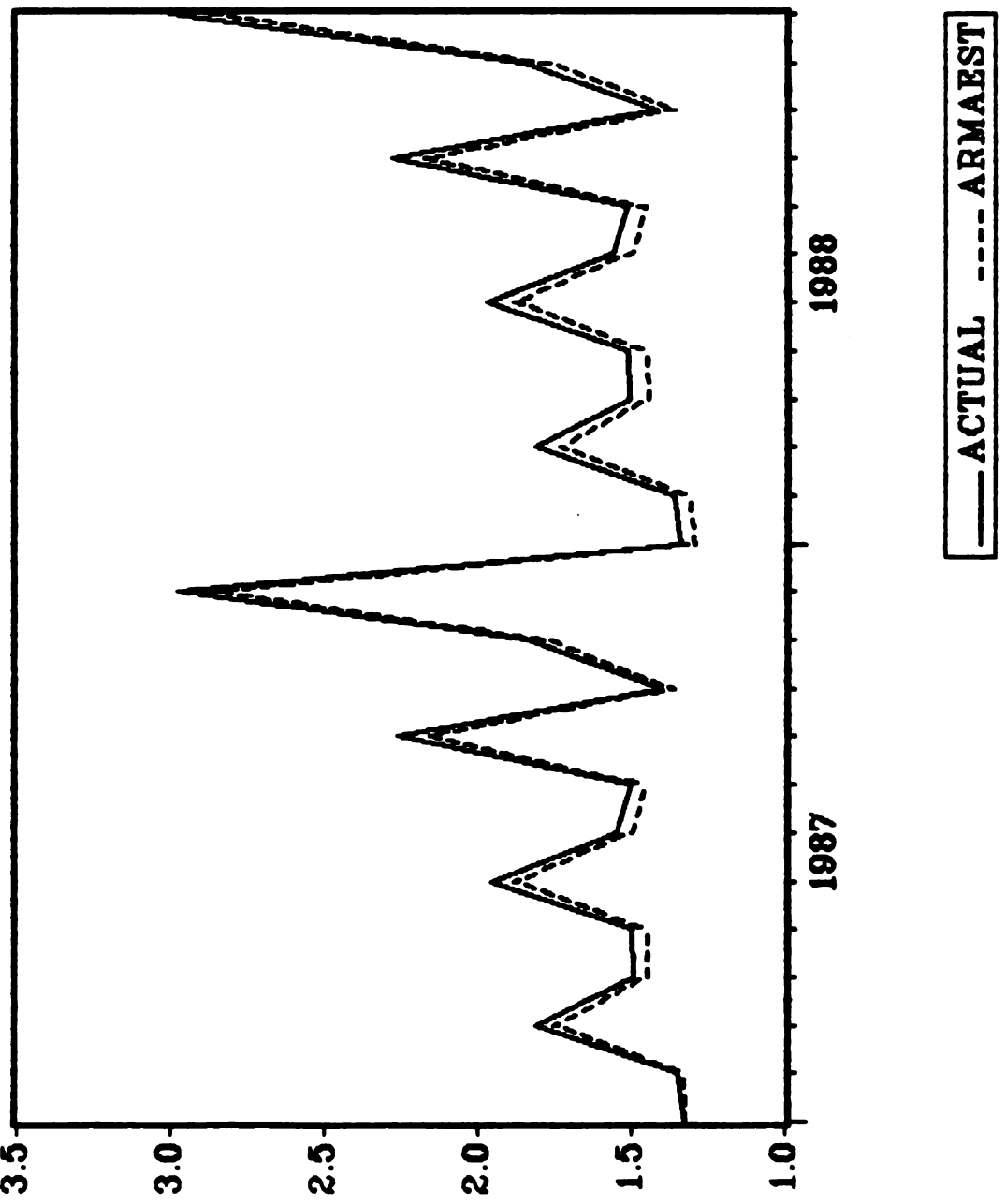


FIGURE 4.23: LIQUOR TAX AT 4%

(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)



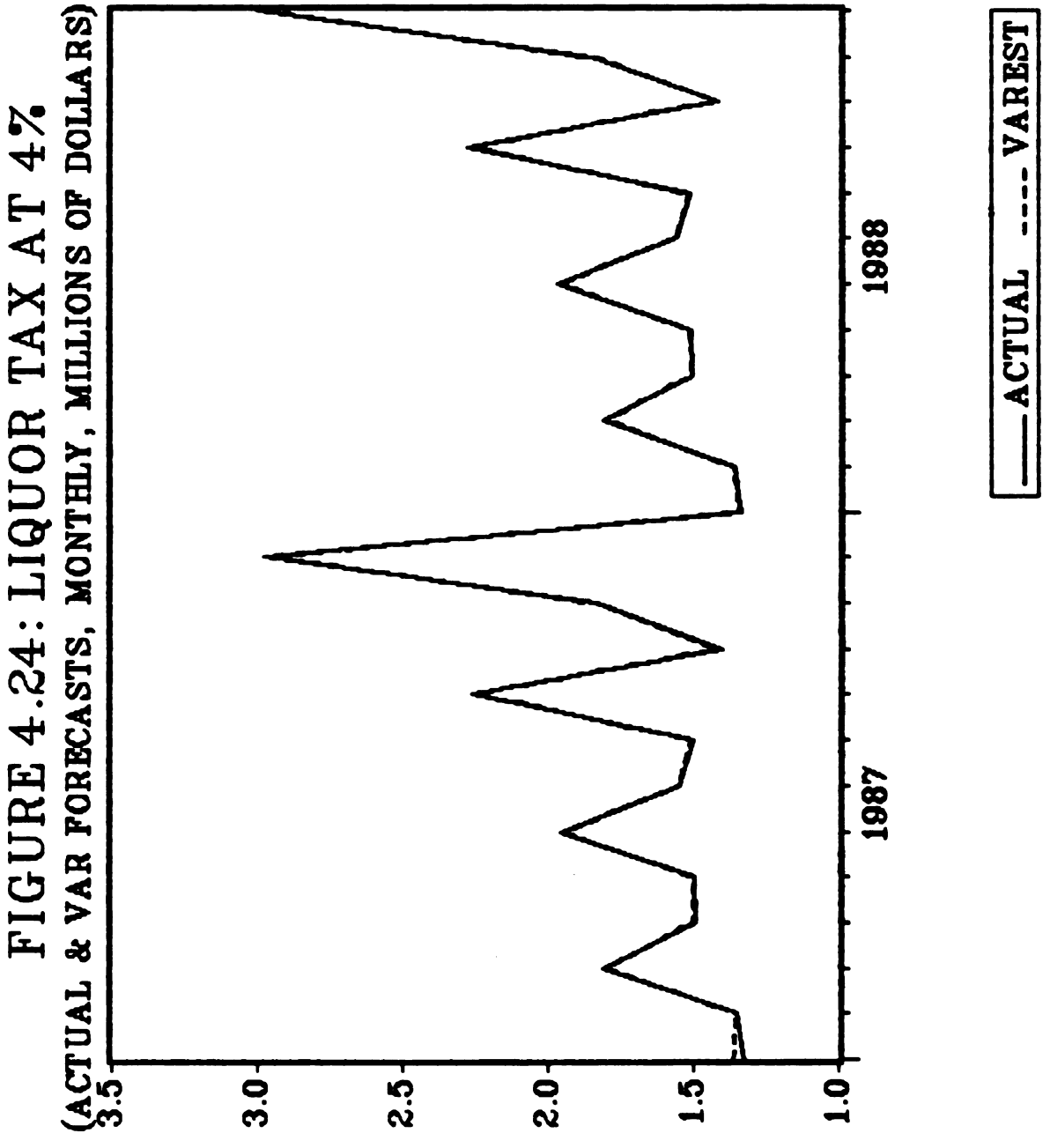


FIGURE 4.24: LIQUOR TAX AT 4%
(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)
3.5
3.0
2.5
2.0
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1987
1988
ACTUAL ---- VAREST

v.2

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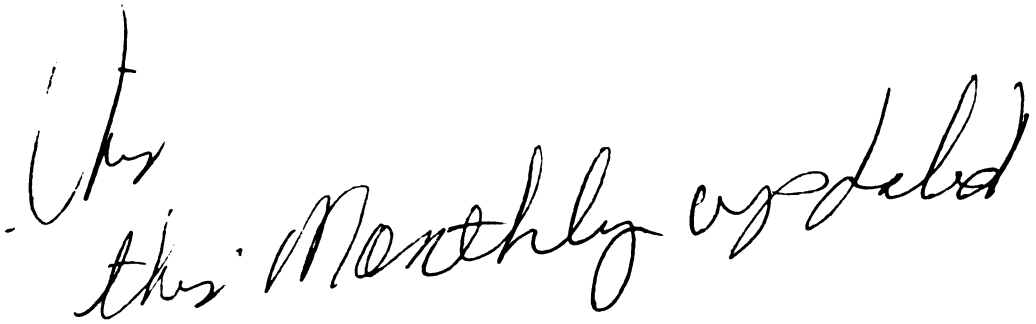

A MONTHLY UPDATED REVENUE FORECASTING MODEL

FOR THE STATE OF MICHIGAN
Volume II

By

David Patrick Comyn Kelly

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
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DOCTOR OF PHILOSOPHY

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1989

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Chapter V

CHAPTER V

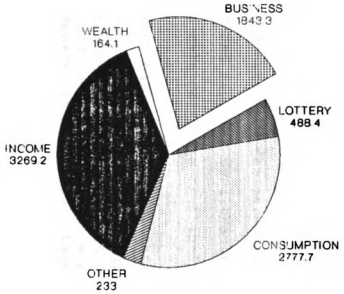
BUSINESS TAXES

5.1 Introduction

Business taxes in Michigan account for about 21% of GFGP/SAF revenue, amounting to $1,843.3 million in fiscal 1988. This chapter considers the main business taxes and outlines the MURF models for forecasting them. There are two omissions in this chapter. First, no attempt is made to forecast revenues from the retaliatory insurance premiums tax. Taxes on insurance companies were radically changed in 1988 and apart from the inherant instability of the new tax, which may be considerable, too few data points exist since the change in tax regime, for useful econometric analysis. Second, it is not possible at this time to construct a meaningful model of the industrial facilities tax because of a lack of data for the key explanatory variables.

This chapter is divided into four sections, including this introduction. The largest of the business taxes, the single business tax (SBT) is examined in section 5.2. Section 5.3 looks at the utility property tax. Section 5.4 considers the oil and gas severance tax. Each section consists of a short history of the tax in question, the MURF

FIGURE 5.1: GFGP/SAF BUSINESS TAXES
FISCAL 1988, MILLIONS OF DOLLARS



Single Business Tax	**1,556.1**
Insurance Premiums Tax	**43.9**
Utility Property Tax	**128.6**
Oil and Gas Severance	**43.6**
Industrial and Commercial Facilities Tax	**68.7**
Other	**2.4**
Total Business Taxes	**1,843.3**

SOURCE: MONTHLY FINANCIAL REPORT, JANUARY 1989

model of the tax and a review of the performance of the MURF model, both in absolute terms and relative to alternative models.

5.2 Single Business Tax

A Short History of the Single Business Tax[1]

The single business tax has been the principal business tax in Michigan since 1976. Prior to 1953, there was no general business tax in the state, with the exception of the corporate franchise fee. In that year the Michigan business activities tax (BAT) was enacted in response to a budgetary crisis. This tax was similar to the SBT in that it was based on value added rather than profits. However, over time, various amendments, such as the net income credit, increased the relative weight of profits in the tax base.

In 1967, as part of the major tax overhaul that included the introduction of the personal income tax, the BAT was repealed and replaced by a traditional corporate income tax. Two main drawbacks to this tax quickly emerged.

1. There are four basic sources for this history. They are:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, Michigan, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.
(iii) "Analysis of the Michigan Single Business Tax", Taxation and Economic Policy Office, Michigan Department of Treasury, January 1985
(iv) "The Michigan Business Activities Tax", Robert D. Ebel, MSU Business Studies, 1972.

First, by using profits as the tax base, the corporate income tax tended to reduce incentives to generate those profits in Michigan. Second, since corporate profits tend to be highly cyclical and since the Michigan economy is, or at least has been, more cyclical than the national economy, the revenues from the corporate income tax tended to be very volatile. In the most extreme example of this, during a national recession, revenues from the corporate income tax fell from $312 million in fiscal 1970 to $176 million in fiscal 1971.

In a move to address these problems and to reduce the overall complexity of business taxation in Michigan, the single business tax (SBT) was introduced in January of 1976. Various business taxes were repealed at the same time, most notably, the corporate income tax, the financial institutions income tax, the corporate franchise fee, and the local property tax on business inventories.

In 1978, the SBT was modified to reduce its burden on small, low-profit businesses and to expand protection to businesses with relatively large wage bills.[2]

In 1982, a ruling of the Supreme Court in the case of Memphis Trust vs. Reilly Garner, outlawed the practice of taxing receipts from federal credit instruments while exempting the interest from state instruments.

In fiscal 1984, the small-business, low-profit tax

2. A 50 percent tax credit was introduced for eligible small/low-profit businesses. The maximum labor component for the tax base was reduced from 65 percent to 63 percent.

credit was expanded, costing about $13 million in fiscal 1984 and about $22 million in fiscal 1985. A further $16 million was removed from revenue in fiscal 1985 by changing the tax treatment of workers' compensation supplemental payments. Also in 1984, action was taken to restore some of the tax base lost due to the Memphis Trust vs. Reilly Garner ruling.

Starting in August of 1987, foreign (out-of-state) insurance companies were forced to pay the higher of the retaliatory insurance premiums tax[3] or the single business tax. This has resulted in approximately $70 million in extra SBT revenues in fiscal 1988.

Finally in December of 1988, the small-business low-profit deduction was expanded again at an estimated fiscal 1989 cost of $10 million.

The MURF model of the Single Business Tax

Unlike the Michigan sales and income taxes, the structure of the single business tax is fairly complicated. Thus, in order to construct an econometric model of the tax it is necessary to look more carefully at some of the key provisions of the tax law.

The SBT for Michigan businesses is determined through a value-added system. In order to determine the value-added base for tax purposes the firm begins with its adjusted

3. The retaliatory premiums tax taxes out-of-state companies according to the way their state treats Michigan companies.

gross income or profit as defined for federal corporate income tax purposes. Next, labor costs, depreciation and other items that represent value-added are added to this measure of profit. Finally, other items contained in the income total that do not constitute value added are subtracted. This formula produces the total SBT value-added base that is then taxed at a 2.35% tax rate, which is the same rate now as it was when the SBT became law, in 1976.

However, some of the most important characteristics of the tax are the various deductions and exemptions allowed to aid certain businesses. First, the approach used in the SBT, when calculating capital costs, is to allow the firm to deduct the full cost of assets when purchased and not allow a periodic deduction for a replacement allowance or depreciation. This probably promotes investment more than other methods of dealing with capital acquisition.

Second, an attempt is also made to ease the burden of taxation for labor-intensive industries. If labor costs exceed 63% of the gross tax base, the adjusted tax base is reduced by the percentage that labor costs exceed this amount. This exception cannot exceed 37% of the base. For example, suppose a firm would otherwise have a tax base of $10,000,000 of which $8,000,000 is workers' compensation. The maximum labor component of the tax base is thus $6,300,000 (= $10,000,000 X .63) so that the firm may reduce its gross tax base by $1,700,000.

Taxes are also limited to 50% of gross receipts and the

first $40,000 of the tax base is exempt from taxation. This latter provision is an attempt to aid smaller firms. All of these provisions add to the difficulty in building a reliable forecasting model.

There are a number of additional major problems in forecasting SBT revenues. First, the relationships which determine annual payments are different from those which affect quarterly payments. The former are comprised of the total payments of many smaller companies and payments by bigger companies to reconcile the difference between their estimated quarterly payments and their annual liability. By law, these bigger companies must pay 90% of their total annual liability in estimated quarterly payments. Thus, apart from the different characteristics of large and small businesses, annual payments will be based on economic variables from the entire year that ended four months previously, whereas quarterly payments may be more influenced by factors in the quarter that ended in the previous month.

The MURF model of the single business tax uses separate equations for quarterly and annual payments to exploit some of the information implicit in these differences. In addition, there is a MURF model of refunds which, although not very accurate, provides a good starting point for estimating future refunds.

A second problem in forecasting SBT concerns the fact that a firm makes its annual and quarterly payments based on

its own fiscal year which is usually not the same as the state's. For most companies, whose fiscal year corresponds to the calendar year, this involves quarterly payments which are supposed to be received on the last days of January, April, July and October and annual payments which are due on the last day of April. However, because of normal accounting difficulties, a large and variable proportion of these revenues are received in the following month. This problem has been, for the most part, solved in the MURF models of single business tax by using 16th of the month to 15th of the month data.[4]

Although DCR figures are not completely accurate, the error involved in using these figures is far less than the errors caused by trying to explain variations in calendar month data. Also, over a number of months all but the first and the last DCR figures are cancelled out so that, from the standpoint of a fiscal year, most of the data are very reliable.[5]

A third problem involves the fact that, due to the natural turnover among firms and changes in accounting practices, the proportion of firms that make payments in any

4. These data are calculated by taking the CDCR end of the month figure, subtracting the DCR mid-month figure and adding the DCR mid-month figure for the next month. DCR Data are reported on weekdays only. If the 15th of the month is a Saturday then I use data from the 14th. If the 15th falls on a Sunday then I use data from the 16th.

5. Strictly speaking ,this basic problem only concerns single business tax estimated payments and annual payments. However, I also estimate refund data using mid-month to mid-month figures as this helps in the overall accounting.

one month changes each year. In recent years the number of firms using the calendar year as the fiscal year seems to have increased. This could be modeled by multiplying the seasonal dummies by time. Unfortunately, at the same time there should be a natural increase in total dollar seasonal variation as receipts from the tax rise and it is clearly difficult to separate these two effects. A further complication is caused by the fact that the coefficients on any economic variables, will tend to be over-estimates in the small revenue months and under-estimates in the larger revenue months. The current MURF SBT quarterly payments model deals with this problem by using three separate quarterly payments equations as is discussed in the next section.

A fourth problem is dealing with a number of changes that occured in the SBT law in its first years of operation. The MURF models all start in 1980 or 1981 which sidesteps this problem. However, the shorter sample range makes it more difficult to distinguish the effects of ecomonic variables.

Lastly, there is the problem of the natural variability of the tax due to various circuit breakers and changes in accounting practices on the part of major firms to try to reduce their liability. There is no obvious solution to this problem, except to track the behavior of various major taxpayers, so far as is possible.

The MURF SBT Estimated Payments Equations: ADJQ1

MURF employs three quarterly equations to model revenues from SBT estimated payments. ADJQ1, the dependent variable in the first equation, represents estimated payments that were due at the end of the first month of each quarter. In the second equation, ADJQ2, represents estimated payments that were due at the end of the second month of each quarter. Finally, ADJQ3, the dependent variable for the third equation represents estimated payments that were due at the end of the third month of each quarter. In all cases, revenues are measured as receipts from the 16th of the current month to the 15th of the next.

Splitting the data into three separate series in this way accomplishes two main objectives. First, by separating the large and small revenue months, the MURF model allows for a more efficient estimation of the coefficients on the economic variables that are likely to affect SBT revenues. Second, by removing a problem of severe heteroskedasticity, the present framework should aid in uncovering changes in the seasonal pattern of SBT payments over time.

The series on ADJQ1 contains two adjustments. First, revenues from some major taxpayers were very erratic in the 1986-1988 period for non-economic reasons. As a result, adjustments are made to each major payment period from 1986 to 1988 to better reflect the amount of money that would have been collected without this erratic behavior. No further adjustments are made to the forecast values, as

there is reason to believe that the behavior of these taxpayers will resume a more normal pattern.

Second, it is necessary to make some adjustments to the model to take account of the larger number of insurance company taxpayers since the start of fiscal 1988. Until the pattern of insurance company payments is better established, it seems appropriate to reduce the monthly payments received in fiscal 1988 by the addition to insurance company revenues in order to estimate what SBT would have been without the change in the law.

Both of these adjustments only affect ADJQ1 which is by far the largest of the three series. This data should include those whose fiscal year is the calendar year as well those who have the same fiscal year as the state.

Two economic variables are included among the set of regressors. ESMSHARE is the share of total wage and salary employment represented by services. This has been rising over time in Michigan as well as nationally. It also appears to be counter-cyclical in Michigan due to the large fall in manufacuring employment that occurs when the Michigan economy falls into recession.

In addition, U.S. pre-tax corporate profits, YCBT, is used as a regressor. Due to various deductions for capital and labor expenses profits still represent a very important part of the SBT tax base. Both YCBT and ESMSHARE are lagged by one quarter.

Three seasonal dummies were employed in the the

equation for ADJQ1. In addition, dummy variables were introduced for three unusually large collection months, January, 1985, July, 1985, and January 1986. An MA(1) term was also introduced to deal with some remaining serial correlation among residuals. The first of the three MURF estimated payments equations is shown below:

$$(5.1) \quad ADJQ1 = a_1 + a_2*TR1 + a_3*TR2 + a_4*TR3 + a_5*ESMSHARE(-1) + a_6*YCBT(-1) + a_7*B851 + a_8*B853 + a_9*B861 + a_{10}*MA(1)$$

Performance Review

The results of regressing equation (5.1) over the period 1980.2 to 1988.4 are shown in Table 5.1. The R^2 is .973 and the partial R^2, given seasonal dummies, outlier dummies and the MA term is .906

A Box-Pierce test for white noise residuals yielded a Chi-square of .862, which, given 7 degrees of freedom, failed to reject that hypothesis.

A likelihood ratio test, conducted to evaluate the hypothesis of insignificant seasonal dummies, generated a Chi-square of 15.8 which, given only three degrees of freedom, caused the null hypothesis to be rejected at the five percent significance level.

Finally, a second likelihood ratio test was conducted to test a null hypothesis of structural stability. For the purposes of this test, the sample was split at 1984.4, its midpoint, and a Chi-square of 13.72 was generated, below the

five percent critical level of 18.31 for a Chi-square with 10 degrees of freedom.

Table 5.1: Statistical Output from the First MURF SBT Quarterly Payments Equation

LS // Dependent Variable is ADJQ1
SMPL range: 1980.2 - 1988.4
Number of observations: 35
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-523563.35	28852.994	-18.145893	0.000
TR1	-10118.153	4975.2165	-2.0337112	0.053
TR2	5018.8779	4399.1237	1.1408813	0.265
TR3	2104.0359	4523.6774	0.4651162	0.646
ESMSHARE(-1)	2947253.4	151935.35	19.398076	0.000
YCBT(-1)	494.69872	47.801456	10.349030	0.000
B851	39838.547	10327.840	3.8573939	0.001
B853	34815.217	9995.4241	3.4831155	0.002
B861	27812.339	10325.935	2.6934451	0.012
MA(1)	0.5029616	0.2117708	2.3750279	0.026

R-squared	0.973002	Mean of dependent var	208319.8
Adjusted R-squared	0.963282	S.D. of dependent var	48477.92
S.E. of regression	9289.300	Sum of squared resid	2.16E+09
Durbin-Watson stat	1.989804	F-statistic	100.1087
Log likelihood	-363.5562		

The MURF SBT Estimated Payments Equations: ADJQ2

The second MURF estimated payments equation, ADJQ2, also uses ESMSHARE and YCBT as independent variables, both lagged by one quarter. In addition, an outlier dummy B884 was introduced to deal with an unusually low level of colections in November 1988. Finally, a MA(4) term is introduced to model a changing pattern of seasonal variation over time. Thus the MURF model for quarterly payments on SBT received in February, May, August and November is given

by equation (5.2) below:

$$(5.2) \quad ADJQ2 = a_1 + a_2*ESMSHARE(-1) + a_3*YCBT(-1) + a_4*B884 + a_5*MA(4)$$

Performance Review

Equation (5.2) was fitted over the period 1980.1 to 1988.4 and the results of the regression are shown in Table 5.2. The R^2 is .924 and a partial R^2, given the outlier dummy and the MA term, was found to be .822.

Table 5.2: Statistical Output from the Second MURF SBT Quarterly Payments Equation

LS // Dependent Variable is ADJQ2
SMPL range: 1980.1 - 1988.4
Number of observations: 36
Convergence achieved after 6 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-69045.496	5652.4699	-12.215102	0.000
ESMSHARE(-1)	398492.53	28415.992	14.023531	0.000
YCBT(-1)	80.346828	10.195210	7.8808406	0.000
B884	-10931.478	2189.1601	-4.9934575	0.000
MA(4)	0.7477471	0.1869401	3.9999282	0.000

R-squared	0.924178	Mean of dependent var	32208.14
Adjusted R-squared	0.914395	S.D. of dependent var	6802.605
S.E. of regression	1990.330	Sum of squared resid	1.23E+08
Durbin-Watson stat	1.849970	F-statistic	94.46351
Log likelihood	-321.8482		

A Q-test for white noise residuals yielded a Chi-square of 6.26, below the five percent critical value of a Chi-square, given seven degrees of freedom, of 14.07. Thus, the null hypothesis of white noise residuals could not be

rejected.

Finally, a likelihood ratio test for structural change, which was conducted by splitting the data at 84.3, yielded a Chi-square of 13.7 which indicates structural change at the five percent significance level, though not at the one percent level.

The MURF SBT Estimated Payments Equations: ADJQ3

The third MURF estimated payments equation, ADJQ3, uses almost the same set of regressors as the second equation. The only difference is the omission of B884 and the inclusion of B834 to deal with an outlier caused by unusually low revenues in December of 1983. The third MURF estimated payments equation is show as equation (5.3) below.

$$(5.3) \quad ADJQ3 = a_1 + a_2*ESMSHARE(-1) + a_3*YCBT(-1) + a_4*B834 + a_5*MA(4)$$

Performance Review

Equation (5.3) was fitted over the period 1980.1 to 1988.4 and the results of the regression are shown in Table 5.3. The R^2 is .852 and a partial R^2, given the outlier dummy and the MA term, was found to be .592.

A Box-Pierce Q-statistic with seven degrees of freedom was evaluated at 6.14 which was too low to reject the null hypothesis of white noise residuals. In addition, a likelihood ratio test for structural stability was conducted, by splitting the data set at December 1983. This

test yielded a Chi-square of 8.94, which, given five degrees of freedom, was insufficient to reject the null hypothesis at the five percent significance level.

Table 5.3: Statistical Output from the Third MURF SBT Quarterly Payments Equation

LS // Dependent Variable is ADJQ3
SMPL range: 1980.1 - 1988.4
Number of observations: 36
Convergence achieved after 3 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-90354.751	10743.742	-8.4099890	0.000
ESMSHARE(-1)	483566.95	55288.867	8.7461903	0.000
YCBT(-1)	98.311312	19.087035	5.1506854	0.000
B834	-12432.636	3997.4295	-3.1101578	0.004
MA(4)	0.6301216	0.1947659	3.2352768	0.003

R-squared	0.852037	Mean of dependent var	32803.71
Adjusted R-squared	0.832945	S.D. of dependent var	9562.435
S.E. of regression	3908.389	Sum of squared resid	4.74E+08
Durbin-Watson stat	1.818730	F-statistic	44.62806
Log likelihood	-346.1419		

The MURF model of SBT estimated payments uses a three-equation approach in order to avoid a problem of severe heterskedasticity. An alternative approach, which is used in some other MURF models, is to convert the dependent variable and the major economic explanatory variables into natural log form.

This approach is particularily valid if the elasticities of revenue with respect to the major economic variables are similar across months. To check this equations (5.1), (5.2) and (5.3) were regressed in log form. The estimated elasticity of revenue with respect to U.S.

corporate profits was found to vary from a low of 0.51 in the case of ADJQ1 to a high of 0.67 in the case of ADJQ3. The elasiticity of revenue with respect to a change in the size of the service sectors share of total wage and salary employment ranged from 2.56 for ADJQ2 to 3.13 in the case of ADJQ1.

A likelihood ratio test was conducted to test the null hypothesis that these three subsamples should be combined. The sum of the log of the likelihood functions for the three separate log equations was found to be 139.80. A monthly logged equation was then estimated over the same period using the monthly equivalent of all the regressor variables in each of the three individual equations. The log likelihood function for this equation was evaluated at 118.39.

The degrees of freedom for the likelihood ratio test was calculated to be six which is the number of additional restrictions on the coefficients in the monthly equation. Twice the difference between unrestricted and restricted log likelihood functions yielded a Chi-square of 42.82. Since this is more than three times the five percent critical value of a Chi-square with six degrees of freedom the null hypothesis was rejected.

Even if this were not the case, however, the use of a log function to deal with the problem of heteroskedasticity might not be appropriate in this case. Because of different fiscal years, the group of companies who make a payment in

January also make payments in April, July and October. The group who pay in February also pay in May, August and November. Consequently, by using the three equation method, the MURF model follows the distinct behaviors of three different groups of companies.

More importantly, however, the natural log solution to heteroskedasticity is probably not appropriate where absolute errors are more important than percentage errors. Clearly, in the context of revenue forecasting, a $35 million error in a month where revenues were expected to be $350 million, is much more important than a $3.5 million mistake in a month where revenues were expected to be $35 million. In a monthly levels equation, least squares will attach 100 times more "importance" to fitting the former data point. This is a classic case of heteroskedasticity. However, in the log case, exactly the same level of "importance" will be attached to each error. This too, is hardly appropriate in the context of revenue estimating. The three equation approach, while not perfect, avoids both of these extremes.

The MURF SBT Annual Payments Equation

The MURF annual payments equation has a dependent variable of ADJA. ADJA is mid-month to mid-month annual payments on SBT, adjusted for one unusual payment in April 1988. No adjustment is made for insurance company payments as it has not proved possible yet to separate the estimated

payments and the annual payments from insurance companies.

Among the independent variables are seasonal dummies TTR1, TTR2 etc. These are generated by multiplying a series of zero/one seasonal dummies by a time trend. In addition a dummy variable is introduced for the observation of December 1987, which was unusually high for reasons which are not yet clear.

AVYPMA is the total value of AVYPM over the year that ended four months prior to the payment date, where AVYPM is a linear interpolation of total Michigan personal income, summed over the three months prior to the quarterly payment. ADJQA is the total value of quarterly payments over the year that ended four months prior to the payment date. Finally, a moving average term with a lag of one month was introduced to deal with some remaining serial correlation.

The MURF annual payments equation is:

$$(5.4) \quad ADJA = a_1 + a_2*TTR1 + \ldots + a_{12}*TTR11 + a_{13}*AVYPMA + a_{14}*ADJQA + a_{15}*B8712 + a_{16}*MA(1)$$

Performance Review

Equation (5.4) was fitted over the period 1981.04 to 1988.12 and the results of the regression are shown in Table 5.4. The R^2 is .987 and a partial R^2, given the outlier dummy, the seasonal dummies and the MA term, was found to be .557.

A Box-Pierce Q-test yielded a Chi-square of 18.13, given 23 degrees of freedom, which failed to reject the

null hypothesis of white noise residuals. Not surprisingly, a likelihood ratio test for the significance of seasonal dummies strongly rejected the null hypothesis of insignificant seasonal dummies, with the calculated Chi-square amounting to almost twenty times the five percent critical value for a Chi-square with 11 degrees of freedom.

Table 5.4: Statistical Output from the MURF SBT Annual Payments Equation

LS // Dependent Variable is ADJA
SMPL range: 1981.04 - 1988.12
Number of observations: 93
Convergence achieved after 4 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-12160.603	2025.7507	-6.0030105	0.000
TTR1	-151.35798	59.656005	-2.5371792	0.013
TTR2	-1.8312530	12.075017	-0.1516564	0.880
TTR3	20.027576	12.017167	1.6665805	0.100
TTR4	479.97651	59.778574	8.0292398	0.000
TTR5	8.2444374	11.820704	0.6974574	0.488
TTR6	-7.9096583	11.766405	-0.6722239	0.504
TTR7	-170.76733	59.433221	-2.8732639	0.005
TTR8	-21.293254	11.668254	-1.8248878	0.072
TTR9	23.276802	11.620185	2.0031353	0.049
TTR10	-84.640586	59.259204	-1.4283112	0.158
TTR11	-1.6940355	11.535469	-0.1468545	0.884
AVYPMA	0.6964652	0.0913761	7.6219645	0.000
ADJQA	0.1137706	0.0373307	3.0476406	0.003
B8712	16984.503	2866.4035	5.9253704	0.000
MA(1)	-0.2615520	0.1151277	-2.2718420	0.026

R-squared	0.987475	Mean of dependent var	19653.85
Adjusted R-squared	0.985035	S.D. of dependent var	20941.52
S.E. of regression	2561.789	Sum of squared resid	5.05E+08
Durbin-Watson stat	1.989528	F-statistic	404.7180
Log likelihood	-853.0892		

Finally, a likelihood ratio test for structual stability which split the data set at March of 1985, yielded

a Chi-square of 7.564, which failed to reject the null hypothesis of stability at the five percent level of significance.

The MURF SBT Refunds Equation

The MURF SBT refunds equation uses mid-month to mid-month refunds as its dependent variable. No adjustments are made to these data, in contrast to ADJQ and ADJA.

The model uses AVYPMA as a regressor, which is defined in the same manner as in the annual payments equation. It also employs seasonal dummies TTR1, TTR2, etc. However, most of its explanatory power is derived from five dummy variables dealing with five outliers in October, 1981, March, 1983, September, 1984, October, 1985 and June, 1988. These dummies are denoted by B8110 etc.

Finally, an MA(12) term is included to deal with remaining seasonality among the residuals and an AR(1) term is employed to model some serial correlation.

The MURF refunds equation is:

$$\text{(5.5)} \quad \text{REFUND} = a_1 + a_2*\text{TTR1} + \ldots + a_{12}*\text{TTR11} + a_{13}*\text{AVYPMA} + a_{14}*\text{B8110} + a_{15}*\text{B8303} + a_{16}*\text{B8409} + a_{17}*\text{B8510} + a_{18}*\text{B8806} + a_{19}*\text{MA(12)} + a_{20}*\text{AR(1)}$$

Performance Review

Equation (5.5) was regressed from 1980.02 to 1988.12. The R^2 is .940 but a partial R^2, given non-economic variables and outlier dummies was estimated at only .172.

Table 5.5: Statistical Output from the MURF SBT Refunds Equation

LS // Dependent Variable is REFUND
SMPL range: 1980.02 - 1988.12
Number of observations: 107
Convergence achieved after 8 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-2846.5867	1446.9005	-1.9673686	0.053
TTR1	41.249586	5.7732241	7.1449827	0.000
TTR2	39.032651	6.5890986	5.9238226	0.000
TTR3	28.276690	6.9525828	4.0670770	0.000
TTR4	9.4441622	6.8201726	1.3847395	0.170
TTR5	13.462337	6.7980847	1.9803133	0.051
TTR6	12.529884	7.1639074	1.7490293	0.084
TTR7	11.353146	6.7897301	1.6721056	0.099
TTR8	12.049650	6.6732507	1.8056641	0.075
TTR9	17.768293	6.6973478	2.6530342	0.010
TTR10	19.238734	6.5248841	2.9485173	0.004
TTR11	25.985407	5.3536060	4.8538138	0.000
AVYPMA	0.1812842	0.0550432	3.2934891	0.002
B8110	8296.5812	1445.5490	5.7393981	0.000
B8303	7891.6485	1463.0851	5.3938410	0.000
B8409	43969.059	1473.8296	29.833203	0.000
B8510	14756.267	1509.5417	9.7753292	0.000
B8806	16461.666	1635.4448	10.065559	0.000
MA(12)	-0.5267827	0.1303551	-4.0411356	0.000
AR(1)	0.3485843	0.0940361	3.7069201	0.000

R-squared	0.939942	Mean of dependent var	5147.027
Adjusted R-squared	0.926826	S.D. of dependent var	5457.390
S.E. of regression	1476.265	Sum of squared resid	1.90E+08
Durbin-Watson stat	1.999504	F-statistic	71.66296
Log likelihood	-921.5641		

A Box-Pierce Q-test yielded a Chi-square of 26.77 which failed to reject the null hypothesis of white noise residuals, given 22 degrees of freedom.

Two likelihood ratio tests were conducted. In the first, the null hypothesis of insignificant seasonal dummies was rejected as the estimated Chi-square of 80.72 was five times the critical value given 11 degrees of freedom.

In the second the null hypothesis of structural stability could not be rejected as the Chi-square generated by splitting the data at July 1984 was less than a quarter of the critical value given 18 degrees of freedom.

The SQEM model of the single business tax is given by equation (5.6).

$$(5.6)\quad \ln TSBQAMNS = a_1 + a_2 * \ln\left[\frac{\sum_{i=0}^{3} .25*(ECCM+ETRM+ESM)}{(EWSM-EGM)}\right]$$

$$+a_3 * \ln\left[\frac{\sum_{i=0}^{3} .25*10^6*MICHFRAC*((GAUTO82+GTRUCK82)/4)*(PCDA/100)}{(WSMFM/EMFM)*1000*EMDVM}\right]$$

$$+ a_4 * \ln\left[\sum_{i=0}^{3} .25*(WSMFM+WSPNMF+YOLM)\right] + a_5 * DSEAS1$$

$$+ a_6 * DSEAS2 + a_7 * DSEAS3$$

The first noteworthy characteristic of this equation is that it condenses 18 independent variables into only six terms. Although this is, at first glance, slightly puzzling, it may be accounted for by the fact that the fit period for this equation includes only 24 observations. Specifically, the fit period extends from 1978.1 to 1983.4.

Overall, this equation achieves an R-squared of .925

with a Durbin-Watson statistic of .925, neither of which appear to be very impressive.

TSBQAMNS denotes total quarterly receipts from annual and quarterly payments from the single business tax. EWSM is wage and salary employment and EGM is government employment. ECCM, ETRM and ESM represent employment in contract construction, retail and wholesale trade, and services respectively. These apparently are sectors which are favourably treated by the SBT as a_2 is significantly negative. One problem with this term and the following two terms, is that no extra weight is given to the quarter on which estimated payments are based.

MICHFRAC is the share of total U.S. SIC 317 (durable manufacturing, autos and related products) employment in Michigan. GAUTO82 and GTRUCK82 represent real gross U.S auto and truck output respectively. PCDA is the GNP deflator for consumer durables, autos. WSMFM and EMFM are total Michigan wages and salaries in manufacturing and employment in manufacturing respectively, whereas EMDVM represents auto-related manufacturing employment. The denominator of this term represents the wage bill in the auto industry and the numerator represents very roughly the gross value of auto output in Michigan. The coefficient on this term is positive reflecting both the positive impact on SBT revenues from increasing auto output and the positive impact of a reduced labor share in total value added, (due to the excess compensation deduction).

The third term includes, wage and salary income in manufacturing, WSMFM, wage and salary income in private nonmanufacturing, WSPNMF and other labor income, YOLM. This has a positive coefficient which shows the effect of increasing overall compensation on revenues. DSEAS1, DSEAS2 and DSEAS3 are seasonal dummies.

A second alternative model is the quarterly Walsh-Fisher (WF) model developed in the Treasury department, shown in equation (5.7).

$$(5.7) \quad SBTREV = a_1 + a_2*AS + a_3*RS + a_4*DIN + a_5*MIUE + a_6*SEAS1 + a_7*SEAS2 + a_8*SEAS3$$

In this equation SBTREV is gross SBT revenues, AS represents factory sales of passenger cars from U.S. plants, RS represents U.S. retail sales, DIN is the change in US business fixed investment, MIUE is the Michigan unemployment rate and SEAS1 etc. are seasonal dummies.

As a test of the relative performance of the MURF, SQEM and WF models of SBT revenues, three simulations were run from the first quarter of 1987 to the last quarter of 1988. The results of the simulations are illustrated in Figures 5.2, 5.3, and 5.4 and are outlined in Table 5.6.

It should be noted that the actual data has not been adjusted to allow for the change in the law regarding insurance companies and the erratic behavior of a major taxpayer. Second, the MURF, SQEM, and WF forecasts are shown in two separate figures since the MURF model uses mid-

FIGURE 5.2: GROSS SBT PAYMENTS

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

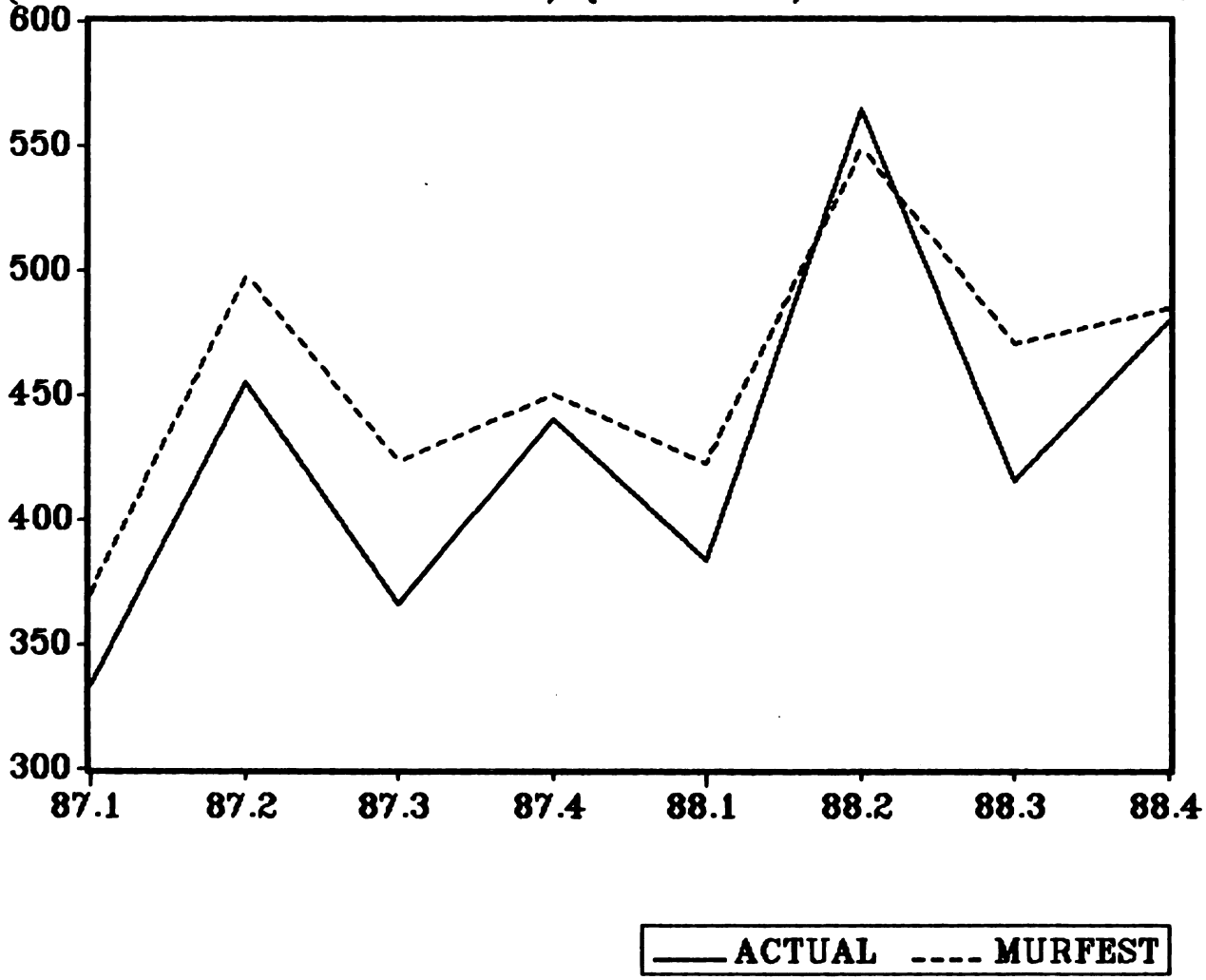


FIGURE 5.3: GROSS SBT PAYMENTS

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

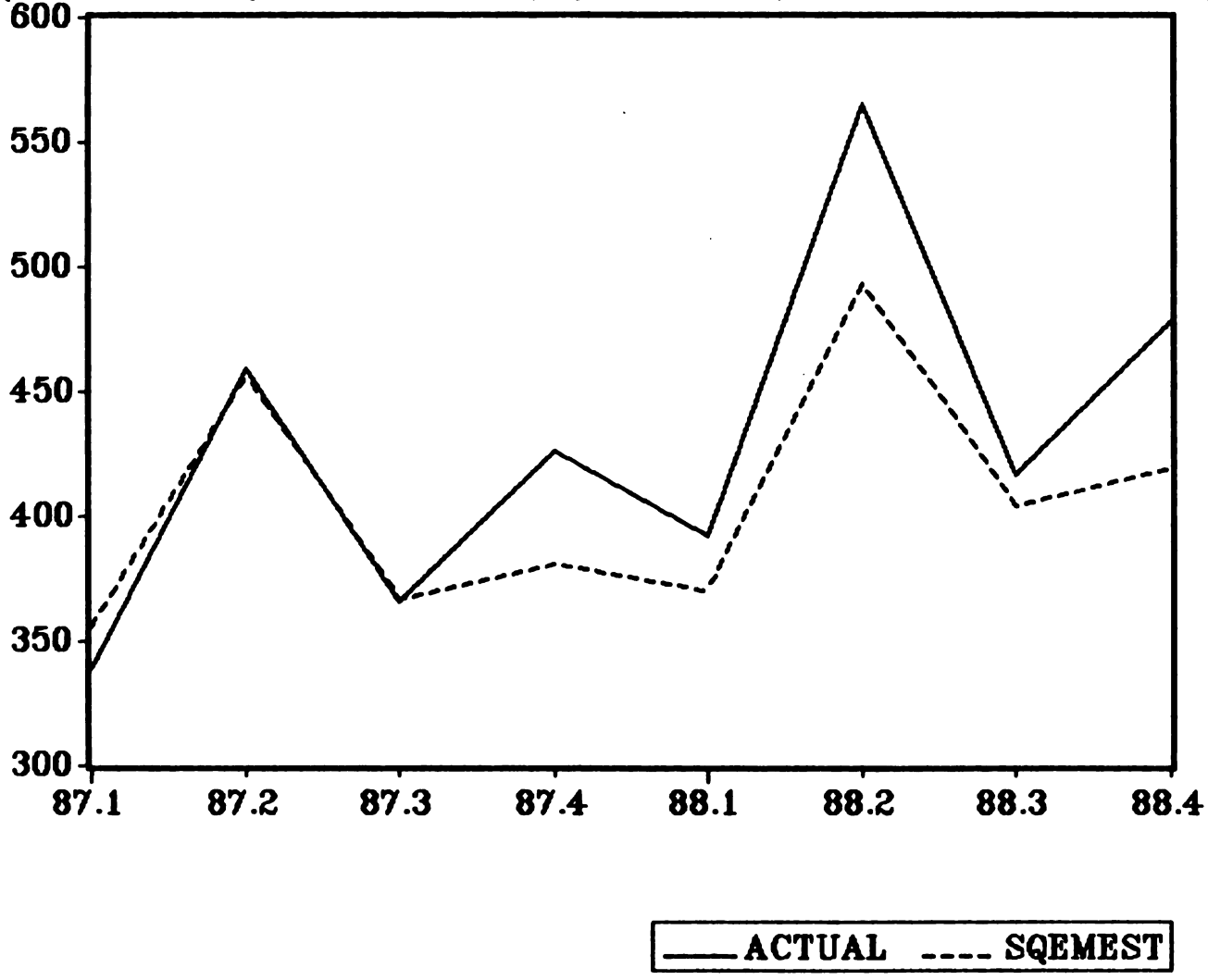
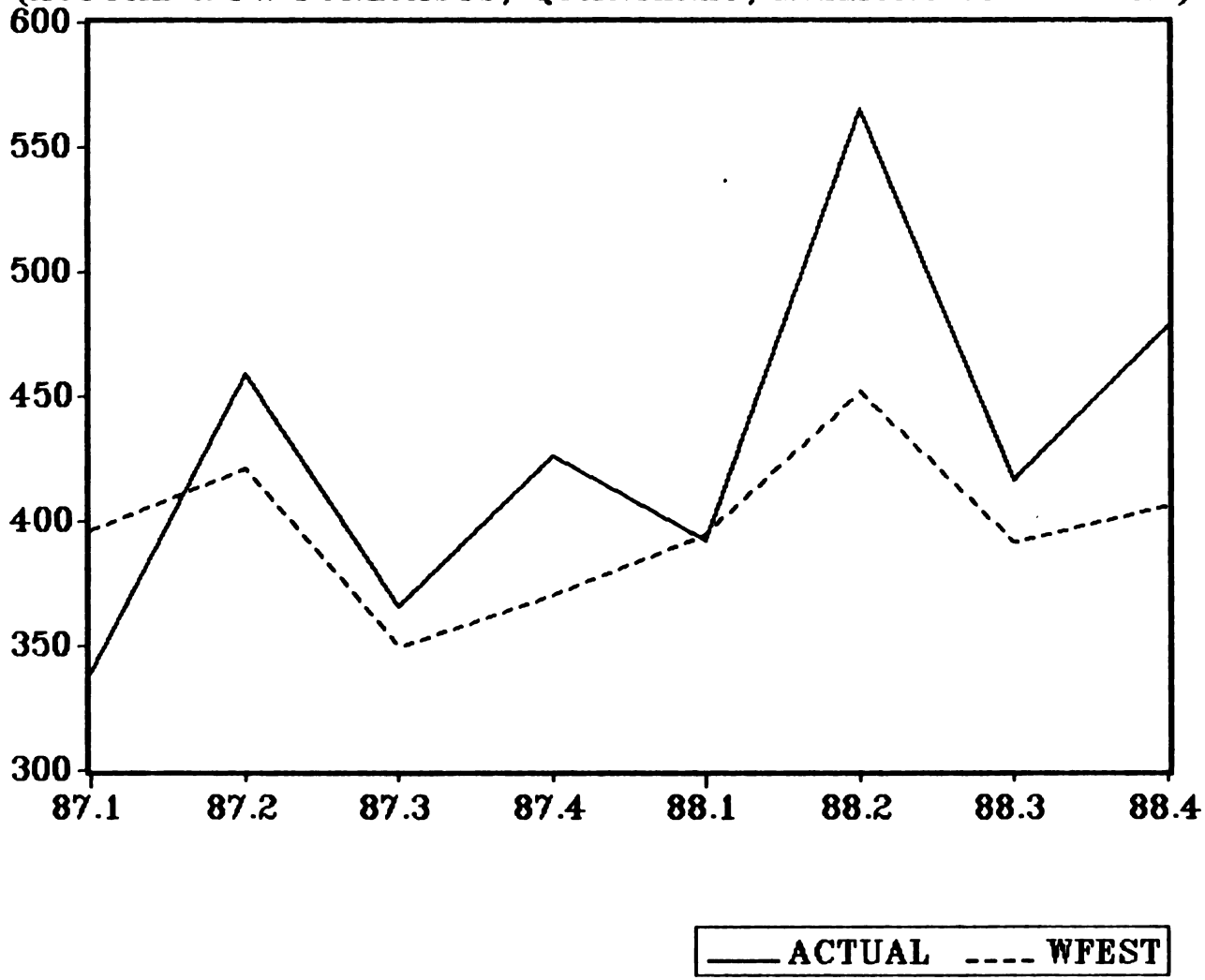


FIGURE 5.4: GROSS SBT PAYMENTS

(ACTUAL & FW FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



month to mid-month data whereas the other two models use calendar month data.

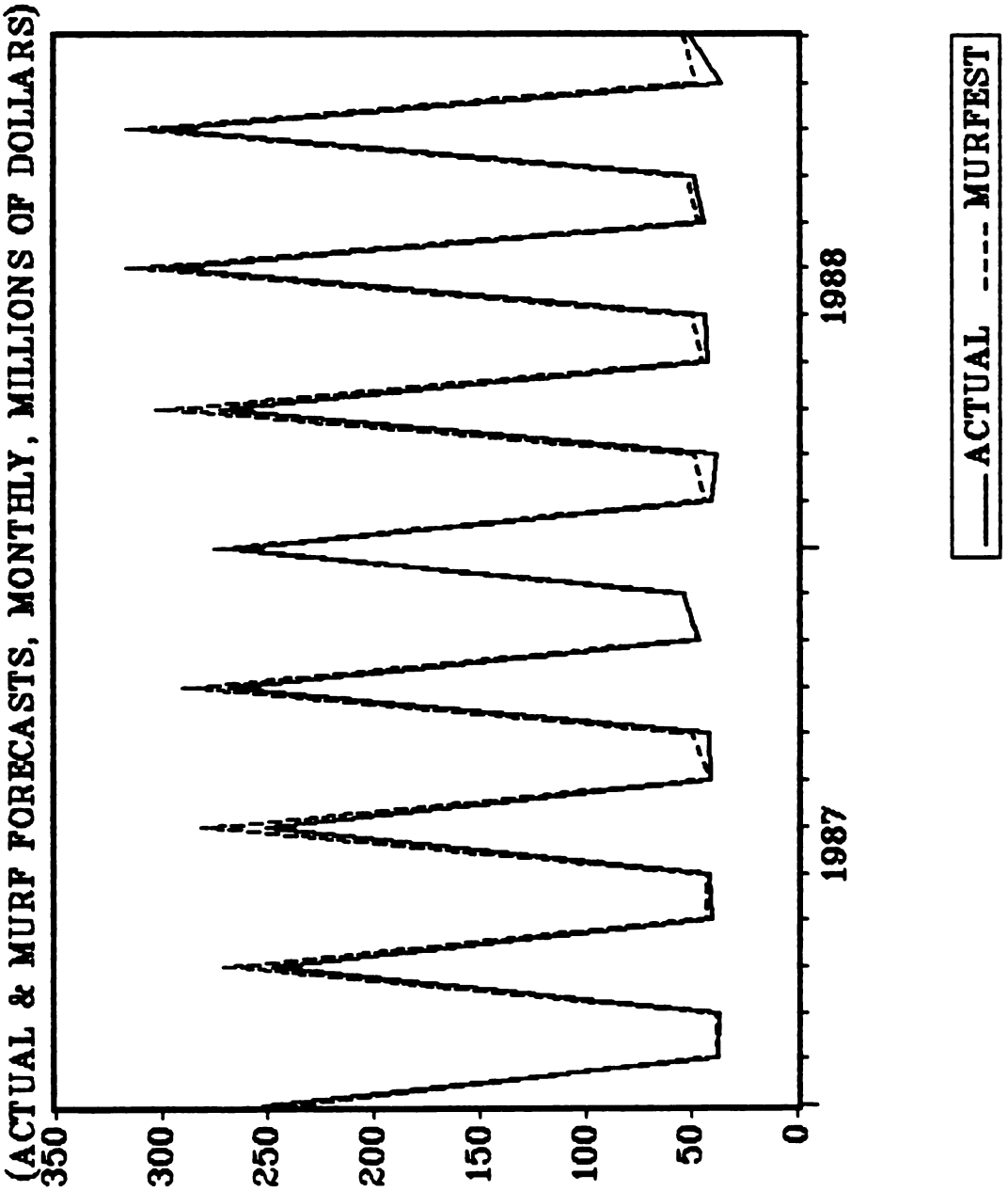
None of the models performs particularily well over this period. The MURF model has a slightly lower RMSE than the other two. However, from a budget standpoint the overall error is unacceptably high. Most of the error in all of these models is due to the erratic behavior of some major taxpayers and the change in insurance tax law. Consequently it is hoped that in the absence of any further major disturbances, the MURF model will perform more accurately in the future.

Table 5.6: Gross SBT Payments (Relative Performance of MURF, SQEM & WF Forecasts, 1987-1988)

	MURF ACTUAL	MURF EST	MURF ERROR	SQEM ACTUAL	SQEM EST	SQEM ERROR	WF EST	WF ERROR
1987								
I	333.7	370.0	36.3	339.0	355.5	16.5	396.1	57.1
II	455.0	498.5	43.5	458.8	457.0	-1.8	421.2	-37.6
III	366.1	423.0	56.9	365.7	366.2	0.5	349.0	-16.7
IV	440.0	450.2	10.2	425.9	380.7	-45.2	370.1	-55.8
1988								
I	383.5	421.9	38.4	391.9	369.7	-22.2	394.5	2.6
II	564.4	549.1	-15.3	565.2	492.9	-72.3	452.1	-113.1
III	415.4	470.2	54.8	416.6	403.8	-12.8	391.1	-25.5
IV	479.3	484.7	5.4	477.8	419.3	-58.5	406.0	-71.8
RMSE			37.6			38.1		57.7

Some grounds for this optimism can be found in Tables 5.7, 5.8 and 5.9. In Table 5.7, and in Figures 5.5 and 5.6, the performance of the MURF quarterly payments equations is contrasted with that of three ARMA models. All three ARMA models contained three seasonal dummies along with AR and MA

FIGURE 5.5: SBT QUARTERLY PAYMENTS
(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)



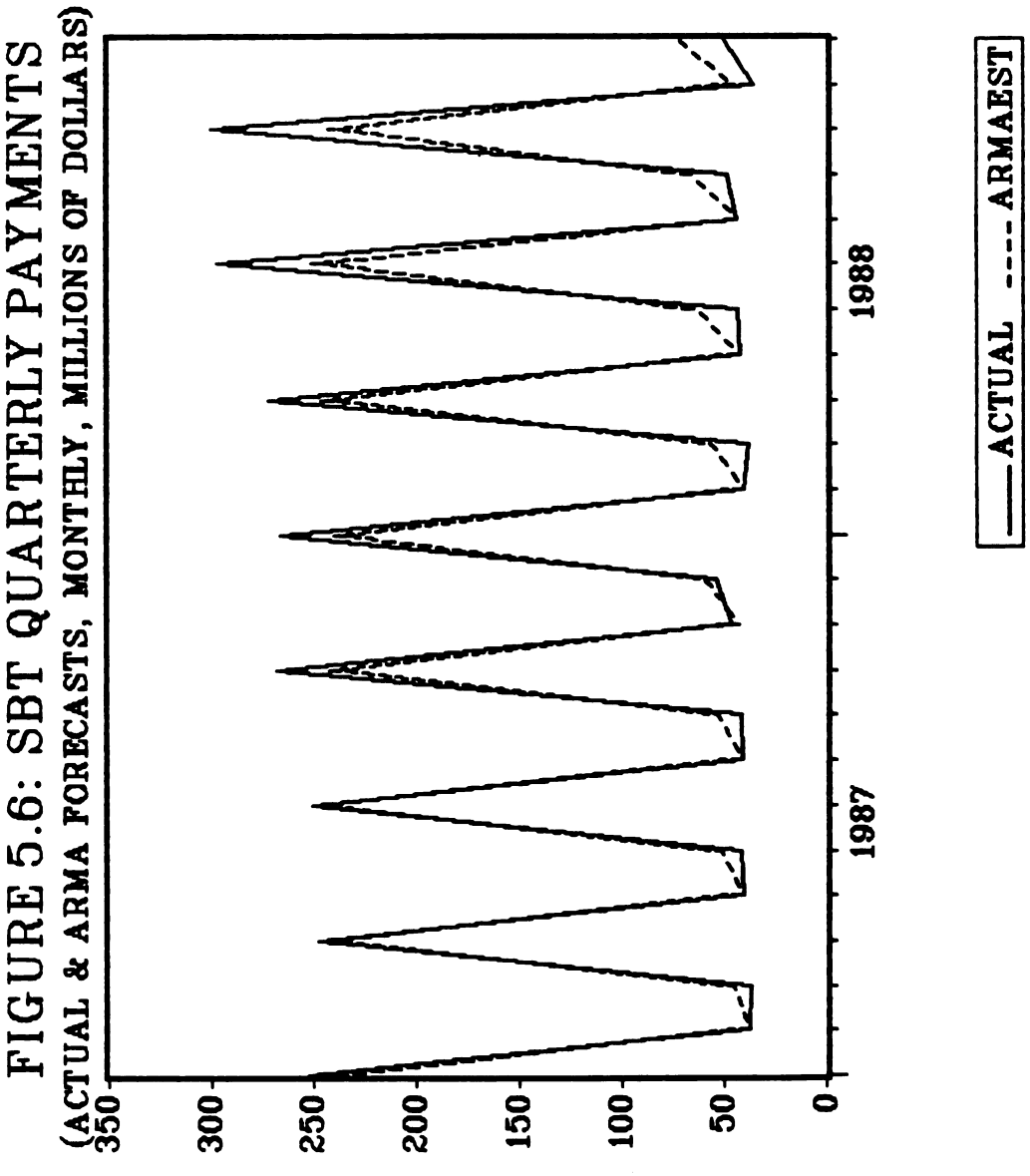


FIGURE 5.6: SBT QUARTERLY PAYMENTS
(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)
350
300
250
200
150
100
50
0
1987
1988
ACTUAL
ARMAEST

terms at lags of one quarter. In addition, the ARMA model for ADJQ2 included a MA term at a lag of two quarters. It should be noted that, in contrast to the last comparison, the data series here is adjusted for the insurance company effect and the erratic behavior of some major taxpayers. It should also be noted that the forecasts from all six equations were generated using models fitted over the period 80.2 to 86.4. The forecasts from these models have been combined to give a monthly forecast through December 1988.

Table 5.7: SBT Quarterly Payments (Relative Performance of MURF & ARMA Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR
1987					
JAN.	251.7	242.3	-9.4	239.4	-12.3
FEB.	37.2	37.4	0.2	37.2	0.0
MAR.	36.6	38.3	1.7	45.3	8.7
APR.	247.1	271.9	24.8	245.6	-1.5
MAY	40.0	42.5	2.5	40.7	0.8
JUN.	41.2	42.7	1.6	51.4	10.3
JUL.	250.1	281.1	31.0	250.6	0.5
AUG.	40.8	40.8	-0.0	40.6	-0.2
SEP.	41.4	49.7	8.3	53.5	12.1
OCT.	267.9	290.4	22.4	242.4	-25.5
NOV.	46.2	46.5	0.3	42.6	-3.7
DEC.	53.6	53.6	-0.0	59.5	5.9
1988					
JAN.	266.0	275.0	9.0	239.8	-26.2
FEB.	40.0	43.5	3.5	40.2	0.1
MAR.	38.0	48.5	10.5	56.5	18.5
APR.	271.9	302.5	30.7	246.0	-25.9
MAY	42.3	44.4	2.1	42.9	0.6
JUN.	43.0	49.7	6.7	63.6	20.6
JUL.	297.2	316.3	19.1	250.9	-46.2
AUG.	44.0	46.2	2.2	42.8	-1.2
SEP.	48.5	52.1	3.6	66.7	18.1
OCT.	299.9	316.5	16.6	242.8	-57.1
NOV.	35.6	47.4	11.8	44.7	9.2
DEC.	50.0	53.7	3.7	73.8	23.8
RMSE			13.3		20.1

Table 5.8: SBT Annual Payments (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	17.0	17.1	0.1	14.1	-3.0	16.7	-0.3
FEB.	12.7	16.0	3.2	11.1	-1.6	14.7	2.0
MAR.	19.5	19.0	-0.4	15.4	-4.1	18.2	-1.3
APR.	101.5	106.9	5.4	83.4	-18.1	81.1	-20.4
MAY	16.0	17.8	1.8	12.7	-3.3	17.2	1.2
JUN.	14.3	16.6	2.4	14.5	0.3	16.2	2.0
JUL.	15.3	15.1	-0.2	11.8	-3.4	17.5	2.3
AUG.	11.3	14.5	3.2	11.4	0.0	15.2	3.9
SEP.	22.2	21.8	-0.4	20.2	-2.0	19.8	-2.4
OCT.	31.2	24.8	-6.4	13.7	-17.5	25.0	-6.2
NOV.	13.7	16.7	3.1	12.8	-0.9	16.9	3.2
DEC.	34.3	18.2	-16.1	13.4	-20.9	17.6	-16.7
1988							
JAN.	21.8	16.9	-4.9	12.9	-8.9	19.7	-2.1
FEB.	18.2	17.5	-0.7	10.4	-7.8	17.7	-0.4
MAR.	21.9	20.6	-1.3	12.2	-9.7	19.6	-2.2
APR.	107.9	115.1	7.2	76.5	-31.4	82.3	-25.6
MAY	18.9	19.5	0.6	11.4	-7.5	19.2	0.3
JUN.	15.5	18.0	2.5	10.5	-5.0	18.0	2.5
JUL.	19.8	15.8	-4.0	11.4	-8.4	19.3	-0.5
AUG.	13.8	16.1	2.3	9.3	-4.5	17.0	3.2
SEP.	16.1	23.7	7.6	14.5	-1.6	21.4	5.4
OCT.	36.2	28.1	-8.0	18.6	-17.6	26.8	-9.4
NOV.	20.3	18.7	-1.7	11.1	-9.2	18.6	-1.7
DEC.	17.4	20.4	3.0	11.7	-5.7	19.3	1.9
			5.0		11.1		8.1

Table 5.8 compares the MURF model of annual payments with a VAR model and an ARMA model with an AR term at a lag of 12 months and MA terms at lags of three, six and 12 months along with 11 seasonal dummies. In these simulations the MURF model performs better than either of the other two models. These results are also outlined in Figures 5.7, 5.8, and 5.9.

Table 5.9 compares the MURF model of refunds with an ARMA model and a VAR model. The VAR model is outlined in Appendix C. The ARMA model has a MA term at a lag of 12 months along with 11 seasonal dummies. Again the MURF model outperforms the other two models. However, none of the models performs very well, as can clearly be seen in Figures 5.10, 5.11 and 5.12. However, if these models are used in conjunction with information about particularily large impending refund claims, they could prove valuable, at least for short-run forecasts.

FIGURE 5.7: SBT ANNUAL PAYMENTS

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

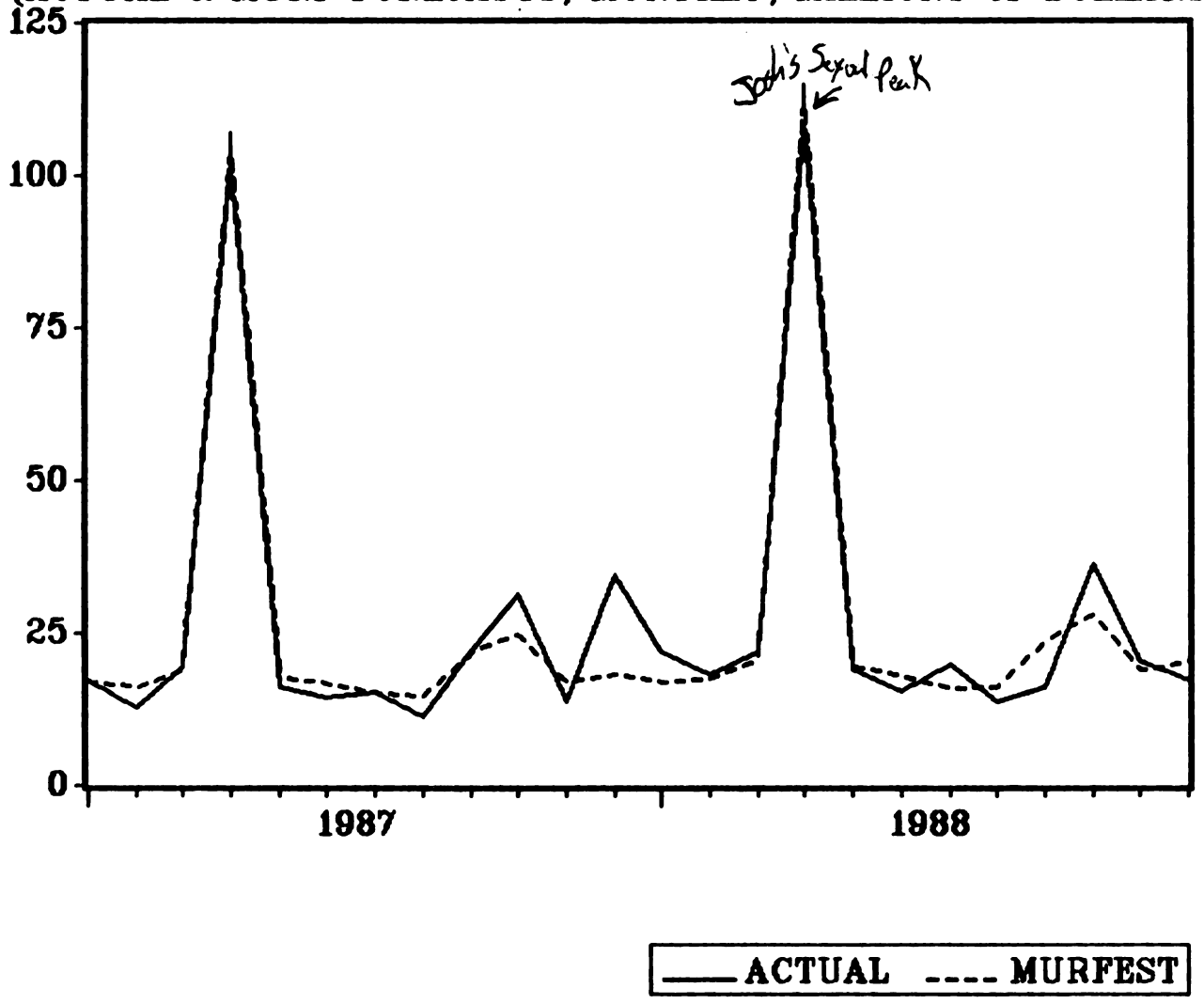


FIGURE 5.8: SBT ANNUAL PAYMENTS

(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

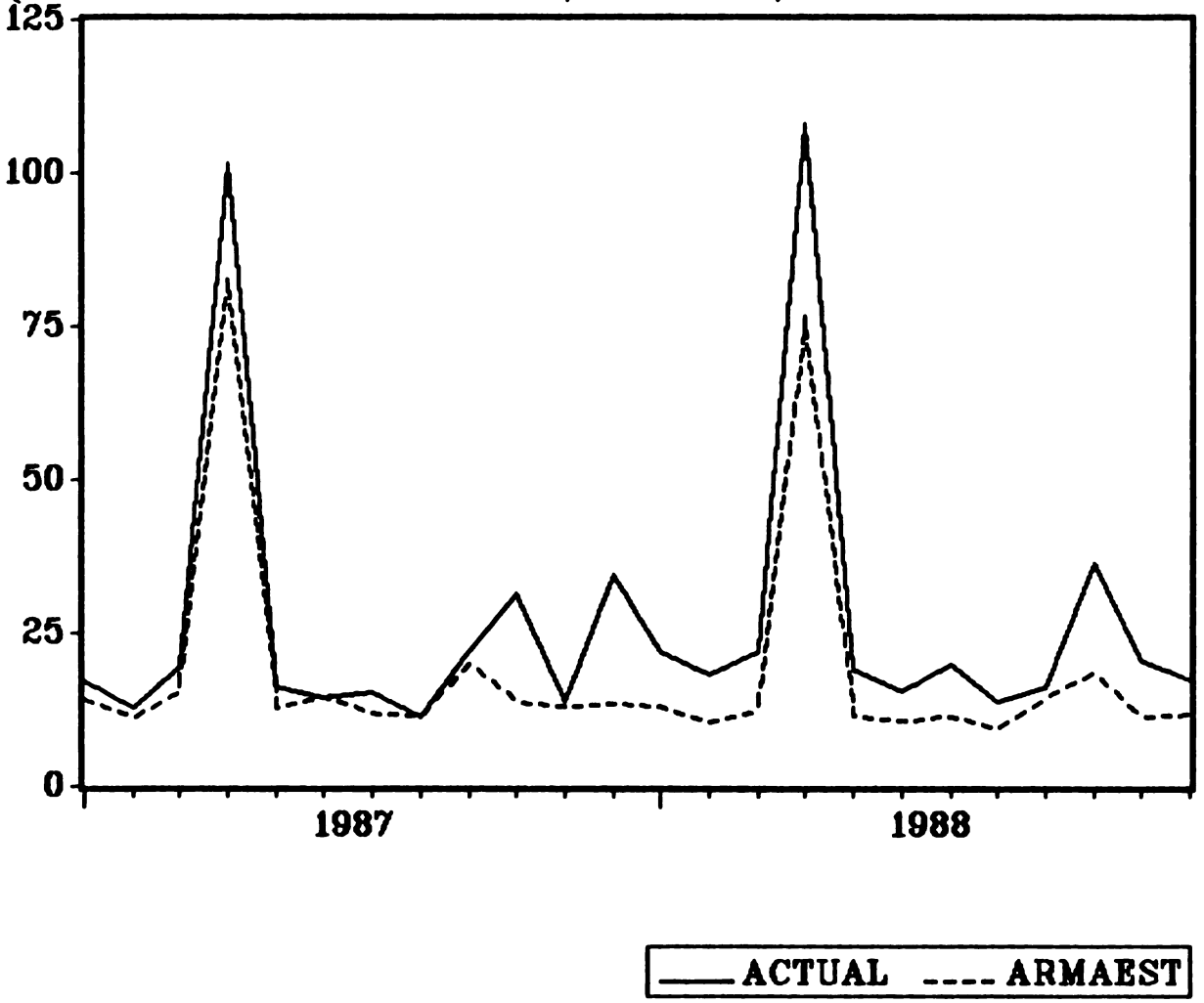


FIGURE 5.9: SBT ANNUAL PAYMENTS

(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

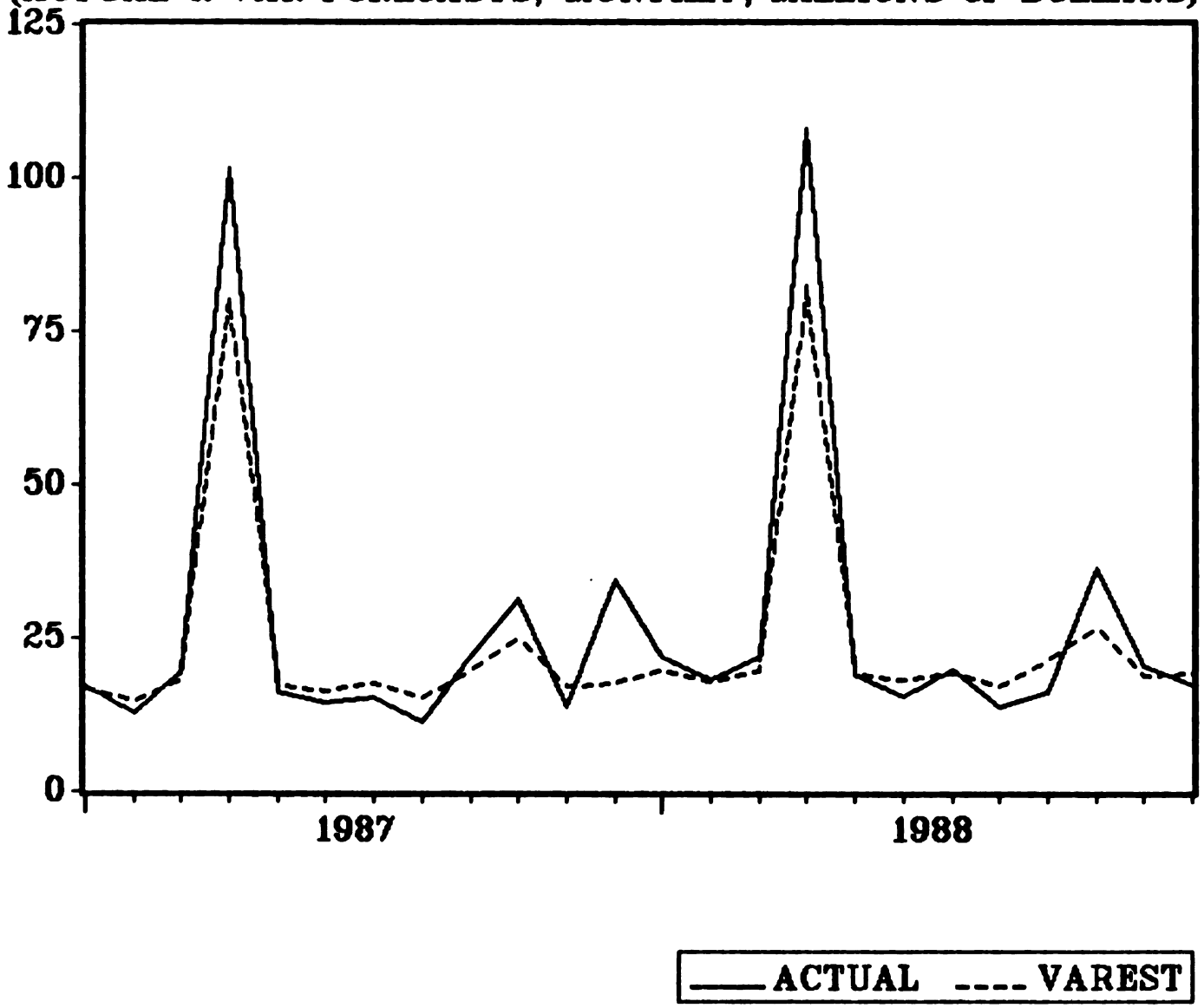


Table 5.9: SBT Refunds (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	6.4	8.4	2.0	3.6	-2.8	5.8	-0.6
FEB.	8.1	7.0	-1.1	3.4	-4.7	2.6	-5.5
MAR.	9.2	5.6	-3.6	5.7	-3.5	4.8	-4.4
APR.	5.1	5.3	0.3	2.7	-2.3	2.2	-2.8
MAY	3.1	6.2	3.1	3.3	0.1	2.7	-0.4
JUN.	7.1	5.6	-1.5	3.3	-3.8	2.7	-4.3
JUL.	4.2	6.2	2.0	3.2	-1.0	3.1	-1.1
AUG.	6.1	5.5	-0.6	3.1	-3.0	3.0	-3.0
SEP.	6.3	6.9	0.6	14.4	8.1	10.8	4.4
OCT.	7.2	5.5	-1.7	6.6	-0.7	7.5	0.2
NOV.	8.4	6.1	-2.3	3.3	-5.2	4.5	-4.0
DEC.	3.8	2.1	-1.7	0.9	-2.9	1.8	-1.9
1988							
JAN.	12.9	8.9	-4.0	5.4	-7.6	5.8	-7.2
FEB.	14.0	7.8	-6.2	4.8	-9.3	5.1	-9.0
MAR.	11.2	5.9	-5.4	5.4	-5.9	5.2	-6.0
APR.	5.4	4.9	-0.5	2.9	-2.5	2.9	-2.4
MAY	7.6	5.9	-1.7	3.5	-4.1	3.5	-4.1
JUN.	20.5	5.0	-15.5	3.2	-17.3	3.3	-17.2
JUL.	1.6	6.3	4.7	3.8	2.2	3.8	2.2
AUG.	4.1	5.5	1.4	3.4	-0.7	3.5	-0.6
SEP.	7.2	6.5	-0.7	12.0	4.8	11.2	4.0
OCT.	4.1	6.5	2.3	7.7	3.6	7.9	3.8
NOV.	6.3	7.5	1.2	4.6	-1.6	4.8	-1.5
DEC.	3.8	3.4	-0.4	2.0	-1.7	2.1	-1.6
RMSE			4.1		5.5		5.2

FIGURE 5.10: SBT REFUNDS

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

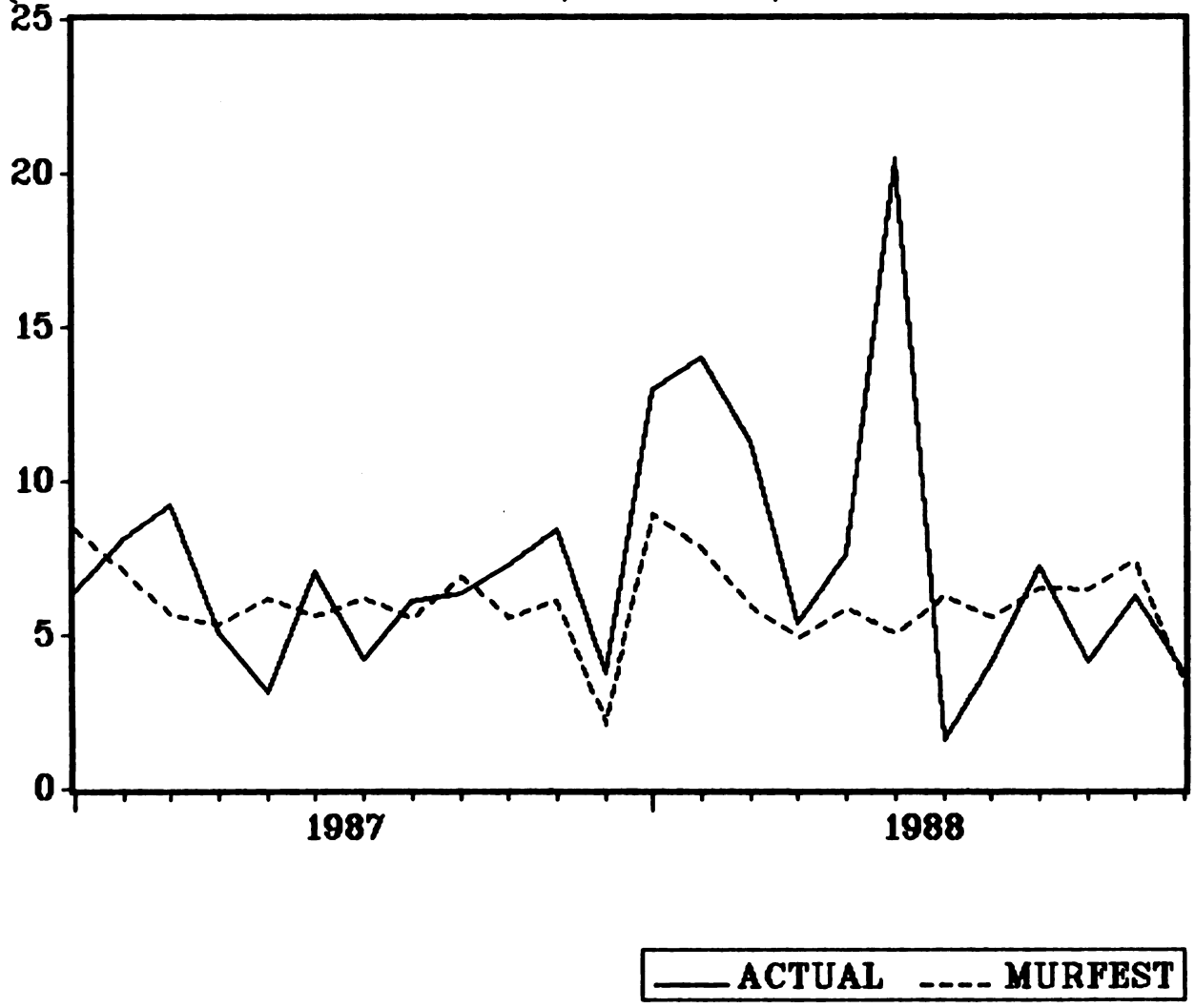
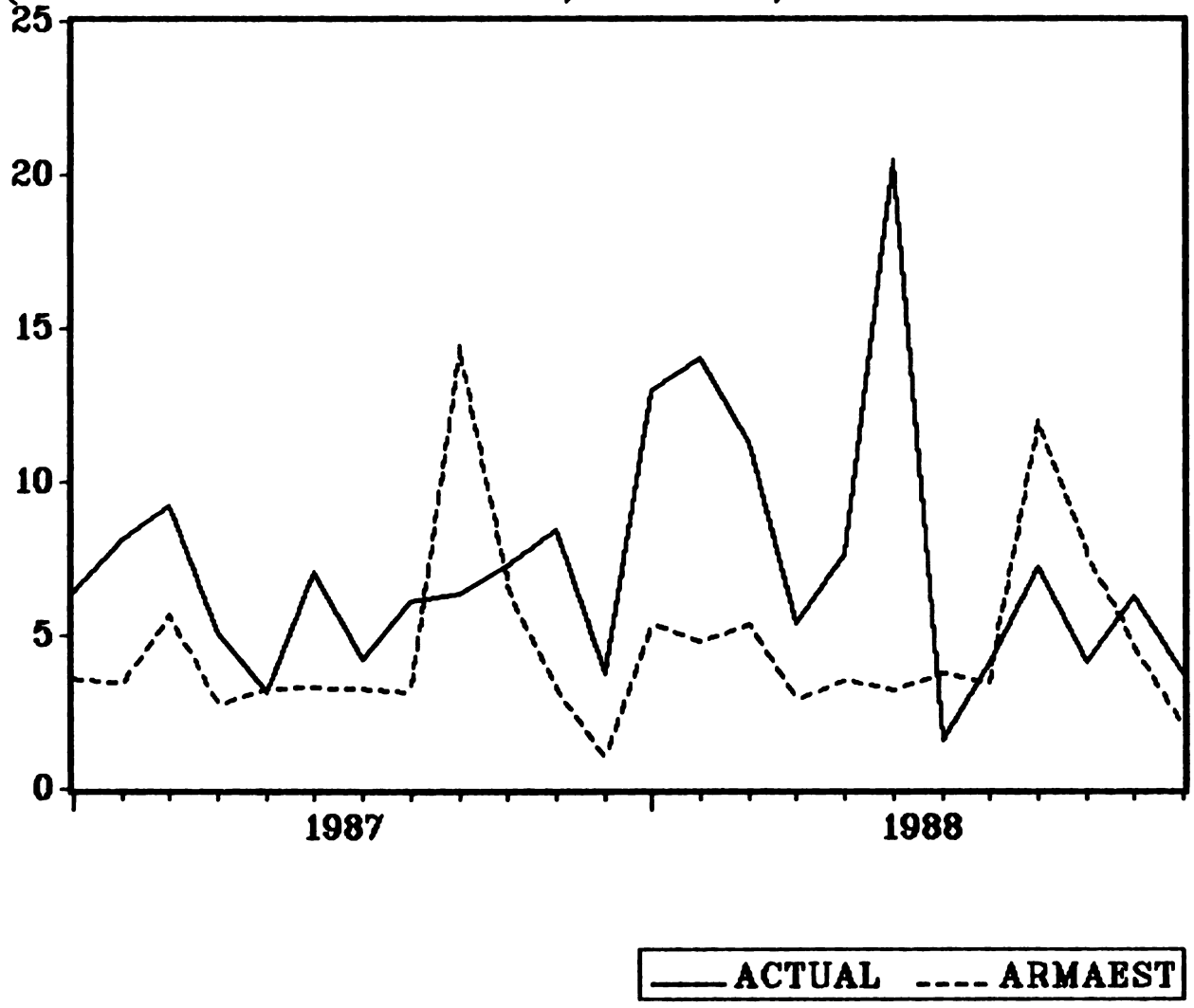


FIGURE 5.11: SBT REFUNDS

(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)



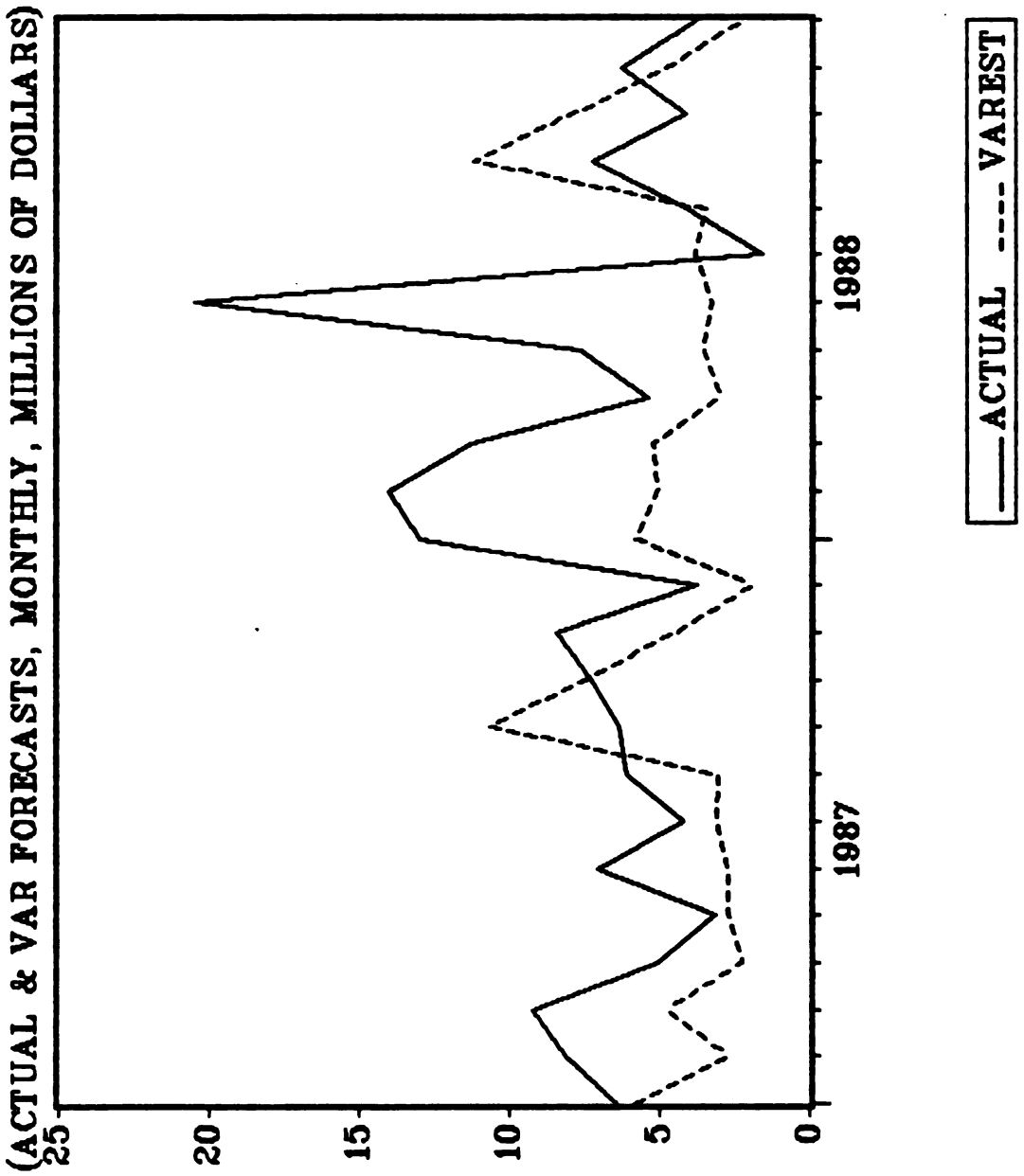


FIGURE 5.12: SBT REFUNDS
(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)
25
20
15
10
5
0
1987
1988
ACTUAL
VAREST

5.3 Utility Property Tax

A Short History of the Michigan Utility Property Tax[6]

The Michigan utility property tax was introduced in 1905 as a method of taxing the property of utilities that extended across local school districts. The tax was, and still is, levied on the current year's state equalized valuation (SEV) of the property using the previous year's state-wide millage rate. Only the property of telephone, telegraph and railroad companies were covered by this tax. The revenues raised by this tax were earmarked to the school aid fund.

In 1963, the new constitution allowed the legislature to discontinue the earmarking of the funds from this tax. The earmarking was accordingly removed in 1964.

In 1975, as part of the package that introduced the single business tax, an exemption was allowed for materials and supplies including repair parts and fuel. In 1977 a tax credit was provided for railroads equal to 25% of their track maintenance expenditures. This had the immediate effect of reducing the railroads share of total revenues

6. There are three basic sources for this history. They are:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, Michigan, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.
(iii) "Outline of the Michigan Tax System", Citizens Research Council of Michigan, May 1987.

from about $10 million to about $1 million.

In 1985, the state equalized valuation of utility property fell by 5.6%, possibly due to the breakup of AT&T. The future revenues from this tax may be affected by a pending decision on a challenge to the assessment of a major communications company.

The MURF Model of the Michigan Utility Property Tax

The utility property tax is due on July 1st or half by August 1st and the rest by December 1st. As with the single business tax, the first of the month payment date increases the difficulty in estimating this tax on a monthly basis. Moreover, an attempt to estimate receipts from this tax on a monthly basis might lead to inaccurate estimates of important coefficients as the regression struggles to explain the high variation between months rather than the smoother long-run pattern of the tax. Even a quarterly model seems inappropriate, since a linear version of the model will not allow the seasonal variation to grow with the overall level of the tax, whereas a log version cannot be estimated with zero value for some of the data points.

Consequently, the MURF model of the utility property tax includes just two observations per year, one for the third calendar quarter and one for the fourth, and the dependent variable is expressed in log form as LUTILTAX. It should be stressed that for all intents and purposes, no money is received in the first two quarters of the year.

Once this decision has been made, the construction of the model is relatively simple. The log of the average millage rate in the previous year is given by the variable LTAXRATE. Clearly, there should be a strong positive relationship between this variable and utility property tax collections. Also, the log of the total SEV of utility property, LUTILSEV, should be highly significant in a model of utility property tax, and this variable is included.

One seasonal dummy, TR1, is employed which takes a value of unity in the third quarter and zero in the fourth quarter. A dummy variable AFT78 which takes a value of zero prior to 1978 and one from 1978 on, is included to model the effect of the railroad tax credit introduced in that year. An AR(1) term is also employed. In combination with TR1, this probably adequately exploits the relationship between third and fourth quarter receipts.

Thus the final MURF utility property tax equation is given by equation (5.8):

(5.8) $LUTILTAX = a_1 + a_2*TR1 + a_3*AFT78 + a_4*LTAXRATE + a_5*LUTILSEV + a_6*AR(1)$

Performance Review

The level of explanation expressed by the R^2 of the MURF utility property tax equation is due in large part to the almost definitional nature of the equation. The results of regressing the MURF equation are given in the next page.

A partial R^2 given the seasonal dummy and the AR(1) term was calculated to be .8934. A Box-Pierce Q-statistic was also estimated yielding a Chi-square of 5.71 as compared with a five percent critical value for Chi-square, given three degrees of freedom of 7.810. This prevented the rejection of the null hypothesis of white noise residuals.

Table 5.10: Statistical Output from the MURF Utility Property Tax Equation

LS // Dependent Variable is LUTILTAX
SMPL range: 1977 III - 1988 IV
Number of observations: 24
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-7.3950110	1.9837185	-3.7278529	0.002
TR1	0.0244607	0.0032867	7.4422914	0.000
AFT78	-0.1322556	0.0118979	-11.115890	0.000
LTAXRATE	1.1736931	0.2163427	5.4251574	0.000
LUTILSEV	0.9117151	0.1031790	8.8362461	0.000
AR(1)	0.8118078	0.1443331	5.6245422	0.000

R-squared	0.996069	Mean of dependent var	10.86919
Adjusted R-squared	0.994977	S.D. of dependent var	0.139159
S.E. of regression	0.009863	Sum of squared resid	0.001751
Durbin-Watson stat	1.996540	F-statistic	912.1639
Log likelihood	80.25334		

A likelihood test for structural change which split the data at the fourth quarter of 1982, generated a Chi-square of 5.78 which, given five degrees of freedom, failed to reject the null hypothesis of stability.

The SQEM model of the Utility Property Tax is given by equation (5.9).

$$(5.9) \quad \ln TUPMNS = a_1 + a_2*D78 + a_3*\ln\left(\sum_{i=3}^{6} YPERM_{-i}/4\right) + a_4*\ln TUPRT + a_5*\ln TUPMNS_{-4}$$

The dependent variable in this equation, lnTUPMNS, is the natural log of utility property tax revenues. By using permanent income, YPERM, as an independent variable, the SQEM equation attempts to model the change in utility property SEV indirectly. lnTUPRT is the property tax rate from the previous year and D78 fulfills the same general function as B78 in the MURF model.

The main problem with the SQEM equation is that it was estimated through the fourth quarter of 1983. Thus it does not take account of the change in the relationship between YPERM and utility property SEVs in 1985. This change is implicitly taken care of in the MURF model by the use of utility property SEVs as a regressor.

As a test of the relative performance of the MURF and SQEM models of the utility property tax, two simulations were run from the first quarter of 1987 to the last quarter of 1988. In addition, the results of a simulation of an ARMA model with an AR term at a lag of one quarter, an MA term at a lag of two quarters and a single seasonal dummy are included. It should be noted that the AR model was constructed in the same way as the MURF model in assuming only two quarters per year. The results of the simulations are illustrated in Figures 5.13, 5.14 and 5.15 and are outlined in Table 5.11.

FIGURE 5.13: UTILITY PROPERTY TAX

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

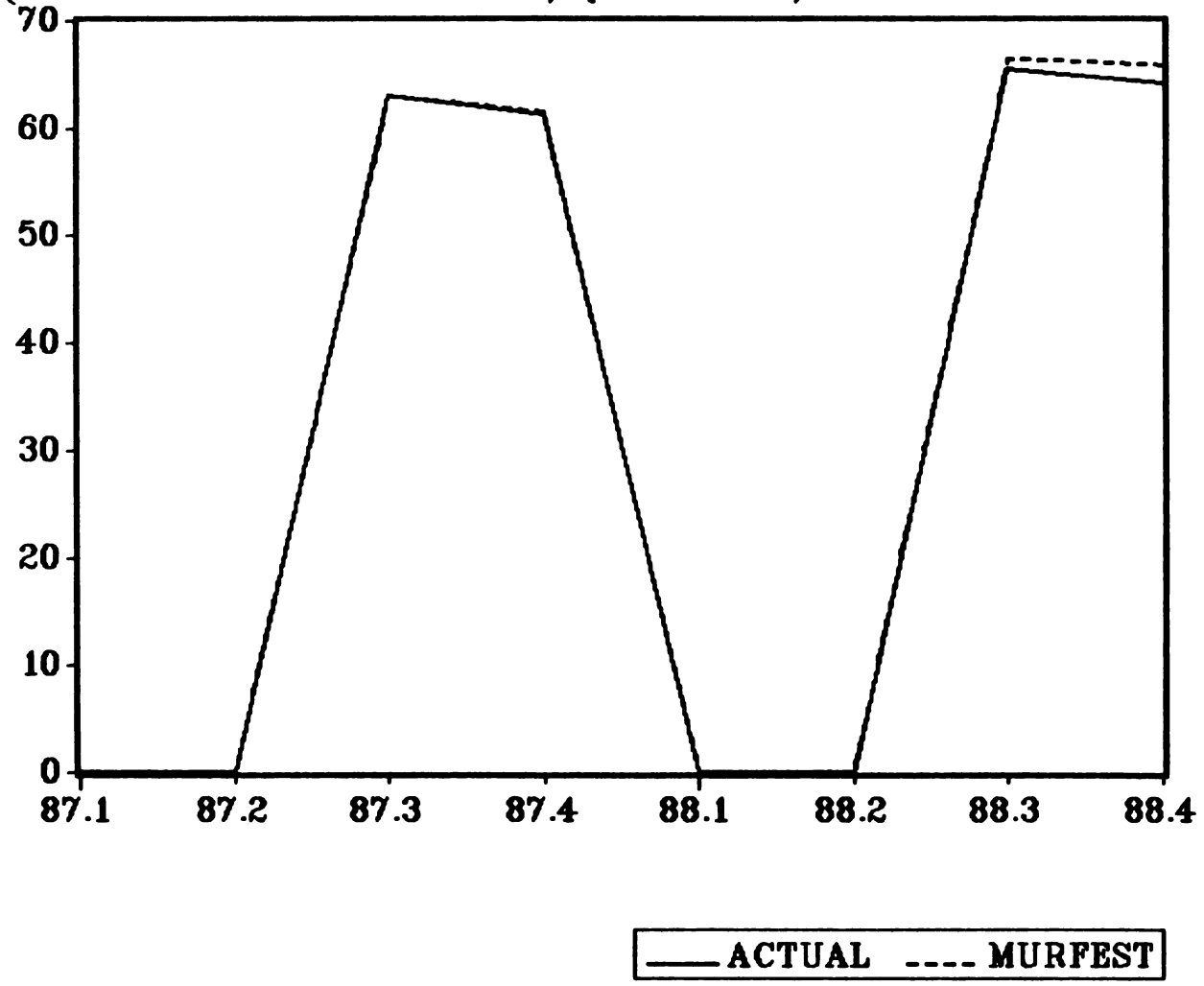


FIGURE 5.14: UTILITY PROPERTY TAX

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

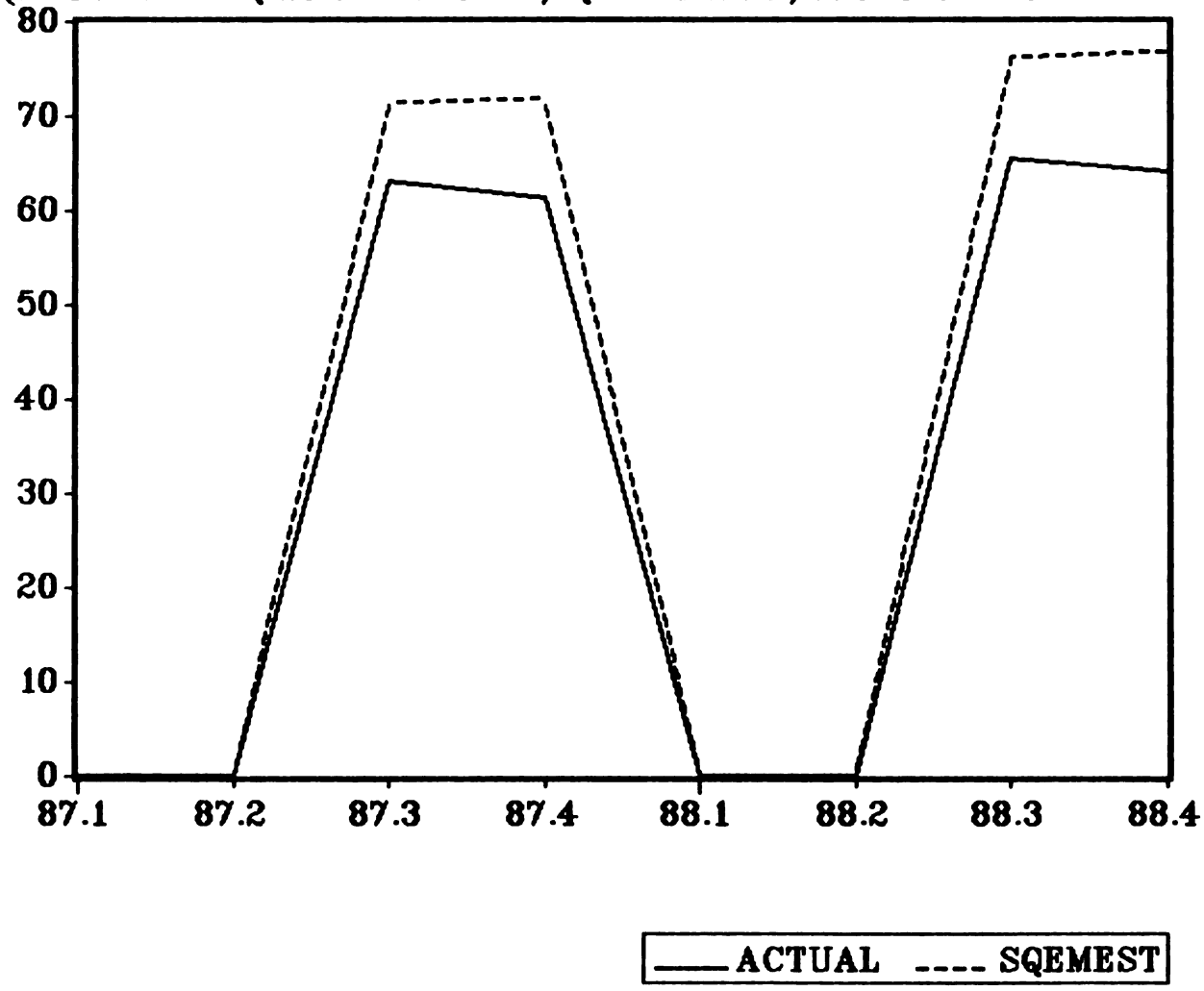


FIGURE 5.15: UTILITY PROPERTY TAX

(ACTUAL & ARMA FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

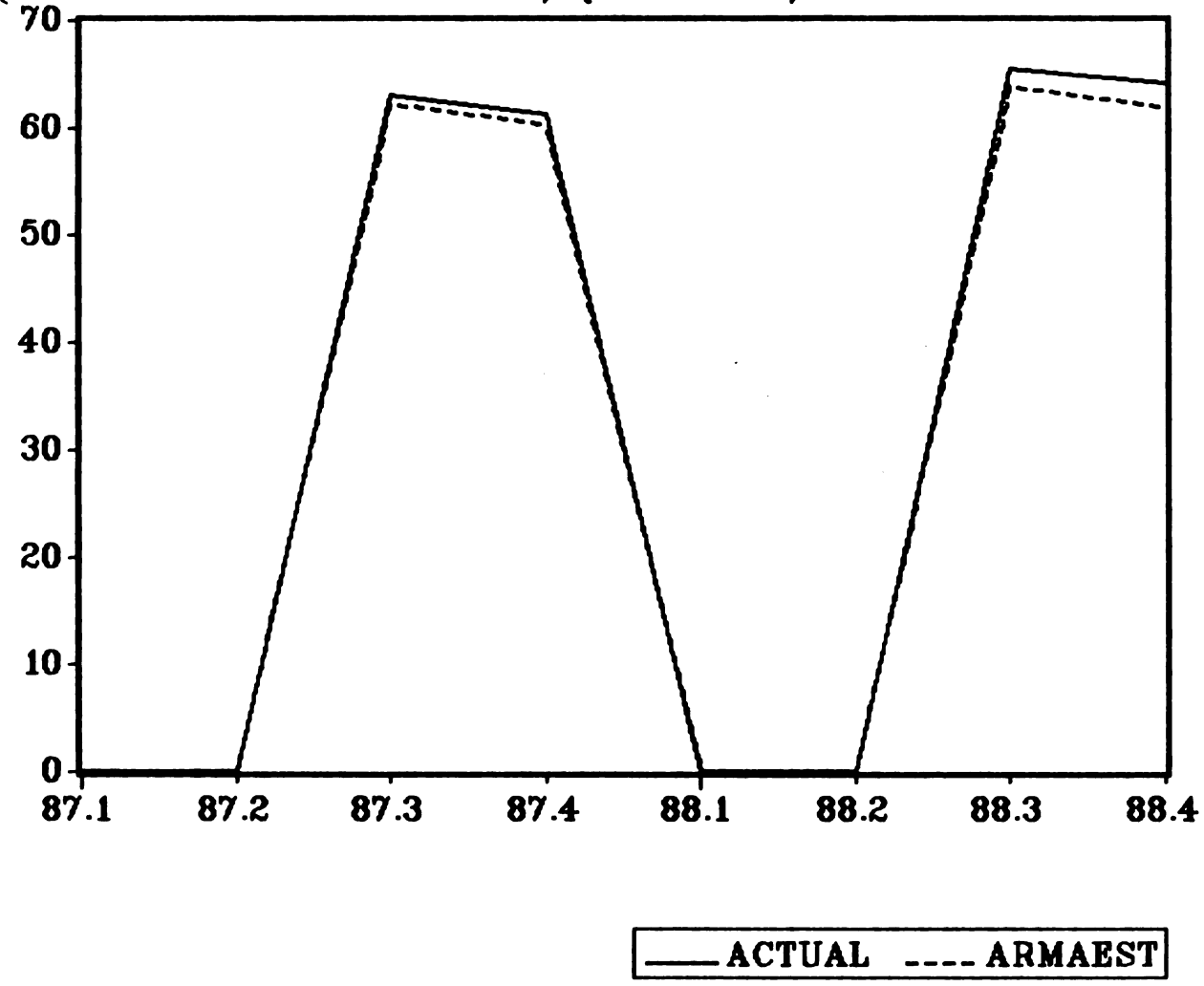


Table 5.11: Utility Property Tax (Relative Performance of MURF, SQEM & ARMA Forecasts, 1987-1988)

	MURF ACTUAL	MURF EST	MURF ERROR	SQEM EST	SQEM ERROR	ARMA EST	ARMA ERROR
1987							
I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
II	0.0	0.0	0.0	0.0	0.0	0.0	0.0
III	63.0	63.0	-0.0	71.4	8.4	62.2	-0.8
IV	61.3	61.5	0.2	71.9	10.6	60.3	-1.0
1987							
I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
II	0.0	0.0	0.0	0.0	0.0	0.0	0.0
III	65.5	66.4	0.9	76.2	10.7	63.8	-1.7
IV	64.2	65.8	1.6	76.9	12.7	61.9	-2.3
RMSE			0.7		7.6		1.1

The MURF model, not surprisingly, outperforms both its competitors in this period. The SQEM model neglects the fall in utility SEVs in 1975, whereas the ARMA model lacks information on the value of utility property and changing tax rates.

5.5 Oil and Gas Severance Tax[7]

The dependent variable in the MURF model of oil and gas severance is expressed in log form, LAJSEVER. This allows the effects of calendar variables to grow with the overall level of revenues. It also makes the equation more nearly

7. Although there is a detailed history of various taxes on natural resources in Michigan, the history of the oil and gas severance tax is so uncomplicated that the history section for this tax has been folded into the general section on the MURF model. Any historical information used can be found in "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, Michigan, May 1983.

homoskedastic which is important in this instance, since, in levels form, the model would attach most weight to observations in the early 1980's with larger absolute errors.

Importantly, LAJSEVER is based on revenues received between the 16th of one month and the 15th of the next. Payments for oil and gas severance must be received by the 25th of the month. Very often, due to delays in postage or accounting, much of this money is not recorded as having been received until the following month. It is no accident that, in a model based on calendar month data, February which normally contains only 3 days after the 25th and November, the end of which is complicated by the Thanksgiving holiday are the most frequent outliers.

The main independent variable is LPOILC, the natural log of the implicit[8] price of Michigan oil. This is used contemporaneously to allow for an immediate price effect on tax revenue. In addition, LRELPOIL, the natural log of the ratio of POILC to PCPID, the Detroit Consumer Price index, is employed as a regressor in an Almon lag specification. This is to allow for the lagged effect on production of changes in the real price of oil. The Almon lag used is a fourth-order polynomial over a lag length of 12 months. No end constraints were imposed.

In order to get mid-month to mid-month data, it was

8. Michigan oil prices are not normally measured in dollars per barrel. POILC is the implied price per barrel.

necessary to shorten fit period to February 1980 to December 1988. Consequently, although the severance tax rate was increased in 1979, no adjustment is needed in the current MURF model to deal with this.

Eleven seasonal dummies, TR1, TR2 etc. are used to deal with seasonal variation and two dummy variables, B8312 and B8401 are used to deal with obvious outliers. Finally, MA terms at lags of one and two months are employed to deal with remaining serial correlation among residuals. Thus the MURF oil and gas severance model is given by equation (5.10):

$$(5.10)\quad LAJSEVER = a_1 + a_2*TR1 + \ldots + a_{12}*TR11 + a_{13}*B8312 + a_{14}*B8401 + a_{15}*LPOILC + a_{16}*PDL(LPOILC) + a_{17}*MA(1) + a_{18}*MA(2)$$

Performance Review

The results of regressing the MURF model of oil and gas severance revenues are given in Table 5.12. One interesting result is the fact the sum of squared residuals for this regression is only 1/20th that of the same regression run with unadjusted data.

The R^2 for this equation is .975 and a partial R^2, given seasonal and outlier dummies and MA terms was found to be .857. A Box-Pierce test for white noise residuals yielded a Chi-square of 33.124 which failed to reject the null hypothesis at the five percent level, given 22 degrees of freedom.

Table 5.12: Statistical Output from the MURF
Oil & Gas Severance Tax Equation.

LS // Dependent Variable is LAJSEVER
SMPL range: 1980.02 - 1988.12
Number of observations: 107
Convergence achieved after 6 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	7.0773039	0.3582364	19.755960	0.000
TR1	-0.0259393	0.0250185	-1.0368064	0.303
TR2	-0.0219511	0.0238589	-0.9200355	0.361
TR3	-0.0892295	0.0237196	-3.7618535	0.000
TR4	-0.0138497	0.0235652	-0.5877189	0.559
TR5	-0.0403406	0.0236447	-1.7061154	0.092
TR6	0.0323575	0.0235067	1.3765231	0.173
TR7	-0.0196081	0.0235457	-0.8327692	0.408
TR8	-0.0114664	0.0236602	-0.4846269	0.629
TR9	0.0098698	0.0235275	0.4194993	0.676
TR10	-0.0134430	0.0233975	-0.5745469	0.567
TR11	0.0450359	0.0234123	1.9236005	0.058
LPOILC	0.6270621	0.0807699	7.7635595	0.000
B8312	-0.1093115	0.0512549	-2.1327020	0.036
B8401	0.1326228	0.0514241	2.5790009	0.012
PDL1	0.0266149	0.0186723	1.4253638	0.158
PDL2	0.0076605	0.0072099	1.0625073	0.292
PDL3	-0.0084062	0.0051994	-1.6167766	0.110
PDL4	-0.0004632	0.0003177	-1.4582217	0.149
PDL5	0.0003277	0.0001636	2.0024352	0.049
MA(1)	0.2987017	0.1107392	2.6973439	0.009
MA(2)	0.2327313	0.1145070	2.0324632	0.046

R-squared	0.975156	Mean of dependent var	8.600044
Adjusted R-squared	0.969018	S.D. of dependent var	0.272709
S.E. of regression	0.048002	Sum of squared resid	0.195854
Durbin-Watson stat	1.966934	F-statistic	158.8722
Log likelihood	185.3957		

A likelihood ratio test for structural stability was conducted by splitting the data at July 1984. This yielded a Chi-square of 9.8, which fails to reject the null hypothesis, given 20 degrees of freedom. By contrast, the null hypothesis of insignificant seasonal dummies was rejected as the Chi-square generated was more than double the five percent critical level.

The SQEM model of revenues from the oil and gas severance tax is given by two econometric equations and an identity:

(5.11) $(\ln OILVAL - \ln OILVAL_{-1}) = a_1$
$+ a_2 * (\ln POIL.C - \ln POIL.C_{-1})$
$+ a_3 * (\ln(AV.POILM/PPNF)_{-1} - \ln(AV.POILM/PPNF)_{-2})$
$+ a_4 * DSEAS1 + a_5 * DSEAS2 + a_6 * DSEAS3 + a_7 * D72.76$

(5.12) $\ln GASVAL = a_1 + a_2 * \ln PGAS.C$
$+ a_3 * \ln(PGAS.C/PPNF)_{-1} + a_4 * \ln GASVAL_{-1} + a_5 * DSEAS1$
$+ a_6 * DSEAS2 + a_7 * DSEAS3$

(5.13) $TOILMNS = STRPFRAC * .04 * OILVAL$
$+ (1 - STRPFRAC) * ROIL * OILVAL + RGAS * GASVAL$

Equation (5.11) regresses, in first difference form, the natural log of the value of Michigan oil production on the implicit price of Michigan oil, POIL.C, and the ratio of a semi-annual average of Michigan oil prices, AV.POILM to the non-farm producer price index, PPNF. The equation also includes seasonal dummies and a dummy variable for the

effects of the first oil price shock.

Equation (5.12) regresses the natural log of the value of Michigan gas production on the implicit price of Michigan gas, PGAS.C, and the ratio of PGAS.C to the non-farm producer price index, PPNF. The equation also includes seasonal dummies and a lagged dependent variable.

Equation (5.13) combines the output of equations (5.11) and (5.12) with the fraction of production from "stripper" wells, STRPFRAC, and the tax rates on oil and gas, ROIL and RGAS, to provide an estimate of revenues, TOILMNS.

This model is, if anything, more elaborate than is warrented by the importance of this tax. However, it should work fairly well <u>if</u> it can reflect the effects of changes in oil prices on overall production levels. Unfortunately, the fit period for the SQEM equations ends in 1983.4, before the slump in world oil prices so that its sensitivity to a fall in these prices may be open to question.

As a test of the relative performance of the MURF and SQEM models of oil and gas severance, two simulations were run from the first quarter of 1986 to the last quarter of 1987. The results of the simulations are illustrated in Figures 5.16 and 5.17 and outlined in Table 5.13. Although both models overestimated revenues in this period, the performance of the MURF model, as measured by the root mean squared error is clearly superior.

As a second test, the MURF model was compared with a VAR model and an ARMA model with MA terms at lags of two and

FIGURE 5.16: OIL & GAS SEVERANCE TAX

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

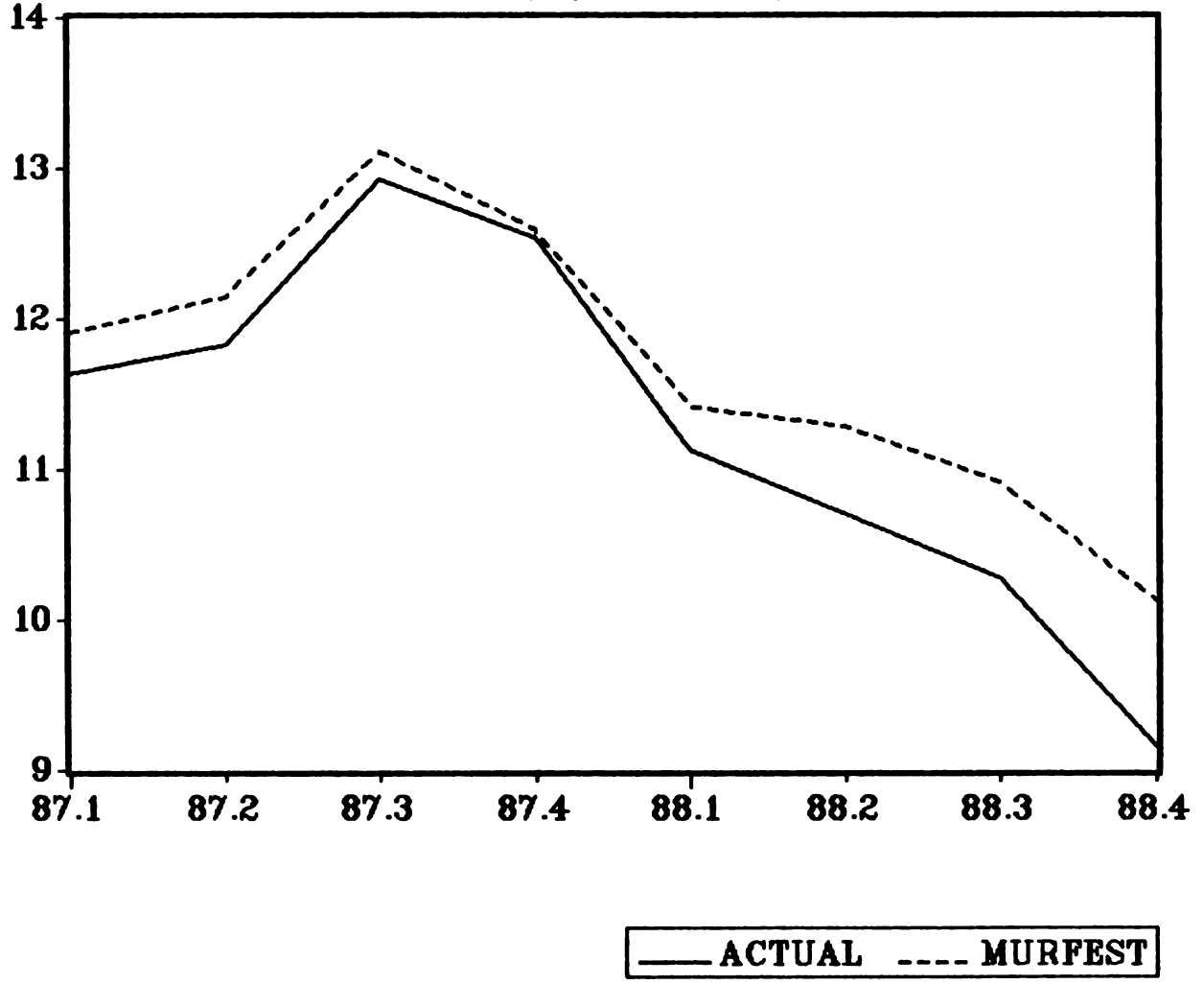
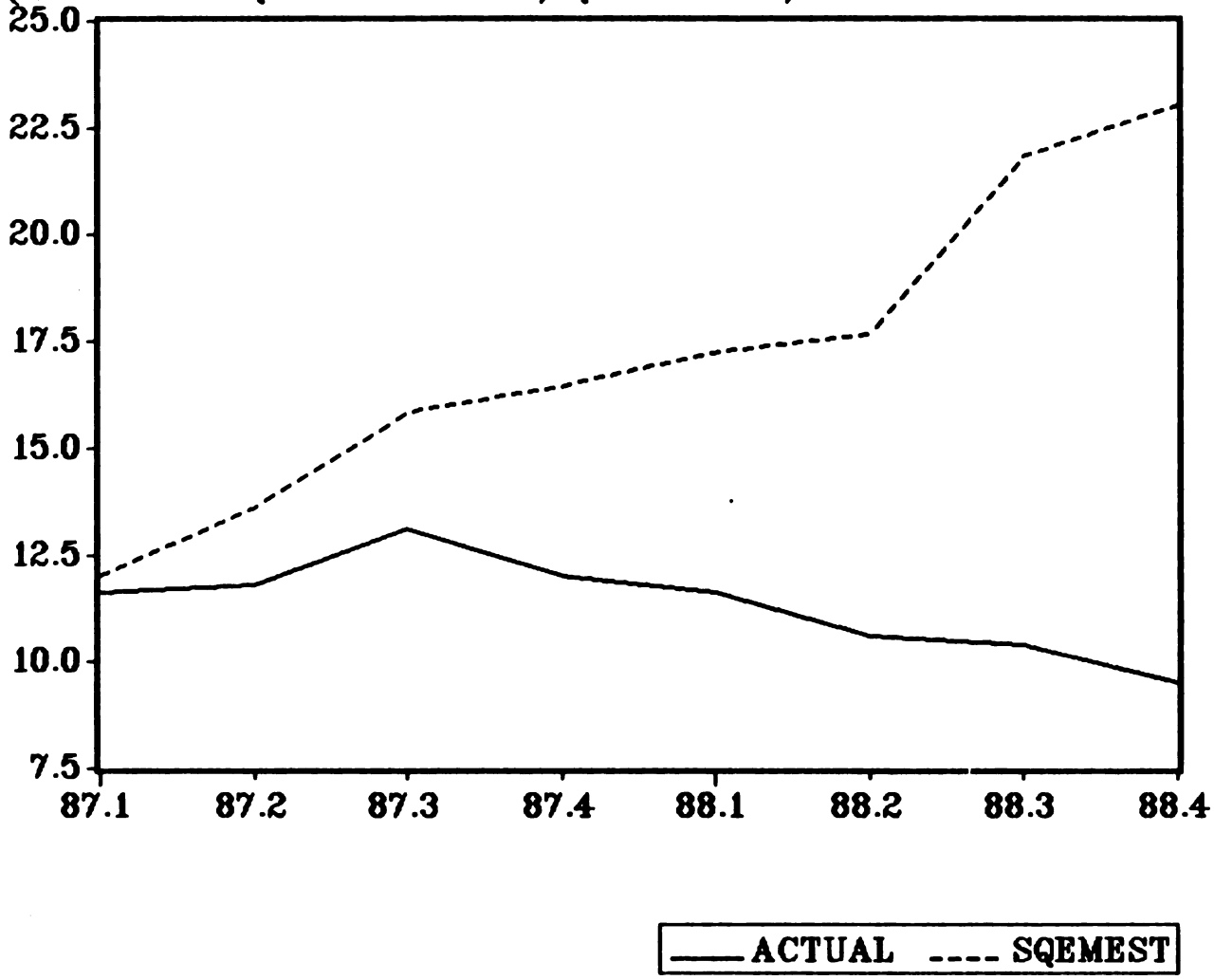


FIGURE 5.17: OIL & GAS SEVERANCE TAX

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



12 months and an AR term at a lag of a single month along with 11 seasonal dummies. The results of three post-sample dynamic simulations are shown in Figures 5.18 thru 5.20 and in Table 5.14. These simulations again tend to support the MURF model.

Table 5.13: Oil & Gas Severance Tax (Relative Performance of MURF & SQEM Forecasts, 1987-1988)

	MURF ACTUAL	MURF EST	MURF ERROR	SQEM ACTUAL	SQEM EST	SQEM ERROR
1987						
I	11.6	11.9	0.3	11.6	12.0	0.4
II	11.8	12.1	0.3	11.8	13.6	1.8
III	12.9	13.1	0.2	13.1	15.8	2.7
IV	12.5	12.6	0.0	12.0	16.4	4.4
1988						
I	11.1	11.4	0.3	11.6	17.2	5.6
II	10.7	11.3	0.6	10.6	17.7	7.1
III	10.3	10.9	0.6	10.4	21.8	11.4
IV	9.2	10.1	1.0	9.5	23.0	13.5
			0.5			7.3

FIGURE 5.18: OIL & GAS SEVERANCE TAX

(ACTUAL & MURF FORECASTS, MONTHLY, MILLIONS OF DOLLARS)

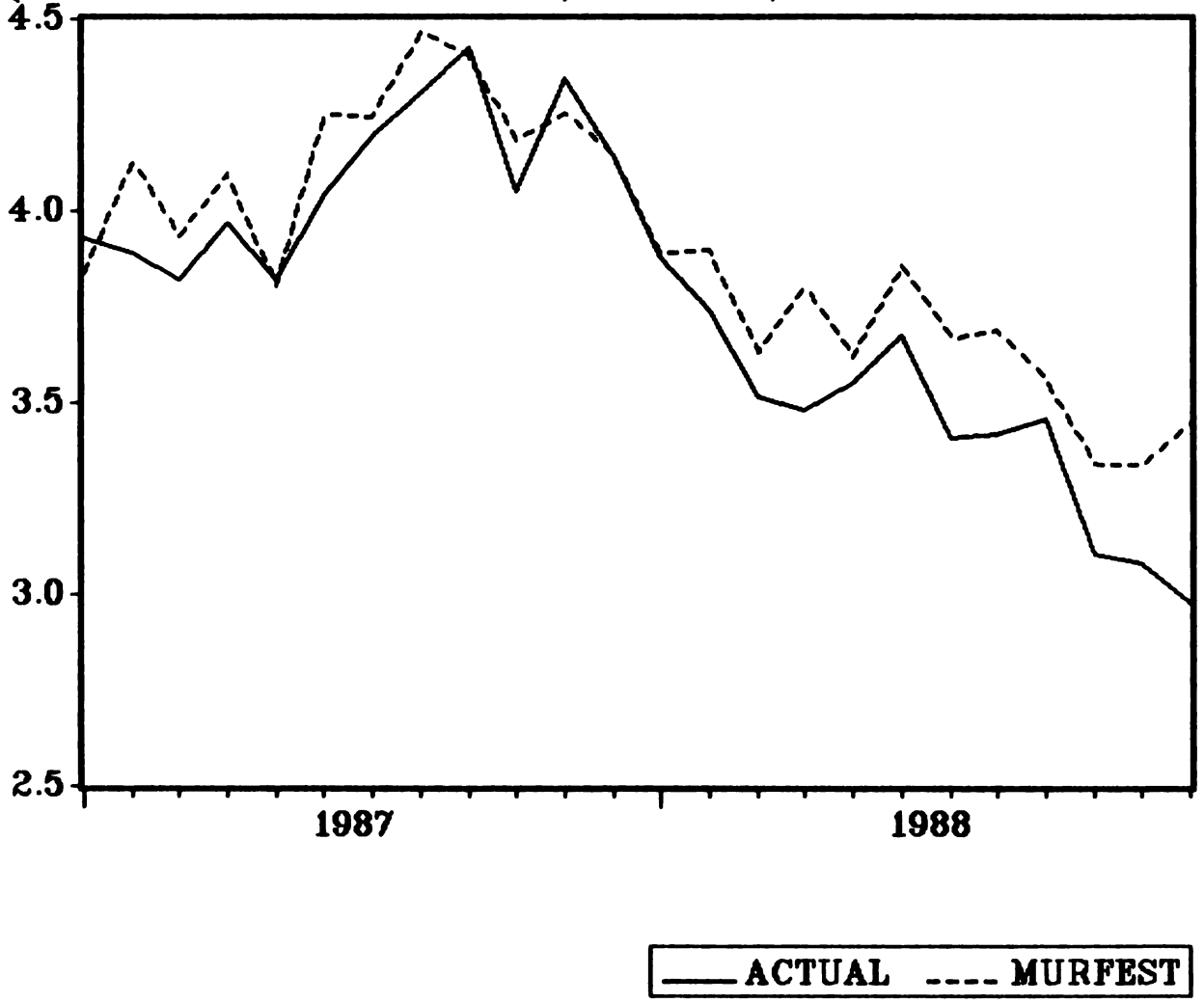
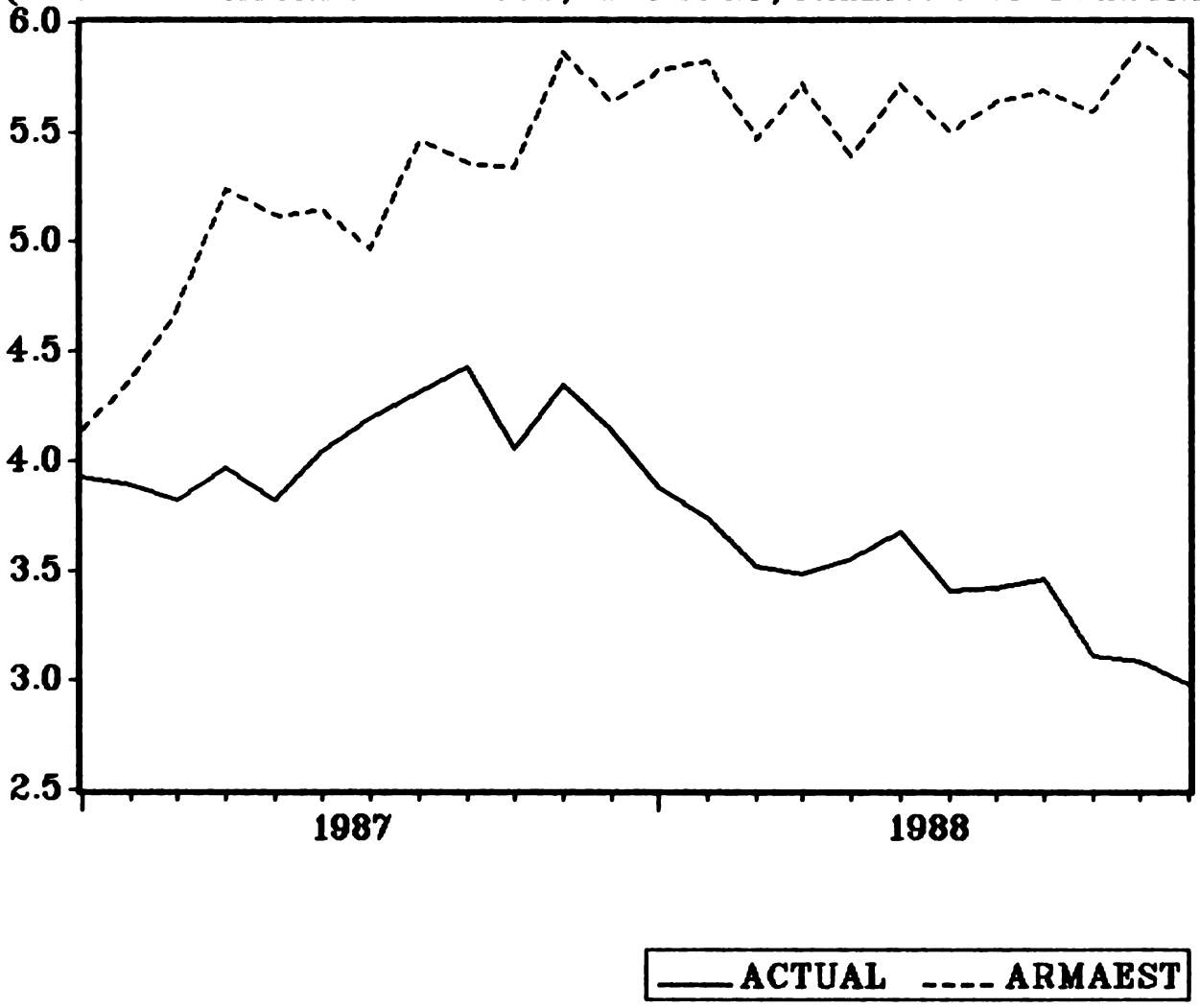


FIGURE 5.19: OIL & GAS SEVERANCE TAX

(ACTUAL & ARMA FORECASTS, MONTHLY, MILLIONS OF DOLLARS)



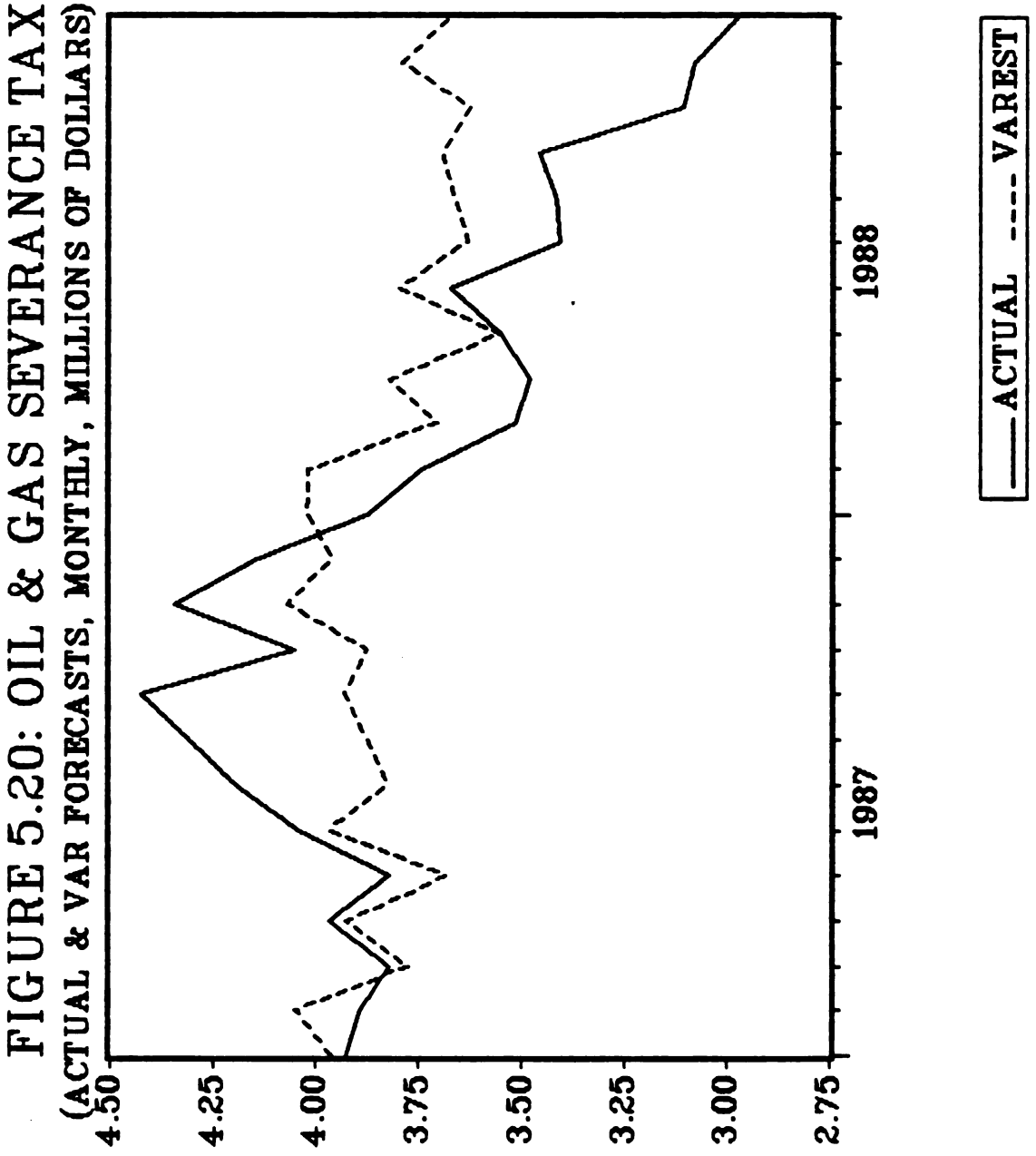


FIGURE 5.20: OIL & GAS SEVERANCE TAX
(ACTUAL & VAR FORECASTS, MONTHLY, MILLIONS OF DOLLARS)
4.50
4.25
4.00
3.75
3.50
3.25
3.00
2.75
1987
1988
ACTUAL
VAREST

Table 5.14: Oil & Gas Severance Tax (Relative Performance of MURF, ARMA & VAR Forecasts, 1987-1988)

	ACTUAL	MURF EST	ERROR	ARMA EST	ERROR	VAR EST	ERROR
1987							
JAN.	3.9	3.8	-0.1	4.1	0.2	4.0	0.0
FEB.	3.9	4.1	0.2	4.4	0.5	4.1	0.2
MAR.	3.8	3.9	0.1	4.7	0.9	3.8	-0.0
APR.	4.0	4.1	0.1	5.2	1.3	3.9	-0.0
MAY	3.8	3.8	-0.0	5.1	1.3	3.7	-0.1
JUN.	4.0	4.3	0.2	5.1	1.1	4.0	-0.1
JUL.	4.2	4.2	0.0	5.0	0.8	3.8	-0.4
AUG.	4.3	4.5	0.2	5.5	1.2	3.9	-0.4
SEP.	4.4	4.4	-0.0	5.4	0.9	3.9	-0.5
OCT.	4.0	4.2	0.1	5.3	1.3	3.9	-0.2
NOV.	4.3	4.3	-0.1	5.9	1.5	4.1	-0.3
DEC.	4.1	4.1	0.0	5.6	1.5	4.0	-0.2
1988							
JAN.	3.9	3.9	0.0	5.8	1.9	4.0	0.1
FEB.	3.7	3.9	0.2	5.8	2.1	4.0	0.3
MAR.	3.5	3.6	0.1	5.5	1.9	3.7	0.2
APR.	3.5	3.8	0.3	5.7	2.2	3.8	0.3
MAY	3.5	3.6	0.1	5.4	1.8	3.5	-0.0
JUN.	3.7	3.9	0.2	5.7	2.0	3.8	0.1
JUL.	3.4	3.7	0.3	5.5	2.1	3.6	0.2
AUG.	3.4	3.7	0.3	5.6	2.2	3.7	0.2
SEP.	3.5	3.6	0.1	5.7	2.2	3.7	0.2
OCT.	3.1	3.3	0.2	5.6	2.5	3.6	0.5
NOV.	3.1	3.3	0.3	5.9	2.8	3.8	0.7
DEC.	3.0	3.4	0.5	5.7	2.8	3.7	0.7
RMSE			0.2		1.8		0.3

CHAPTER VI

WEALTH TAXES

6.1 Introduction

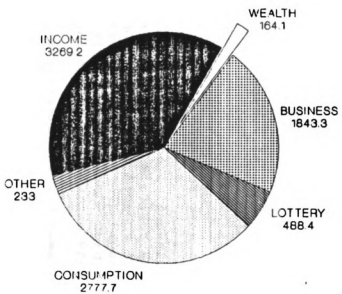
The category of taxes which I have loosely described as wealth taxes, is quite small at the state level.[1] Only two major taxes fall into this category, the intangibles tax which raised a net[2] $70.3 million for the general fund in fiscal 1988 and the inheritance tax, whose proceeds amounted to $93.8 million in that year. These two taxes combined account for less than 2% of GFGP/SAF revenue.

Chapter 6 is divided into three sections including this introduction. Section 6.2 looks at the inheritance tax and section 6.3 considers the intangibles tax. Each section consists of a short history of the tax, the MURF model of the tax and a review of the performance of the MURF model, both in absolute terms and relative to the SQEM model.

1. This does not imply that "wealth" is insufficiently taxed in Michigan as it ignores local property taxes, which are high by national standards.

2. $9.5 million of intangibles tax revenues are paid to local units of government and so are not available to the general fund.

FIGURE 6.1: GFGP/SAF WEALTH TAXES
FISCAL 1988, MILLIONS OF DOLLARS



Inheritance Tax	**93.8**
Intangibles Tax	**79.8**
Less: Revenue Sharing	**9.5**
Net Wealth Taxes to GFGP	**164.1**

SOURCE: MONTHLY FINANCIAL REPORT, JANUARY 1989

6.2 Inheritance Tax

A Short History of the Inheritance Tax[3]

The Michigan inheritance tax was enacted in 1899. Originally, a flat rate of 5% was applied with a more generous exemption for direct heirs. In 1919, a progressive tax rate system was adopted and in 1929, a "pickup tax" was added to take advantage of the new federal credit for state death taxes.[4]

In 1978, the exemption for spouses was increased from $30,000 to $65,000, and the exemption for other close relatives was doubled to $10,000. The tax rate was increased by 2% for all inheritances except the first $250,000 inherited from a close relative. Inheritances of farmland enrolled in the Farmland Preservation Act were granted a 50% exemption and payment on the balance could be deferred for up to 10 years. In 1980, a similar deferment

3. This history has been compiled from the following sources:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.
(iii) "Michigan's Inheritance tax and Senate Bill 1", Senate Fiscal Agency Memorandum, November 1988.

4. The interaction of state and federal estate taxes leaves open the possibility that the state could increase its revenue from an estate without increasing the total tax burden on the estate, as additional state taxes could be used as credits at the federal level. The "pickup tax" is used to ensure that the state exploits any revenue that can be raised in this manner.

was granted to inheritors of the property of professional artists.

In 1982, an unlimited exemption was granted to spouses except for the transfer of trusts which do not qualify for an unlimited federal exemption. Since 1978 the inheritance tax has been levied according to the schedule outlined below:

Table 6.1: Inheritance Tax, Value of Inheritance & Tax Rates for Close Relatives and Others

VALUE OF INHERITANCE (dollars)	TAX RATE Close Relative[4]	Others
0 - 10,000	0%	12%
10,000 - 50,000	2%	12%
50,000 - 250,000	4%	14%
250,000 - 500,000	7%	14%
500,000 - 750,000	8%	17%
750,000 +	10%	17%

The MURF Model of Inheritance Tax Revenues

By far the largest problem in forecasting the Michigan inheritance tax is that revenues are very dependent on the average wealth of decedents and the speed with which their estates are settled. Moreover, the highly progressive nature of the tax structure, as outlined in Table 6.1, makes revenues highly dependent on receipts from a few large estates. Consequently, there is a good deal of truly random noise in the data which lowers the overall explanatory power

5. Close relative is defined as including spouse, parents, children, children-in-law, grandparents, and siblings.

of any model. Moreover, the higher is the frequency of the data set the more dominant is the noise component of the data. Because of this fact, the MURF model of inheritance tax revenue employs quarterly rather than monthly data.

The dependent variable, LNINHRTQ, is the natural log of quarterly inheritance tax revenues. A natural log form was choosen both to avoid a problem of heteroskedasticity and also to prevent the equation from paying too much attention to outliers.

Various income and wealth variables were tried as explanatory variables. All of these variables, however, failed to predict a large upswing in revenues in the last three years. It is probably more than a coincidence that exactly the same problem has occured in quarterly payments on income tax and intangibles tax, both of which are collected disproportionately from the very rich in Michigan.

It is quite possible that the income data on dividends, interest and proprietors income will be revised upwards in the future for the period 1986 to 1988. However, in the absence of such a revision, a variable called LNAVQTAX is used as the main explanatory variable in the MURF inheritance tax model. LNAVQTAX is the natural log of the sum of estimated payments on income tax over the last four quarters, adjusted to a constant rate of 4.6 percent.

The number of deaths in Michigan is not used as an explanatory variable. Even if quarterly death data were available, it is unlikely that much of the non-seasonal

variation in revenues can be explained by non-seasonal variation in the overall death rate. The former shows large percentage changes from quarter-to-quarter whereas the latter is probably a very smooth series, given the large overall number of deaths.

In addition, it is unlikely that changes in the overall death rate are responsible for much of the year-to-year variation in revenues, since, even on an annual basis, the number of deaths is a much smoother series than revenues.

Two quarters are treated as outliers. Revenues in these months were especially large, presumably because of the processing of particularily large estates. They are the third quarter of 1977 and the second quarter of 1979. Seasonal dummies were not employed as they were found to be insignificant.

In addition, a dummy variable is introduced to deal with the change in the tax base brought about by the granting of an unlimited spousal exemption at the end of 1982. This variable, BAFT833 takes a value of zero prior to 1983.4 and a value of one from then on.

Thus the final MURF inheritance tax equation is:

$$(6.1) \quad LNINHRTQ = a_1 + a_2*B773 + a_3*B792 + a_4*LNAVQTAX + a_5*BAFT833 + a_6*MA(1)$$

Performance Review

The results of regressing equation (6.1) over the period 1977.1 to 1988.4 are shown in Table 6.2. The R^2 of

.878 is quite respectable given the amount of noise in the data set. Moreover, a partial R^2, given outlier dummies and the MA term is .804.

Table 6.2: Statistical Output from the MURF Inheritance Tax Equation

LS // Dependent Variable is LNINHRTQ
SMPL range: 1976.1 - 1988.4
Number of observations: 52
Convergence achieved after 4 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.2916177	0.7627175	0.3823403	0.704
B773	0.6077739	0.1121536	5.4191216	0.000
B792	0.4365742	0.1142282	3.8219471	0.000
LNAVQTAX	0.6863189	0.0650083	10.557402	0.000
BAFT833	-0.0701050	0.0574313	-1.2206759	0.228
MA(1)	-0.2870271	0.1619631	-1.7721760	0.083

R-squared	0.878274	Mean of dependent var	8.546879
Adjusted R-squared	0.865043	S.D. of dependent var	0.294935
S.E. of regression	0.108349	Sum of squared resid	0.540016
Durbin-Watson stat	1.929349	F-statistic	66.37956
Log likelihood	44.96758		

A likelihood ratio test for structural stability was conducted by splitting the data set at the third quarter of 1983. The calculated Chi-square of 6.64 was too small to reject the null hypothesis of structural stability at the five percent level, given four degrees of freedom.

The Box-Pierce test for white noise residuals was also employed. Given 7 degrees of freedom, this yielded a Chi-square of 1.86, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

The SQEM model of inheritance tax is given by equation

(6.2) below:

$$(6.2) \quad \ln TINHMNS = a_1 + a_2 * \ln\left(\sum_{i=1}^{12} YDM67_{-i}/12\right) + a_3 * \left(\sum_{i=3}^{6} RAAA_{-i}/4\right) + a_4 * DSEAS1 + a_5 * DSEAS2 + a_6 * DSEAS3 + a_7 * DEATHDUM$$

TINHMNS represents quarterly revenues from the inheritance tax. YDM67 is real disposable income and RAAA is a triple-A rated corporate bond rate. DSEAS1 etc., are seasonal dummies. DEATHDUM is used to explain the effect of unusually large estate settlements. It takes a value of .95 in 1977 III, .5 in 1979 II, .37 in 1980 I, .5 in 1980 III and zero elsewhere. This is not strictly speaking a dummy variable as the relative magnitudes of its different values are based on known amounts of estates settled.

The R^2 on this equation, fitted from 68 I to 83 IV, is .724 which is not surprising, given the extreme difficulty in estimating an equation which is so heavily dependent on random events, namely the death of very wealthy individuals. It is, however, hard to explain why the income term is expressed in real rather than nominal terms since the dependent variable is the log of a nominal magnitude. It is also not clear why disposable income is used as that income variable.

As a second test of the relative performance, the results of a MURF forecast simulation were compared with those produced by an ARMA model fitted over the same time-

frame with MA terms at a lags of one, two, three, and four quarters.[6]

The results of dynamic forecasts of inheritance tax revenues over the period 1987 I to 1988 IV are shown in Figures 6.2, 6.3, and 6.4 and are displayed in Table 6.3. These results are quite encouraging for the MURF model which only seriously underestimates revenues in the second half of 1988. In contrast, the SQEM model underestimates revenues by an average of more than $10 million per quarter and the ARMA model performs only marginally better than the SQEM equation.

Table 6.3: Inheritance Tax, (Relative Performance of MURF, SQEM & ARMA Forecasts, 1987-1988)

		MURF		SQEM		ARMA	
	ACTUAL	EST	ERROR	EST	ERROR	EST	ERROR
1987							
I	20.9	21.8	0.9	12.2	-8.7	18.1	-2.8
II	21.5	22.0	0.5	13.8	-7.7	15.7	-5.8
III	19.2	22.0	2.8	10.3	-8.9	15.3	-3.9
IV	25.0	22.1	-2.9	10.1	-14.9	14.6	-10.4
1988							
I	21.4	22.4	1.0	11.0	-10.4	13.8	-7.6
II	21.2	23.7	2.5	13.4	-7.8	13.8	-7.4
III	26.0	24.2	-1.8	10.8	-15.2	13.8	-12.2
IV	28.1	24.1	-4.0	11.3	-16.8	13.8	-14.3
RMSE			2.3		11.8		8.9

6. It should be noted that $807,000 has been subtracted from both MURF and ARMA forecasts for each quarter. This represents average quarterly refunds on inheritance tax in 1987 and 1988 and is subtracted from the MURF and ARMA forecasts of gross inheritance tax receipts to make them comparable with the output of the SQEM equation for net inheritance tax revenues.

FIGURE 6.2: INHERITANCE TAX

(ACTUAL & MURF FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)

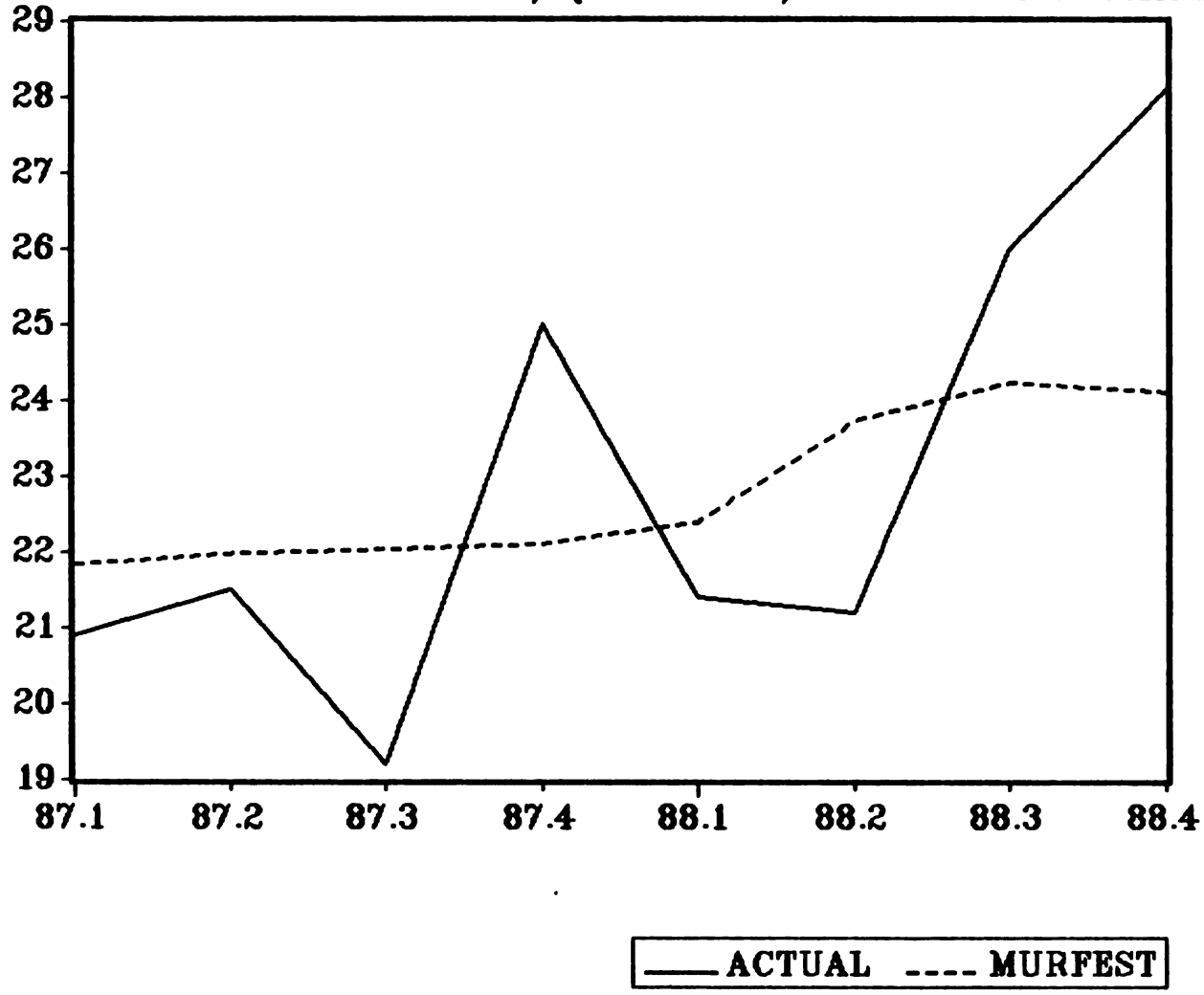
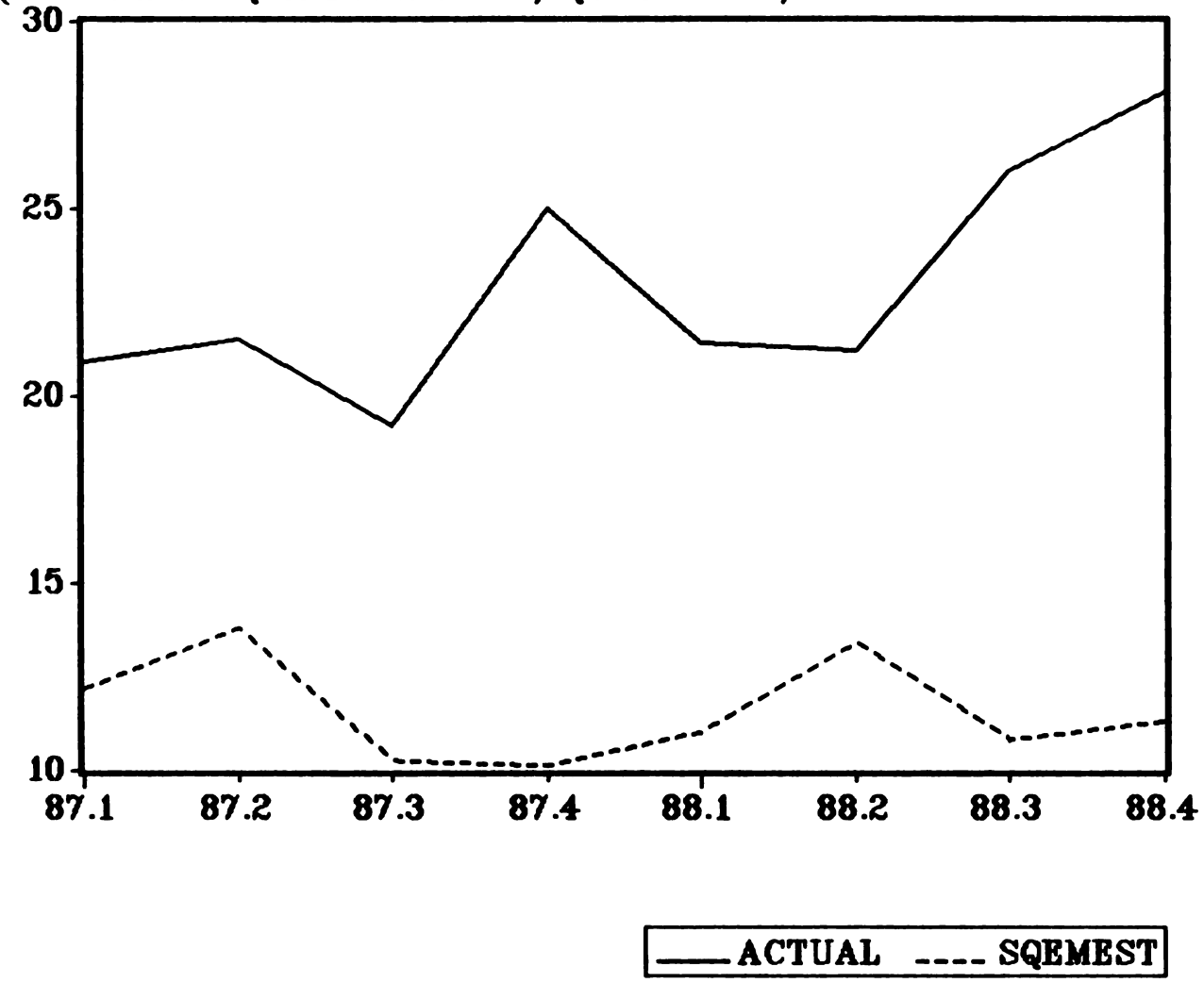


FIGURE 6.3: INHERITANCE TAX

(ACTUAL & SQEM FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)



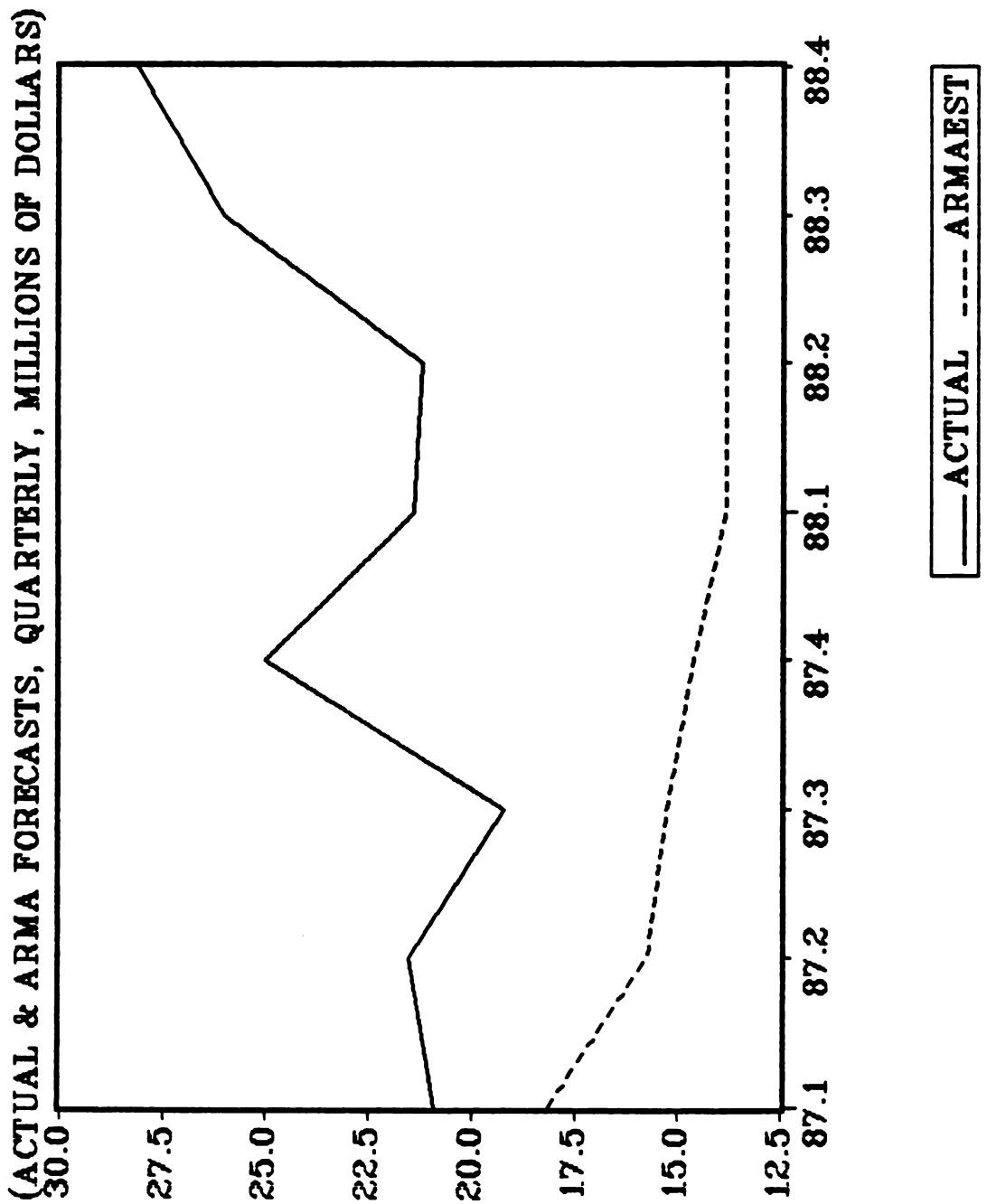


FIGURE 6.4: INHERITANCE TAX
(ACTUAL & ARMA FORECASTS, QUARTERLY, MILLIONS OF DOLLARS)
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
87.1
87.2
87.3
87.4
88.1
88.2
88.3
88.4
ACTUAL
ARMAEST

6.3 Intangibles Tax

A Short History of the Intangibles Tax[7]

Prior to 1939, intangible personal property, such as stocks, bonds, notes, and money, were subject to local property taxes. In practice, however, the enforcement of this tax was very difficult. This led to the introduction of the intangibles tax in that year.

When it was introduced, the intangibles tax was levied at a rate of 6% on earnings from intangibles. In 1941, pensions, royalties, insurance policies and the first $3,000 in savings and loan deposits were exempted. In 1945, this latter exemption was repealed and banks were required to pay the tax for their depositors. In the same year, the tax rate was reduced to 3% and mortgages on land held by religious and charitable institutions were exempted.

In 1952, the tax rate was increased to 3.5% and a special excise tax of 4 mills was imposed on banks and trust companies. This excise tax was raised to 5.5 mills in the following year. In 1959, the tax rate on bank and S&L deposits and cash was raised from 40 cents to 50 cents per $1,000.

In 1967, the tax credit was increased from $20 to $100

7. Information for this history was garnered from:
(i) "Michigan's Fiscal Structure: Background and Current Issues", Committee on Taxation, Michigan House of Representatives and Committee on Finance and Municipalities, Michigan State Senate, State Capitol, Lansing, May 1983.
(ii) "Michigan's Fiscal and Economic Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.

for an individual and from $40 to $200 for a joint return. The tax on the stock of bank and trust companies was repealed. In 1973, the tax credit was increased to $175 for an individual and $350 for a joint return. The tax rate on bank and S&L deposits and cash was returned to 40 cents per $1,000.

In 1975, as part of the single business tax package, property subject to the SBT was exempted. The tax on bank and S&L deposits and cash was halved to 20 cents per $1,000. At the same time the bank or S&L was specified as being the taxpayer.

The Michigan intangibles tax is currently levied at a rate of 3.5% on income generated from intangible property, or 0.1% of the face value of the asset, whichever is the greater. Cash on hand and deposits in S&Ls and banks, (though not credit unions), is taxed at a rate of 0.2%. The statutary deduction is $175 for individuals, effectively exempting at least the first $5,000 in taxable, intangible property income.

Exempt intangible property includes federal, state and local government securities, old age and retirement pensions, the cash surrender value of life insurance policies and stock in banks, trust companies and national banking associations.

The MURF model of the Intangibles Tax

For taxpayers whose fiscal year corresponds to the calendar year, the payment date for the intangibles tax is on the last day in April. Moreover, for the intangibles tax, almost all taxpayers are on a calendar year. Thus most revenues from the intangible tax come in in April and May. A significant amount of money is also received at the end of the year. This is due to the intangibles tax section of the treasury department, cross checking intangibles tax receipts with federal income tax returns and billing those who should have filed intangibles tax returns but didn't.

The point of this digression is that although intangibles tax receipts are received throughout the calendar year, the distribution of receipts, as in the case of annual payments on income tax, is due primarily to non-economic factors. The economic factors that determine the actual level of the year's receipts are economic variables from the previous calendar year.

Given this, it is clearly inappropriate to specify a monthly or quarterly model of intangibles tax revenues. Consequently, the MURF model of intangibles tax receipts is an annual model.

This, however, presents further problems. The nature of the intangibles tax changed radically in 1976 due to changes in the treatment of business intangibles. Thus the usable data set for a forecasting model really only starts in 1977. By the end of 1988, this gives us only 12

observations. This limits the number of independent variables that can be used.

The dependent variable in the MURF model, INTANGTX, gives total fiscal year receipts from the intangibles tax. The main independent variable is YPRM, which represents total rental, personal interest and dividend income in the state in each calendar year. This variable is lagged by one year since 1988 tax receipts are based on 1987 income.

One of the main criticisms of the intangibles tax is that it represents double taxation, since individuals paying tax on intangible property have already paid income tax on this property. The focus of this dissertation is not on the fairness of the Michigan tax system. However, the above criticism suggests an opportunity to the forecaster. Estimated payments on income tax for 1987 are due on April 15th, 1987, June 15th, 1987, September 15th, 1987 and January 15th, 1988. The intangibles tax payment for the same period is not due until the last day of April 1988. If the double taxation criticism of the intangibles tax is correct then information about 1988's intangibles tax receipts is contained in the estimated payments on income tax received in 1987.

Consequently, ADJQURTX, lagged by one year is employed as a regressor in the intangibles tax model. ADJQURTX represents, April through March, estimated payments on income tax, adjusted to a constant 4.6% rate. This variable is forecast elsewhere in the MURF model of state taxes and

then feeds back recursively into the intangibles tax equation.

Thus the MURF intangibles tax model is given by equation (6.3) below:

(6.3) $INTANGTX = a_1 + a_2*YPRM(-1) + a_3*ADJQURTX(-1)$

Performance Review

The results of regressing the MURF intangibles tax model are shown on the next page. The t-statistics, R^2 and Durbin-Watson statistics are all satisfactory although caution is naturally called for in interpreting the results of a regression over only 12 observations.

The Box-Pierce test for white noise residuals was used. Given 2 degrees of freedom this yields a Chi-square of 0.2, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

Table 6.4: Statistical Output from the MURF Intangibles Tax Equation

LS // Dependent Variable is INTANGTX
SMPL range: 1977 - 1988
Number of observations: 12

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	7.5326122	1.7407607	4.3271958	0.002
YPRM(-1)	0.0016826	0.0002998	5.6129556	0.000
ADJQURTX(-1)	0.1102204	0.0189348	5.8210460	0.000

R-squared	0.990610	Mean of dependent var	52.20000
Adjusted R-squared	0.988523	S.D. of dependent var	17.42156
S.E. of regression	1.866374	Sum of squared resid	31.35017
Durbin-Watson stat	1.814962	F-statistic	474.7252
Log likelihood	-22.78914		

The SQEM model of the intangibles tax is given by the equation:

(6.4) $\ln TINTMNS = a_1 + a_2 * \ln(YPRM*(YPDIV+YPINT)/(YPDIV+YPINT+YPRENT))$

The dependent variable in this equation is lnTINTMNS, the natural log of intangibles tax receipts. YPRM represents total rental, personal interest and dividend income in the state in the preceeding calendar year. YPDIV, YPINT and YPRENT are the previous calendar year's U.S totals for dividends, personal interest and rental income respectively. This variable is used as an estimate of the fraction of dividend, proprietor's and interest income, that is included in the intangibles tax base.

There are three possible avenues for criticism of this equation. First, the equation is regressed using only seven observations between 1977 and 1983. This is understandable given the lack of good data prior to 1977, although it would seem that the equation should be reestimated as soon as possible to increase the number of observations.

Second, the use of the term (YPDIV+YPINT)/(YPDIV+YPINT +YPRENT) is somewhat questionable. The use of this term requires the implicit assumption that the U.S ratio is approximately the same as the Michigan ratio. Also relative to YPDIV and YPINT, YPRENT is very small. In the period 1977 to 1987, this ratio never took a value lower than .959 or a value higher than .984. Finally, although YPRENT is

small relative to other income variables it is highly volatile as it is derived in the national income accounts as the difference between rental income and depreciation of rental property. This suggests that this variable may be very difficult to forecast accurately.

Third, some potentially valuable information from estimated payments on income tax is ignored.

The MURF model of intangibles tax receipts was estimated over the period 1977 to 1986 and used to forecast the period 1987-1988. This forecast is compared with a simulation of the RSQE model of the same period. In addition an ARMA model with an AR term at a lag of one year and MA terms at lags of one and two years was used to forecast the 1987-1988 period. The results of these forecasts are shown in Table 6.5 below:

Table 6.5: Intangibles Tax, (Relative Performance of MURF, SQEM & ARMA Forecasts, 1987-1988)

		MURF		SQEM		ARMA	
	ACTUAL	EST	ERROR	EST	ERROR	EST	ERROR
1987	76.8	79.5	2.7	63.4	-13.4	72.2	-4.6
1988	82.6	82.1	-0.5	65.7	-16.9	73.8	-8.8
RMSE			1.9		15.3		7.0

The superior performance of the MURF model should probably be ascribed to the use of the ADJQURTX variable.

CHAPTER VII

THE STATE LOTTERY

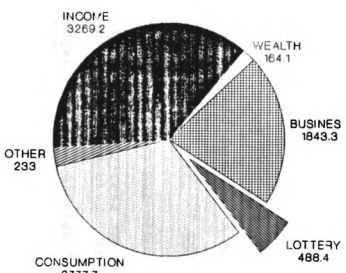
7.1 Introduction

The Michigan State Lottery has been the fastest growing source of funds for the GFGP/SAF budget in the last decade. It is now the fourth largest revenue source, exceeded only by the income tax, the sales tax and the single business tax. There are currently three types of games run by the bureau of state lottery, the "Daily" 3-digit and 4-digit games, the "Super-Lotto" game and Instant games.

Chapter 7 is divided into six sections, including this introduction. The history of the state lottery is reviewed the next section. A forecasting model for Lotto ticket sales is outlined in section 7.3. Section 7.4 looks at the Daily game and section 7.5 examines Instant game sales. Finally, the performance of these models is reviewed in section 7.6 relative to ARMA, VAR and SUR equations.[1]

1. There are, so far as I know, no other econometric models of the Michigan state lottery. In fact, there may not be a formal econometric model of lottery sales in operation in any of the states. In 1987, as part of the Citizens' Task Force Analysis of the Michigan State Lottery, a survey was conducted among ten other states with comparable lotteries. Not one of these states was utilizing an econometric model to forecast sales.

FIGURE 7.1: LOTTERY REVENUE SOURCES & USES
FISCAL 1988, MILLIONS OF DOLLARS



Daily Game Sales	**532.6**
Lotto Sales	**538.6**
Instant Game Sales	**130.5**
Total Ticket Sales	**1,201.7**
Undistributed Prizes	**14.8**
Less: Prizes	**585.2**
Net Expenses	**142.9**
Net to School Aid Fund	**488.4**

SOURCE: MONTHLY FINANCIAL REPORT, JANUARY 1989

7.2 A Short History of the Michigan State Lottery[2]

On May 16, 1972 Michigan voters approved a constitutional amendment authorizing a state lottery. The lottery formally began its operations on August 1st, 1972 with net revenues going to the general fund.

During its first two years of operation, the only game offered by the state lottery was a weekly lottery game in which pre-numbered tickets were sold with a weekly drawing to determine winners. In October of 1975, the Instant game was introduced and in its first year, yielded three times as much revenue as the weekly game. In July 1977 the three-digit Daily game was introduced to compete with the illegal numbers game. This game had 300 terminals and was the first "on-line"[3] game. In October of 1980 the four-digit Daily game was introduced.

In May of 1981, revenues from the lottery were earmarked for the school aid fund.[4] In August of 1984, the 6/40 Lotto game was introduced and one year later it was

2. Information for this history was compiled from the following sources:
(i) "Michigan's Economic and Fiscal Structure", Harvey E. Brazer, ed., The University of Michigan Press, Ann Arbor, Michigan, 1982.
(ii) "Executive Budget, State of Michigan", various editions, 1970 - 1988.
(iii) "Budget Message of the Governor", various editions, 1970 - 1988.
(iv) "The Michigan Lottery: Computer Terminals and On-Line Game Sales" by Robert Black and Neal Johnson, Senate Fiscal Agency Issue Papers, September 1987"

3. The phrase "on-line" refers to the use of terminals which are hooked up to a central system which records the tickets bought.

expanded to two drawings per week, on Wednesday and Saturday. In April 1986, the Super-Lotto (6/44) began with a drawing on Saturdays. The Lotto then returned to one drawing a week on Wednesdays. In May of 1987, the Super-Lotto replaced the Lotto entirely and was extended to two drawings per week.

In January of 1989, lottery winnings were made subject to the state income tax for the first time. Two other innovations were introduced early in 1989. First, a television show, "Fame & Fortune" was introduced in January to boost sales of instant game tickets. Second, the "Zinger" was added to lotto tickets in March. This addition prints an extra six digit number on each ticket, which individuals can bet on for the payment of an extra dollar.

7.3 Lotto Sales

The Super-Lotto became the largest single source of ticket sales for the state lottery in fiscal 1988. It is also the most variable of the three sources and so requires special attention. The population which plays Lotto may change from week to week, depending on the size of the

4. In fact, the earmarking of lottery revenues or other revenues to the school aid fund probably has no real impact on either the general fund or the school aid fund since the SAF receives an inter-fund transfer of about $500 million each year from the general fund. If a new source of revenue is earmarked to the SAF, then in real terms, the general fund transfer can be reduced to leave both funds in the same position as before. However, given the political controversy surrounding the alleged regressivity of the lottery, it is politically useful to earmark the proceeds to a popular area of state spending.

jackpot. If the jackpot is especially large then individuals, who normally don't play the Lotto may buy tickets.

One of the serious problems in forcasting lottery revenues is in deciding whether large revenues in a particular period are the result of general economic trends or an unusually large number of high jackpots in a particular period. There is also a need for a procedure for predicting the likelihood of the Lotto jackpot rolling over in any given draw. One extra problem with this game is that its revenues are highly dependent upon public interest which will tend to decline over time as individuals regard large jackpots as more normal.

Forecasting Lotto revenues is hindered by the above uncertainties, but is aided by a relatively good data set. The models of revenues from lottery ticket sales are based on more than four years of weekly data, which, for the most part, seems to be free of measurement error.

Constructing a Distribution of Lotto Jackpots

In order to forecast sales of Lotto tickets, it is vital to make an unbiased forecast of the distribution of Lotto jackpots. This involves a number of steps whose results are displayed in Table 7.2. First, per-draw Lotto ticket sales,[5] SALES, are regressed on a 13-week linear interpolation of nominal disposable income, AVYDM, the level of the jackpot, JAKPOT, the jackpot-squared, J2, and the

jackpot-cubed, J3. This is shown in equation (7.1) below and the results of the regression are outlined over the next five pages.

(7.1) $SALES = a_1 + a_2*JAKPOT + a_3*J2 + a_4*J3 + a_5*AVYDM$

For this regression, data are used from the 185 drawings between 5/9/87 and 2/11/89.[6] As can be seen in Table 7.1, all the independent variables appear to be significant. The R-squared is seems reasonable at .956 but the Durbin-Watson statistic suggests the possibility of autocorrelation.[7] The income elasticity of lotto ticket sales was calculated at the mean of both variables and found to be .832.

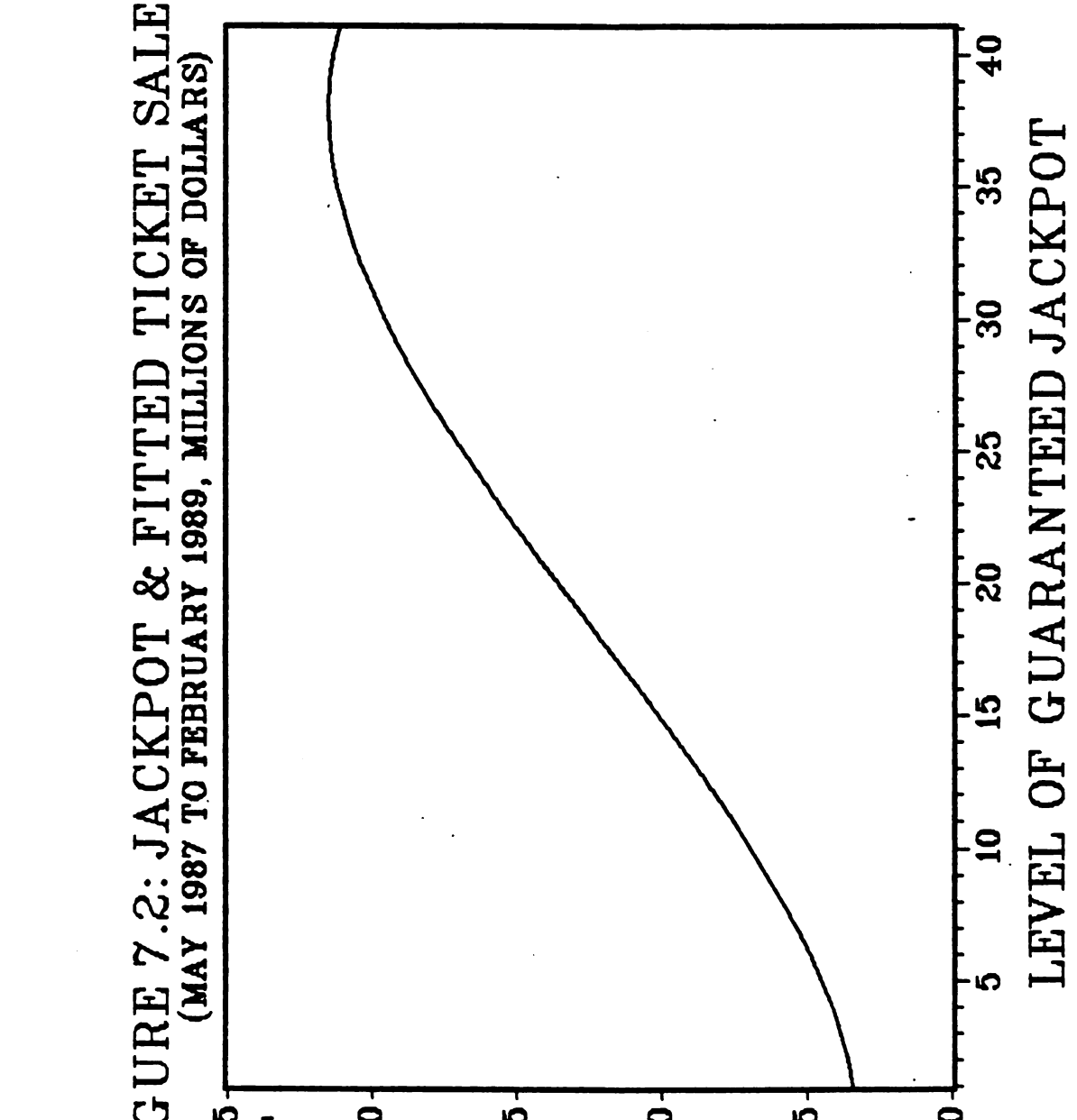
The fitted value of the polynominal generated by the coefficients on JAKPOT, J2 and J3 are shown in Figure 7.2. Some simple calculus reveals that as the absolute level of

5. Over the entire period of the regressions used in this chapter, the price of all lotto tickets was constant at one dollar per ticket. Thus the number of tickets sold and the number of dollars spent on these tickets can be used interchangably in this analysis. I believe that nominal disposable income should be used in preference to real disposable income as an explanatory variable.

6. Drawings before 5/9/87 were not used due to the fact that before this date the Super-Lotto game involved only one drawing per week, with the other weekly draw being for the 6/40 game.

7. A Cochrane-Orcutt correction was not employed, however, as the purpose of this exercise was to determine the relationship between jackpots and sales <u>independently of lagged values of either</u>.

FIGURE 7.2: JACKPOT & FITTED TICKET SALES
(MAY 1987 TO FEBRUARY 1989, MILLIONS OF DOLLARS)



the jackpot rises, ticket sales accelerate, until a jackpot of $18.3 million is reached. At this point an extra $1 in the level of the guaranteed jackpot should secure an extra 60 cents in sales. After this point, the impact of increasing the jackpot declines and given the cubic nature of the relationship as fitted, this curve suggests that sales would actually decline as the level of the jackpot rises after a jackpot of $36.6 million, which of course is not realistic. However, since the highest jackpot recorded so far for the Lotto game is $33 million, I do not regard this as a serious problem in the analysis.

Table 7.1: Statistical Output from the MURF
Per-Draw Lotto Game Sales Equation

LS // Dependent Variable is SALES
SMPL range: 1 - 185
Number of observations: 185

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.0793194	0.8301375	0.0955497	0.924
JAKPOT	0.0948319	0.0454322	2.0873296	0.037
J2	0.0329563	0.0043579	7.5624066	0.000
J3	-0.0006010	0.0001017	-5.9077739	0.000
AVYDM	9.646E-05	2.508E-05	3.8455169	0.000

R-squared	0.955835	Mean of dependent var	4.784337
Adjusted R-squared	0.954854	S.D. of dependent var	2.504544
S.E. of regression	0.532155	Sum of squared resid	50.97397
Durbin-Watson stat	1.113037	F-statistic	973.9177
Log likelihood	-143.2674		

The second step in this procedure involves forecasting the level of sales that would be associated with each level of the jackpot in the remaining 66 draws in fiscal 1989 and the 104 draws of fiscal 1990. For this purpose AVYDM is set

at its average forecast value[8] for the remaining three quarters of fiscal 1989 and at the average of the four quarters of fiscal 1990 for fiscal 1990.[9]

Table 7.2: Calculations for Future Jackpot Distributions

FISCAL 1989

GUARANTEED JACKPOT	EXPECTED SALES	PROB. OF ROLLOVER	PROB. OF ROLLOVER ENDING	JACKPOT LEVEL FREQUENCY	OUT OF 66 DRAWS
1.500	3.752	0.588	0.412	1.000	30.434
3.500	4.248	0.548	0.266	0.587	17.881
5.000	4.761	0.509	0.158	0.322	9.790
8.000	6.098	0.422	0.095	0.164	4.981
11.000	7.769	0.333	0.046	0.069	2.092
16.000	11.030	0.210	0.018	0.023	0.687
25.000	17.116	0.089	0.004	0.004	0.134
TOTAL			1.000	2.168	66.000

FISCAL 1990

GUARANTEED JACKPOT	EXPECTED SALES	PROB. OF ROLLOVER	PROB. OF ROLLOVER ENDING AT	JACKPOT LEVEL FREQUENCY	OUT OF 104 DRAWS
1.500	3.888	0.576	0.424	1.000	48.860
3.500	4.384	0.537	0.267	0.576	28.160
5.000	4.897	0.500	0.155	0.309	15.125
8.000	6.234	0.414	0.091	0.154	7.550
11.000	7.905	0.326	0.043	0.064	3.111
16.000	11.166	0.206	0.017	0.021	1.003
25.000	17.252	0.087	0.004	0.004	0.192
TOTAL			1.000	2.128	104.000

Seven levels of the guaranteed jackpot are examined, as is shown in Table 7.2. The steps which the bureau employs

8. AVYDM is derived from a forecast of personal income and withholding as explained in section 3.2.

9. As the intention is to establish a random distribution of jackpots over the 66 remaining draws in 1989 and the 104 draws in 1990, it is necessary to use the same level of income within each distribution.

in building up the jackpot do vary somewhat, but this is a fairly good representation of the recent behavior of the bureau.[10] Table 7.2 shows the expected sales associated with each level of the jackpot in fiscal 1989 and fiscal 1990.

The third step in the procedure is determining the probability that the jackpot will not be won, (i.e. the probability that the jackpot will roll over), given a certain level of sales.

In the 6/44 game, six numbers are chosen between 1 and 44. Numbers cannot repeat and order is not important. Thus the probability of choosing all six numbers correctly is

10. The steps used by the bureau should, at least in part, be determined by the question of what the profit-maximizing jackpot level is. This question is complicated by the possibilities that the rollovers which occur before a large jackpot may attract public attention, or that huge jackpots may attract less attention, the second time they are offered. It is further complicated by the fact that the lottery is bound by law to return a minimum of 45 percent of its gross receipts to the public in the form of prizes.

However, ignoring these problems, it is possible to work out the optimal level of the guaranteed jackpot. First, using a discount rate of 10%, the actual cost of a guaranteed jackpot to the Lottery Bureau is roughly half the level of the actual jackpot due to delayed payment structure. Thus, the expected profit from any jackpot level is approximately given by sales, less the probability of the jackpot being won multiplied by one half the level of that jackpot.

Applying this to data from 5/9/87 to 3/05/88, expected profits for each draw were calculated. These expected profits were then regressed on a jackpot term, a jackpot-squared term and a jackpot-cubed term. Differentiating the resulting estimated equation with respect to the jackpot, gives a revenue-maximizing jackpot of $73 million! This result should not be taken too seriously in light of the problems mentioned above. However, a more sophisticated analysis along these lines might prove beneficial.

given by:[11]

(7.2) $$\frac{38!6!}{44!} = \frac{1}{7,059,052}$$

This implies that the probability of any one ticket losing is 7,059,051/7,059,052. The probability of 3,765,000 tickets, drawn independently, all losing is:

(7.3) $(7,059,051/7,059,052)^{3,765,000} = 0.587$

This calculation can be worked out for each of the average sales levels associated with different jackpot levels. The probability of a jackpot which started at $1.5 million ending at each level can then be estimated. For example, the probability of a jackpot growing to $5 million and then being won, in the remainder of 1989, is estimated to be:

11. The number of different combinations that are possible choosing r numbers from n numbers without replacement is n!/r!(n-r)!. Thus the probability of choosing the correct combination with one ticket is 1/[n!/r!(n-r)!] or r!(n-r)!/n!.

In general, the probability of r winners, given n tickets and a probability p of any one ticket being a winner is:

$Pr(r \text{ winners}) = p^r * (1-p)^{n-r} * (n!/r!(n-r)!)$

Thus, if p = (1/7,059,052) and n = 3,765,000 then:

$Pr(0 \text{ winners}) = (7,059,051/7,059,052)^{3,765,000} = .587$

$Pr(1 \text{ winner}) = (1/7,059,052)*(7,059,051/7,059,052)^{3,764,999}$

*(3,765,000,) = .313 etc.

(7.4) (Probability of rollover at $1.5 million)*(Probability of rollover at $3.5 million)*(Probability of jackpot being won at $5.0 million) = (.587)*(.547)*(1 - .509) = .158

Since each jackpot starts at $1.5 million, the relative frequency of each jackpot occuring in a given cycle can be found. A jackpot of $1.5 million occurs in every cycle. A jackpot of $3.5 million occurs in every cycle that doesn't end at $1.5 million. A jackpot of $5.0 million occurs in every cycle that doesn't end in a $1.5 Million or $3.5 million jackpot etc. Thus within each cycle, the probabilty of a $5.0 million jackpot occuring is given by:

(7.5) (Probability of $1.5 million occuring) - (Probability of jackpot ending at $1.5 million) - (Probability of jackpot ending at $3.5 million) = 1-.413-.266 = .320

The expected length of a cycle is found by adding up these relative frequencies and is found to be 2.164 in 1989. The frequency given 66 draws is then found by multiplying each relative frequency by 66/2.164.

Using these frequencies, a distribution of jackpots in is constructed within each fiscal year. These are shown in Figures 7.3 and 7.4.

FIGURE 7.3: RANDOM DISTRIBUTION OF 1989 JACKPOT LEVELS, (MILLIONS OF DOLLARS)

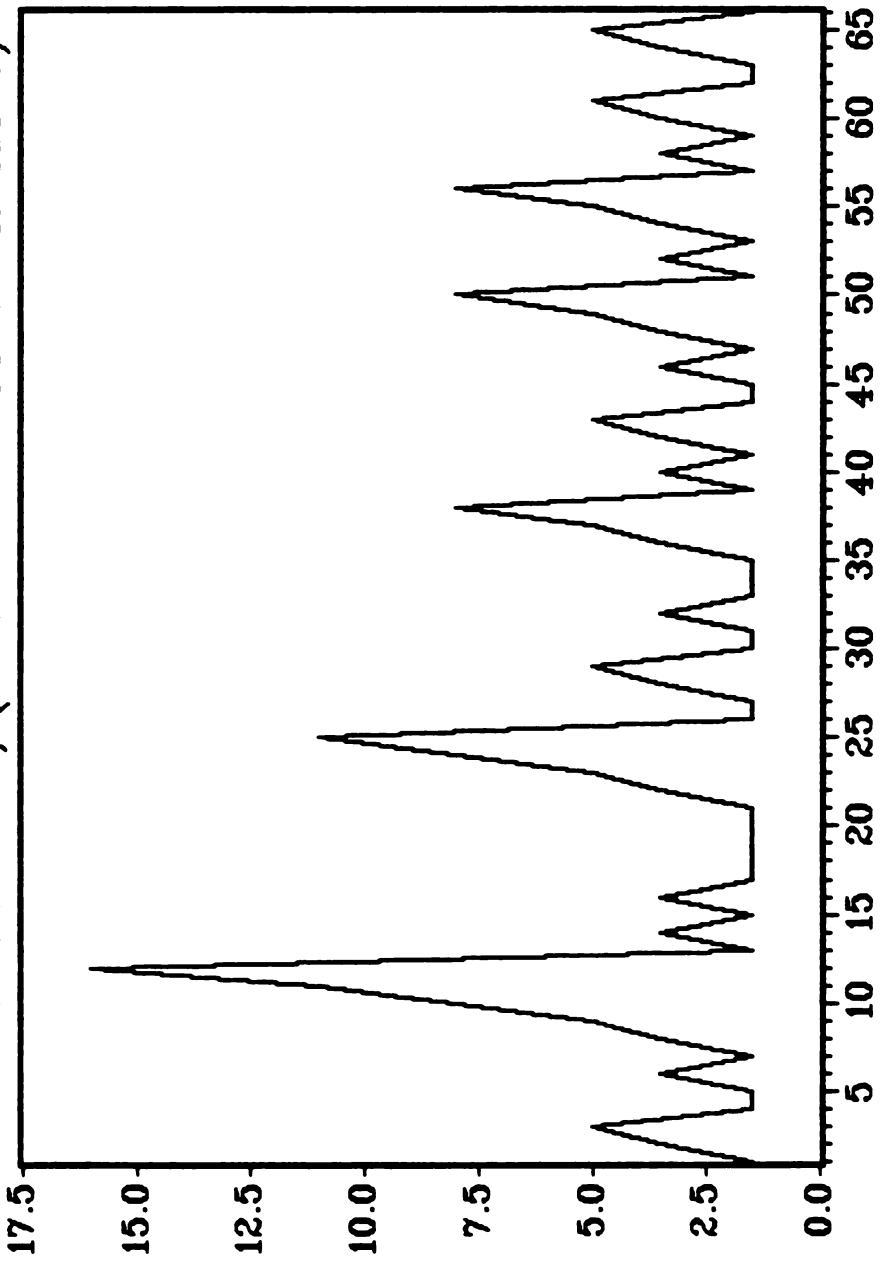
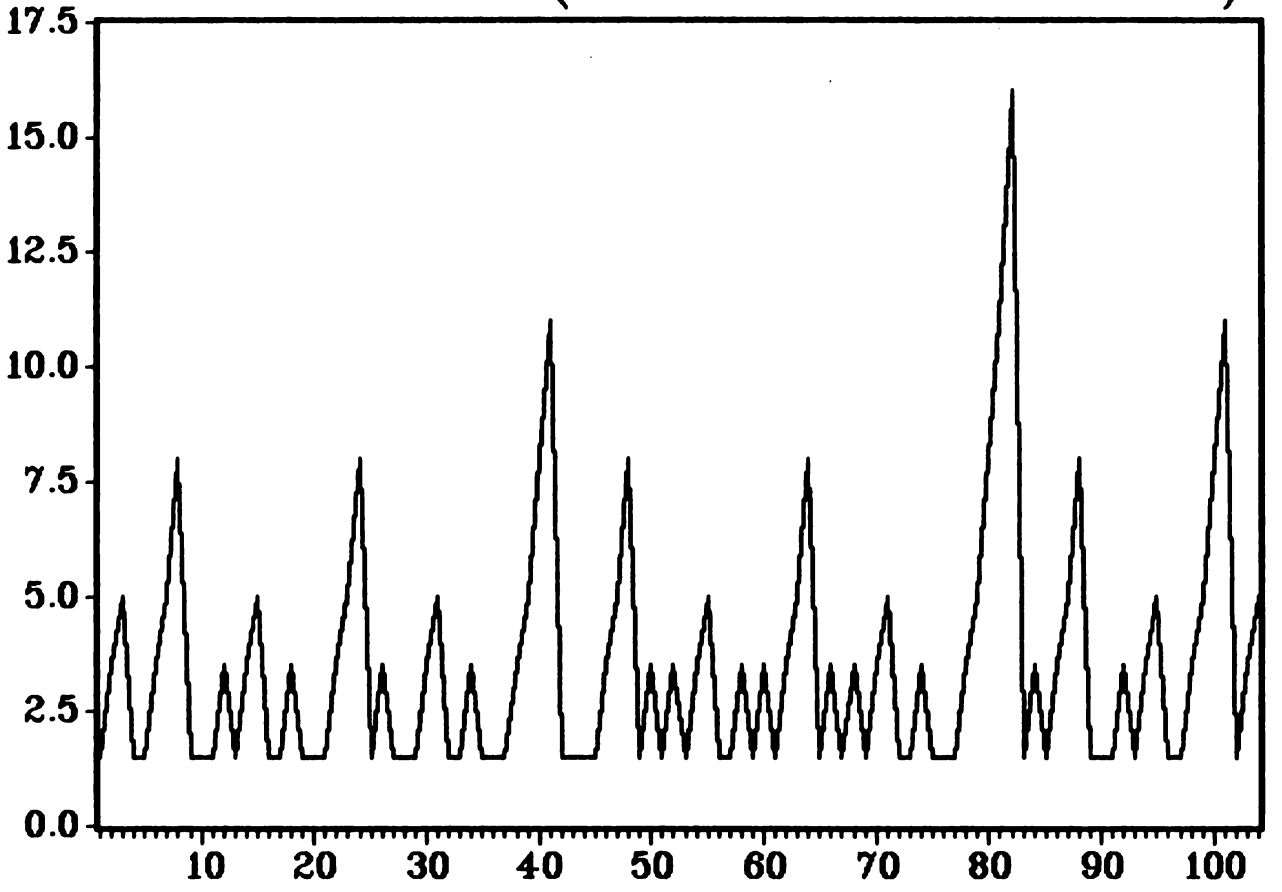


FIGURE 7.4: RANDOM DISTRIBUTION OF 1990 JACKPOT LEVELS (MILLIONS OF DOLLARS)



Forecasting Lotto Ticket Sales

In estimating a Lotto equation, 147 weekly observations on Lotto sales, LOTTO, are used.[12] Given the extra interest in large jackpots, terms in jackpot-squared, J2, jackpot-cubed, J3, and jackpot raised to the fourth power, J4, are included, in addition to the jackpot, JAKPOT, term.

Imposing weekly seasonal dummies is computationally impractical, whereas using monthly seasonal dummies is slightly artificial in the context of a model with weekly observations on the dependent variable. In place of these monthly seasonal dummies an MA term at a lag of 52 weeks was introduced. However, this term was dropped as it was insignificant and thus suggested no seasonality in Lotto sales.

Although the effect is not as noticeable as in the Daily game, as the month progresses, there is a falloff in Lotto ticket sales. This is probably due to individuals receiving social security checks or pay checks in the first week of the month. To measure this effect, a cubic is fitted on a variable called DATE which takes a value of one in a week ending in the first of the month, two in a week ending in the second of the month, etc.

A 13-week linear interpolation of Michigan nominal

12. It should be noted that weekly data are employed rather than per-draw (semi-weekly) data, due to the lack of a sufficiently long series on per-draw data and the need to use a data series which is compatable with the data for the other games

disposable personal income, AVYDM, is also employed as a regressor.

Dummy variables are used to deal with outliers caused by the jackpot exceeding a certain level for the first time, as it is felt that this creates a level of excitement that will not be matched when this jackpot recurs. Also a dummy variable is included for the second week in February, 1988, when the jackpot hit $17 million, only three and a half weeks after reaching $28 million. Low sales in this week could be the result of "player burn-out".

An AR(1) term is included as a regressor in this model. This is done in order to measure some of the lagged effects of growing and then waning interest in the Lotto game as the jackpot rises and falls. In addition, values of JAKPOT, lagged over one, two, three and four weeks are included as regressors.

Another possible explanatory variable in the on-line games is the number of terminals in operation, although Black and Johnson[13] argue that the increase in these terminals has had no significant effect on sales for either type of game. I also found no significant coefficient on a terminal term. This, however, may be the result of a variable lag in the effect of new terminals on sales rather than a complete insensitivity of total sales to the number of terminals in operation.

Thus the Lotto sales equation is shown as equation (7.6) on the next page:

$$(7.6) \quad LOTTO = a_1 + a_2*JAKPOT + a_3*AVYDM + a_4*J2 + a_5*J3 + a_6*J4 + a_7*B143 + a_8*B172 + a_9*B176 + a_{10}*DATE + a_{11}*DATESQ + a_{12}*DATECU + a_{13}*JAKPOT(-1) + a_{14}*JAKPOT(-2) + a_{15}*JAKPOT(-3) + a_{16}*JAKPOT(-4) + a_{17}*AR(1)$$

The results of regressing equation (7.6) are shown on the next page. The R-squared is .986 and a partial R^2, given the AR term and outlier dummies was calculated to be .8627. The income elasticity of Lotto ticket sales was found to be .863 which confirms the earlier finding from the per-draw equation. Although, the forecast generated by this model should be unbiased, it will in general have greater variance than the forecasts for other taxes, due the variance in actual jackpot distribution.

A likelihood ratio test for structural stability was conducted by splitting the data set at the third week in September, 1987. This yielded an Chi-square of 13.8 with 16 degrees of freedom. This fails to reject the null hypothesis of structural stability at the five percent level.

The Box-Pierce test for white noise residuals was also employed. Given 25 degrees of freedom this yields a Chi-square of 28.62, which fails to reject the null hypothesis of white noise residuals at the five percent level.

13. See "The Michigan Lottery: Computer Terminals and On-Line Game Sales" by Robert Black and Neal Johnson, Senate Fiscal Agency Issue Papers, September 1987"

Table 7.3: Statistical Output from the MURF
Weekly Lotto Game Sales Equation

LS // Dependent Variable is LOTTO
SMPL range: 82 - 228
Number of observations: 147
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-2391315.6	1550631.5	-1.5421560	0.123
JAKPOT	255362.95	82401.876	3.0989944	0.002
AVYDM	235.30147	49.784199	4.7264288	0.000
J2	-1592.9145	8069.6144	-0.1973966	0.844
J3	498.67571	275.92518	1.8072860	0.071
J4	-7.2412510	2.7867300	-2.5984760	0.009
B143	1556445.6	414766.41	3.7525835	0.000
B172	4376190.3	420702.70	10.402097	0.000
B176	-2896553.3	447768.56	-6.4688625	0.000
DATE	78572.856	39648.722	1.9817248	0.048
DATESQ	-5484.1433	2921.2238	-1.8773445	0.060
DATECU	98.915137	60.843830	1.6257217	0.104
JAKPOT(-1)	30470.953	6494.8466	4.6915586	0.000
JAKPOT(-2)	25236.953	6338.4448	3.9815685	0.000
JAKPOT(-3)	10627.628	6187.5984	1.7175691	0.086
JAKPOT(-4)	10867.114	5845.0569	1.8591974	0.063
AR(1)	0.5828975	0.0696181	8.3727925	0.000

R-squared	0.986311	Mean of dependent var	8633801.
Adjusted R-squared	0.984626	S.D. of dependent var	3567876.
S.E. of regression	442387.7	Sum of squared resid	2.54E+13
Durbin-Watson stat	1.922146	F-statistic	585.4099
Log likelihood	-2110.542		

Figure 7.5 shows the relationship between the level of the jackpot and sales as implied by the polynomial in JAKPOT estimated in regressing equation (7.6). This appears to be very much like the relationship shown in Figure 7.2 for equation (7.1).

Figure 7.6 shows the within month variation in Lotto sales implied by the cubic in DATE in the same equation. Again this is in line with expectations and shows an estimated swing of more than $250,000 in weekly Lotto sales due purely to the time of the month, with the earlier half of the month faring best.

A forecast for Lotto game sales through the end of fiscal 1990,[14] derived from this analysis, is displayed in Figure 7.7.

7.4 Daily Game Sales

The populations involved in each of the three types of games are probably slightly different. The biggest games, in fiscal 1987, (though not in fiscal 1988), from the point of view of revenue, were the three- and four-digit "Daily" games which are based on the same concept as the illegal numbers game. For the three-digit game there are 1,000 possible three-digit combinations and a winning ticket on a

14. No adjustment has been made to lotto sales forecasts yet to account for the impact of the "Zinger" as it has been in operation for too short a period for meaningful analysis. However, preliminary data suggests that much of its gross effect on sales will be offset by a fall in Daily game sales and a reduction in the overall number of Lotto tickets bought.

FIGURE 7.5: JACKPOT & FITTED LOTTO SALES

(APRIL 1986 TO FEBRUARY 1989, THOUSANDS OF DOLLARS)

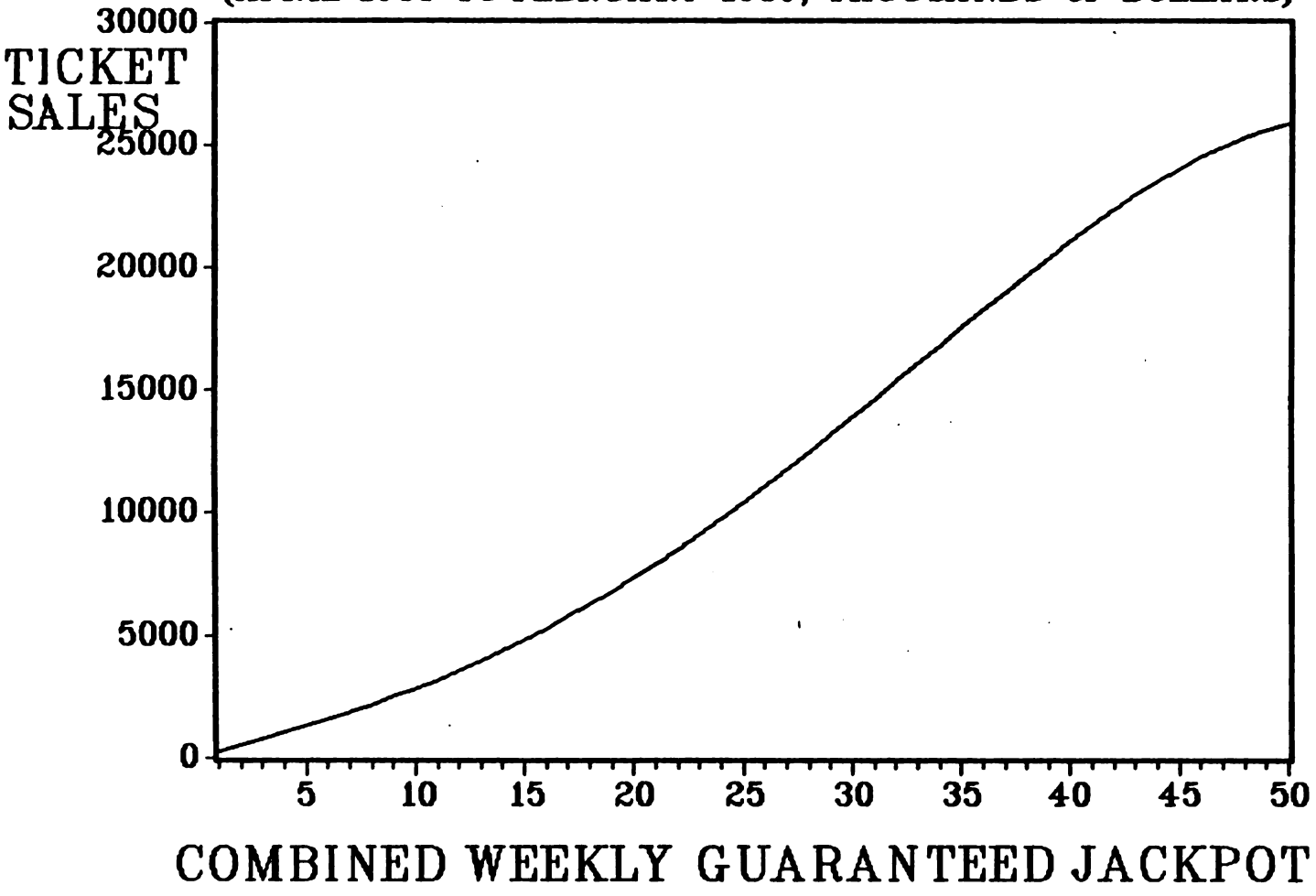


FIGURE 7.6: WITHIN-MONTH SALES VARIATION

(DEVIATIONS FROM MEAN LOTTO SALES BY DATE, THOUSANDS OF DOLLARS)

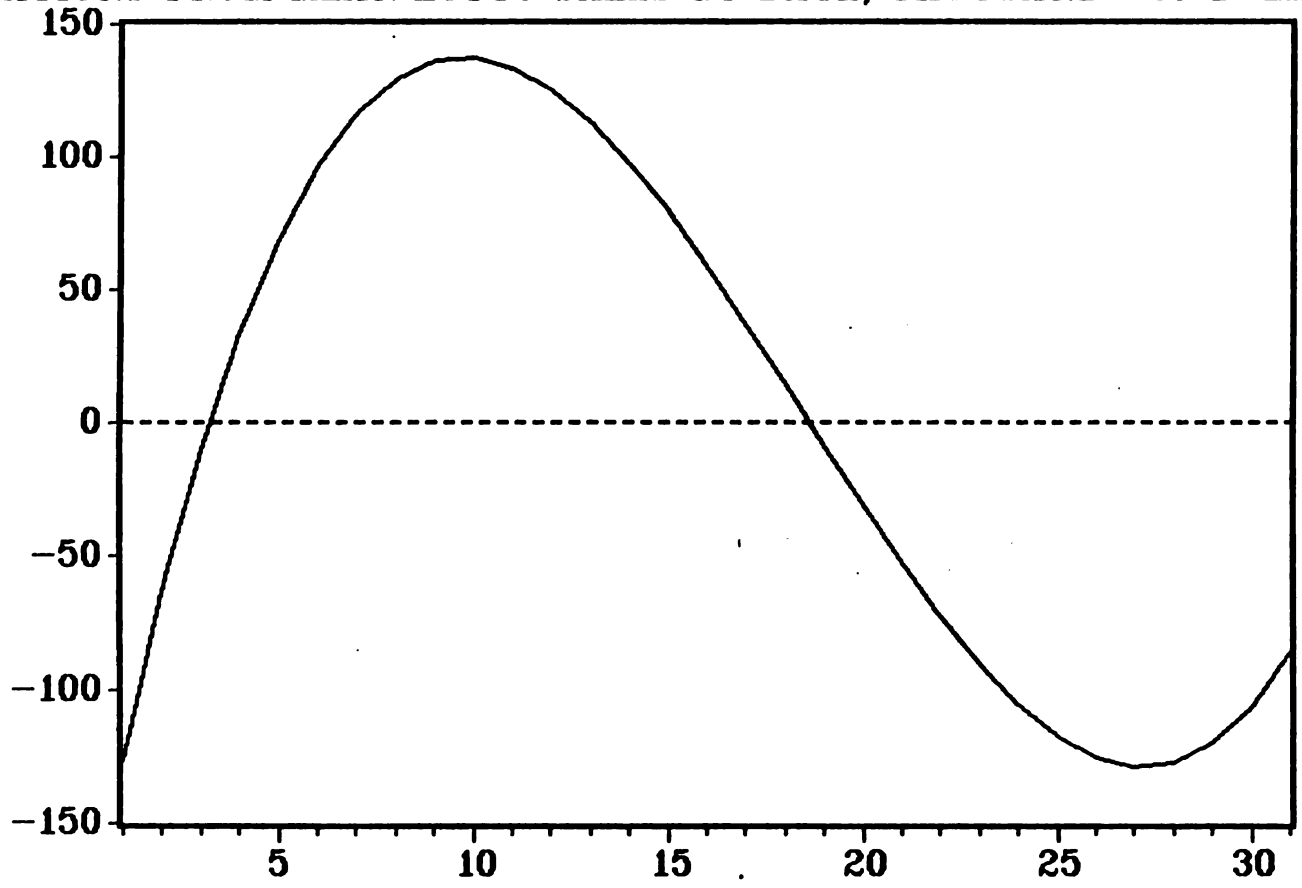
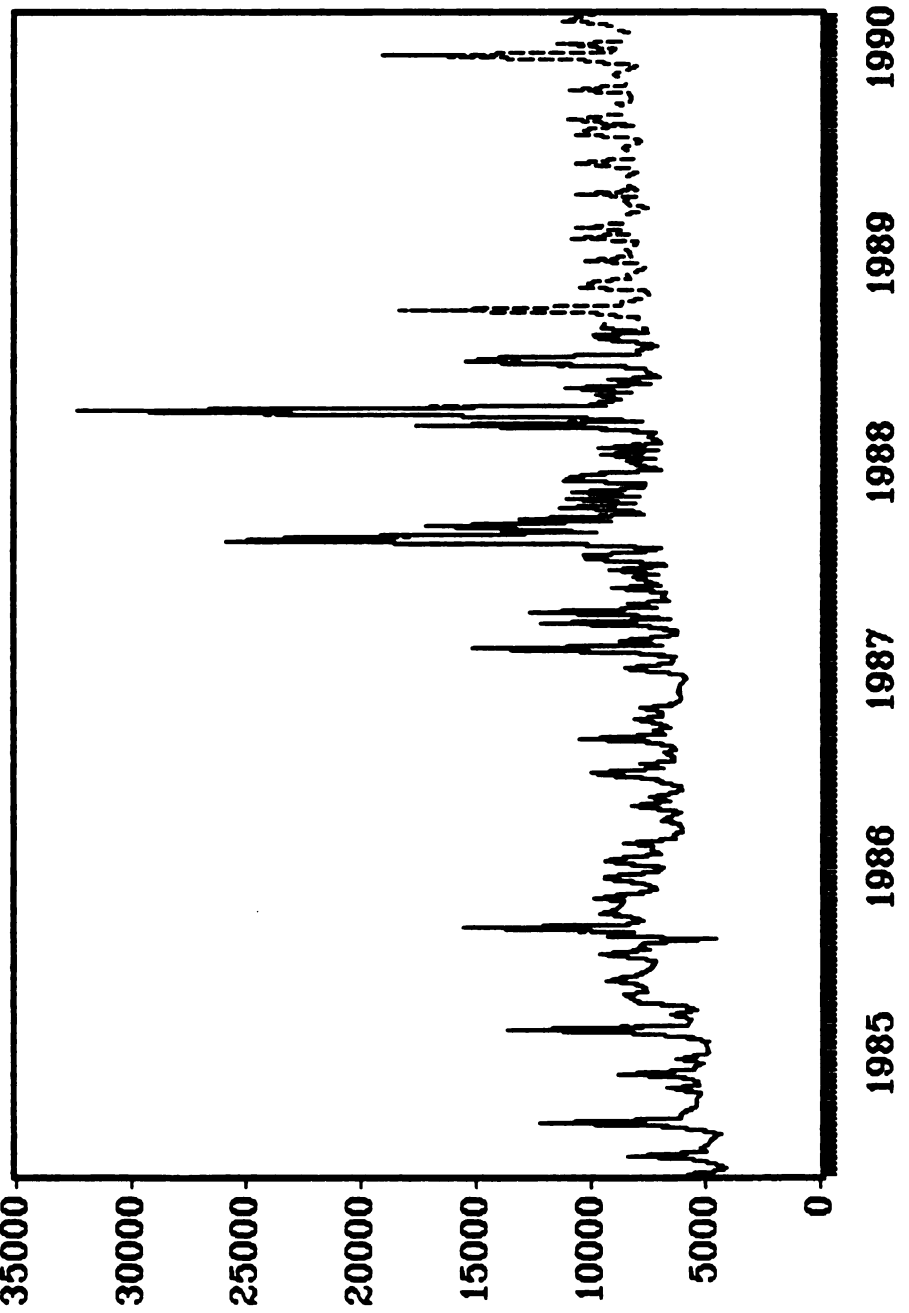


FIGURE 7.7: LOTTO GAME SALES

(ACTUAL & MURF FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)



straight wager pays $500.

These are the steadiest games from a revenue perspective which may be the result of compulsive behavior on the part of purchasers. More than $10 million worth of tickets are sold each week in a state with a total population of 9.3 million people. Anecdotal evidence suggests that these are the most regressive[15] of the three main types of lottery games which again suggests compulsive rather than income-related behavior.

The revenues from this source seem to be very smooth over time and should be related to personal disposable income in Michigan. Other factors which may be important are the strength of advertising campaigns and possibly the economic health of Detroit and Flint since most Daily game

15. There is some controversy concerning whether state lotteries are, in fact, regressive at all. Daniel Suits, using a nationwide survey of gambling habits in 1975, determined that state lotteries were more than twice as regressive as sales taxes, as measured by his "S" index of tax progressivity.

On the other hand, William McConkey and William Warren found in 1987 that "heavy" purchasers of tickets tended to be richer on average than non-purchasers. However, some doubt might be cast on their findings due to the fact that they used reponses from an all-female "Market Facts Mail Panel" which may not be a representative sample. More importantly, they defined heavy purchasers as those who bought 12 or more tickets per year. This is hardly a good cutoff point as more than 129 tickets were bought in Michigan in fiscal 1988 for every individual in the state.

See:
"Gambling Taxes; Regressivity and Revenue Potential", Daniel B. Suits, National Tax Journal, March 1977, Vol. 30, no. 1

"Psychographic and Demographic Profiles of State Lottery Ticket Purchasers", C. William McConkey and William E. Warren, Journal of Consumer Affairs, Vol. 21, Winter 1987

tickets are sold in these cities. The first of these is very difficult to measure in a quantitative manner. In the long-run it may be possible to measure the second of these two effects, but not in the short time horizon of lottery games.

The model of the Daily game uses a dependent variable of weekly sales of Daily game tickets, DAILY. Among the regressors are a linear interpolation of Michigan personal disposable income. An MA term with a lag of 52 weeks is found to be significant and is included to measure seasonal variation.

A dummy variable for the week containing the fourth of July, JULY4, is also included, as that week tends to be characterized by a particularily high level of sales. The same is done for the week preceding Christmas which also shows robust sales. The week containing Christmas day, in contrast, tends to have lower than average sales and so this week is also given a dummy variable. These dummies are named BXMAS and AXMAS respectively.

One interesting feature of Daily game sales is that, as the month progresses, there is a definite falloff in Daily game ticket sales. This is probably due to individuals receiving social security checks or pay checks in the first week of the month. To measure this effect, a cubic is fitted on a variable called DATE which takes a value of one in a week ending in the first of the month, two in a week ending in the second of the month, etc.

Lotto sales, LOTTO, and the level of the Lotto jackpot, JAKPOT, are included as regressors to deal with the conflicting effects of higher Lotto jackpots increasing interest in lottery games in general, but perhaps causing some substitution of Lotto tickets for Daily game tickets.

The first week of fiscal 1987 appears to be a definite outlier, so that observation has a dummy variable to prevent it from affecting the regression coefficients. The last week in January 1988 had artificially low sales due to a promotional giveaway of "Daily-three" game tickets in these weeks. Three other outliers have also been included in the current model in January 1986, June 1986, and December 1988.

Finally, an AR(1) term is included to pick up trends in Daily game sales that are not explained by the other variables.

The data for fiscal 1985 shows a pattern that has not repeated since, so the Daily game regression equation is estimated using only the last five weeks of that year. This leaves 181 observations over which to run the regression.

Thus the Daily Game sales equation is:

$$\begin{aligned}(7.7)\quad DAILY = {} & a_1 + a_2*AVYDM + a_3*LOTTO + a_4*JAKPOT \\ & + a_5*JULY4 + a_6*BXMAS + a_7*AXMAS + a_8*B66 + a_9*B89 \\ & + a_{10}*B105 + a_{11}*B173 + a_{12}*B221 + a_{13}*DATE \\ & + a_{14}*DATESQ + a_{15}*DATECU + a_{16}*MA(52) + a_{17}*AR(1)\end{aligned}$$

The results of regressing equation (7.7) are shown on the next page and the forecast for Daily game sales through

Table 7.4: Statistical Output from the MURF
Weekly Daily Game Sales Equation

LS // Dependent Variable is DAILY
SMPL range: 48 - 228
Number of observations: 181
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	3238619.0	1324363.1	2.4454163	0.014
AVYDM	191.09151	42.381648	4.5088268	0.000
LOTTO	0.0431472	0.0206952	2.0848913	0.037
JAKPOT	-17459.447	8999.0282	-1.9401480	0.052
JULY4	258726.10	121229.61	2.1341824	0.033
BXMAS	327948.13	119693.24	2.7399052	0.006
AXMAS	-585544.64	141007.92	-4.1525656	0.000
B66	681879.37	211301.25	3.2270484	0.001
B89	617046.04	201114.82	3.0681282	0.002
B105	-1062073.0	201835.78	-5.2620650	0.000
B173	-1021419.1	203777.80	-5.0124161	0.000
B221	1725973.4	235361.06	7.3333003	0.000
DATE	133210.50	17980.909	7.4084406	0.000
DATESQ	-9973.2110	1331.1022	-7.4924459	0.000
DATECU	186.18480	27.802947	6.6965851	0.000
MA(52)	0.3302747	0.0960509	3.4385383	0.001
AR(1)	0.7816923	0.0512187	15.261839	0.000

R-squared	0.865381	Mean of dependent var	9686073.
Adjusted R-squared	0.852248	S.D. of dependent var	658288.7
S.E. of regression	253036.5	Sum of squared resid	1.05E+13
Durbin-Watson stat	1.962524	F-statistic	65.89104
Log likelihood	-2499.775		

the end of fiscal 1990 is displayed in Figure 7.9. The R-squared is .87 and the Durbin-Watson statistic is 1.96. The lower R-squared for the Daily game model relative to the Lotto model is presumably due to the fact that there is no corresponding variable with the explanatory power of JAKPOT in the Lotto equation.

An income elasticity of .61 was estimated for Daily game sales based on the estimated coefficients and a partial R^2 of .19 was calculated, given the effects of outlier dummies and AR and MA terms.

A likelihood ratio test for structural stability was conducted by splitting the data set at the last week in May 1987. This yielded a Chi-square of 102 with 14 degrees of freedom, thus rejecting the null hypothesis of structural stability at the five percent level. However, the current equation has been retained, because the most obvious cure, shortening the fit period, would reduce the precision with which the income elasticity can be measured.

The Box-Pierce test for white noise residuals was also employed. Given 24 degrees of freedom this yields a Chi-square of 18.31, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

Finally, the within-month variation in sales based on the coefficients on DATE, DATESQ and DATECU is shown in Figure 7.8. This suggests a strong effect with Daily game sales in a week ending in the 9th of the month exceeding sales in a week ending in the 27th by more than $500,000.

FIGURE 7.8: WITHIN-MONTH SALES VARIATION

(DEVIATIONS FROM MEAN DAILY SALES BY DATE, THOUSANDS OF DOLLARS)

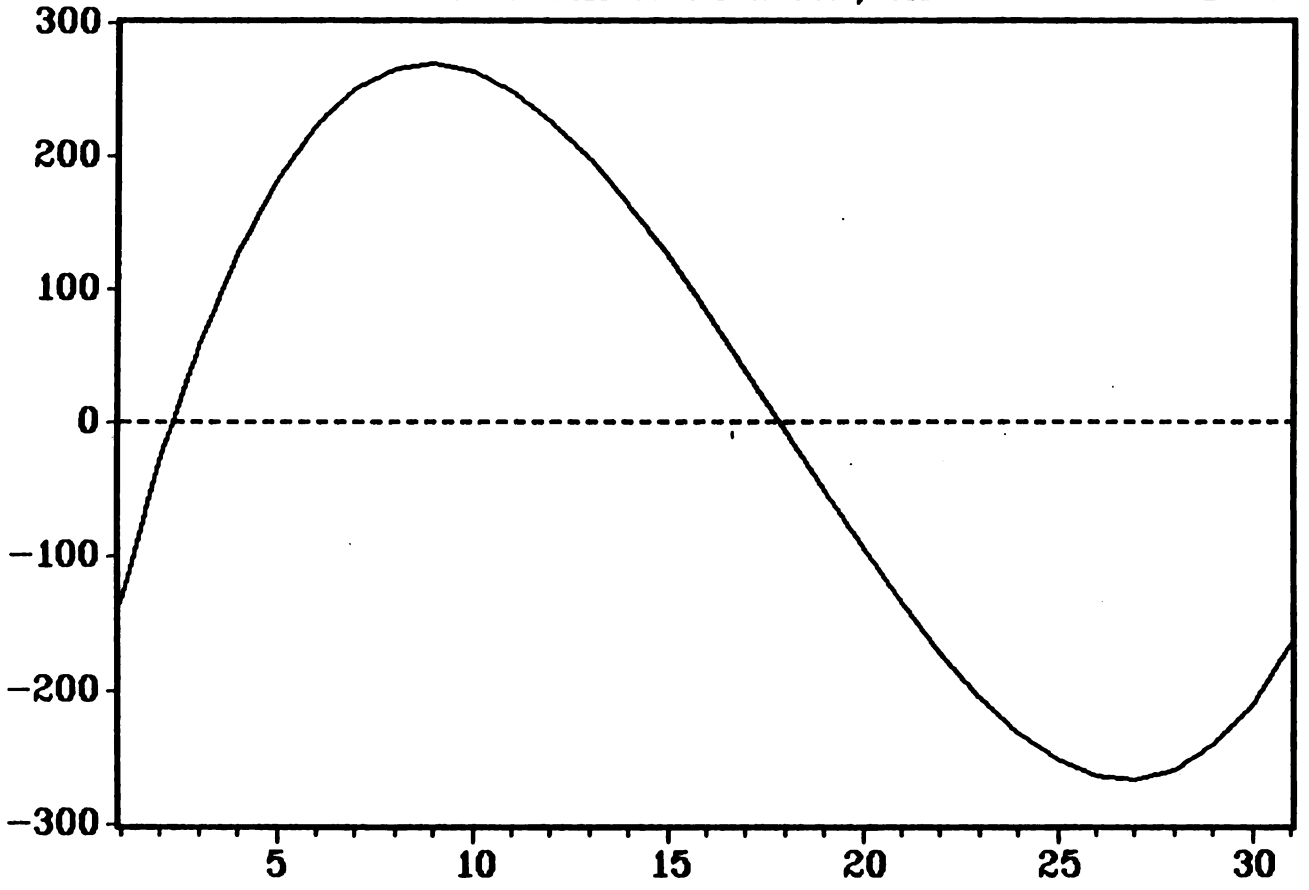
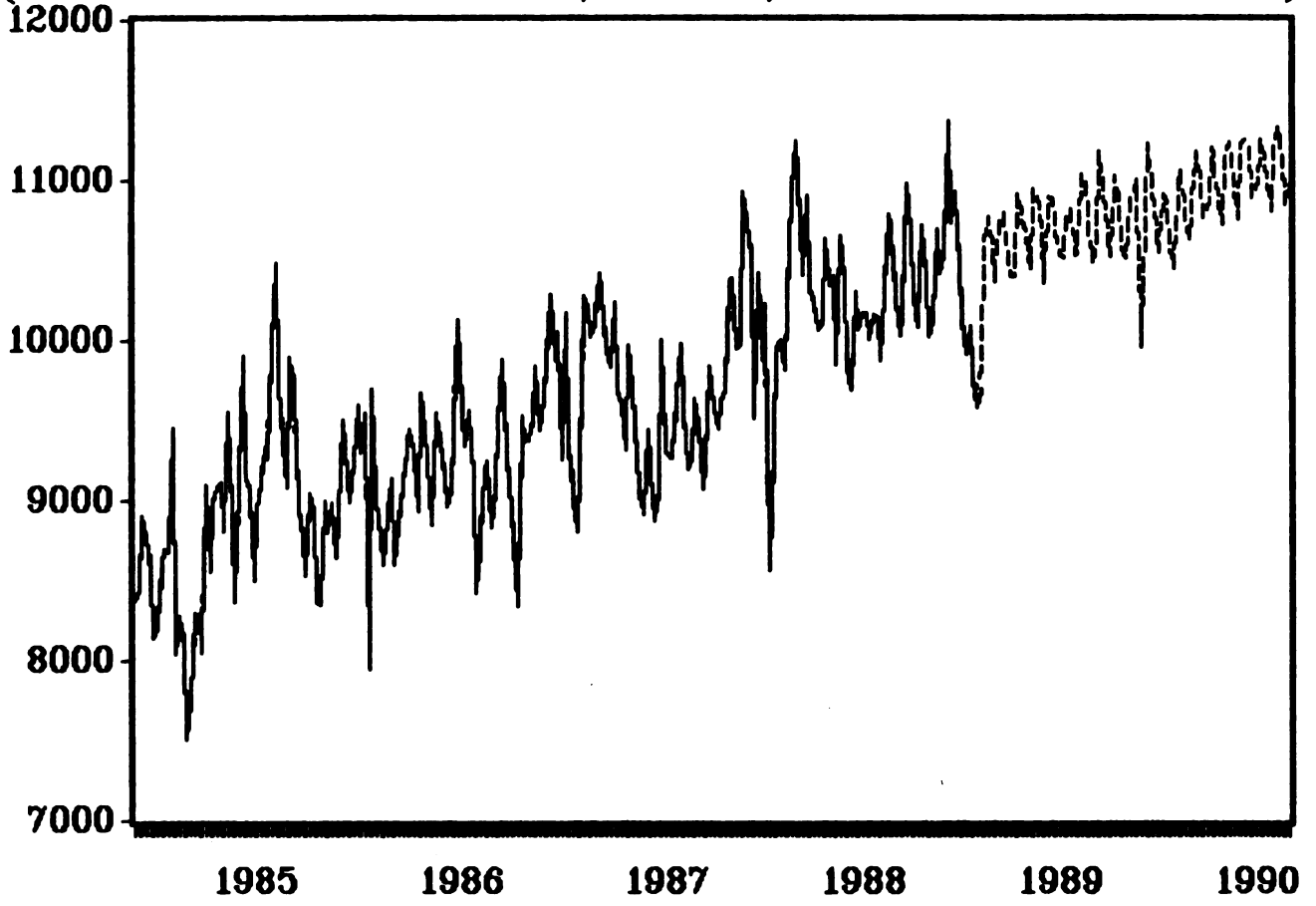


FIGURE 7.9: DAILY GAME SALES

(ACTUAL & MURF FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)



7.5 Instant Game Sales

Of the three types of lottery games run by the State of Michigan, the "Instant" game provides the least revenue. In the past, the game has changed about every nine weeks and revenues tend to vary considerably between popular and unpopular concepts.

The population which plays Instant lottery games is probably more diverse than for the other two types of games. Also, given the highly impulsive nature of the decision to buy these tickets, advertising and concept are probably the two most important factors in determining sales. Presumably, the Lottery Bureau learns over time which concepts and campaigns are more successful, but on the other hand, the public may have a growing immunity over time to these campaigns. It is not clear whether the combination of these two factors should increase or decrease revenues over time.

An added complication is the fact that over the past three years the method for collecting revenues has changed twice, which has left a large amount of noise in the data which distracts attention from the long-term trend in Instant lottery games.

In response to this last problem, only data after the first week of fiscal 1987 is used to help predict Instant game revenues. This still leaves 118 observations over which a regression can be fitted.

The dependent variable, INSTAT, represents weekly sales

of instant game tickets. As in the Daily game, an MA(52) term is employed to explain seasonal variation in sales, and a cubic is fitted on a variable called DATE to measure within-month seasonal variation.

One of the factors that is very noticeable in Instant lottery sales is a falloff in sales as the current game gets older. This is the result of both falling public interest and retailers running out of tickets. This effect is simulated by a variable which called "NEWGME". This variable takes a value of one in the first week of a new game, two in the second week and so on. We would expect this term to have a negative coefficient in an estimated regression equation of Instant lottery ticket sales, which indeed it does. A new game has almost always lasted nine weeks which accounts for the significance of an MA(9) term.

In the forecast of Instant game sales, a new game is assumed to be introduced every nine weeks. However, the Lottery Bureau expects that since new games will all be tied into the on-going "Fame & Fortune" game show, the nine-week cycle may become less pronounced in the future than in the past. No modification of the model has yet been introduced to deal with this change as there are too few data points after the change, as yet, for formal analysis.

In addition, no general term has been introduced to deal with the increase in sales associated with the "Fame and Fortune" show. Again it is too soon for formal analysis, although the show does seem to have had some positive impact

on sales. The model of Instant lottery ticket sales also contains a term in average nominal Michigan disposable personal income, AVYDM.

There seems to be a negative effect from large Lotto sales in the previous week on Instant game sales. Possibly, this is due to ticket buyers regreting the money they invested in the lottery in the previous week. Instant game sales also appears to be positively correlated with Daily game sales in the current week. An AR(1) term is also included to deal with autocorrelation, possibly due to different degrees of popularity of different nine-week games.

Two outliers are omitted from the start of the sample period by the use of the dummy variables B120 and B128. The Instant game equation is thus:

$$
\begin{aligned}
(7.8) \quad \text{INSTAT} = {} & a_1 + a_2 * \text{AVYDM} + a_3 * \text{DATE} + a_4 * \text{DATESQ} \\
& + a_5 * \text{DATECU} + a_6 * \text{NEWGME} + a_7 * \text{LOTTO}(-1) + a_8 * \text{DAILY} \\
& + a_9 * \text{B120} + a_{10} * \text{B128} + a_{11} * \text{MA}(9) + a_{12} * \text{MA}(52) \\
& + a_{13} * \text{AR}(1)
\end{aligned}
$$

The results of regressing equation (7.8) are shown in Table 7.4. The R-squared is .87 and the Durbin-Watson statistic is 1.99. While the overall level of explanation leaves some thing to be desired, it is not entirely surprising given different Instant games and the impulsive nature of purchases.

The income elasticity of sales was evaluated at 1.99

which suggests that the effects of income on sales are probably being confused with a trend increase in Instant game sales in the last two years due to more successful marketing techniques.

Table 7.5: Statistical Output from the MURF Instant Game Sales Equation

LS // Dependent Variable is INSTAT
SMPL range: 111 - 228
Number of observations: 118
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-3196439.5	831211.71	-3.8455179	0.000
AVYDM	155.37365	26.523726	5.8579119	0.000
DATE	-38858.281	22298.338	-1.7426537	0.085
DATESQ	4318.0814	1656.2566	2.6071331	0.011
DATECU	-94.342331	34.071730	-2.7689328	0.007
NEWGME	-122601.84	8827.0977	-13.889258	0.000
LOTTO(-1)	-0.0350652	0.0063522	-5.5201899	0.000
DAILY	0.1547808	0.0596376	2.5953563	0.011
B120	402290.16	193400.85	2.0800848	0.040
B128	538737.33	192945.85	2.7921686	0.006
MA(9)	0.2801462	0.1020655	2.7447695	0.007
MA(52)	0.7964569	0.0944004	8.4370075	0.000
AR(1)	0.5329586	0.0582790	9.1449586	0.000

R-squared	0.872113	Mean of dependent var	2491902.
Adjusted R-squared	0.857497	S.D. of dependent var	552339.1
S.E. of regression	208505.5	Sum of squared resid	4.56E+12
Durbin-Watson stat	1.996825	F-statistic	59.66970
Log likelihood	-1605.779		

A likelihood ratio test for structural stability was conducted by splitting the data set in the last week of 1987. This yielded a Chi-square of 91.88 with 11 degrees of freedom. This caused the rejection of the null hypothesis of structural stability at the five percent level. This specification was retained, however, for the same basic

reason as in the Daily game model.

The Box-Pierce test for white noise residuals was also employed. Given 23 degrees of freedom this yields a Chi-square of 15.53, insufficient to reject the null hypothesis of white noise residuals at the five percent level.

The monthly variation in sales implied by the cubic in DATE is displayed in Figure 7.10. The pattern shown is exactly the opposite of that shown by the other two models. However, this may be related to the inclusion of Lotto and Daily game sales as regressors. In the absence of these two variables the t-statistics on all three terms fall below one. This suggests that the date variables are serving to "deseasonalize" the relationship between the dependent variable and DAILY and LOTTO. The fact that in the absence of these two regressors, there is no significant within-month variation in Instant game sales and the much higher income elasticity calculated for these games tends to support the idea that the population which plays these games is different from that of the other two games. Finally, the forecast for Instant game sales through the end of fiscal 1990 is displayed in Figure 7.11.

7.6 Performance Review

Although I was unable to find another formal econometric model of lottery game sales, I did compare the post-sample dymamic forecast performance of the MURF lottery equations with three other types of models. First, pure

FIGURE 7.10: WITHIN-MONTH SALES VARIATION

(DEVIATIONS FROM MEAN INSTANT SALES BY DATE, THOUSANDS OF DOLLARS)

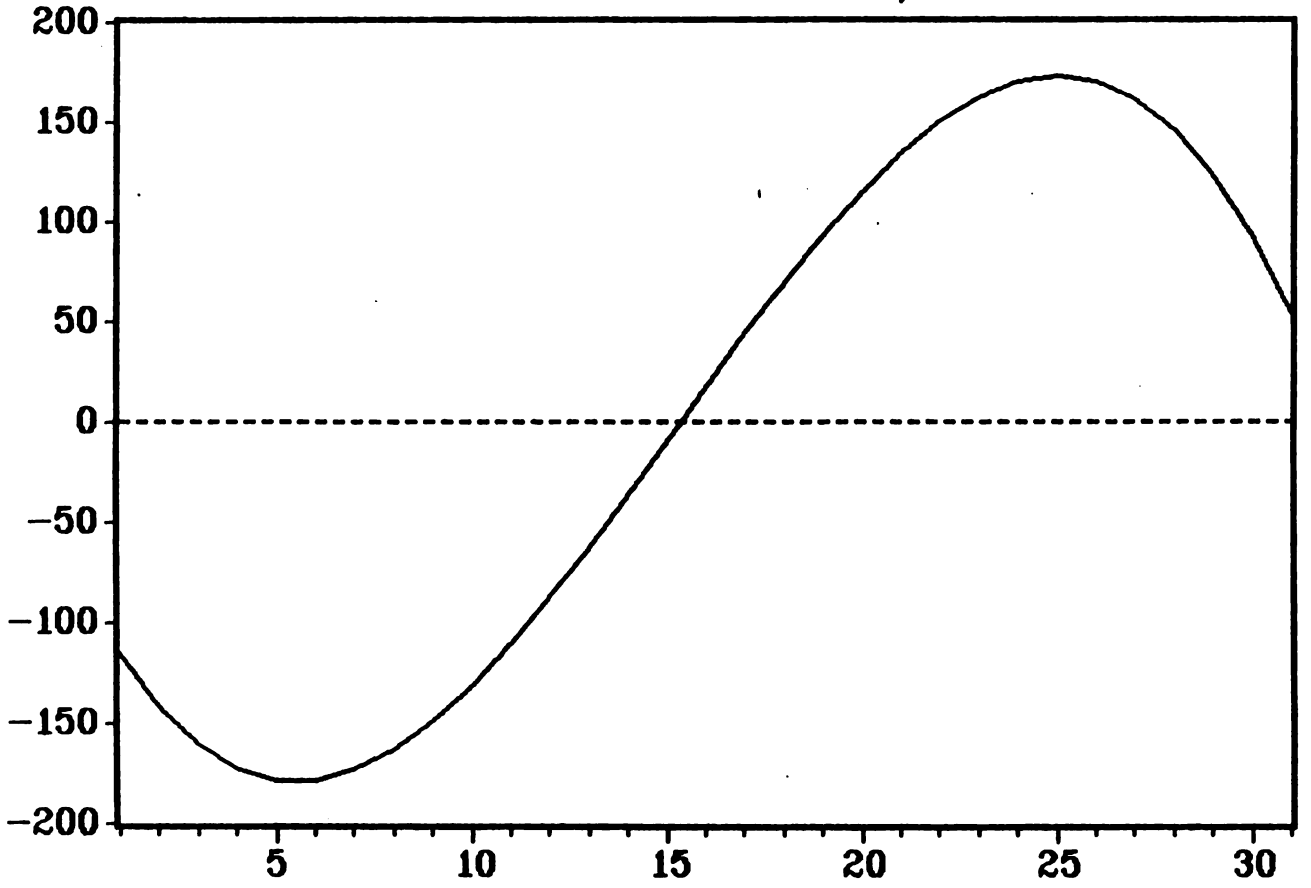
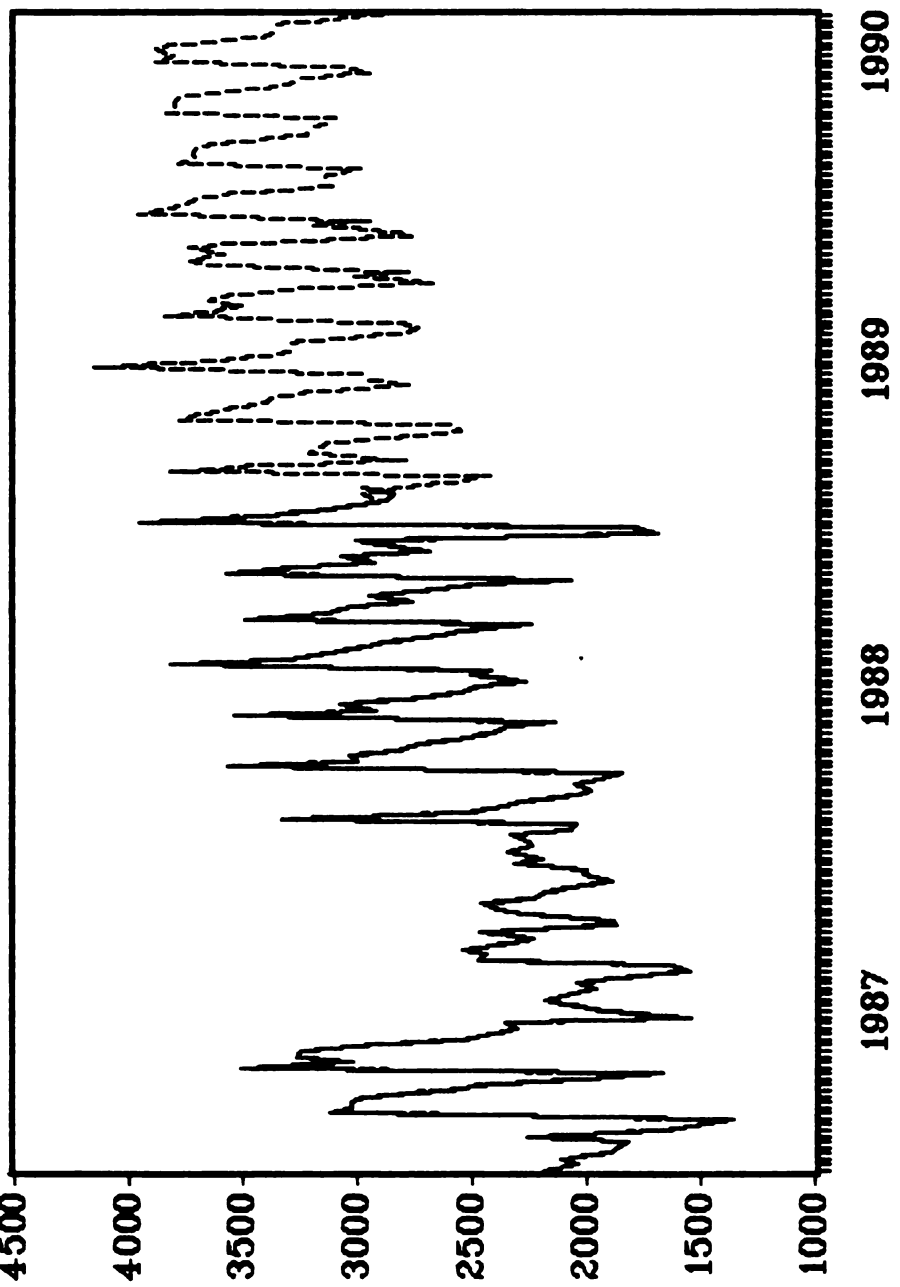


FIGURE 7.11: INSTANT GAME SALES

(ACTUAL & MURF FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)



ARMA models were constructed for each of the three games. In the Lotto game, the ARMA model had AR terms at lags of one and four weeks and MA terms at lags of two and 52 weeks. In the ARMA Daily game models, AR terms were employed at lags of one four and nine weeks and an MA(52) term was used to capture seasonal variation. In the Instant game ARMA model, an AR term with a lag of one week was used along with MA terms at lags of two, eight, nine, and 52 weeks.

Second, a Vector Auto Regressive (VAR) model of the three types of games with lags at one, two, three, four and 52 weeks was estimated.

Finally, a Seemingly Unrelated Regressions (SUR) model was estimated using the MURF equations without AR and MA terms. The results of simulating these models over the twenty week period from the first week in October, 1988 to the second week in February, 1989 are shown in Tables 7.6 through 7.11 and illustrated in Figures 7.12 through 7.23. It should be noted that the simulations for all models are based on regressions run between November 1986 and February 1989. Overall the results are very encouraging, with the MURF models equaling or outperforming the competition in all but one instance. This was in models of the Daily game where the MURF model was outperformed by the ARMA model.

Table 7.6: Lotto Game Sales, (Performance of MURF & ARMA Forecasts, October 1988 to February 1989)

	LOTTO	MURF EST	ERROR	ARMA EST	ERROR
209	10.0	10.0	-0.0	10.3	0.3
210	8.7	8.8	0.1	13.5	4.8
211	9.7	10.0	0.3	20.2	10.5
212	8.2	7.6	-0.6	13.9	5.7
213	11.1	11.1	-0.0	12.1	1.0
214	7.4	7.5	0.1	12.4	5.0
215	9.2	9.4	0.2	14.6	5.4
216	7.0	7.3	0.3	14.3	7.3
217	7.5	7.9	0.4	12.5	5.0
218	7.6	7.8	0.2	12.2	4.6
219	9.4	9.3	-0.1	14.3	4.9
220	15.4	14.4	-1.0	14.1	-1.3
221	13.5	13.5	-0.0	12.4	-1.1
222	7.9	8.7	0.8	10.8	2.9
223	8.0	8.6	0.6	12.4	4.4
224	7.1	7.8	0.7	20.4	13.3
225	7.6	7.9	0.3	18.4	10.8
226	9.6	9.1	-0.5	12.1	2.5
227	9.9	9.8	-0.1	13.4	3.5
228	7.5	8.2	0.7	15.4	7.9
RMSE			0.4		6.1

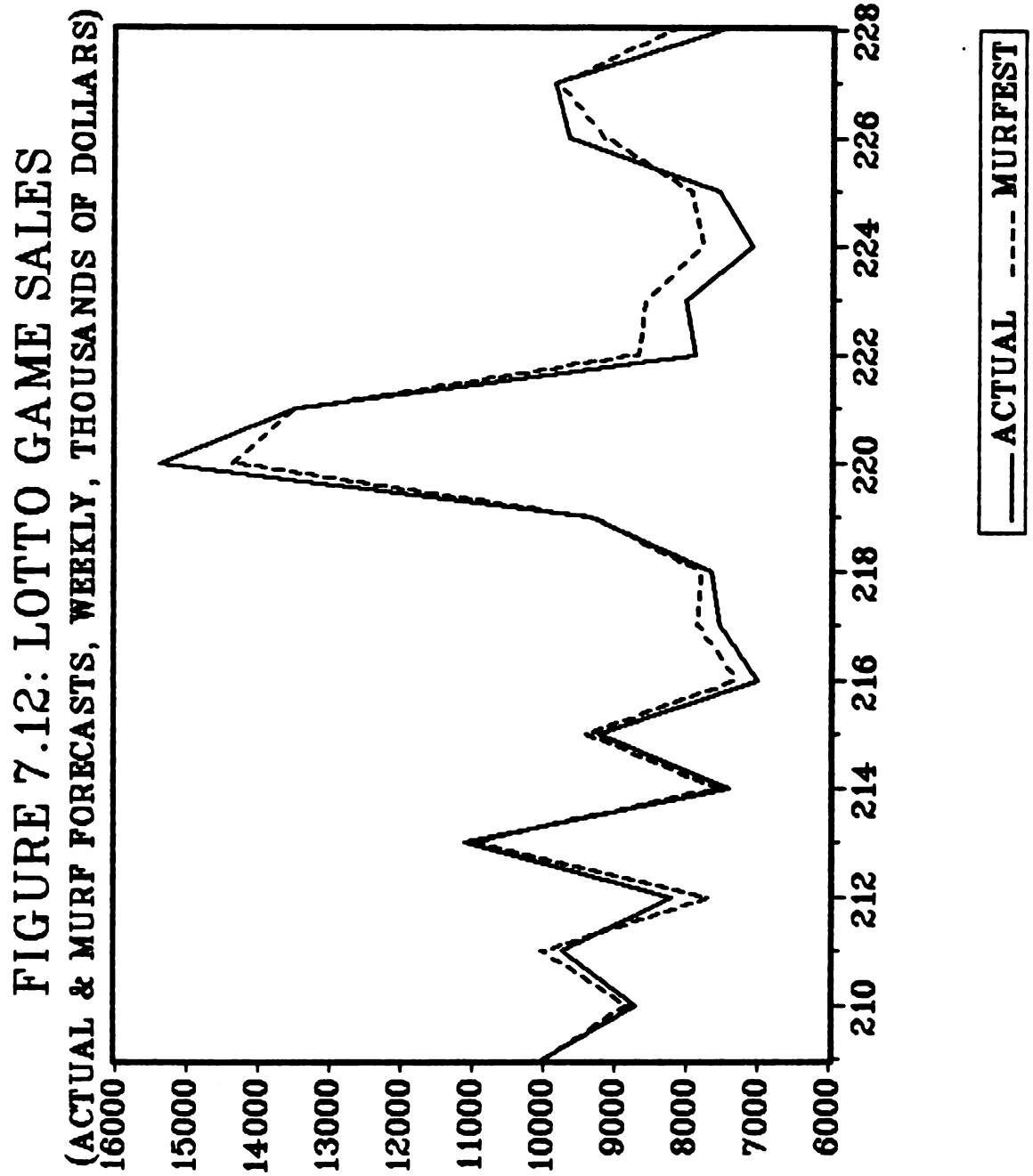


FIGURE 7.12: LOTTO GAME SALES
(ACTUAL & MURF FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
210
212
214
216
218
220
222
224
226
228
ACTUAL
MURFEST

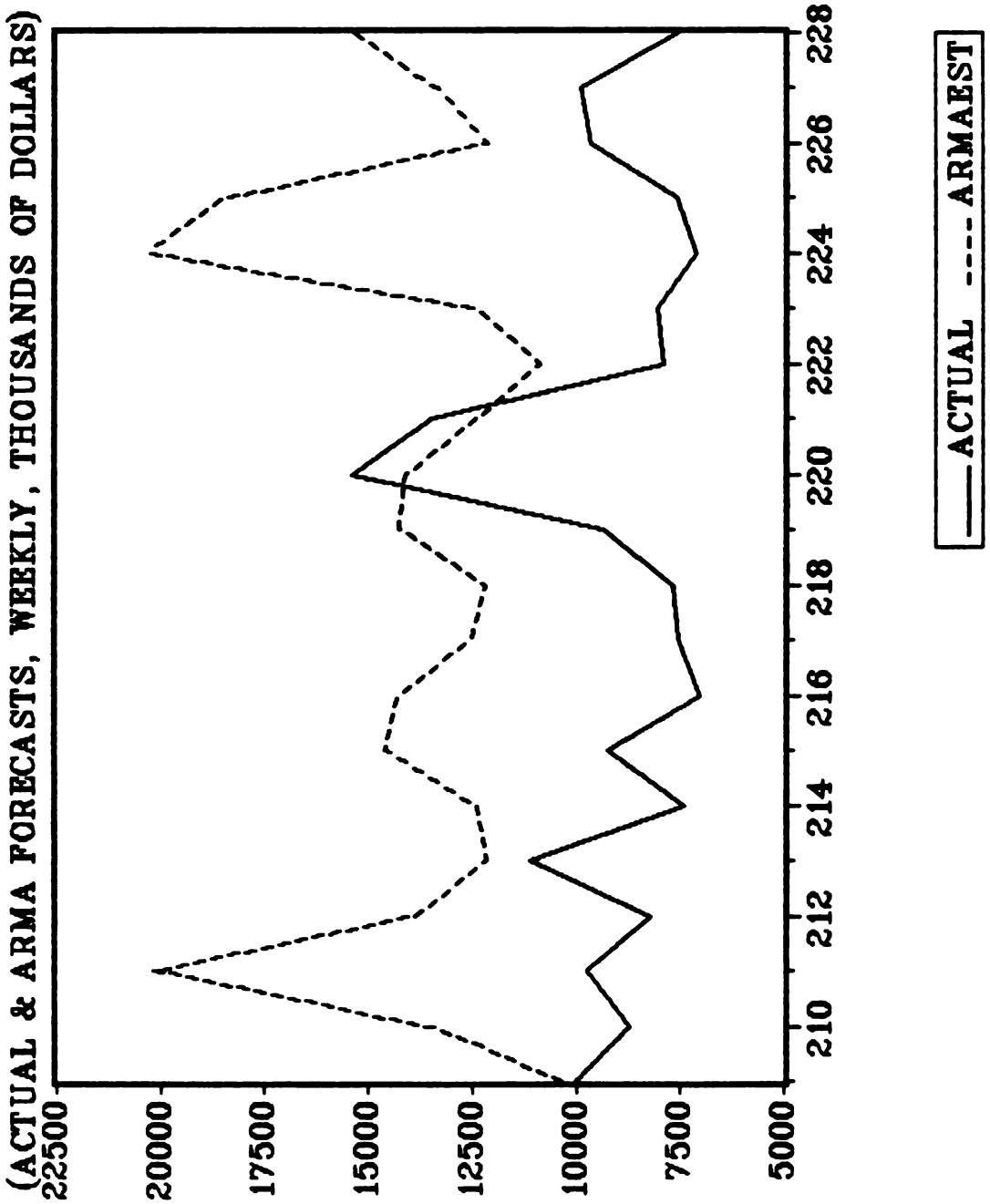


FIGURE 7.13: LOTTO GAME SALES
(ACTUAL & ARMA FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)
22500
20000
17500
15000
12500
10000
7500
5000
210
212
214
216
218
220
222
224
226
228
ACTUAL
ARMAEST

Table 7.7: Lotto Game Sales, (Performance of VAR & SUR Forecasts, October 1988 to February 1989)

	LOTTO	VAR EST	ERROR	SUR EST	ERROR
209	10.0	8.6	-1.4	11.2	1.2
210	8.7	17.1	8.4	9.5	0.8
211	9.7	20.9	11.2	10.7	1.0
212	8.2	12.9	4.7	7.2	-1.0
213	11.1	10.7	-0.4	10.9	-0.2
214	7.4	14.0	6.6	7.0	-0.4
215	9.2	15.6	6.4	9.1	-0.1
216	7.0	14.0	7.0	6.6	-0.4
217	7.5	12.0	4.5	7.5	-0.0
218	7.6	11.7	4.1	7.2	-0.4
219	9.4	13.6	4.2	8.8	-0.6
220	15.4	14.1	-1.3	13.9	-1.5
221	13.5	13.5	0.0	13.3	-0.2
222	7.9	11.9	4.0	8.6	0.7
223	8.0	13.5	5.5	8.3	0.3
224	7.1	17.4	10.3	7.4	0.3
225	7.6	17.9	10.3	7.5	-0.1
226	9.6	13.8	4.2	8.6	-1.0
227	9.9	13.5	3.6	9.3	-0.6
228	7.5	17.6	10.1	7.5	0.0
RMSE			6.3		0.7

FIGURE 7.14: LOTTO GAME SALES

(ACTUAL & VAR FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)

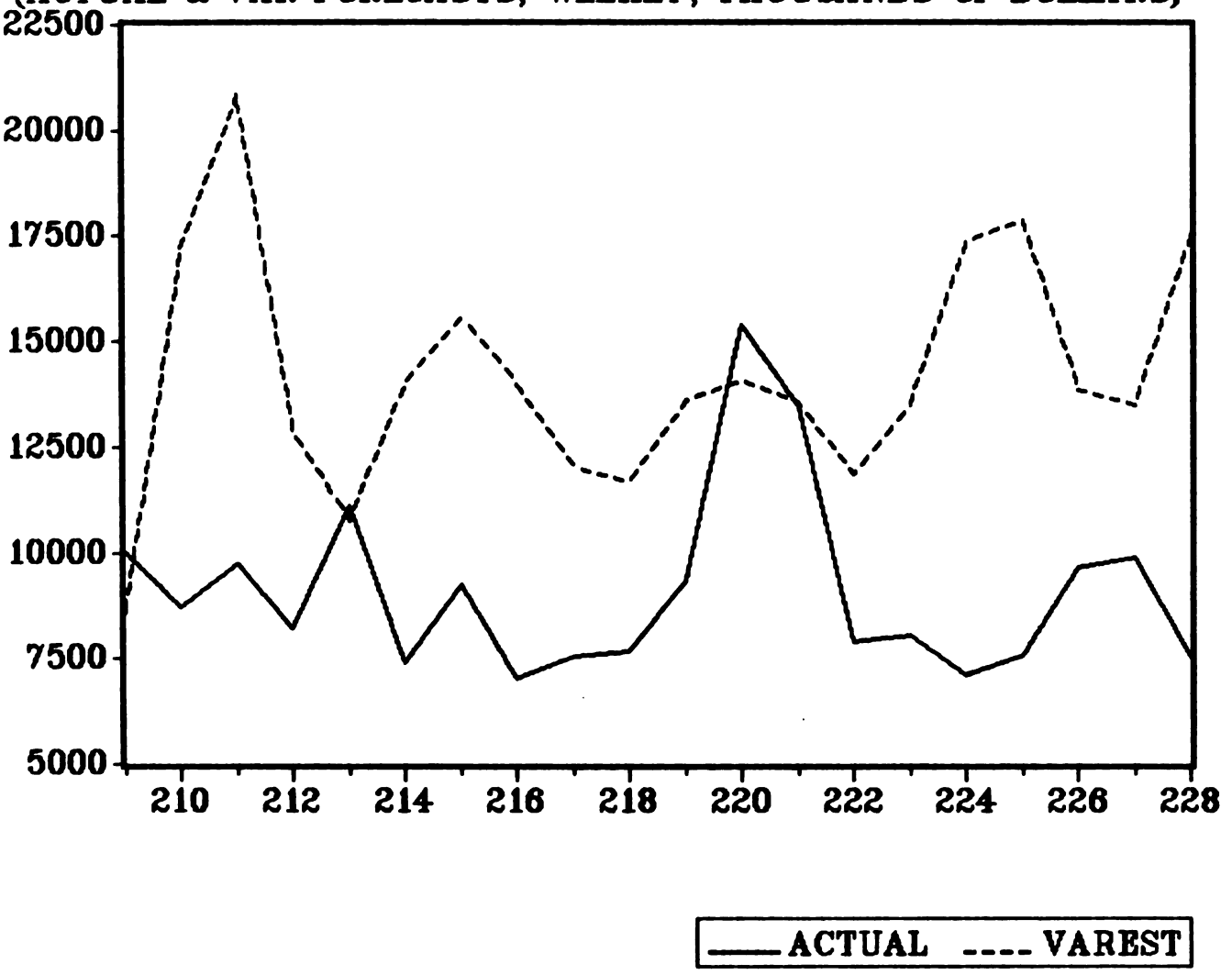


FIGURE 7.15: LOTTO GAME SALES

(ACTUAL & SUR FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)

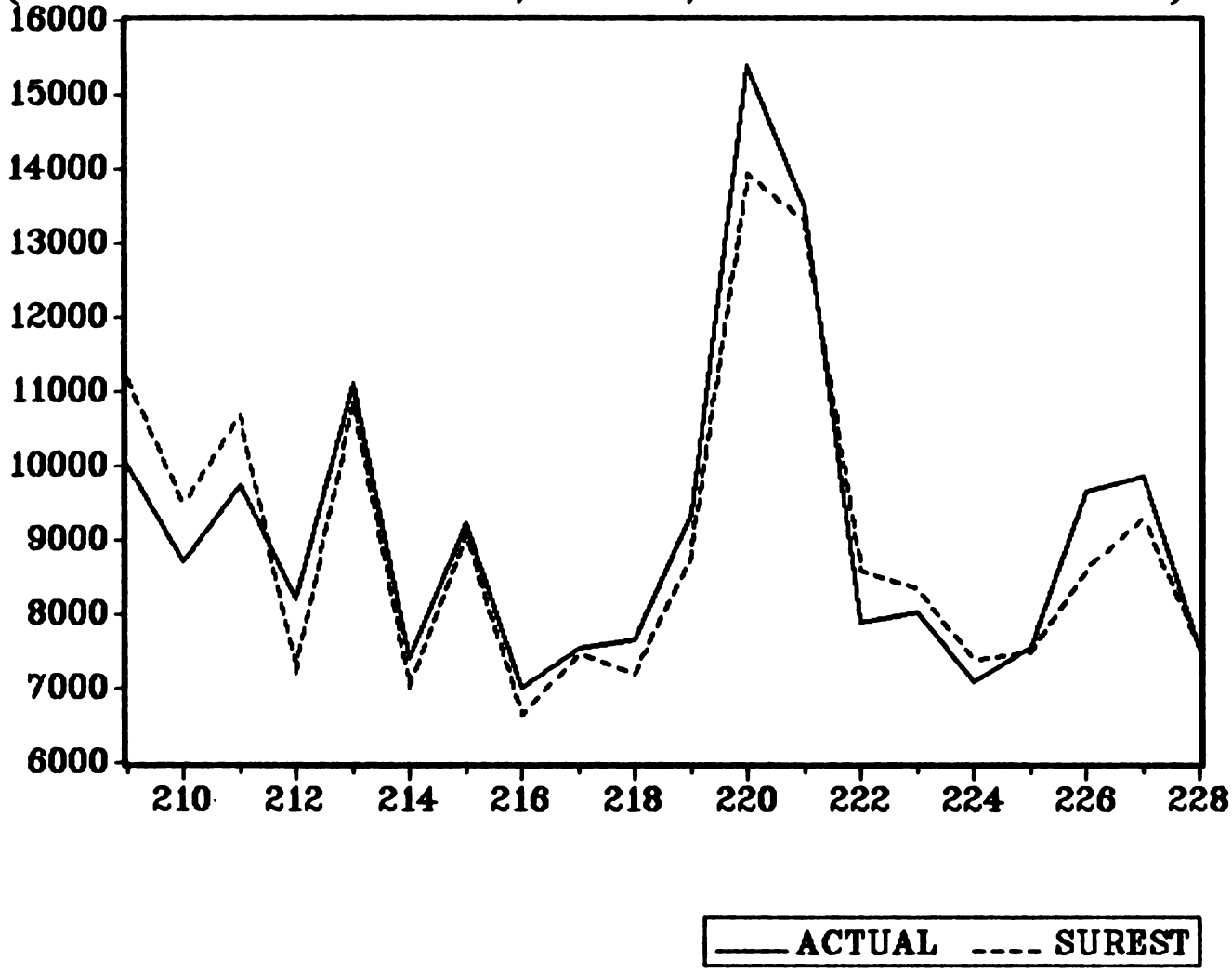
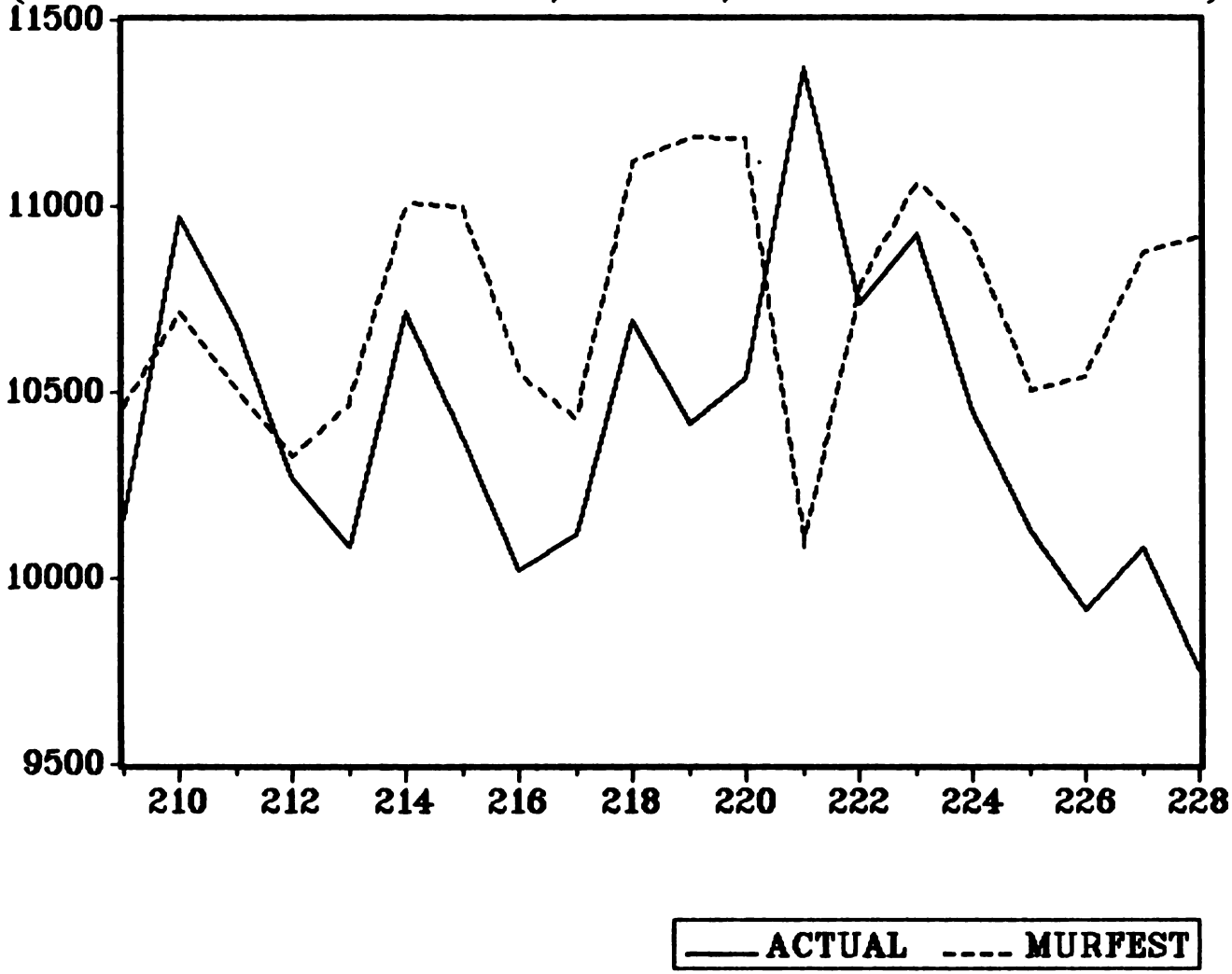


Table 7.8: Daily Game Sales, (Performance of MURF & ARMA Forecasts, October 1988 to February 1989)

	DAILY	MURF EST	ERROR	ARMA EST	ERROR
209	10.2	10.5	0.3	10.4	0.2
210	11.0	10.7	-0.3	10.4	-0.6
211	10.7	10.5	-0.2	10.4	-0.3
212	10.3	10.3	0.0	10.3	0.0
213	10.1	10.5	0.4	10.3	0.2
214	10.7	11.0	0.3	10.6	-0.1
215	10.4	11.0	0.6	10.7	0.3
216	10.0	10.6	0.6	10.5	0.5
217	10.1	10.4	0.3	10.4	0.3
218	10.7	11.1	0.4	10.7	-0.0
219	10.4	11.2	0.8	10.7	0.3
220	10.5	11.2	0.7	10.6	0.1
221	11.4	10.1	-1.3	10.4	-1.0
222	10.7	10.8	0.1	10.5	-0.2
223	10.9	11.1	0.2	10.5	-0.4
224	10.4	10.9	0.5	10.7	0.3
225	10.1	10.5	0.4	10.1	0.0
226	9.9	10.5	0.6	10.3	0.4
227	10.1	10.9	0.8	10.4	0.3
228	9.8	10.9	1.1	10.4	0.6
RMSE			0.6		0.4

FIGURE 7.16: DAILY GAME SALES

(ACTUAL & MURF FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)



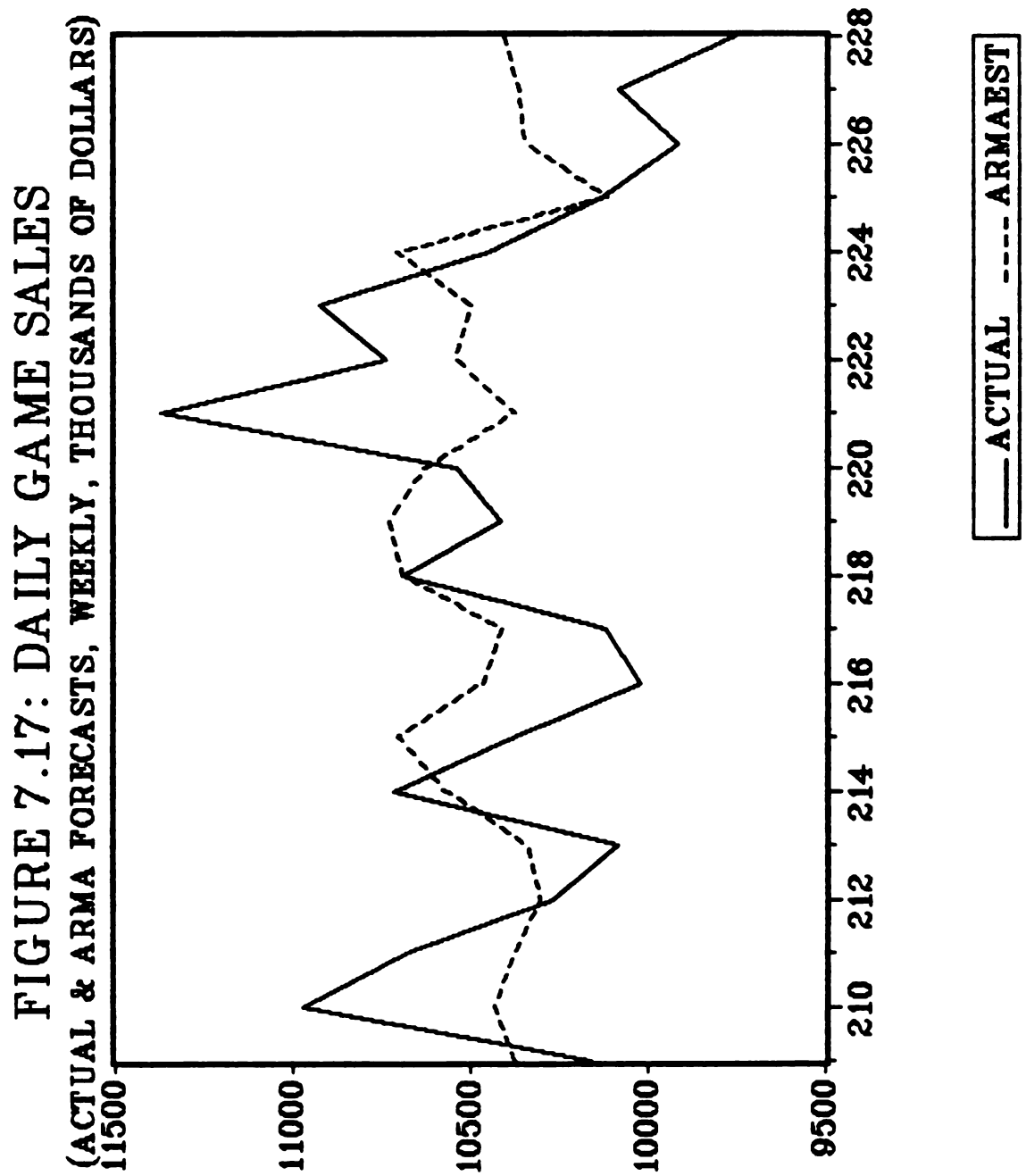


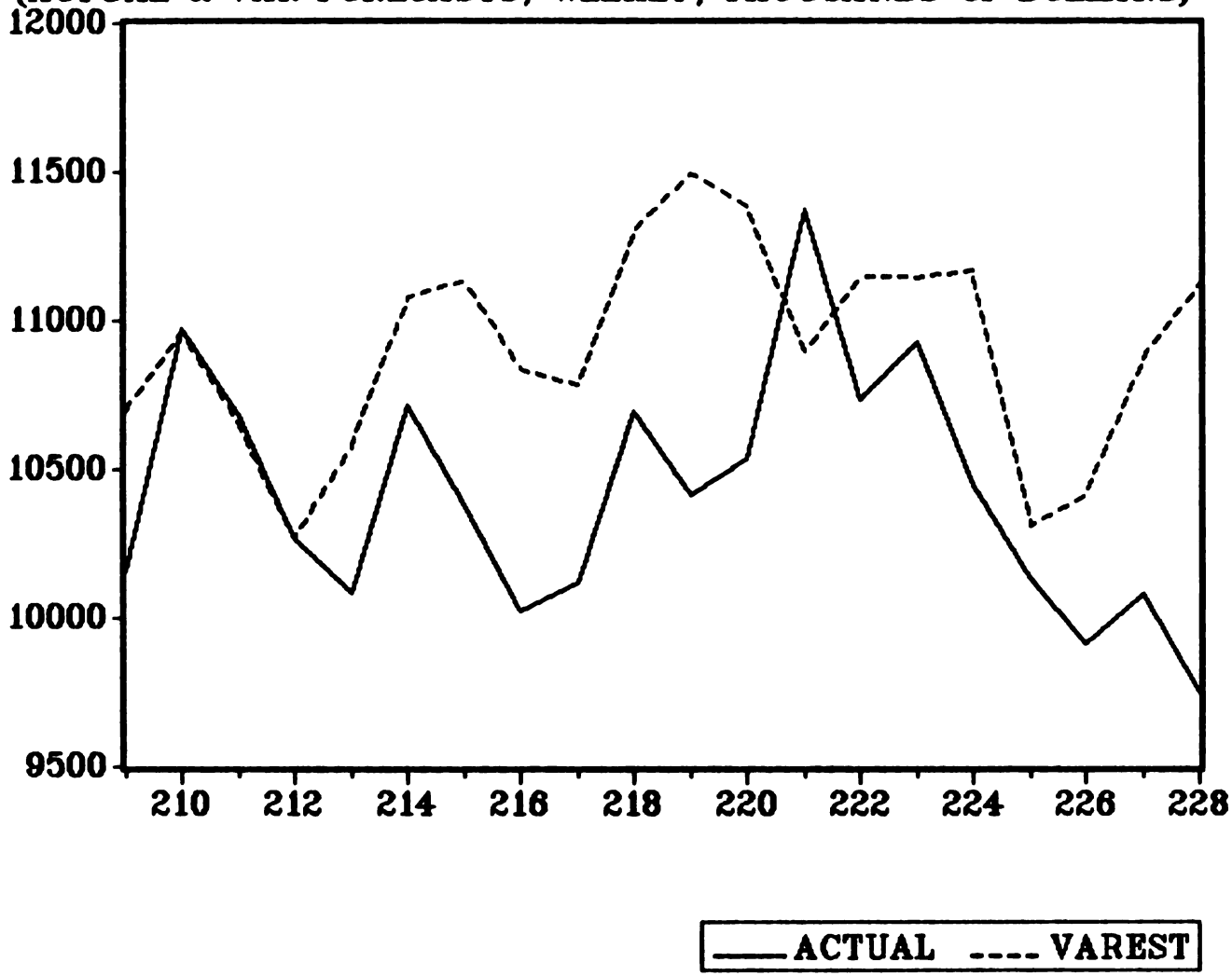
FIGURE 7.17: DAILY GAME SALES
(ACTUAL & ARMA FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)
11500
11000
10500
10000
9500
210
212
214
216
218
220
222
224
226
228
ACTUAL
ARMAEST

Table 7.9: Daily Game Sales, (Performance of VAR & SUR Forecasts, October 1988 to February 1989)

	DAILY	VAR EST	ERROR	SUR EST	ERROR
209	10.2	10.7	0.5	10.7	0.5
210	11.0	11.0	0.0	11.0	-0.0
211	10.7	10.6	-0.1	10.7	-0.0
212	10.3	10.3	0.0	10.4	0.1
213	10.1	10.6	0.5	10.5	0.4
214	10.7	11.1	0.4	11.0	0.3
215	10.4	11.1	0.7	10.9	0.5
216	10.0	10.8	0.8	10.6	0.6
217	10.1	10.8	0.7	10.5	0.4
218	10.7	11.3	0.6	11.0	0.3
219	10.4	11.5	1.1	11.0	0.6
220	10.5	11.4	0.9	11.2	0.7
221	11.4	10.9	-0.5	10.3	-1.1
222	10.7	11.1	0.4	10.8	0.1
223	10.9	11.1	0.2	11.2	0.3
224	10.4	11.2	0.8	10.9	0.5
225	10.1	10.3	0.2	10.6	0.5
226	9.9	10.4	0.5	10.7	0.8
227	10.1	10.9	0.8	11.1	1.0
228	9.8	11.1	1.3	11.1	1.3
RMSE			0.6		0.6

FIGURE 7.18: DAILY GAME SALES

(ACTUAL & VAR FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)



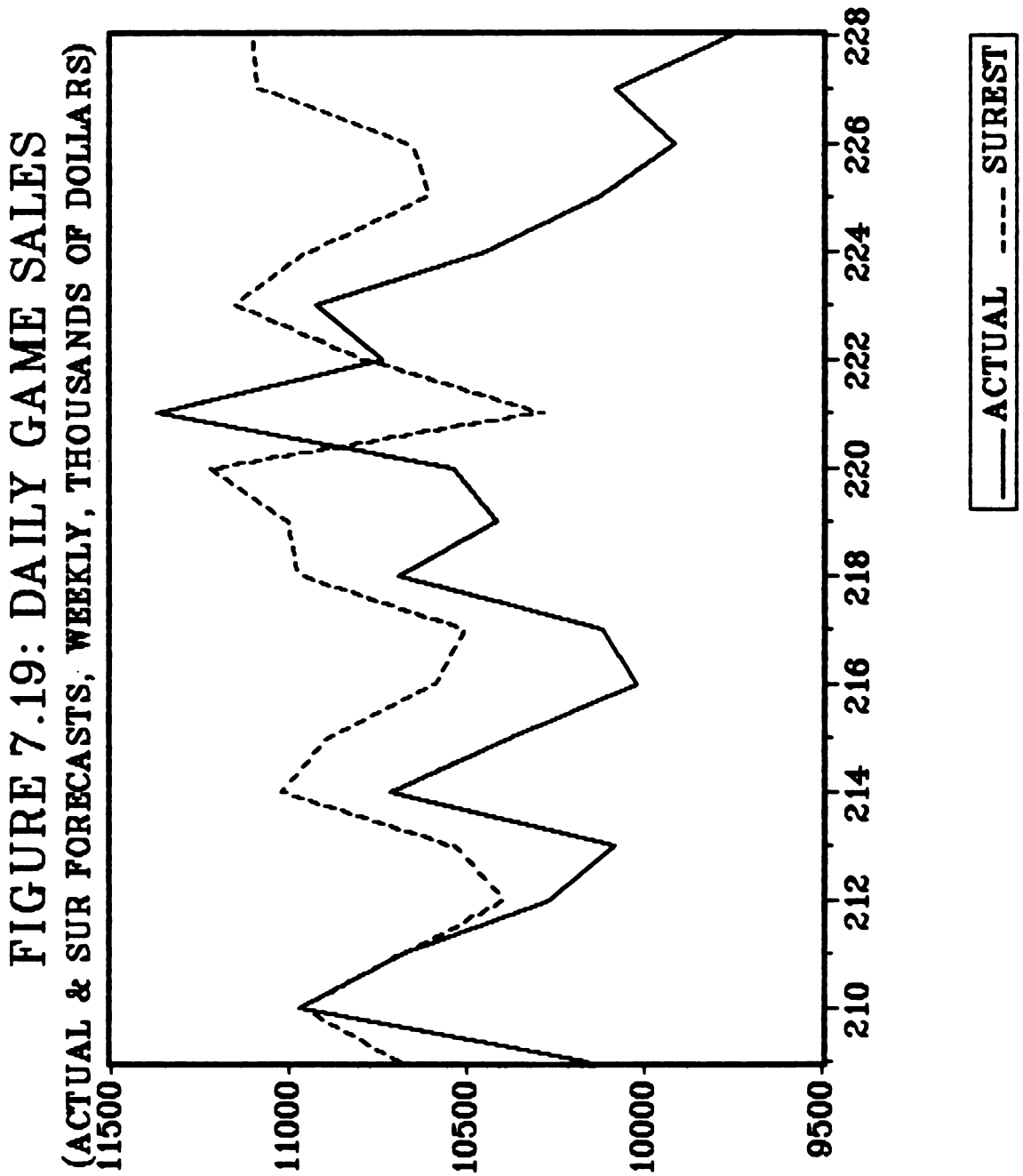


FIGURE 7.19: DAILY GAME SALES
(ACTUAL & SUR FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)
11500
11000
10500
10000
9500
210
212
214
216
218
220
222
224
226
228
ACTUAL
SUREST

Table 7.10: Instant Game Sales, (Performance of MURF & ARMA Forecasts, October 1988 to February 1989)

	INSTANT	MURF EST	ERROR	ARMA EST	ERROR
209	3.0	3.1	0.1	3.0	-0.0
210	2.8	3.0	0.2	2.5	-0.3
211	2.9	3.0	0.1	2.5	-0.4
212	2.7	2.9	0.2	2.4	-0.3
213	2.5	2.8	0.3	2.5	0.0
214	2.1	2.5	0.4	2.7	0.6
215	3.6	3.4	-0.2	2.8	-0.8
216	3.2	3.4	0.2	2.7	-0.5
217	2.9	3.4	0.5	2.5	-0.4
218	3.1	3.1	-0.0	2.5	-0.6
219	2.7	2.9	0.2	2.5	-0.2
220	2.9	3.0	0.1	2.4	-0.5
221	3.0	3.1	0.1	2.5	-0.5
222	1.7	2.6	0.9	2.4	0.7
223	1.8	2.6	0.8	2.3	0.5
224	4.0	3.6	-0.4	2.7	-1.3
225	3.4	3.6	0.2	2.5	-0.9
226	3.2	3.4	0.2	2.3	-0.9
227	3.0	3.0	0.0	2.3	-0.7
228	2.9	2.9	-0.0	2.3	-0.6
RMSE			0.4		0.6

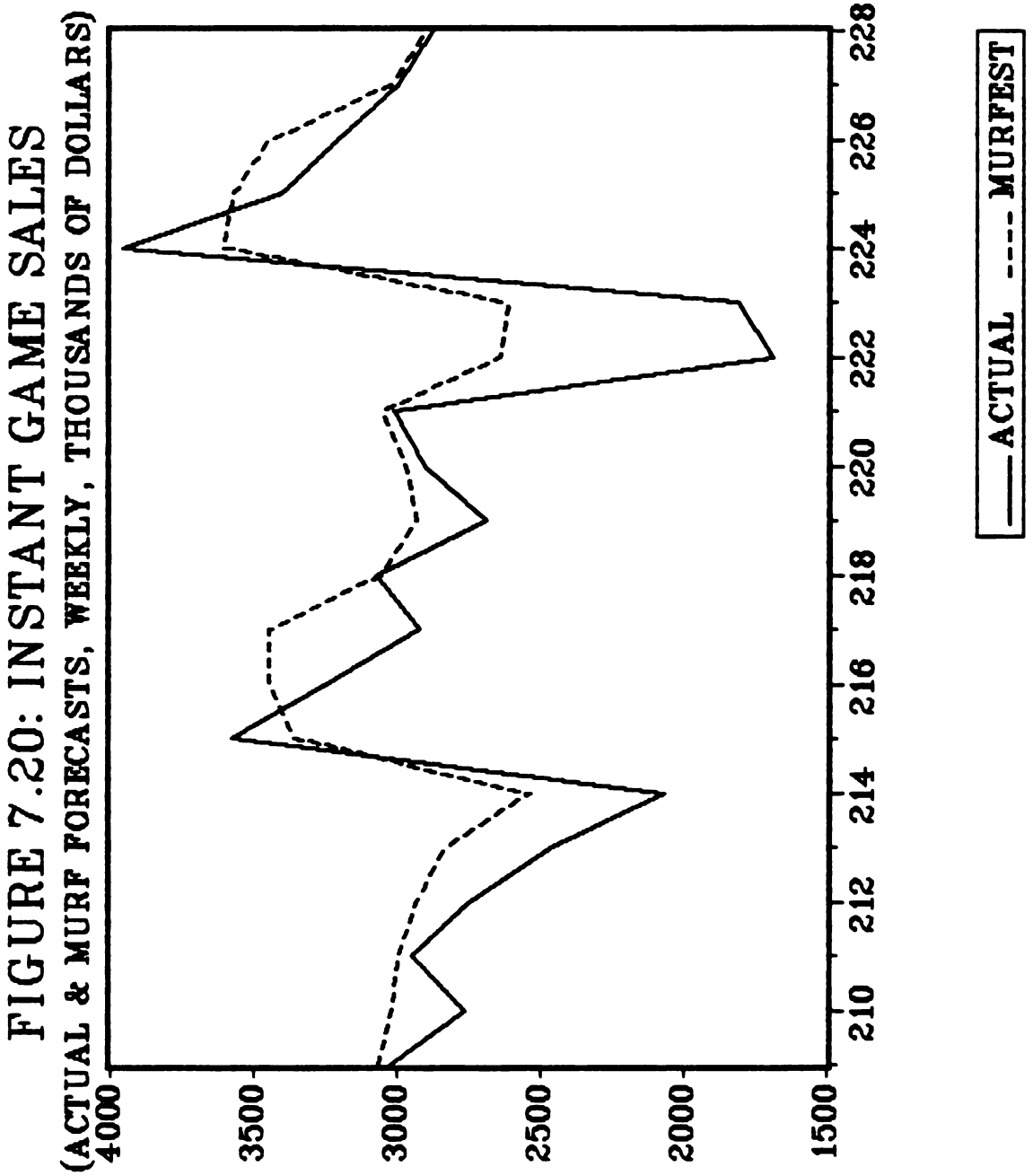


FIGURE 7.20: INSTANT GAME SALES
(ACTUAL & MURF FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)
4000
3500
3000
2500
2000
1500
210
212
214
216
218
220
222
224
226
228
ACTUAL
MURFEST

FIGURE 7.21: INSTANT GAME SALES

(ACTUAL & ARMA FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)

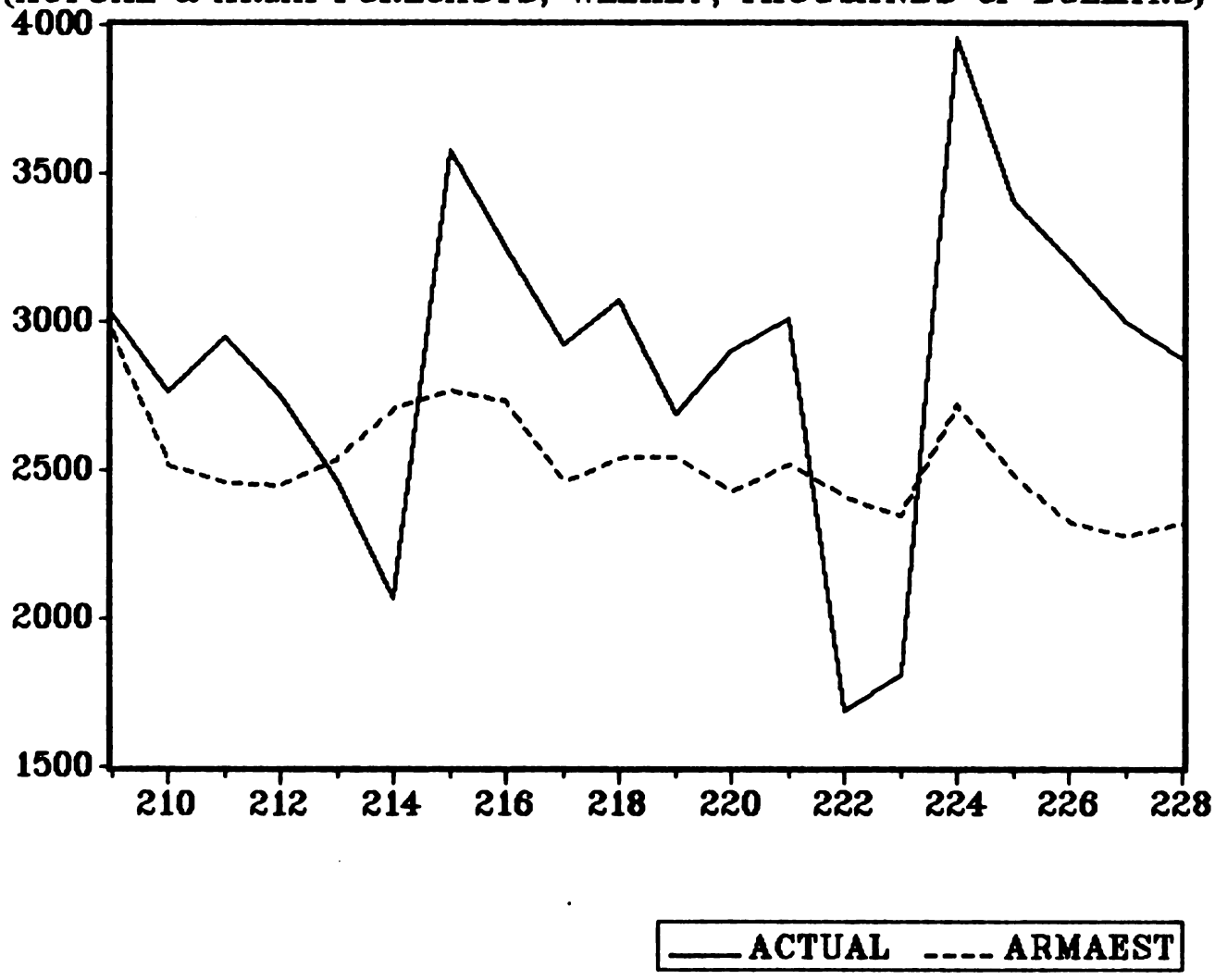


Table 7.11: Instant Game Sales, (Performance of VAR & SUR Forecasts, October 1988 to February 1989)

INSTANT	VAR EST	ERROR	SUR EST	ERROR	
209	3.0	3.0	0.0	3.1	0.1
210	2.8	2.9	0.1	3.0	0.2
211	2.9	3.4	0.5	3.0	0.1
212	2.7	3.0	0.3	3.0	0.3
213	2.5	2.9	0.4	3.0	0.5
214	2.1	2.8	0.7	2.6	0.5
215	3.6	2.7	-0.9	3.5	-0.1
216	3.2	2.9	-0.3	3.5	0.3
217	2.9	2.9	0.0	3.5	0.6
218	3.1	2.8	-0.3	3.2	0.1
219	2.7	2.9	0.2	3.1	0.4
220	2.9	3.1	0.2	3.1	0.2
221	3.0	3.3	0.3	2.9	-0.1
222	1.7	3.2	1.5	2.7	1.0
223	1.8	3.3	1.5	2.7	0.9
224	4.0	4.1	0.1	3.6	-0.4
225	3.4	4.5	1.1	3.6	0.2
226	3.2	4.1	0.9	3.6	0.4
227	3.0	3.6	0.6	3.2	0.2
228	2.9	3.5	0.6	3.1	0.2
RMSE			0.7		0.4

FIGURE 7.22: INSTANT GAME SALES

(ACTUAL & VAR FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)

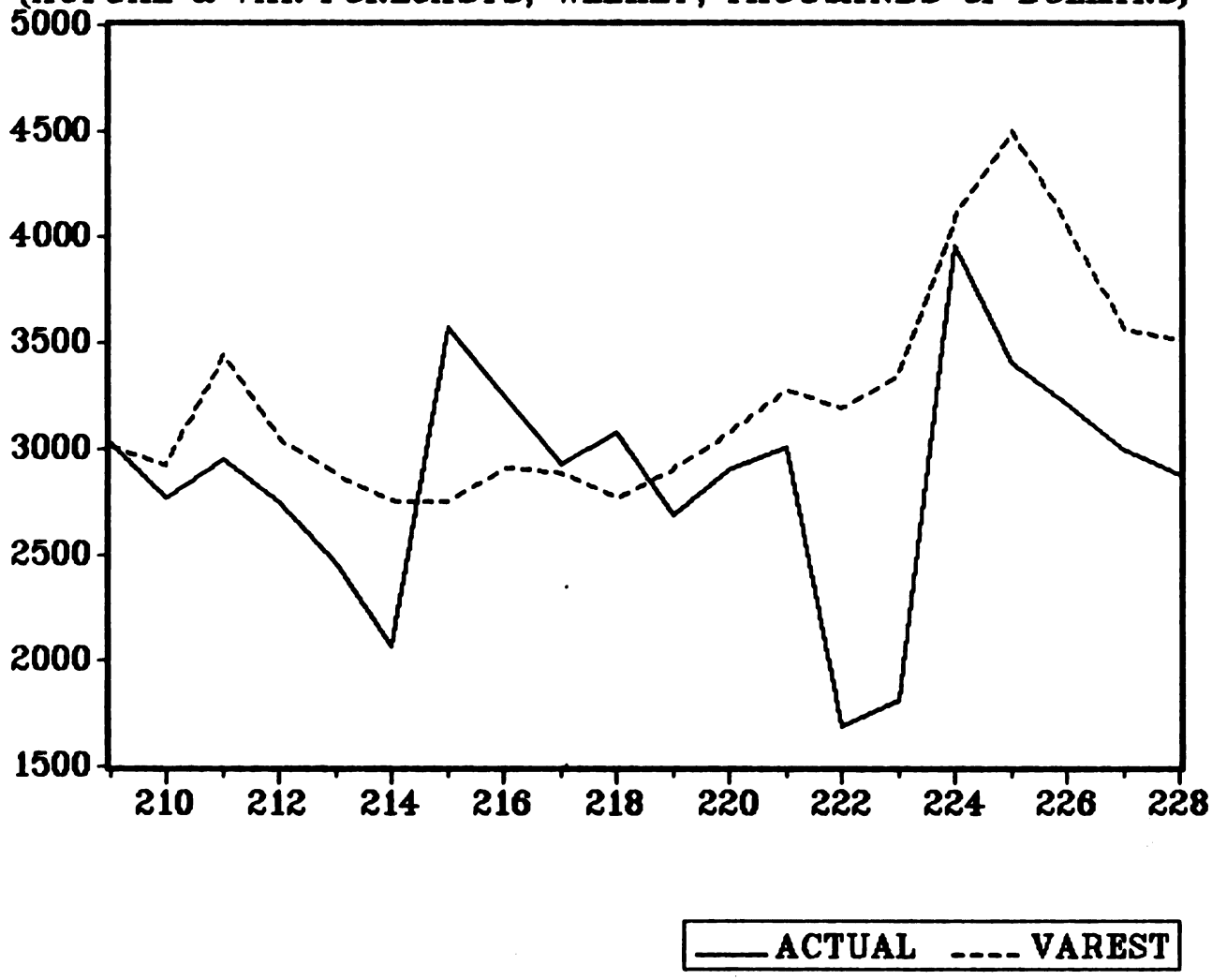
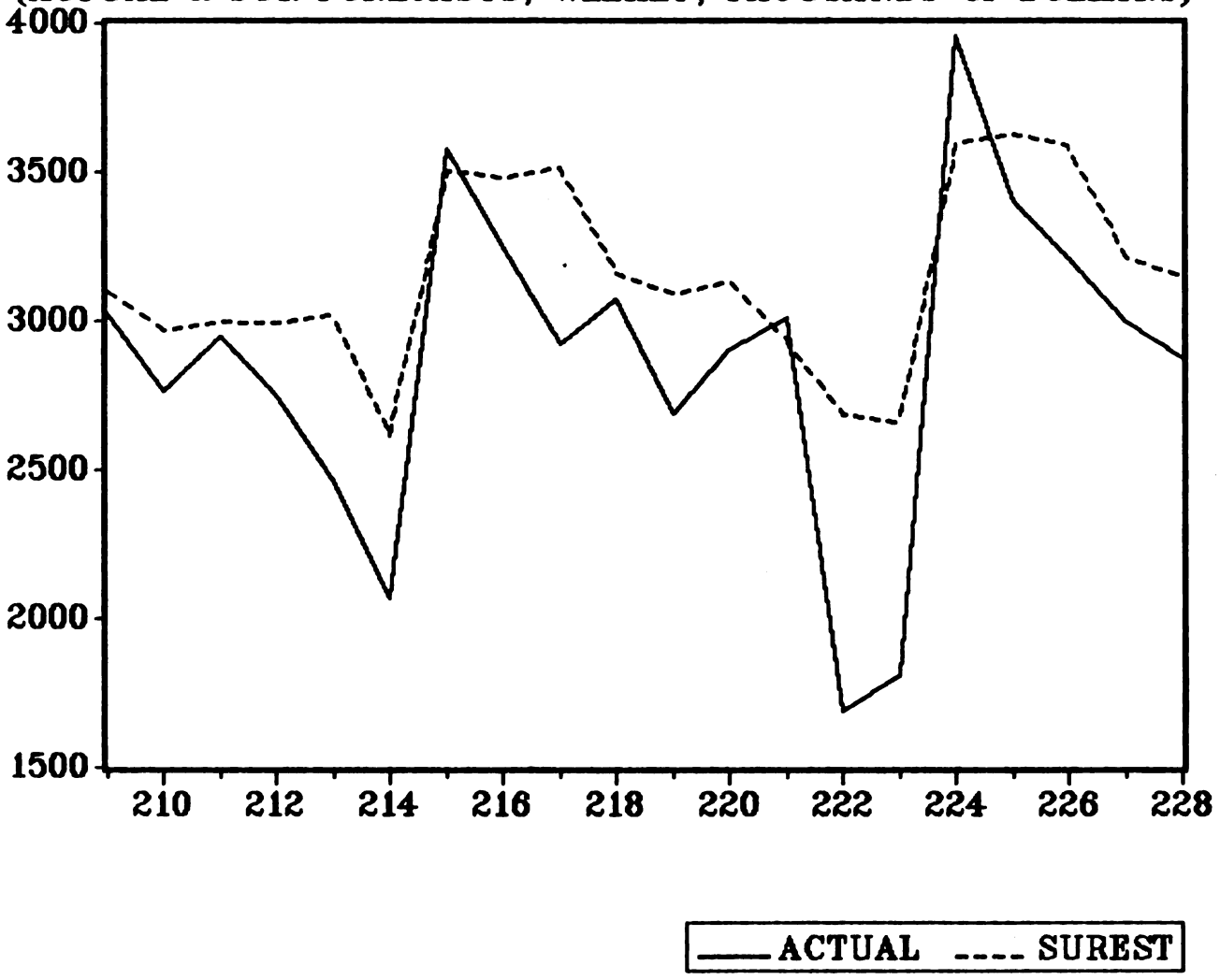


FIGURE 7.23: INSTANT GAME SALES

(ACTUAL & SUR FORECASTS, WEEKLY, THOUSANDS OF DOLLARS)



CHAPTER VIII

CONCLUSION

Having steadfastly resisted the urge to be concise in every other part of this work, I will at least be brief in its conclusion. It is normal, at this point in a thesis, to reiterate observations already made in the abstract, introduction and in each of the chapters. I will not do so here. If the reader has reached this 301st page the hard way, he or she deserves a break.

It is also standard practice to proclaim the urgent need for further research in this area. This convention I am willing to adhere to, although with a slight feeling of hypocrisy. After being deprived for months of adequate sleep or social contact in the preparation of this dissertation, urging others to follow seems a little too like a swimmer, who diving into lake Michigan about four weeks too early in the year, conjures up a smile, in spite of his pain, and urges those on the shore to "come on in - the water's fine!".

Nevertheless, some serious points should be made in conclusion. The MURF models, as currently constructed generally performed well in a battery of specification tests. In every equation in which seasonal dummies are

employed, they were found to be significant by likelihood ratio tests. The Box-Pierce test for white noise residuals was failed only once in 26 equations, at the five percent level. Tests for structural stability were failed in only three equations.[1]

The partial R^2, given seasonal dummies, MA and AR terms, ranged from highs of .97 and .98 in the case of the sales and use tax equations to a low of .09 in the case of the beer & wine excise tax equation. I hope and generally believe that where low partial R^2's are encountered, this is due to the dominance of seasonal trends over measurable economic forces rather than gross misspecification.

The model of state revenues, outlined in these chapters, also clearly outperforms its competitors in terms of forecasting ability. In 11 of 12 forecast simulation comparisons with SQEM models, the MURF equations were found to produce lower root mean square errors. The same result occured in 13 of 16 comparisons with ARMA models and 7 of 11 comparisons with VAR models.

The credit for performance of these equations should not be ascribed to any unique insight of their author. For the most part the accuracy of these equations is derived from the fact that they are in a constant state of flux, with all issues of specification being frequently reviewed.

No outlier, still tolerated or undiscovered as I write,

1. The reasons for the maintenance of the current specification for the four equations which fail one of these tests are outlined in the text.

can feel assured that it will not be summarily replaced by a dummy variable within the next few months or even weeks. No regressor, even after being cut from the team, should dispair of receiving another audition. Moreover, independent variables as yet unknown are constantly being scouted.

This is as it should be. The MURF models as currently constructed reflect the state taxes and the Michigan economy as they are in 1989. If they are left unchanged then in five years they will be barely adequate. In ten years they will be obsolete.

It would be pleasant to believe that MURF will continue to evolve long after its author has ceased to tend to it. If this does not occur then I would be satisfied if those who follow in this endeavour adhere to just one tenet of this work. That is to recognize that the economy and the structure of taxes in Michigan are in a constant state of evolution and that the best forecasts can only be obtained from models that evolve with them.

APPENDICES

APPENDIX A

THE USE OF DCR, CDCR AND MRSB DATA

In using MURF models of state revenues, decisions have to be made about data sources which are known to contain some degree of error. Within a few days of the end of a month, Daily Collection Record, (DCR), data is released for that month for all the major taxes. One month after that, Corrected Daily Collection Record, (CDCR), data is published. After a further month, the data along with some additional corrections is published in the Monthly Research and Statistical Bulletin, (MRSB). This means that at any point in time, data for the last two months of revenue collections are preliminary.[1]

There is no doubt that the revisions to the data will tend to make the MRSB data the most accurate. But this still leaves the question of whether the DCR and CDCR data should be incorporated into forecasts, and if so, how.

For both the DCR data and the CDCR data, there are three possible courses of action. First, this data could be ignored entirely. Second, the data could be used to replace

1. Although this is a key question in the month-to-month operations of MURF, it does not affect any of the regressions in this dissertation, since all regressions examined extend no further than December 1988, for which we now have final data.

forecast values, but be left out of the fit period for the regression. Third, the regression could be reestimated using the new data.

Dealing first with the use of CDCR data, the key question is whether this data is more accurate than a one-month-ahead forecast of that tax. If it is, then it would clearly be inefficient to ignore the data entirely. But if it inefficient to ignore the data entirely, it is probably also inefficient to omit it from the fit period of the regression. This is especially the case because of the AR and MA terms in nine of the ten regressions for which this decision needs to be made.

Including this data has two other advantages. First, by pulling the regression line down in the case of an unexpectedly weak month or by pushing it up in the case of an especially strong one, forecasts are adjusted in the light of new data. This adjustment should be at least in the intuitively correct direction, even if not, necessarily, of a sufficient magnitude. Second, from a purely operational point of view, working with the freshest data allows for a very early warning on budgetary problems ahead.

If the decision is made to use CDCR data, then the same question may be asked of DCR data. Is DCR data better than the best forecast that can be made using a fit period that ends two months previously. If it is, then it should probably be included both in the forecast and in regressions used to forecast future months.

Tables A1 through A14 compare the errors associated with relying on short-term forecasts with those associated with relying on preliminary data. With the single exception of the use tax, the preliminary data is found to be superior judged by the criteria of root mean squared error.[2] Moreover, the problem with the use tax is entirely due to one clerical error in December of 1987, when $7.3 million was omitted from preliminary collection data for that month.

Consequently, in all MURF models for which such data is available, DCR data is used as the last sample observation and CDCR data is used as the penultimate sample observation along with MRSB data for all other sample points on a monthly basis.

2. In addition to root mean squared error, these tables also show average error. These statistics may prove useful in evaluating the size of probable upward revisions in DCR and CDCR data ahead of time.

Income Tax Withholding

Table A.1: Income Tax Withholding: CDCR Data & One-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	CDCR EST.	ERROR	1 MONTH AHEAD EST.	ERROR
JAN.	330,312	330,545	233	332,518	2,206
FEB.	316,638	316,808	170	318,386	1,748
MAR.	279,065	279,217	152	274,770	(4,295)
APR.	297,240	294,801	(2,439)	296,111	(1,129)
MAY	285,951	286,155	204	288,036	2,085
JUN.	298,282	298,466	184	307,015	8,733
JUL.	311,842	312,045	203	308,843	(2,999)
AUG.	315,754	315,979	225	315,130	(624)
SEP.	269,018	260,739	(8,279)	271,425	2,407
OCT.	288,806	288,914	108	300,358	11,552
NOV.	318,104	318,276	172	326,835	8,731
DEC.	275,941	275,959	18	285,786	9,845
RMSE			2,497		5,986
MEAN ERROR			(754)		3,188

Table A.2: Income Tax Withholding: DCR Data & Two-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	DCR EST.	ERROR	2 MONTH AHEAD EST.	ERROR
JAN.	330,312	328,774	(1,538)	332,858	2,546
FEB.	316,638	314,399	(2,239)	317,890	1,252
MAR.	279,065	280,602	1,537	274,776	(4,289)
APR.	297,240	299,066	1,826	295,919	(1,321)
MAY	285,951	284,517	(1,434)	288,036	2,085
JUN.	298,282	305,190	6,908	306,910	8,628
JUL.	311,842	304,328	(7,514)	309,004	(2,838)
AUG.	315,754	314,016	(1,738)	315,180	(574)
SEP.	269,018	260,021	(8,997)	271,425	2,407
OCT.	288,806	287,453	(1,353)	300,376	11,570
NOV.	318,104	312,801	(5,303)	326,890	8,786
DEC.	275,941	270,385	(5,556)	285,864	9,923
RMSE			4,691		5,991
MEAN ERROR			(2,117)		3,181

Net Sales Tax

Table A.3: Net Sales Tax: CDCR Data
& One-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	CDCR EST.	ERROR	1 MONTH AHEAD EST.	ERROR
JAN.	234,099	233,751	(348)	242,724	8,625
FEB.	166,316	166,487	171	182,621	16,305
MAR.	161,072	160,598	(474)	163,037	1,965
APR.	183,614	183,411	(203)	194,211	10,597
MAY	198,348	199,279	931	190,502	(7,846)
JUN.	196,026	197,807	1,781	202,965	6,939
JUL.	211,788	209,108	(2,680)	208,835	(2,953)
AUG.	199,892	199,920	28	198,206	(1,687)
SEP.	208,106	203,645	(4,461)	206,299	(1,808)
OCT.	209,669	210,415	746	199,335	(10,335)
NOV.	205,451	204,726	(725)	204,792	(659)
DEC.	188,284	187,532	(752)	194,808	6,524
RMSE			1,663		7,804
MEAN ERROR			(499)		2,139

Table A.4: Net Sales Tax: DCR Data
& Two-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	DCR EST.	ERROR	2 MONTH AHEAD EST.	ERROR
JAN.	234,099	236,299	2,200	243,069	8,970
FEB.	166,316	168,659	2,343	183,146	16,830
MAR.	161,072	160,216	(856)	165,365	4,293
APR.	183,614	184,664	1,050	194,746	11,132
MAY	198,348	194,909	(3,439)	190,693	(7,655)
JUN.	196,026	195,663	(363)	203,606	7,580
JUL.	211,788	210,440	(1,348)	208,339	(3,450)
AUG.	199,892	201,371	1,479	198,097	(1,795)
SEP.	208,106	205,841	(2,265)	206,509	(1,597)
OCT.	209,669	211,529	1,860	199,902	(9,768)
NOV.	205,451	207,095	1,644	207,627	2,176
DEC.	188,284	195,561	7,277	195,280	6,996
RMSE			2,775		8,108
MEAN ERROR			799		2,809

Gross Use Tax

Table A.5: Gross Use Tax: CDCR Data
& One-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	CDCR EST.	ERROR	1 MONTH AHEAD EST.	ERROR
JAN.	36,842	36,171	(671)	34,292	(2,550)
FEB.	30,941	31,097	156	29,852	(1,089)
MAR.	27,775	27,855	80	28,674	899
APR.	33,715	33,718	3	34,107	392
MAY	35,284	34,854	(430)	33,930	(1,354)
JUN.	32,585	32,842	257	34,468	1,883
JUL.	37,356	37,110	(246)	37,686	330
AUG.	35,785	35,856	71	35,925	140
SEP.	33,175	31,818	(1,357)	35,825	2,650
OCT.	36,301	36,552	251	38,754	2,453
NOV.	34,101	34,000	(101)	35,379	1,278
DEC.	32,814	25,521	(7,293)	33,784	970
RMSE			2,158		1,575
MEAN ERROR			(773)		500

Table A.6: Gross Use Tax: DCR Data
& Two-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	DCR EST.	ERROR	2 MONTH AHEAD EST.	ERROR
JAN.	36,842	36,086	(756)	34,421	(2,421)
FEB.	30,941	30,638	(303)	29,713	(1,228)
MAR.	27,775	23,642	(4,133)	28,605	830
APR.	33,715	28,514	(5,201)	34,176	461
MAY	35,284	34,821	(463)	33,952	(1,332)
JUN.	32,585	32,163	(422)	34,409	1,824
JUL.	37,356	36,827	(529)	37,776	420
AUG.	35,785	35,841	56	35,944	159
SEP.	33,175	31,846	(1,329)	35,832	2,657
OCT.	36,301	36,256	(45)	38,907	2,606
NOV.	34,101	34,592	491	35,502	1,401
DEC.	32,814	24,102	(8,712)	33,845	1,031
RMSE			3,206		1,593
MEAN ERROR			(1,779)		534

Cigarette Tax[3]

Table A.7: Cigarette Tax: CDCR Data & One-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	CDCR EST.	ERROR	MURF ACTUAL	1 MONTH AHEAD EST.	ERROR
JAN.	25,095	25,205	110	25,069	24,967	(102)
FEB.	20,781	20,834	53	20,739	21,688	949
MAR.	20,199	20,242	43	20,218	20,901	683
APR.	22,802	22,820	18	22,763	22,874	111
MAY	22,864	22,887	23	22,981	23,376	395
JUN.	23,301	23,332	31	23,410	22,846	(564)
JUL.	24,474	24,525	51	23,741	25,242	1,501
AUG.	26,079	26,112	33	26,079	26,353	274
SEP.	23,730	23,763	33	23,744	23,995	251
OCT.	25,264	25,278	14	25,338	23,988	(1,350)
NOV.	24,006	24,046	40	23,763	23,387	(376)
DEC.	21,996	22,026	30	21,911	22,282	371
RMSE			47			728
MEAN ERROR			40			179

3. It should be noted that for cigarette tax, as well as single business tax and oil and gas severance tax, the MURF data do not correspond to the MRSB data. In the case of cigarette tax, months are measured as going from the 11th of one month to the 10th of the next. In the case of the single business tax and the oil and gas severance tax, months are measured from the 16th of one month to the 15th of the next. However, since the DCR data are only corrected in a month-end basis, the correction to the MURF data occasioned by the release of CDCR and MRSB data, is exactly the same as the correction to calendar month data.

Table A.8: Cigarette Tax: DCR Data
& Two-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	DCR EST.	ERROR	MURF ACTUAL	2 MONTH AHEAD EST.	ERROR
JAN.	25,095	25,192	97	25,069	24,979	(90)
FEB.	20,781	20,834	53	20,739	21,684	945
MAR.	20,199	20,242	43	20,218	20,942	724
APR.	22,802	22,815	13	22,763	22,924	161
MAY	22,864	22,875	11	22,981	23,381	400
JUN.	23,301	23,329	28	23,410	22,860	(550)
JUL.	24,474	24,529	55	23,741	25,211	1,470
AUG.	26,079	26,109	30	26,079	26,430	351
SEP.	23,730	23,762	32	23,744	24,004	260
OCT.	25,264	25,268	4	25,338	24,002	(1,336)
NOV.	24,006	24,043	37	23,763	23,312	(451)
DEC.	21,996	22,025	29	21,911	22,263	352
RMSE			43			729
MEAN ERROR			36			186

Single Business Tax[4]

Table A.9: SBT Estimated Payments: DCR Data
& One-Month Ahead MURF Forecasts

1987	CDCR ACTUAL	DCR EST.	ERROR	MURF ACTUAL	1 MONTH AHEAD EST.	ERROR
JAN.	85,426	85,434	8	243,720	265,607	21,887
FEB.	165,193	164,992	(201)	37,160	37,369	209
MAR.	38,735	40,095	1,360	36,577	38,644	2,067
APR.	89,200	89,022	(178)	248,100	263,453	15,353
MAY	187,845	183,825	(4,020)	39,965	42,262	2,297
JUN.	46,604	46,164	(440)	41,178	41,684	506
JUL.	151,242	151,039	(203)	241,098	265,873	24,775
AUG.	125,837	125,725	(112)	40,843	40,447	(396)
SEP.	40,522	40,392	(130)	41,427	48,948	7,521
OCT.	88,315	88,127	(188)	265,939	270,661	4,722
NOV.	211,692	211,551	(141)	46,240	45,757	(483)
DEC.	48,876	48,667	(209)	53,588	51,471	(2,117)
RMSE			1,240			10,886
MEAN ERROR			(371)			6,362

Table A.10: SBT Annual Payments: DCR Data
& One-Month Ahead MURF Forecasts

1987	CDCR ACTUAL	DCR EST.	ERROR	MURF ACTUAL	1 MONTH AHEAD EST.	ERROR
JAN.	15,854	14,718	(1,136)	17,023	17,240	217
FEB.	14,752	13,311	(1,441)	12,475	16,103	3,628
MAR.	18,994	17,336	(1,658)	19,455	19,310	(145)
APR.	21,224	19,178	(2,046)	101,529	106,113	4,584
MAY	95,045	92,778	(2,267)	15,951	18,563	2,612
JUN.	18,919	16,787	(2,132)	14,274	17,171	2,897
JUL.	13,373	11,949	(1,424)	15,258	14,270	(988)
AUG.	12,450	11,045	(1,405)	11,311	13,900	2,589
SEP.	22,328	14,123	(8,205)	22,170	22,125	(45)
OCT.	15,652	13,972	(1,680)	31,200	23,242	(7,958)
NOV.	28,496	26,799	(1,697)	13,690	14,933	1,243
DEC.	32,896	30,410	(2,486)	34,294	18,017	(16,277)
RMSE			2,932			5,678
MEAN ERROR			(2,298)			(637)

Table A.11: SBT Refunds: CDCR Data
& One-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	CDCR EST.	ERROR	MURF ACTUAL	1 MONTH AHEAD EST.	ERROR
JAN.	5,246	5,091	(155)	6,398	7,992	1,594
FEB.	6,848	6,339	(509)	8,117	7,202	(915)
MAR.	9,103	8,931	(172)	9,219	5,698	(3,521)
APR.	6,284	5,701	(583)	5,050	5,953	903
MAY	5,163	4,857	(306)	3,136	6,114	2,978
JUN.	4,740	4,416	(324)	7,061	6,147	(914)
JUL.	4,043	3,872	(171)	4,193	5,976	1,783
AUG.	6,718	6,719	1	6,081	4,854	(1,227)
SEP.	7,133	6,998	(135)	6,324	6,725	401
OCT.	8,177	8,061	(116)	7,246	5,198	(2,048)
NOV.	3,510	3,506	(4)	8,425	6,040	(2,385)
DEC.	9,337	9,304	(33)	3,757	2,578	(1,179)
RMSE			276			1,880
MEAN ERROR			(209)			(378)

4. MRSB data combine single business tax annual and estimated payments so that the data for the MURF models are revised only once, with the release of CDCR data.

Table A.12: SBT Refunds: DCR Data
& Two-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	DCR EST.	ERROR	MURF ACTUAL	2 MONTH AHEAD EST.	ERROR
JAN.	5,246	5,245	(1)	6,398	7,997	1,599
FEB.	6,848	6,837	(11)	8,117	7,298	(819)
MAR.	9,103	9,101	(2)	9,219	5,667	(3,552)
APR.	6,284	6,306	22	5,050	5,772	722
MAY	5,163	5,142	(21)	3,136	6,091	2,955
JUN.	4,740	3,752	(988)	7,061	6,373	(688)
JUL.	4,043	4,037	(6)	4,193	5,929	1,736
AUG.	6,718	6,718	0	6,081	4,870	(1,211)
SEP.	7,133	7,129	(4)	6,324	6,705	381
OCT.	8,177	8,178	1	7,246	5,189	(2,057)
NOV.	3,510	3,506	(4)	8,425	5,667	(2,758)
DEC.	9,337	9,337	0	3,757	2,267	(1,490)
RMSE			285			1,920
MEAN ERROR			(85)			(432)

Oil and Gas Severance Tax

Table A.13: Oil & Gas Severance Tax: CDCR Data
& One-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	CDCR EST.	ERROR	MURF ACTUAL	1 MONTH AHEAD EST.	ERROR
JAN.	3,947	3,946	(1)	3,926	3,854	(72)
FEB.	3,671	3,671	0	3,891	4,152	261
MAR.	3,979	3,980	1	3,819	3,740	(79)
APR.	3,638	3,638	0	3,966	4,125	159
MAY	4,252	4,251	(1)	3,821	3,963	142
JUN.	3,909	3,910	1	4,038	4,401	363
JUL.	4,390	4,389	(1)	4,194	4,221	27
AUG.	4,316	4,316	0	4,308	4,457	149
SEP.	4,359	4,359	0	4,425	4,422	(3)
OCT.	4,024	4,024	0	4,050	4,247	197
NOV.	3,899	3,898	(1)	4,343	4,323	(20)
DEC.	4,169	4,170	1	4,140	4,101	(39)
RMSE			1			164
MEAN ERROR			(0)			90

Table A.14: Oil & Gas Severance Tax: DCR Data
& Two-Month Ahead MURF Forecasts

1987	MRSB ACTUAL	DCR EST.	ERROR	MURF ACTUAL	2 MONTH AHEAD EST.	ERROR
JAN.	3,947	3,947	0	3,926	3,864	(62)
FEB.	3,671	3,671	0	3,891	4,130	239
MAR.	3,979	3,979	0	3,819	3,791	(28)
APR.	3,638	3,638	0	3,966	4,119	153
MAY	4,252	4,246	(6)	3,821	3,965	144
JUN.	3,909	3,909	0	4,038	4,411	373
JUL.	4,390	4,390	0	4,194	4,247	53
AUG.	4,316	4,316	0	4,308	4,460	152
SEP.	4,359	4,358	(1)	4,425	4,427	2
OCT.	4,024	4,024	0	4,050	4,246	196
NOV.	3,899	3,899	0	4,343	4,332	(11)
DEC.	4,169	4,169	0	4,140	4,101	(39)
RMSE			2			161
MEAN ERROR			(1)			98

APPENDIX B

RULES OF ACCRUAL AND PAYMENT DATES

A basic requirement in forecasting revenues for any fiscal year is converting a forecast of monthly cash receipts into a forecast of fiscal year revenue. The basic rule-of-thumb that governs the accrual of revenue, is that revenues should be regarded as belonging to the fiscal year in which the economic activity that generated that revenue occured. This rule has not been univerally followed, however, and consequently, it is important to have some understanding of current practice with regard to the accrual of revenues.

Another important issue, both for determining to which year revenue should be accrued and for purposes of model building, is the date on which payment of various revenues should be made to the state. The table on the following pages outlines both rules of accrual and payment dates for the major GFGP/SAF revenue sources.

==========

REVENUE SOURCE: Income tax (Withholding)

PAYMENT DATE: 15 days after the end of the month in which the money is withheld by employers.

RULES OF ACCRUAL: October receipts are accrued back to the old fiscal year.

==========

REVENUE SOURCE: Income tax (Estimated Payments)

PAYMENT DATE: 15th day of April, June, September and January for those on a calendar year fiscal year.

RULES OF ACCRUAL: Quarterly payments of individual income tax due on September 15th but received in October are accrued back to the old fiscal year. For practical purposes all of October and none of November should be accrued back.

==========

REVENUE SOURCE: Income tax (Annual Payments)

PAYMENT DATE: 15th day of April for those on a calendar year fiscal year.

RULES OF ACCRUAL: October receipts are accrued back to the old fiscal year.

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REVENUE SOURCE: Income Tax (Refunds)

PAYMENT DATE: 15th day of April for those on a calendar fiscal year.

RULES OF ACCRUAL: About 75% of calendar 1988 refunds are accrued back to 1987. Fraction is based on fraction of Feb. 1987 - Jan. 1988 gross income tax receipts accrued to fiscal 1987.

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REVENUE SOURCE: Sales Tax

PAYMENT DATE: 15 days after the end of the month.

RULES OF ACCRUAL: October receipts plus adjustments are accrued back to the old fiscal year.

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REVENUE SOURCE: Use Tax

PAYMENT DATE: 15 days after the end of the month.

RULES OF ACCRUAL: October receipts plus adjustments are accrued back to the old fiscal year.

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REVENUE SOURCE: Cigarette Tax

PAYMENT DATE: 20 days after the end of the month.

RULES OF ACCRUAL: October receipts are accrued back to the old fiscal year.

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REVENUE SOURCE: Beer and Wine

PAYMENT DATE: Added to the wholesale cost.

RULES OF ACCRUAL: Monthly receipts as reported by the Liquor Control Commission are dealt with on a cash basis.

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REVENUE SOURCE: Liquor Specific

PAYMENT DATE: Added to the wholesale cost.

RULES OF ACCRUAL: Monthly receipts as reported by the Liquor Control Commission are dealt with on a cash basis.

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REVENUE SOURCE: Single Business Tax (Annual Payments)

PAYMENT DATE: 4 months after end of firm's fiscal year. (usually 30th April).

RULES OF ACCRUAL: All money due at the end of October and the end of November is accrued back.

==========

REVENUE SOURCE: Single Business Tax (Estimated Payments)

PAYMENT DATE: 4 months, 7 months, 10 months and 13 months after start of firm's fiscal year. (Usually, 30th April, 31st July, 31st October and 31st January).

RULES OF ACCRUAL: All of October money, and 2/3 of money due on November 30th is accrued back.

==========

REVENUE SOURCE: Single Business Tax (Refunds)

RULES OF ACCRUAL: Complicated but as an approximation we can treat all money paid before December 15th as accrued back.

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REVENUE SOURCE: Retaliatory Insurance Premiums Tax (Estimated Payments)

PAYMENT DATES: 1st January, 31st March, 30th June, 30th September

RULES OF ACCRUAL: All of October money, and 2/3 of money due on November 30th is accrued back.

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REVENUE SOURCE: Retaliatory Insurance Premiums Tax (Annual Payments)

PAYMENT DATE: 1st March

RULES OF ACCRUAL: All money due at the end of October and the end of November is accrued back.

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REVENUE SOURCE: Horse Racing Taxes

PAYMENT DATE: 5 days after races.

RULES OF ACCRUAL: Cash basis

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REVENUE SOURCE: Oil and Gas Severance

PAYMENT DATE: 25 days after the end of the month.

RULES OF ACCRUAL: October receipts are accrued back to the old fiscal year.

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REVENUE SOURCE: Inheritance Tax

PAYMENT DATE: Within nine months of death.

RULES OF ACCRUAL: October receipts are accrued back to the old fiscal year.

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REVENUE SOURCE: Intangibles Tax

PAYMENT DATE: 4 months after end of individual's fiscal year (usually 30th April).

RULES OF ACCRUAL: Cash basis

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REVENUE SOURCE: Utility Property Tax

PAYMENT DATE: Due 1st August and 1st December

RULES OF ACCRUAL: December payment is accrued back to the old fiscal year.

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REVENUE SOURCE: Lottery

PAYMENT DATE: Ticket agents pay the Bureau of State Lottery every Wednesday.

RULES OF ACCRUAL: Cash Basis

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REVENUE SOURCE: Industrial Facilities Tax, Commercial Facilities Tax, Commercial Forest Tax.

PAYMENT DATE: July 1st and December 1st to units of local government. However, companies can pay without penalty by the 15th of February for the December payment and the 15th of September for the July payment.

RULES OF ACCRUAL: All monies received by end of November that are attributable to the July 1st tax bill are accrued back.

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APPENDIX C

ESTIMATED VAR, ARMA AND SUR EQUATIONS

This appendix contains the results of the regressions of the various vector auto regression, (VAR), auto-regressive moving average, (ARMA), and seemingly unrelated regressions, (SUR), whose forecasts are compared with those of the MURF models in chapters III through VII.

Section C.1 contains the estimated coefficients for the two VAR models used. In the larger model, nine monthly variables were regressed on lagged values of themselves and each other. The lags were chosen to be at one and two months. In addition, 11 seasonal dummies were included as exogeneous variables for all nine equations.

In the smaller model, sales from the three main lottery games were regressed on lagged values of themselves and each other. Here lags were specified at one, two, three, four and fifty-two weeks.

Table C.1: Statistical Output from the VAR
Income Tax Withholding Equation.

VAREST // Dependent Variable is LNAJWITH
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	-0.3105851	0.1402901	-2.2138775	0.032
LNAJWITH(-2)	0.0993037	0.1319788	0.7524213	0.456
LNSALETX(-1)	0.3843613	0.2800326	1.3725590	0.177
LNSALETX(-2)	0.5585329	0.3113281	1.7940330	0.080
LNUSETAX(-1)	0.0264593	0.1025054	0.2581253	0.798
LNUSETAX(-2)	0.0177845	0.1002944	0.1773233	0.860
BEER(-1)	-2.740E-06	1.729E-05	-0.1585013	0.875
BEER(-2)	-3.493E-05	1.664E-05	-2.0994590	0.042
LOGLIQTX(-1)	0.1174576	0.1707788	0.6877758	0.495
LOGLIQTX(-2)	0.3721846	0.1561554	2.3834241	0.022
LAJC25TX(-1)	0.2209277	0.1006166	2.1957384	0.034
LAJC25TX(-2)	-0.1634548	0.1049124	-1.5580124	0.127
LAJSEVER(-1)	-0.0257968	0.0986442	-0.2615138	0.795
LAJSEVER(-2)	0.0401567	0.0997378	0.4026222	0.689
ADJA(-1)	1.990E-07	1.338E-06	0.1487374	0.882
ADJA(-2)	3.433E-06	1.280E-06	2.6820699	0.010
REFUND(-1)	1.532E-07	1.101E-06	0.1392017	0.890
REFUND(-2)	-2.818E-07	1.218E-06	-0.2313504	0.818
TR1	0.1483346	0.1037920	1.4291531	0.160
TR2	-0.1308069	0.1648942	-0.7932780	0.432
TR3	0.0538233	0.0903134	0.5959621	0.554
TR4	0.2790626	0.0524587	5.3196606	0.000
TR5	0.0680240	0.0975186	0.6975494	0.489
TR6	-0.0744219	0.0974011	-0.7640767	0.449
TR7	0.1694770	0.0664062	2.5521270	0.014
TR8	-0.0074189	0.0895955	-0.0828048	0.934
TR9	0.0504036	0.0726337	0.6939423	0.492
TR10	0.1159218	0.0923707	1.2549637	0.216
TR11	0.0556074	0.1032078	0.5387903	0.593
C	-1.0091133	1.9552300	-0.5161097	0.608

R-squared	0.946296	Mean of dependent var	12.37269
Adjusted R-squared	0.909215	S.D. of dependent var	0.150382
S.E. of regression	0.045311	Sum of squared resid	0.086230
Durbin-Watson stat	1.959141	F-statistic	25.51942
Log likelihood	140.0229		

Table C.2: Statistical Output from the VAR
Net Sales Tax Equation.

VAREST // Dependent Variable is LNSALETX
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	0.0475666	0.0802510	0.5927234	0.557
LNAJWITH(-2)	-0.0218682	0.0754966	-0.2896576	0.774
LNSALETX(-1)	0.6255887	0.1601887	3.9053242	0.000
LNSALETX(-2)	0.3092848	0.1780908	1.7366691	0.090
LNUSETAX(-1)	-0.0455604	0.0586368	-0.7769933	0.442
LNUSETAX(-2)	0.0243749	0.0573720	0.4248568	0.673
BEER(-1)	6.372E-06	9.890E-06	0.6442798	0.523
BEER(-2)	-5.897E-06	9.518E-06	-0.6195801	0.539
LOGLIQTX(-1)	-0.1268300	0.0976916	-1.2982691	0.201
LOGLIQTX(-2)	-0.0585090	0.0893265	-0.6550019	0.516
LAJC25TX(-1)	-0.0256778	0.0575563	-0.4461346	0.658
LAJC25TX(-2)	-0.0258156	0.0600136	-0.4301627	0.669
LAJSEVER(-1)	0.0594783	0.0564280	1.0540559	0.298
LAJSEVER(-2)	-0.0677391	0.0570536	-1.1872881	0.242
ADJA(-1)	1.678E-06	7.652E-07	2.1934885	0.034
ADJA(-2)	1.019E-06	7.323E-07	1.3910281	0.172
REFUND(-1)	-5.887E-07	6.298E-07	-0.9347438	0.355
REFUND(-2)	1.016E-06	6.968E-07	1.4582152	0.152
TR1	0.3366157	0.0593727	5.6695355	0.000
TR2	-0.1743717	0.0943254	-1.8486197	0.072
TR3	-0.1568161	0.0516625	-3.0353962	0.004
TR4	0.1249907	0.0300083	4.1652095	0.000
TR5	-0.0523549	0.0557841	-0.9385265	0.353
TR6	-0.0047481	0.0557169	-0.0852176	0.932
TR7	0.0906802	0.0379867	2.3871573	0.022
TR8	-0.0137148	0.0512519	-0.2675970	0.790
TR9	0.0071237	0.0415491	0.1714514	0.865
TR10	0.1055456	0.0528393	1.9974818	0.052
TR11	-0.0231649	0.0590386	-0.3923693	0.697
C	2.5764364	1.1184615	2.3035539	0.026

R-squared	0.986047	Mean of dependent var	11.95130
Adjusted R-squared	0.976413	S.D. of dependent var	0.168767
S.E. of regression	0.025920	Sum of squared resid	0.028217
Durbin-Watson stat	2.102850	F-statistic	102.3475
Log likelihood	180.2388		

Table C.3: Statistical Output from the VAR
Gross Use Tax Equation.

VAREST // Dependent Variable is LNUSETAX
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	-0.0255481	0.2291103	-0.1115101	0.912
LNAJWITH(-2)	0.0105283	0.2155370	0.0488469	0.961
LNSALETX(-1)	0.7662261	0.4573262	1.6754475	0.101
LNSALETX(-2)	-0.0383449	0.5084355	-0.0754173	0.940
LNUSETAX(-1)	0.2033901	0.1674035	1.2149696	0.231
LNUSETAX(-2)	0.0636316	0.1637926	0.3884886	0.700
BEER(-1)	-4.765E-06	2.824E-05	-0.1687639	0.867
BEER(-2)	9.077E-06	2.717E-05	0.3340635	0.740
LOGLIQTX(-1)	0.1358823	0.2789020	0.4872043	0.629
LOGLIQTX(-2)	-0.3124739	0.2550202	-1.2252906	0.227
LAJC25TX(-1)	-0.1219126	0.1643187	-0.7419276	0.462
LAJC25TX(-2)	-0.0629566	0.1713343	-0.3674488	0.715
LAJSEVER(-1)	-0.0995276	0.1610976	-0.6178090	0.540
LAJSEVER(-2)	0.0802692	0.1628836	0.4928013	0.625
ADJA(-1)	2.240E-06	2.185E-06	1.0252162	0.311
ADJA(-2)	3.069E-07	2.091E-06	0.1468077	0.884
REFUND(-1)	7.253E-08	1.798E-06	0.0403412	0.968
REFUND(-2)	8.854E-07	1.989E-06	0.4450563	0.659
TR1	0.0436661	0.1695045	0.2576101	0.798
TR2	0.0343503	0.2692916	0.1275582	0.899
TR3	0.0127515	0.1474923	0.0864553	0.932
TR4	0.0890746	0.0856713	1.0397255	0.304
TR5	0.0091943	0.1592593	0.0577314	0.954
TR6	0.0933638	0.1590675	0.5869447	0.560
TR7	0.1190621	0.1084491	1.0978615	0.279
TR8	0.1349052	0.1463201	0.9219870	0.362
TR9	0.1723091	0.1186194	1.4526211	0.154
TR10	0.1302112	0.1508522	0.8631709	0.393
TR11	0.1391859	0.1685505	0.8257814	0.414
C	2.1094696	3.1931211	0.6606294	0.512

R-squared	0.920801	Mean of dependent var	10.12720
Adjusted R-squared	0.866115	S.D. of dependent var	0.202235
S.E. of regression	0.073998	Sum of squared resid	0.229982
Durbin-Watson stat	2.007620	F-statistic	16.83815
Log likelihood	104.7076		

Table C.4: Statistical Output from the VAR
Cigarette Tax Equation.

VAREST // Dependent Variable is LAJC25TX
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	-0.2804543	0.1950722	-1.4376948	0.158
LNAJWITH(-2)	0.4638502	0.1835155	2.5275805	0.015
LNSALETX(-1)	-0.1219421	0.3893830	-0.3131676	0.756
LNSALETX(-2)	0.0301449	0.4328991	0.0696348	0.945
LNUSETAX(-1)	-0.1945934	0.1425330	-1.3652519	0.179
LNUSETAX(-2)	-0.0301856	0.1394586	-0.2164482	0.830
BEER(-1)	2.934E-06	2.404E-05	0.1220232	0.903
BEER(-2)	-1.017E-06	2.314E-05	-0.0439712	0.965
LOGLIQTX(-1)	0.1202671	0.2374666	0.5064591	0.615
LOGLIQTX(-2)	-0.0570655	0.2171328	-0.2628136	0.794
LAJC25TX(-1)	0.4038262	0.1399065	2.8864009	0.006
LAJC25TX(-2)	-0.1079540	0.1458798	-0.7400200	0.463
LAJSEVER(-1)	0.3773132	0.1371640	2.7508193	0.009
LAJSEVER(-2)	-0.3266827	0.1386846	-2.3555802	0.023
ADJA(-1)	2.456E-06	1.860E-06	1.3201830	0.194
ADJA(-2)	2.745E-06	1.780E-06	1.5421331	0.131
REFUND(-1)	-8.825E-07	1.531E-06	-0.5765019	0.567
REFUND(-2)	4.487E-07	1.694E-06	0.2648658	0.792
TR1	0.1057187	0.1443218	0.7325207	0.468
TR2	0.0918043	0.2292840	0.4003957	0.691
TR3	-0.0800864	0.1255800	-0.6377319	0.527
TR4	0.0419587	0.0729434	0.5752229	0.568
TR5	-0.0685255	0.1355988	-0.5053551	0.616
TR6	-0.1017062	0.1354354	-0.7509574	0.457
TR7	0.1601145	0.0923372	1.7340194	0.090
TR8	0.2306208	0.1245818	1.8511592	0.071
TR9	0.1177029	0.1009966	1.1654147	0.250
TR10	0.0673844	0.1284406	0.5246350	0.603
TR11	0.2076458	0.1435096	1.4469123	0.155
C	7.1506182	2.7187311	2.6301307	0.012

R-squared	0.741275	Mean of dependent var	10.09840
Adjusted R-squared	0.562632	S.D. of dependent var	0.095268
S.E. of regression	0.063005	Sum of squared resid	0.166723
Durbin-Watson stat	1.975956	F-statistic	4.149466
Log likelihood	116.2876		

Table C.5: Statistical Output from the VAR
Beer & Wine Excise Tax Equation.

VAREST // Dependent Variable is BEER
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	-1363.0114	1220.4452	-1.1168149	0.270
LNAJWITH(-2)	-245.90158	1148.1420	-0.2141735	0.831
LNSALETX(-1)	-1075.4550	2436.1267	-0.4414611	0.661
LNSALETX(-2)	1873.3506	2708.3799	0.6916868	0.493
LNUSETAX(-1)	237.05677	891.73982	0.2658363	0.792
LNUSETAX(-2)	431.52506	872.50525	0.4945816	0.623
BEER(-1)	-0.5647402	0.1504119	-3.7546248	0.001
BEER(-2)	-0.2683252	0.1447448	-1.8537815	0.071
LOGLIQTX(-1)	-559.97451	1485.6802	-0.3769146	0.708
LOGLIQTX(-2)	-350.47197	1358.4647	-0.2579912	0.798
LAJC25TX(-1)	-1090.3687	875.30772	-1.2456976	0.220
LAJC25TX(-2)	1338.4784	912.67899	1.4665380	0.150
LAJSEVER(-1)	-212.15168	858.14933	-0.2472200	0.806
LAJSEVER(-2)	-360.83224	867.66306	-0.4158668	0.680
ADJA(-1)	0.0024726	0.0116373	0.2124712	0.833
ADJA(-2)	0.0081737	0.0111361	0.7339845	0.467
REFUND(-1)	0.0010881	0.0095773	0.1136143	0.910
REFUND(-2)	0.0069349	0.0105976	0.6543867	0.516
TR1	719.51164	902.93181	0.7968616	0.430
TR2	854.85356	1434.4868	0.5959299	0.554
TR3	-546.92122	785.67554	-0.6961159	0.490
TR4	1033.6178	456.36142	2.2649106	0.029
TR5	2023.7152	848.35703	2.3854523	0.022
TR6	1593.9369	847.33509	1.8811176	0.067
TR7	2605.7163	577.69646	4.5105284	0.000
TR8	2821.9627	779.43093	3.6205424	0.001
TR9	3896.7830	631.87278	6.1670372	0.000
TR10	564.53603	803.57289	0.7025324	0.486
TR11	497.51631	897.85004	0.5541196	0.582
C	19210.839	17009.405	1.1294245	0.265

R-squared	0.926936	Mean of dependent var	4322.847
Adjusted R-squared	0.876487	S.D. of dependent var	1121.606
S.E. of regression	394.1812	Sum of squared resid	6525911.
Durbin-Watson stat	2.227611	F-statistic	18.37379
Log likelihood	-513.0901		

Table C.6: Statistical Output from the VAR
4% Liquor Tax Equation.

VAREST // Dependent Variable is LOGLIQTX
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	0.0591329	0.1372115	0.4309618	0.669
LNAJWITH(-2)	0.1325880	0.1290826	1.0271561	0.310
LNSALETX(-1)	0.0098070	0.2738874	0.0358068	0.972
LNSALETX(-2)	-0.0692119	0.3044961	-0.2272997	0.821
LNUSETAX(-1)	-0.0793363	0.1002560	-0.7913374	0.433
LNUSETAX(-2)	0.0054297	0.0980935	0.0553519	0.956
BEER(-1)	-2.337E-05	1.691E-05	-1.3819180	0.174
BEER(-2)	-1.189E-05	1.627E-05	-0.7309255	0.469
LOGLIQTX(-1)	0.0441018	0.1670312	0.2640335	0.793
LOGLIQTX(-2)	-0.0166731	0.1527287	-0.1091684	0.914
LAJC25TX(-1)	0.0489278	0.0984086	0.4971909	0.622
LAJC25TX(-2)	0.0536264	0.1026101	0.5226224	0.604
LAJSEVER(-1)	0.0188267	0.0964795	0.1951364	0.846
LAJSEVER(-2)	-0.0881995	0.0975491	-0.9041546	0.371
ADJA(-1)	8.003E-07	1.308E-06	0.6117034	0.544
ADJA(-2)	5.039E-07	1.252E-06	0.4024705	0.689
REFUND(-1)	3.346E-06	1.077E-06	3.1077649	0.003
REFUND(-2)	2.336E-07	1.191E-06	0.1960595	0.846
TR1	-0.7896472	0.1015143	-7.7786814	0.000
TR2	-0.7626444	0.1612756	-4.7288264	0.000
TR3	-0.4960571	0.0883315	-5.6158600	0.000
TR4	-0.6768305	0.0513075	-13.191641	0.000
TR5	-0.6866982	0.0953786	-7.1997111	0.000
TR6	-0.3937321	0.0952637	-4.1330766	0.000
TR7	-0.5879602	0.0649489	-9.0526564	0.000
TR8	-0.6036311	0.0876294	-6.8884546	0.000
TR9	-0.2091800	0.0710398	-2.9445464	0.005
TR10	-0.6863711	0.0903436	-7.5973402	0.000
TR11	-0.4640499	0.1009429	-4.5971503	0.000
C	6.4975299	1.9123232	3.3977153	0.001

R-squared	0.978780	Mean of dependent var	7.400229
Adjusted R-squared	0.964128	S.D. of dependent var	0.233987
S.E. of regression	0.044317	Sum of squared resid	0.082487
Durbin-Watson stat	2.031864	F-statistic	66.80277
Log likelihood	141.6205		

Table C.7: Statistical Output from the VAR
SBT Annual Payments Equation.

VAREST // Dependent Variable is ADJA
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	23886.274	15004.257	1.5919665	0.119
LNAJWITH(-2)	9086.9072	14115.355	0.6437605	0.523
LNSALETX(-1)	-70467.281	29949.948	-2.3528349	0.023
LNSALETX(-2)	67457.840	33297.053	2.0259403	0.049
LNUSETAX(-1)	7194.9730	10963.125	0.6562885	0.515
LNUSETAX(-2)	-1278.6550	10726.654	-0.1192035	0.906
BEER(-1)	-1.4822914	1.8491766	-0.8015953	0.427
BEER(-2)	-1.0413383	1.7795049	-0.5851843	0.562
LOGLIQTX(-1)	23413.554	18265.079	1.2818753	0.207
LOGLIQTX(-2)	882.19260	16701.081	0.0528225	0.958
LAJC25TX(-1)	-10063.884	10761.107	-0.9352090	0.355
LAJC25TX(-2)	-2139.9865	11220.553	-0.1907202	0.850
LAJSEVER(-1)	-22335.872	10550.161	-2.1171121	0.040
LAJSEVER(-2)	25532.112	10667.123	2.3935330	0.021
ADJA(-1)	-0.1702661	0.1430695	-1.1900941	0.241
ADJA(-2)	-0.0740615	0.1369085	-0.5409565	0.591
REFUND(-1)	-0.1405500	0.1177438	-1.1936930	0.239
REFUND(-2)	-0.2326129	0.1302875	-1.7853810	0.081
TR1	-4036.8285	11100.720	-0.3636546	0.718
TR2	23885.670	17635.702	1.3543929	0.183
TR3	-8719.6559	9659.1618	-0.9027342	0.372
TR4	63890.825	5610.5460	11.387631	0.000
TR5	29502.586	10429.773	2.8286891	0.007
TR6	14517.044	10417.210	1.3935636	0.171
TR7	9715.9372	7102.2493	1.3680085	0.179
TR8	9021.4724	9582.3900	0.9414637	0.352
TR9	10381.747	7768.2976	1.3364249	0.189
TR10	15417.961	9879.1933	1.5606498	0.126
TR11	15443.911	11038.245	1.3991274	0.169
C	-497160.57	209115.07	-2.3774497	0.022

R-squared	0.960188	Mean of dependent var	16907.68
Adjusted R-squared	0.932699	S.D. of dependent var	18680.22
S.E. of regression	4846.097	Sum of squared resid	9.86E+08
Durbin-Watson stat	1.942192	F-statistic	34.92981
Log likelihood	-693.7466		

Table C.8: Statistical Output from the VAR
SBT Refunds Equation.

VAREST // Dependent Variable is REFUND
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	-18375.091	20200.922	-0.9096164	0.368
LNAJWITH(-2)	4363.0605	19004.152	0.2295846	0.820
LNSALETX(-1)	-7246.4660	40322.993	-0.1797105	0.858
LNSALETX(-2)	29666.701	44829.354	0.6617695	0.512
LNUSETAX(-1)	2955.6107	14760.160	0.2002425	0.842
LNUSETAX(-2)	484.84052	14441.787	0.0335721	0.973
BEER(-1)	-0.8115101	2.4896316	-0.3259559	0.746
BEER(-2)	-0.1044720	2.3958293	-0.0436058	0.965
LOGLIQTX(-1)	14338.607	24591.116	0.5830808	0.563
LOGLIQTX(-2)	13437.279	22485.434	0.5975993	0.553
LAJC25TX(-1)	-9267.7578	14488.174	-0.6396774	0.526
LAJC25TX(-2)	-380.20092	15106.747	-0.0251676	0.980
LAJSEVER(-1)	9519.2527	14204.167	0.6701733	0.506
LAJSEVER(-2)	1959.0276	14361.639	0.1364070	0.892
ADJA(-1)	0.0114682	0.1926210	0.0595375	0.953
ADJA(-2)	-0.0060013	0.1843262	-0.0325578	0.974
REFUND(-1)	-0.0387455	0.1585240	-0.2444142	0.808
REFUND(-2)	-0.0466939	0.1754121	-0.2661957	0.791
TR1	-5379.0077	14945.410	-0.3599103	0.721
TR2	3444.0546	23743.757	0.1450510	0.885
TR3	1884.2436	13004.574	0.1448908	0.885
TR4	2611.9297	7553.7362	0.3457798	0.731
TR5	7193.5677	14042.084	0.5122863	0.611
TR6	4870.2790	14025.168	0.3472528	0.730
TR7	2487.6878	9562.0850	0.2601616	0.796
TR8	2450.1208	12901.213	0.1899140	0.850
TR9	11180.005	10458.817	1.0689550	0.291
TR10	5210.5884	13300.813	0.3917496	0.697
TR11	813.01292	14861.297	0.0547067	0.957
C	-331413.24	281541.25	-1.1771392	0.246

R-squared	0.298418	Mean of dependent var	4901.792
Adjusted R-squared	-0.186008	S.D. of dependent var	5991.079
S.E. of regression	6524.524	Sum of squared resid	1.79E+09
Durbin-Watson stat	2.022391	F-statistic	0.616024
Log likelihood	-715.1590		

Table C.9: Statistical Output from the VAR
Oil & Gas Severance Tax Equation.

VAREST // Dependent Variable is LAJSEVER
SMPL range: 1981.01 - 1986.12
Number of observations: 72

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LNAJWITH(-1)	-0.2586847	0.2348886	-1.1013082	0.277
LNAJWITH(-2)	-0.2399051	0.2209730	-1.0856760	0.284
LNSALETX(-1)	0.0680252	0.4688603	0.1450863	0.885
LNSALETX(-2)	0.2859927	0.5212585	0.5486580	0.586
LNUSETAX(-1)	-0.1850303	0.1716255	-1.0781049	0.287
LNUSETAX(-2)	0.0473662	0.1679236	0.2820699	0.779
BEER(-1)	1.180E-05	2.895E-05	0.4076203	0.686
BEER(-2)	-1.646E-05	2.786E-05	-0.5906799	0.558
LOGLIQTX(-1)	-0.3010693	0.2859361	-1.0529251	0.298
LOGLIQTX(-2)	0.3637199	0.2614520	1.3911536	0.172
LAJC25TX(-1)	0.1458944	0.1684629	0.8660328	0.391
LAJC25TX(-2)	0.0205311	0.1756555	0.1168826	0.908
LAJSEVER(-1)	0.8562173	0.1651606	5.1841497	0.000
LAJSEVER(-2)	0.0063480	0.1669916	0.0380139	0.970
ADJA(-1)	-1.031E-06	2.240E-06	-0.4601259	0.648
ADJA(-2)	2.855E-06	2.143E-06	1.3322748	0.190
REFUND(-1)	-5.626E-07	1.843E-06	-0.3051956	0.762
REFUND(-2)	3.138E-06	2.040E-06	1.5383775	0.131
TR1	0.1694832	0.1737795	0.9752773	0.335
TR2	-0.2409123	0.2760833	-0.8726071	0.388
TR3	-0.0833939	0.1512122	-0.5515022	0.584
TR4	0.1608037	0.0878319	1.8308114	0.074
TR5	-0.0316422	0.1632760	-0.1937957	0.847
TR6	-0.0920369	0.1630793	-0.5643691	0.576
TR7	0.0516380	0.1111843	0.4644366	0.645
TR8	-0.0459605	0.1500104	-0.3063823	0.761
TR9	-0.0065201	0.1216111	-0.0536143	0.957
TR10	0.1106939	0.1546568	0.7157389	0.478
TR11	-0.0588829	0.1728015	-0.3407549	0.735
C	2.3654369	3.2736537	0.7225678	0.474

R-squared	0.914432	Mean of dependent var	8.730550
Adjusted R-squared	0.855349	S.D. of dependent var	0.199471
S.E. of regression	0.075865	Sum of squared resid	0.241729
Durbin-Watson stat	1.935400	F-statistic	15.47717
Log likelihood	102.9142		

Table C.10: Statistical Output from the VAR
Weekly Lotto Game Sales Equation.

VAREST // Dependent Variable is LOTTO
SMPL range: 111 - 208
Number of observations: 98

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LOTTO(-1)	0.3977524	0.1156876	3.4381610	0.001
LOTTO(-2)	-0.1056976	0.1461724	-0.7231026	0.472
LOTTO(-3)	0.1760899	0.1478961	1.1906319	0.238
LOTTO(-4)	0.2715134	0.1441070	1.8841093	0.064
LOTTO(-52)	0.1601691	0.2302692	0.6955732	0.489
DAILY(-1)	0.9370313	1.0369504	0.9036414	0.369
DAILY(-2)	0.7830593	1.1590579	0.6755998	0.501
DAILY(-3)	-0.9605742	1.1067870	-0.8678944	0.388
DAILY(-4)	0.7513457	1.0028540	0.7492074	0.456
DAILY(-52)	-1.1376886	0.9370514	-1.2141154	0.229
INSTAT(-1)	-1.0369207	0.9567422	-1.0838037	0.282
INSTAT(-2)	0.2980521	1.0723138	0.2779523	0.782
INSTAT(-3)	0.7035620	1.1062199	0.6360055	0.527
INSTAT(-4)	-0.0689108	0.9562802	-0.0720613	0.943
INSTAT(-52)	0.3924892	0.2681327	1.4637872	0.148
C	-3609434.5	10483844.	-0.3442854	0.732

R-squared	0.345195	Mean of dependent var	8948601.
Adjusted R-squared	0.225413	S.D. of dependent var	4139354.
S.E. of regression	3643070.	Sum of squared resid	1.09E+15
Durbin-Watson stat	1.913399	F-statistic	2.881874
Log likelihood	-1610.939		

Table C.11: Statistical Output from the VAR
Weekly Daily Game Sales Equation.

VAREST // Dependent Variable is DAILY
SMPL range: 111 - 208
Number of observations: 98

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LOTTO(-1)	-0.0135617	0.0109714	-1.2360985	0.220
LOTTO(-2)	0.0056446	0.0138624	0.4071873	0.685
LOTTO(-3)	0.0114819	0.0140259	0.8186234	0.416
LOTTO(-4)	0.0075491	0.0136666	0.5523758	0.582
LOTTO(-52)	-0.0009329	0.0218379	-0.0427188	0.966
DAILY(-1)	0.4825043	0.0983405	4.9064647	0.000
DAILY(-2)	0.0726816	0.1099207	0.6612184	0.511
DAILY(-3)	-0.0549131	0.1049635	-0.5231633	0.602
DAILY(-4)	0.1854519	0.0951069	1.9499302	0.055
DAILY(-52)	0.3974029	0.0888665	4.4719113	0.000
INSTAT(-1)	-0.1210376	0.0907339	-1.3339854	0.186
INSTAT(-2)	0.2063946	0.1016942	2.0295600	0.046
INSTAT(-3)	0.0014303	0.1049098	0.0136338	0.989
INSTAT(-4)	-0.0571467	0.0906900	-0.6301323	0.531
INSTAT(-52)	-0.0328406	0.0254287	-1.2914782	0.201
C	-688569.46	994248.70	-0.6925525	0.491

R-squared	0.659185	Mean of dependent var	9900214.
Adjusted R-squared	0.596841	S.D. of dependent var	544131.6
S.E. of regression	345495.2	Sum of squared resid	9.79E+12
Durbin-Watson stat	1.647917	F-statistic	10.57334
Log likelihood	-1380.090		

Table C.12: Statistical Output from the VAR
Weekly Instant Game Sales Equation.

VAREST // Dependent Variable is INSTAT
SMPL range: 111 - 208
Number of observations: 98

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
LOTTO(-1)	-0.0061944	0.0133024	-0.4656647	0.643
LOTTO(-2)	0.0055938	0.0168077	0.3328137	0.740
LOTTO(-3)	-0.0081278	0.0170059	-0.4779398	0.634
LOTTO(-4)	0.0283438	0.0165702	1.7105260	0.092
LOTTO(-52)	0.0443648	0.0264776	1.6755618	0.098
DAILY(-1)	-0.0398556	0.1192341	-0.3342633	0.739
DAILY(-2)	0.3275015	0.1332747	2.4573419	0.016
DAILY(-3)	-0.0201699	0.1272643	-0.1584884	0.875
DAILY(-4)	0.1165642	0.1153135	1.0108460	0.316
DAILY(-52)	-0.2088208	0.1077472	-1.9380630	0.057
INSTAT(-1)	0.4775959	0.1100113	4.3413338	0.000
INSTAT(-2)	0.0609395	0.1233004	0.4942358	0.623
INSTAT(-3)	-0.0119997	0.1271991	-0.0943382	0.925
INSTAT(-4)	-0.1587249	0.1099582	-1.4435023	0.153
INSTAT(-52)	0.0418530	0.0308313	1.3574835	0.179
C	-905911.72	1205488.5	-0.7514893	0.455

R-squared	0.458767	Mean of dependent var	2415255.
Adjusted R-squared	0.359761	S.D. of dependent var	523526.9
S.E. of regression	418899.7	Sum of squared resid	1.44E+13
Durbin-Watson stat	2.125047	F-statistic	4.633730
Log likelihood	-1398.970		

Section C.2 contains the estimated coefficients for 17 ARMA models used. The AR and MA terms for each model were chosen by examining auto-correlations and partial auto-correlations, and adding AR and MA terms until the pattern of residuals resembled white noise.

Table C.13: Statistical Output from the ARMA Income Tax Withholding Equation

LS // Dependent Variable is LNAJWITH
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 6 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	12.614945	0.3548975	35.545321	0.000
TR1	0.1370945	0.0561639	2.4409714	0.018
TR2	0.0357021	0.0560836	0.6365881	0.527
TR3	-0.0459262	0.0212616	-2.1600508	0.035
TR4	0.0549757	0.0563406	0.9757751	0.334
TR5	-0.0593169	0.0560344	-1.0585794	0.295
TR6	0.0215307	0.0245580	0.8767294	0.385
TR7	0.0474015	0.0563949	0.8405284	0.404
TR8	-0.0158104	0.0557003	-0.2838479	0.778
TR9	-0.0241442	0.0212708	-1.1350855	0.261
TR10	-0.0022923	0.0563659	-0.0406684	0.968
TR11	0.0136519	0.0555494	0.2457605	0.807
MA(1)	-0.3598340	0.1830952	-1.9652839	0.055
MA(2)	0.3939032	0.1464462	2.6897466	0.009
MA(3)	-0.3099539	0.1773950	-1.7472533	0.086
MA(5)	0.3779636	0.1530308	2.4698526	0.017
AR(1)	0.1512829	0.1340055	1.1289311	0.264
AR(3)	0.8033865	0.1368205	5.8718301	0.000

R-squared	0.901913	Mean of dependent var	12.37269
Adjusted R-squared	0.871034	S.D. of dependent var	0.150382
S.E. of regression	0.054005	Sum of squared resid	0.157493
Durbin-Watson stat	2.008612	F-statistic	29.20776
Log likelihood	118.3378		

Table C.14: Statistical Output from the ARMA Income Tax Estimated Payments Equation

LS // Dependent Variable is LAJQUARQ
SMPL range: 1977.1 - 1987.4
Number of observations: 44
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	14.455934	9.2138571	1.5689340	0.125
TR1	1.2729488	0.1054464	12.072000	0.000
TR2	1.5172196	0.1236196	12.273293	0.000
TR3	0.9453698	0.1187000	7.9643649	0.000
MA(5)	0.4724926	0.1915518	2.4666566	0.018
AR(1)	0.2928508	0.1033885	2.8325270	0.007
AR(4)	0.6847820	0.1037145	6.6025688	0.000

R-squared	0.974884	Mean of dependent var	10.55804
Adjusted R-squared	0.970811	S.D. of dependent var	0.689774
S.E. of regression	0.117847	Sum of squared resid	0.513850
Durbin-Watson stat	1.688855	F-statistic	239.3586
Log likelihood	35.46702		

Table C.15: Statistical Output from the ARMA Net Sales Tax Equation

LS // Dependent Variable is LNSALETX
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 8 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	16.378899	43.419728	0.3772225	0.707
TR1	0.2188042	0.0101421	21.573803	0.000
TR2	-0.0695795	0.0136898	-5.0825697	0.000
TR3	-0.1188815	0.0159218	-7.4665634	0.000
TR4	0.0013280	0.0173466	0.0765586	0.939
TR5	0.0126311	0.0181493	0.6959537	0.489
TR6	0.0503043	0.0184084	2.7326802	0.008
TR7	0.0865977	0.0181463	4.7721871	0.000
TR8	0.0187217	0.0173409	1.0796268	0.285
TR9	0.0238061	0.0159136	1.4959552	0.140
TR10	0.0614053	0.0136787	4.4891275	0.000
TR11	-0.0176586	0.0101278	-1.7435734	0.087
MA(1)	-0.3464198	0.1345742	-2.5741910	0.013
AR(1)	0.9988654	0.0212309	47.047740	0.000

R-squared	0.980849	Mean of dependent var	11.95130
Adjusted R-squared	0.976557	S.D. of dependent var	0.168764
S.E. of regression	0.025840	Sum of squared resid	0.038726
Durbin-Watson stat	1.979852	F-statistic	228.5101
Log likelihood	168.8416		

Table C.16: Statistical Output from the ARMA Gross Use Tax Equation

LS // Dependent Variable is LNUSETAX
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	11.484830	18.506439	0.6205856	0.537
TR1	0.0266581	0.0284221	0.9379358	0.352
TR2	-0.0922447	0.0384114	-2.4014934	0.020
TR3	-0.1005443	0.0447849	-2.2450481	0.029
TR4	-0.0007627	0.0488126	-0.0156257	0.988
TR5	0.0383342	0.0510493	0.7509257	0.456
TR6	0.0913753	0.0517631	1.7652609	0.083
TR7	0.1590789	0.0510178	3.1181083	0.003
TR8	0.1089570	0.0487272	2.2360629	0.029
TR9	0.1424331	0.0446778	3.1880055	0.002
TR10	0.1829668	0.0383619	4.7694923	0.000
TR11	0.1043755	0.0283568	3.6807975	0.001
MA(1)	-0.5842737	0.1552461	-3.7635317	0.000
MA(4)	-0.3202703	0.1404955	-2.2795765	0.026
AR(1)	0.9954408	0.0591121	16.839890	0.000

R-squared	0.897944	Mean of dependent var	10.12720
Adjusted R-squared	0.872878	S.D. of dependent var	0.202234
S.E. of regression	0.072105	Sum of squared resid	0.296350
Durbin-Watson stat	2.025646	F-statistic	35.82277
Log likelihood	95.58011		

Table C.17: Statistical Output from the ARMA Cigarette Tax Equation

LS // Dependent Variable is LAJC25TX
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	10.061277	0.0277517	362.54570	0.000
TR1	0.0967380	0.0333408	2.9014906	0.005
TR2	-0.0586798	0.0361765	-1.6220419	0.110
TR3	-0.1027046	0.0328765	-3.1239522	0.003
TR4	0.0019644	0.0359960	0.0545739	0.957
TR5	-0.0097732	0.0369193	-0.2647185	0.792
TR6	0.0061108	0.0358592	0.1704099	0.865
TR7	0.0996013	0.0368753	2.7010266	0.009
TR8	0.1162619	0.0359818	3.2311286	0.002
TR9	0.0858072	0.0328134	2.6150075	0.011
TR10	0.0476945	0.0361179	1.3205203	0.192
TR11	0.0628024	0.0332020	1.8915238	0.064
MA(9)	0.4938792	0.1374911	3.5920825	0.001
AR(1)	0.2352357	0.1091149	2.1558541	0.035
AR(3)	0.2433280	0.1094404	2.2233843	0.030

R-squared	0.652767	Mean of dependent var	10.09840
Adjusted R-squared	0.567481	S.D. of dependent var	0.095268
S.E. of regression	0.062654	Sum of squared resid	0.223757
Durbin-Watson stat	1.905668	F-statistic	7.653911
Log likelihood	105.6954		

Table C.18: Statistical Output from the ARMA
Beer & Wine Excise Tax Equation

LS // Dependent Variable is BEER
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 3 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	3804.7623	161.03662	23.626690	0.000
TR1	-193.05108	227.96499	-0.8468453	0.401
TR2	-155.69271	227.74368	-0.6836313	0.497
TR3	-128.65874	227.74061	-0.5649354	0.574
TR4	700.23202	227.74022	3.0746964	0.003
TR5	922.87970	227.74017	4.0523360	0.000
TR6	1090.6022	227.74016	4.7888003	0.000
TR7	1210.1233	227.74016	5.3136138	0.000
TR8	1244.7979	227.74016	5.4658691	0.000
TR9	2713.3009	227.74016	11.914020	0.000
TR10	-1711.6979	227.74016	-7.5160126	0.000
TR11	490.30250	227.74016	2.1529031	0.035
MA(1)	-0.5281575	0.1315411	-4.0151533	0.000

R-squared	0.897219	Mean of dependent var	4322.847
Adjusted R-squared	0.876314	S.D. of dependent var	1121.606
S.E. of regression	394.4575	Sum of squared resid	9180208.
Durbin-Watson stat	2.001199	F-statistic	42.91958
Log likelihood	-525.3758		

Table C.19: Statistical Output from the ARMA 4% Liquor Tax Equation

LS // Dependent Variable is LOGLIQTX
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 3 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	7.9617731	0.0188689	421.95251	0.000
TR1	-0.7985062	0.0234871	-33.997712	0.000
TR2	-0.7856306	0.0260007	-30.215757	0.000
TR3	-0.5053828	0.0265405	-19.041925	0.000
TR4	-0.6879728	0.0266491	-25.815941	0.000
TR5	-0.6849997	0.0266757	-25.678832	0.000
TR6	-0.4227437	0.0266807	-15.844566	0.000
TR7	-0.6524738	0.0266755	-24.459687	0.000
TR8	-0.6824543	0.0266468	-25.611159	0.000
TR9	-0.2765326	0.0265204	-10.427148	0.000
TR10	-0.7505991	0.0259653	-28.907831	0.000
TR11	-0.4809837	0.0234061	-20.549516	0.000
MA(3)	0.3108452	0.1361169	2.2836637	0.026
AR(1)	0.2306299	0.1222411	1.8866797	0.064

R-squared	0.969822	Mean of dependent var	7.400229
Adjusted R-squared	0.963058	S.D. of dependent var	0.233987
S.E. of regression	0.044973	Sum of squared resid	0.117310
Durbin-Watson stat	2.080919	F-statistic	143.3791
Log likelihood	128.9422		

Table C.20: Statistical Output from the First ARMA SBT Estimated Payments Equation

LS // Dependent Variable is ADJQ1
SMPL range: 1980.2 - 1986.4
Number of observations: 27
Convergence achieved after 2 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	201030.70	1458022.9	0.1378790	0.892
TR1	-3288.0653	6527.0041	-0.5037633	0.620
TR2	2201.7587	7257.7252	0.3033676	0.765
TR3	7294.9234	6203.2192	1.1759899	0.253
MA(1)	-0.5018842	0.2641172	-1.9002331	0.071
AR(1)	1.0027633	0.1028549	9.7492980	0.000

R-squared	0.828414	Mean of dependent var	191460.5
Adjusted R-squared	0.787561	S.D. of dependent var	40801.28
S.E. of regression	18805.77	Sum of squared resid	7.43E+09
Durbin-Watson stat	1.888875	F-statistic	20.27759
Log likelihood	-300.6504		

Table C.21: Statistical Output from the Second ARMA SBT Estimated Payments Equation

LS // Dependent Variable is ADJQ2
SMPL range: 1980.2 - 1986.4
Number of observations: 27
Failure to improve SSR achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-90696.614	2383118.3	-0.0380580	0.970
TR1	-2931.2197	656.32565	-4.4661057	0.000
TR2	-742.82912	723.73905	-1.0263770	0.317
TR3	-1406.4630	617.81549	-2.2765098	0.034
MA(1)	-0.7062555	0.2303875	-3.0655112	0.006
MA(2)	0.5131541	0.2280610	2.2500743	0.036
AR(1)	1.0040468	0.0795228	12.625902	0.000

R-squared	0.906092	Mean of dependent var	29986.63
Adjusted R-squared	0.877919	S.D. of dependent var	5355.132
S.E. of regression	1871.088	Sum of squared resid	70019384
Durbin-Watson stat	1.970649	F-statistic	32.16224
Log likelihood	-237.6854		

Table C.22: Statistical Output from the Third ARMA SBT Estimated Payments Equation

LS // Dependent Variable is ADJQ3
SMPL range: 1980.2 - 1986.4
Number of observations: 27
Convergence achieved after 8 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	23078.032	11761.182	1.9622205	0.063
TR1	-6175.6902	1040.6580	-5.9344089	0.000
TR2	-2526.5336	1160.4175	-2.1772625	0.041
TR3	-3107.0356	990.99936	-3.1352549	0.005
MA(1)	-0.3457577	0.2346205	-1.4736889	0.155
AR(1)	1.0863076	0.1008876	10.767502	0.000

R-squared	0.873442	Mean of dependent var	29811.93
Adjusted R-squared	0.843309	S.D. of dependent var	7875.303
S.E. of regression	3117.378	Sum of squared resid	2.04E+08
Durbin-Watson stat	1.853242	F-statistic	28.98630
Log likelihood	-252.1268		

Table C.23: Statistical Output from the ARMA SBT Annual Payments Equation

LS // Dependent Variable is ADJA
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	11707.120	1845.0087	6.3452925	0.000
TR1	880.44728	2387.0567	0.3688422	0.714
TR2	-1372.3671	2573.4207	-0.5332852	0.596
TR3	504.11122	2614.4246	0.1928192	0.848
TR4	64770.507	2653.1143	24.413010	0.000
TR5	-289.09170	2612.9499	-0.1106381	0.912
TR6	-1217.7598	2607.4075	-0.4670386	0.642
TR7	-330.66444	2610.9933	-0.1266432	0.900
TR8	-2392.7549	2604.5214	-0.9186928	0.362
TR9	2787.2085	2603.2231	1.0706760	0.289
TR10	6868.7086	2576.5134	2.6658929	0.010
TR11	-589.25502	2379.6018	-0.2476276	0.805
MA(12)	0.7448541	0.1389356	5.3611452	0.000
MA(3)	0.3094941	0.1406495	2.2004637	0.032
MA(6)	0.2612998	0.1465355	1.7831844	0.080
AR(1)	0.1661425	0.0873915	1.9011285	0.062

R-squared	0.955243	Mean of dependent var	16907.68
Adjusted R-squared	0.943255	S.D. of dependent var	18680.22
S.E. of regression	4449.856	Sum of squared resid	1.11E+09
Durbin-Watson stat	2.112252	F-statistic	79.68068
Log likelihood	-697.9614		

Table C.24: Statistical Output from the ARMA SBT Refunds Equation

LS // Dependent Variable is REFUND
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 11 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2017.9965	2232.6403	0.9038610	0.370
TR1	3370.9469	3156.7115	1.0678667	0.290
TR2	2741.9230	3156.7085	0.8686019	0.389
TR3	3341.6561	3157.9059	1.0581874	0.294
TR4	853.02603	3157.1267	0.2701906	0.788
TR5	1523.9636	3157.0043	0.4827246	0.631
TR6	1180.2217	3156.8717	0.3738580	0.710
TR7	1746.8850	3156.9359	0.5533483	0.582
TR8	1404.9904	3156.8706	0.4450580	0.658
TR9	10019.653	3169.1764	3.1615951	0.002
TR10	5707.2605	3156.7169	1.8079735	0.076
TR11	2615.0289	3156.7074	0.8284039	0.411
MA(12)	-0.4642992	0.1324753	-3.5047968	0.001

R-squared	0.307893	Mean of dependent var	4901.792
Adjusted R-squared	0.167126	S.D. of dependent var	5991.079
S.E. of regression	5467.576	Sum of squared resid	1.76E+09
Durbin-Watson stat	1.789121	F-statistic	2.187246
Log likelihood	-714.6695		

Table C.25: Statistical Output from the ARMA Utility Property Tax Equation

LS // Dependent Variable is LUTILTAX
SMPL range: 3 - 22
Number of observations: 20
Convergence achieved after 6 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	11.482431	1.1493174	9.9906530	0.000
TR1	0.0439803	0.0059275	7.4196635	0.000
MA(2)	-0.9919771	0.2715217	-3.6533989	0.002
AR(1)	0.9716994	0.0464318	20.927453	0.000

R-squared	0.966245	Mean of dependent var	10.83197
Adjusted R-squared	0.959916	S.D. of dependent var	0.120796
S.E. of regression	0.024184	Sum of squared resid	0.009358
Durbin-Watson stat	1.529368	F-statistic	152.6685
Log likelihood	48.29356		

Table C.26: Statistical Output from the ARMA
Oil & Gas Severance Tax Equation

LS // Dependent Variable is LAJSEVER
SMPL range: 1981.01 - 1986.12
Number of observations: 72
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	8.6913311	0.2112697	41.138560	0.000
TR1	0.0238792	0.0254191	0.9394192	0.351
TR2	0.0294217	0.0344013	0.8552499	0.396
TR3	-0.0359651	0.0396227	-0.9076889	0.368
TR4	0.0082252	0.0431220	0.1907429	0.849
TR5	-0.0557960	0.0450983	-1.2372080	0.221
TR6	0.0046506	0.0456828	0.1018029	0.919
TR7	-0.0372446	0.0450485	-0.8267670	0.412
TR8	-0.0136572	0.0430321	-0.3173726	0.752
TR9	-0.0062475	0.0395599	-0.1579238	0.875
TR10	-0.0251237	0.0341190	-0.7363571	0.465
TR11	0.0304083	0.0252165	1.2058900	0.233
MA(2)	0.2704245	0.1427554	1.8943199	0.063
MA(12)	-0.6250351	0.1700933	-3.6746613	0.001
AR(1)	0.9630485	0.0419487	22.957780	0.000

R-squared	0.919144	Mean of dependent var	8.730550
Adjusted R-squared	0.899285	S.D. of dependent var	0.199471
S.E. of regression	0.063303	Sum of squared resid	0.228417
Durbin-Watson stat	2.054252	F-statistic	46.28284
Log likelihood	104.9534		

Table C.27: Statistical Output from the ARMA Inheritance Tax Equation

LS // Dependent Variable is LNINHRTQ
SMPL range: 1976.1 - 1986.4
Number of observations: 44
Convergence achieved after 4 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	8.4915302	0.0316495	268.29910	0.000
MA(1)	0.3407765	0.1610041	2.1165704	0.041
MA(2)	0.3432352	0.1606952	2.1359391	0.039
MA(3)	0.4138455	0.1599099	2.5879913	0.013
MA(4)	0.3073683	0.1679703	1.8298965	0.075

R-squared	0.376364	Mean of dependent var	8.470372
Adjusted R-squared	0.312402	S.D. of dependent var	0.248271
S.E. of regression	0.205870	Sum of squared resid	1.652923
Durbin-Watson stat	1.962309	F-statistic	5.884132
Log likelihood	9.762876		

Table C.28: Statistical Output from the ARMA Intangibles Tax Equation

LS // Dependent Variable is INTANGTX
SMPL range: 1978 - 1986
Number of observations: 9
Convergence achieved after 11 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
MA(2)	-0.9550576	0.2405165	-3.9708604	0.005
AR(1)	1.0846012	0.0127556	85.029552	0.000

R-squared	0.986318	Mean of dependent var	48.87778
Adjusted R-squared	0.984364	S.D. of dependent var	11.61871
S.E. of regression	1.452863	Sum of squared resid	14.77567
Durbin-Watson stat	2.034817	F-statistic	504.6308
Log likelihood	-15.00136		

Table C.29: Statistical Output from the ARMA Weekly Lotto Game Sales Equation

LS // Dependent Variable is LOTTO
SMPL range: 111 - 208
Number of observations: 98
Convergence achieved after 9 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	11754663.	1782481.1	6.5945514	0.000
MA(2)	-0.1183045	0.1163114	-1.0171366	0.312
MA(52)	0.8036319	0.0947127	8.4849468	0.000
AR(1)	0.4187667	0.0710123	5.8971037	0.000
AR(4)	0.3493008	0.0891368	3.9187060	0.000

R-squared	0.589585	Mean of dependent var	8948601.
Adjusted R-squared	0.571933	S.D. of dependent var	4139354.
S.E. of regression	2708249.	Sum of squared resid	6.82E+14
Durbin-Watson stat	1.980629	F-statistic	33.39997
Log likelihood	-1588.048		

Table C.30: Statistical Output from the ARMA Weekly Daily Game Sales Equation

LS // Dependent Variable is DAILY
SMPL range: 111 - 208
Number of observations: 98
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	10980564.	3376435.0	3.2521177	0.002
MA(52)	0.8584524	0.0884226	9.7085228	0.000
AR(1)	0.6049914	0.0538923	11.225934	0.000
AR(4)	0.3052396	0.0557237	5.4777306	0.000
AR(9)	0.0658350	0.0493166	1.3349450	0.186

R-squared	0.777356	Mean of dependent var	9900214.
Adjusted R-squared	0.767780	S.D. of dependent var	544131.7
S.E. of regression	262213.0	Sum of squared resid	6.39E+12
Durbin-Watson stat	2.008672	F-statistic	81.17667
Log likelihood	-1359.227		

Table C.31: Statistical Output from the ARMA Weekly Instant Game Sales Equation

LS // Dependent Variable is INSTAT
SMPL range: 111 - 208
Number of observations: 98
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2480098.3	68004.633	36.469550	0.000
MA(2)	0.2417451	0.1111925	2.1741131	0.033
MA(8)	0.3681091	0.1056051	3.4857143	0.001
MA(9)	0.3386048	0.1090103	3.1061730	0.003
MA(52)	0.4410019	0.1276024	3.4560629	0.001
AR(1)	0.4359633	0.0750922	5.8057105	0.000

R-squared	0.568494	Mean of dependent var	2415255.
Adjusted R-squared	0.545043	S.D. of dependent var	523526.9
S.E. of regression	353121.5	Sum of squared resid	1.15E+13
Durbin-Watson stat	2.029740	F-statistic	24.24140
Log likelihood	-1387.868		

Section C.3 contains the estimated coefficients of the SUR model examined as an alternative to the MURF lottery models.

Table C.32: Statistical Output from the SUR
Weekly Lotto Game Sales Equation

SYS - SUR // Dependent Variable is LOTTOS
SMPL range: 111 - 208
Number of observations: 98
System: SURE.SYS - Equation 1 of 3
LOTTOS=C(1)+C(2)*JAKPOT+C(3)*AVYDM+C(4)*J2+C(5)*J3+C(6)*J4
+C(7)*B143+C(8)*B172+C(9)*B176+C(10)*DATE+C(11)*DATESQ
+C(12)*DATECU+C(13)*JAKPOT(-1)+C(14)*JAKPOT(-2)
+C(15)*JAKPOT(-3)+C(16)*JAKPOT(-4)

	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C(1)	248441.69	1552931.7	0.1599824	0.873
C(2)	418931.49	130310.87	3.2148623	0.002
C(3)	124.92461	51.504665	2.4255009	0.018
C(4)	-14350.941	12522.354	-1.1460258	0.256
C(5)	904.51532	419.97219	2.1537505	0.035
C(6)	-11.340830	4.1950838	-2.7033621	0.009
C(7)	1025245.5	539860.60	1.8990930	0.062
C(8)	5479018.0	580122.07	9.4445951	0.000
C(9)	-2909599.0	597623.05	-4.8686192	0.000
C(10)	15140.817	61544.644	0.2460136	0.806
C(11)	-2579.6686	4532.1295	-0.5691957	0.571
C(12)	65.322989	95.617647	0.6831688	0.497
C(13)	42104.635	7690.1264	5.4751552	0.000
C(14)	40575.834	8918.5891	4.5495799	0.000
C(15)	24288.240	9256.2286	2.6239888	0.011
C(16)	39900.682	9873.0814	4.0413606	0.000

R-squared	0.986439	Mean of dependent var	8948601.
Adjusted R-squared	0.983958	S.D. of dependent var	4139353.
S.E. of regression	524279.9	Sum of squared resid	2.25E+13
Durbin-Watson stat	1.329248	F-statistic	397.6392

Table C.33: Statistical Output from the SUR
Weekly Daily Game Sales Equation

SYS - SUR // Dependent Variable is DAILYS
SMPL range: 111 - 208
Number of observations: 98
System: SURE.SYS - Equation 2 of 3
DAILYS=C(17)+C(18)*AVYDM+C(19)*LOTTOS+C(20)*JAKPOT
+C(21)*JULY4+C(22)*BXMAS+C(23)*AXMAS+C(24)*B173+C(25)*DATE
+C(26)*DATESQ+C(27)*DATECU

	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C(17)	2076374.1	1139491.0	1.8221944	0.072
C(18)	235.35058	37.558865	6.2661793	0.000
C(19)	0.0220303	0.0362159	0.6083042	0.545
C(20)	-14425.792	17794.638	-0.8106820	0.420
C(21)	10554.911	274781.93	0.0384120	0.969
C(22)	599617.00	275641.72	2.1753492	0.033
C(23)	-165053.94	281453.97	-0.5864332	0.559
C(24)	-1399295.4	419388.15	-3.3365164	0.001
C(25)	166304.39	46924.825	3.5440598	0.001
C(26)	-12650.117	3475.9889	-3.6392857	0.001
C(27)	243.22687	73.530526	3.3078354	0.001

R-squared	0.497329	Mean of dependent var	9900214.
Adjusted R-squared	0.439551	S.D. of dependent var	544131.6
S.E. of regression	407354.1	Sum of squared resid	1.44E+13
Durbin-Watson stat	0.622545	F-statistic	8.607544

Table C.34: Statistical Output from the SUR
Weekly Instant Game Sales Equation

SYS - SUR // Dependent Variable is INSTATS
SMPL range: 111 - 208
Number of observations: 98
System: SURE.SYS - Equation 3 of 3
INSTATS=C(28)+C(29)*AVYDM+C(33)*DATE+C(34)*DATESQ
+C(35)*DATECU+C(36)*NEWGME+C(38)*LOTTOS(-1)+C(39)*B120
+C(40)*DAILYS+C(41)*B128

	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C(28)	-3589705.3	994207.70	-3.6106191	0.001
C(29)	170.75919	38.572358	4.4269834	0.000
C(33)	-45491.413	43319.820	-1.0501293	0.297
C(34)	3768.2705	3208.9476	1.1743010	0.244
C(35)	-69.096907	66.821452	-1.0340528	0.304
C(36)	-106353.24	13200.831	-8.0565564	0.000
C(38)	-0.0204506	0.0095911	-2.1322361	0.036
C(39)	606721.47	344722.95	1.7600263	0.082
C(40)	0.1340029	0.0830184	1.6141346	0.111
C(41)	830306.71	344701.78	2.4087683	0.018

R-squared	0.597022	Mean of dependent var	2415255.
Adjusted R-squared	0.555809	S.D. of dependent var	523526.9
S.E. of regression	348918.4	Sum of squared resid	1.07E+13
Durbin-Watson stat	0.699389	F-statistic	14.48605

APPENDIX D

NOTATION

Listed below are the variable names in MURF. Three general conventions should be noted. First, seasonal dummies are denoted by TR followed by the month or quarter number in which they occur. Thus TR7 is a seasonal dummy which takes a value of one in July and zero elesewhere.

Second, individual outlier dummies are denoted by B followed by a number denoting the observation which is treated as an outlier. Thus, in a monthly model, B8412 takes a value of one in December 1984 and zero elsewhere. In a weekly model, B105 takes a value of one in week 105 and zero elsewhere. Likewise in an annual model B1984 takes a value of one in 1984 and zero elsewhere.

Third, throughout this appendix, a * after a variable denotes a variable which is endogenous to MURF.

Variable List
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ADJA * Annual payments on single business tax adjusted for the erratic behavior of a major taxpayer, measured from the 16th of the current month to the 15th of the next month.

ADJQA * The sum of a ADJQ1, ADJQ2 and ADJQ3, over the year ending in the four months prior to annual single business tax payments.

ADJQ1 * Estimated payments on SBT adjusted for the erratic behavior of major taxpayers and the change in insurance company taxation, measured from the 16th of the first month in each calendar quarter to the 15th of the next month.

ADJQ2 * Estimated payments on SBT adjusted for the erratic behavior of major taxpayers, measured from the 16th of the second month in each calendar quarter to the 15th of the next month.

ADJQ3 * Estimated payments on SBT adjusted for the erratic behavior of major taxpayers, measured from the 16th of the third month in each calendar quarter to the 15th of the next month.

ADJQURTX * Total estimated payments on income tax at a 4.6 percent rate as measured from February of the prior year to January of the current year.

ADJRFDOL * Total calendar year income tax refunds less the value of all credits due to credit programs started after 1975.

AFT78 A dummy variable which takes a value of one from 1978 on and zero otherwise.

ANNDOL * Annual payments on income tax.

ARATE * The average annual income tax rate.

AVPCPID A five-month normalized geometric interpolation of the Detroit consumer price index (1982=100).

AVWSM A five-month normalized geometric interpolation of Michigan wage and salary income.

AVYDM A 13-week linear interpolation of disposable personal income in Michigan, centered in the current month. (In the lottery sales equations).

AVYDM82 A five-month normalized geometric interpolation of real disposable personal income in Michigan, centered in the current month.

AVYPMA The sum of a three-month linear interpolation of Michigan personal income over the year ending in the four months prior to annual single business tax payments.

AVYQ A three-month linear interpolation of YQ, the SQEM income construct in their quarterly income tax model.

AVYTNS		A five-month normalized geometric interpolation of transitory disposable personal income in Michigan, centered in the current month.
AXMAS		A dummy variable for the week containing Christmas.
BAFT76		A dummy variable which takes a value of one from 1976 on and zero otherwise.
BAFT8601		A dummy variable which takes a value of one from January 1986 on and zero otherwise.
BAFT863		A dummy variable which takes a value of one from the fourth quarter of 1986 and zero otherwise.
BEER	*	Monthly Beer and Wine excise tax collections as reported by the Liquor Control Commission.
BXMAS		A dummy variable for the week before Christmas
DAILY	*	Weekly revenues from Daily-three and Daily-four games combined
DATE		A variable which takes a value of one in a week ending in the first day of the month, two in a week ending in the second day of the month, etc.
DATECU		DATE cubed.
DATESQ		DATE squared.
DIFF		The difference between FYAAAC and RCPCD, the rate on four to six month commercial paper.
ESMSHARE		The ratio of private service sector employment in Michigan to total wage and salary employment in Michigan.
ESTTAX	*	An estimate of total property taxes paid, based on total state SEV and the state-wide average millage rate.
EXEMPT		The ratio of Michigan population to AVWSM.
FILERS	*	Total number of Michigan 1040 forms filed,
FRI5		A dummy variable which takes a value of one in a month containing five Fridays and zero otherwise.
GDFR1		A dummy variable which takes a value of one in January, minus one in February and zero otherwise, if Good Friday falls on the first of April.

GENERAL * Annual general property tax credits.

HOUSSIZE Average U.S. household size.

INCENT A dummy variable which takes a value of one in October of each year from 1985 on, to deal with incentive driven car sales.

INSTAT * Weekly revenues from instant lottery games.

INTANGTX * Annual gross intangibles tax receipts.

JAKPOT * Weekly guaranteed jackpots for Lotto drawings.

JAKPOT Per-draw guaranteed jackpots for Lotto drawings.

JAN1F A dummy variable which takes a value of one in January, minus one in February and zero otherwise, if the first of January falls on a Friday.

JAN1T A dummy variable which takes a value of one in January, minus one in February and zero otherwise, if the first of January falls on a Thursday.

JULY4 A dummy variable for the week containing July fourth.

J2 * JAKPOT squared.

J3 * JAKPOT cubed.

J4 * JAKPOT raised to the fourth power.

LAJC25TX * The natural log of cigarette tax at 25 cents, as measured from the 11th of the current month to the 10th of the next.

LAJSEVER * The natural log of oil and gas severance tax revenues, as measured from the 16th of the current month to the 15th of the next.

LAJQUARQ * The natural log of quarterly values of estimated payments on income tax at a constant rate of 4.6 percent.

LIQUORTX * 4% of Monthly Gross Liquor Sales as reported by the Liquor Control Commission.

LLIQSALE * The difference between the natural log of LIQUORTX and the natural log of PLIQUOR, the U.S. consumer price index for alcoholic beverages, all urban consumers.

LNAJWITH * The natural log of income tax withholding at a 4.6 percent rate

LNAVQTAX * Total estimated payments on income tax for the the current quarter and the last three quarters.

LNAVSEV * The natural log of a 13-month linear interpolation of total SEV in Michigan.

LNAVWSM The natural log of a five-month normalized geometric interpolation of Michigan wage and salary income.

LNAVYDM The natural log of a five-month normalized geometric interpolation of Michigan disposable income.

LNAVYPRM The natural log of a five-month normalized geometric interpolation of YPRM.

LNINHRTQ * The natural log of quarterly inheritance tax revenues.

LNPCPID The natural log of the average annual value of the Detroit consumer price index (1982=100).

LNSALETX * The natural log of monthly sales tax revenues.

LNSEV * The natural log of total state equalized valuation of property.

LNTOTPOP The natural log of the total population of Michigan.

LNUSETAX * The natural log of monthly use tax revenues.

LNYQ The natural log of YQ

LOTTO * Weekly revenues from Lotto and Super Lotto combined.

LPOILC The natural log of the value of Michigan produced oil, measured in dollars per barrel.

LRATE The natural log of the state tax rate on cigarettes per pack.

LRELPCIG The ratio of PRICE, a price index of the U.S. price of tobacco products, to PCPID.

LRLPLIQ The natural log of the ratio of PLIQUOR,

LTAXRATE The natural log of the state-wide average millage rate.

LUTILSEV		The natural log of total SEV of utility property.
LUTILTAX	*	The natural log of receipts from the utility property tax.
LYDM82		The natural log of real personal disposable income in Michigan.
LYPERM82		The natural log of real personal permanent disposable income in Michigan.
NEWGME		A variable which takes a value of one in the first week of a new Instant game, two in the second week etc.
OLDPOP	*	The total population of age 65 and over in Michigan.
OVERWITH	*	The difference between total income tax refunds and total income tax credits paid.
PRICE		A price index of the U.S. price of tobacco products, PZU63
RAAA		U.S corporate Aaa bond rate
RATE		The state individual income tax rate. (In the withholding and estimated payments equations.)
RATE		The Michigan cigarette tax rate in cents per pack. (In the cigarette tax equation)
REFUND	*	Single business tax refunds.
RELPBEER		The ratio of PCPIB, the U.S. consumer price index for alcoholic beverages, wage-earners and clerical workers, to PCPID.
RUMICH		The Michigan unemployment rate.
SALES	*	Per-draw lotto sales.
TAXRATE		The Michigan income tax rate.
TEMP		The monthly average temperature in Metro Detroit.
THURS5		A dummy variable which takes a value of one in a month containing five Thursdays and zero otherwise.
TIME		A variable which takes a value of one in the first sample observation, two in the second sample observation, etc.

TTR1	A dummy variable which takes a value of TIME in January and zero elsewhere.
TOTPOP	The total population of Michigan.
UEMPMI	The unemployment rate in Michigan in the current calender year.
WEEKDY	The number of weekdays in the current month.
WSM	Wage and salary income in Michigan.
YCBT	U.S. before-tax corporate profits.
YDM82	Real disposable income in Michigan
YPERM	A six-quarter lagged weighted average of disposable income with successive weights equaling 80 percent of the previous weight and summing to unity.
YPM	Personal income in Michigan
YPRM	A annual average of a six-quarter lagged weighted average of disposable income with successive weights equaling 80 percent of the previous weight and summing to unity. (In the intangibles tax equation).
YQ	Dividends and proprietors', personal interest and rental income.

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