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AN ECONOMETRIC FORECASTING MODEL OF THE MICHIGAN ECONOMY

by
Joan Marcia Weiss

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Economics)
in The University of Michigan
1976

Doctoral Committee:

Professor Saul H. Hymans, Chairman
Professor Harvey E. Brazer
Professor Harold T. Shapiro
Professor W. Allen Spivey

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CHAPTER I

INTRODUCTION

The rapid advance of computer technology in the past decade has made it possible for business and government to explore more fully the quantitative aspects of planning. Operations research has become an important part of the business curriculum. In order to optimize the behavior of an individual unit in some future period, a projection of the state of the overall economy at that time is necessary. To fill this need, econometric models of the United States economy have been developed.

As the current recession has underlined, the behavior of subnational units may not parallel that of the entire United States. Some areas have remained quite prosperous while others have experienced a more than proportional decline in economic activity. One region of the latter type is the State of Michigan. The State government and businesses that have major facilities in the state are anxious to know just how bad the effects of the slump will be. The Federal government also needs information as to the relative impact of economic events on various areas in order to best allocate specific types of aid. National firms, too, make use of regional data in their marketing plans.

Why is a separate model valuable for Michigan in particular? Table 1.1 compares personal income in Michigan to analogous data for the United States for the year 1973. The most obvious difference between the two economies is in the proportion of personal income generated in the manufacturing sector. In Michigan, 30 per cent of personal income originates in manufacturing, while for the nation the comparable figure is 18.6 per cent. The difference in composition of manufacturing is even more striking. While Michigan produces less than its share of non-durables and only slightly more than its share of non-automotive durables, 12.4 per cent of Michigan personal income (about half of manufacturing wages and salaries) arises from motor vehicles and parts, as opposed to 1.2 per cent nationwide (about 7 per cent of manufacturing income).

From the above comparison, it is apparent that the Michigan economy is more susceptible to cyclical fluctuations in automobile production than the United States economy as a whole. This sensitivity naturally affects other parts of the Michigan economy which depend on automobile activity and payrolls to generate their revenue. Government transfer payments in Michigan increase and personal tax levies decrease more than in most other states during a recession. If a businessman or government official wants to predict the effect of a policy on the Michigan economy, a national model is not

Table 1.1: Personal Income in Michigan and the United States -- 1973

	MICHIGAN		UNITED STATES	
	Amount (billions)	%	Amount (billions)	%
Total Personal Income	50.20		1055.0	
Wages and Salaries	34.11	67.9	691.5	65.5
Farming	0.08	0.2	5.6	0.5
Mining	0.15	0.3	7.4	0.7
Contract Construction	1.69	3.4	42.3	4.0
Manufacturing	15.05	30.0	196.6	18.6
Durables	12.66	25.2	124.3	11.8
Motor Vehicles and Equipment	6.24	12.4	13.1	1.2
Other Durables	6.42	12.8	111.2	10.5
Nondurables	2.39	4.8	72.3	6.9
Wholesale and Retail Trade	4.98	9.9	113.2	10.7
Finance, Insurance, and Real Estate	1.15	2.3	35.3	3.3
Transportation, Communication, and Utilities	1.88	3.7	51.8	4.9
Services	3.87	7.7	92.8	8.8
Government	5.26	10.4	146.5	13.9
Non-wage and Salary Income	16.09	32.1	363.5	34.5

Sources of Data: 1975 Michigan Economic Report of the Governor, Table VII

Survey of Current Business, July, 1974, Tables 2.1 and 6.2

likely to be sufficient (although a close look at the automotive sector would help).

Such is the motivation behind the forecasting model constructed in this paper--the desire to predict how the Michigan economy will behave for a given set of national conditions. It is hoped that these forecasts will enable better planning by business, as well as state, local, and even federal government units, to serve the needs of Michigan residents.

Chapter II of the dissertation explores the area of regional econometric modeling. It considers the reasons for the increasing popularity of such models, their structure, and the problems encountered in their specification, estimation, and use.

Chapter III describes the main features of the Michigan Model and provides a framework for the individual equations and estimation results presented in Chapter IV.

Chapter V includes error statistics for various predictions generated by the model and results of simulations run under a number of alternative assumptions. It gives an indication of what can be expected when actually forecasting with the model. Suggestions for improvement and further development (Chapter VI) conclude the discussion.

Appendix A contains mnemonics, units, sources, and other information concerning the 119 variables (exogenous and endogenous)

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present in the final model. Due to the large number of variables and observations, the data values themselves are not included but may be obtained from the Research Seminar in Quantitative Economics at the University of Michigan. The equations of the model are found in Appendix B, while Appendix C presents the ordinary least squares versions of the instrumental variables equations found in Appendix B. The variables used in creating each of the instruments are listed in Appendix D.

CHAPTER II

REGIONAL ECONOMETRIC MODELING

Since the 1965 publication of the Burton and Dyckman California study,[1] multi-equation econometric models have become an increasingly familiar tool in analyzing regional economies. L'Esperance and King list approximately forty such models in their "Review of the State of the Art" paper;[2] others are currently being developed. Rather than summarize and criticize a representative sample of the earlier works on a model-by-model basis, as has been done in the past,[3] this chapter takes a different approach. It explores, with liberal reference to the literature, why econometric modeling, an increasingly accepted technique on the national level, has been extended to regional economies. It also considers major decisions and problems associated with the construction of a subnational model.

CONCEPT OF A REGION

A recurrent problem in the literature of regional economics has been how, in fact, to define a region. Usually homogeneity of some economic or social characteristic or a clustering around a nodal point (e.g., a central city) has been sought. A state does not

perfectly meet either of these criteria, yet we would like to consider it a region. John Meyer, in his "pre-econometric" survey article, proposes the programming or policy-oriented region, stressing the "identity between the area being studied and available political institutions for effectuating policy decisions."[4] A region for econometric modeling purposes is thus, of necessity, defined as a convenient unit of data collection and political action, rather than a theoretical economic entity.

On one hand, this is a useful definition because sub-national political units have the power to make decisions that have economic effects within their jurisdictions. Obvious examples are the level and distribution of taxation and expenditure. On the other hand, in specifying a model of such a region, one must make the implicit assumption that the underlying economic theory holds over the political unit in much the same way it holds over the economic one.

THE CASE FOR REGIONAL ECONOMETRIC MODELS

Traditional quantitative approaches to the study of regional economies have included input-output analysis, economic base models, and location theory.[5] Although these tools continue to be used, they no longer tell the whole story. A number of factors account for the growing interest in sub-national, especially state, econometric models.

Econometric forecasting models of the type developed in this dissertation are primarily tools for short-run prediction. Input-output and economic base models, in contrast, stress long-run or developmental considerations. State governments, or more accurately the politicians composing them, while not unconcerned about the distant future, find more use for accurate near-term projections of employment, output, and governmental revenue.[6] They, therefore, should be expected to appropriate the funds necessary to construct state econometric models. The cost-effectiveness of such models is a strong point in their favor. Estimated mainly from data already collected for other purposes, econometric models can often avoid the expensive and time-consuming surveys associated with other types of modeling. Once constructed, econometric models can be maintained to provide forecasts at regular intervals, insuring a continued return on the original investment. Governments and businesses have become more sophisticated in their view of econometric techniques and are more able to use and appreciate the results of the models constructed.

Realistic econometric models contain a rich variety of policy parameters. The planner or policy maker can simulate the regional economy to measure the effects of proposed actions, enabling him to compare quantitative as well as qualitative effects.

Econometric models can increase the usefulness of existing base or input-output models. For the latter, a regression model

is used to predict the final demand vector which the input-output model then disaggregates. Some of the disaggregated information may then serve as exogenous input for a subsequent run of the regression model. Econometric models can be designed to predict the output in basic or export industries to which one can apply the multiplier calculated from an economic base model.[7] Employment estimates from regression models are also valuable in implementing the location quotient technique to estimate the future economic base.[8]

Computer hardware and software have been greatly improved in the past decade. As a result, estimation and multiple equation solution have become routine and inexpensive procedures. The development of large-scale national econometric models, contingent upon this computer backup, has provided forecasts of the variables which serve as inputs to regional models.

STRUCTURE OF A REGIONAL MODEL

A fundamental concern in constructing a sub-national model is how to define the type of structure that will best replicate two critical sets of relationships. The first is the role to be assigned to national variables in the regional economy. It is essential to recognize the openness of a regional economy and its sensitivity to the national business cycle.[9] Thus national variables must be included. One should be careful, for instance, not to hypothesize the state economy

to be a self-sufficient unit with, say, a labor market independent of that in neighborhing states. The data would discredit such a hypothesis.

At the other extreme, regions are not scaled-down replicas of the nation. One should resist the temptation to use powerful national variables as sole determinants of regional activity. Region-specific variables, especially in the short run, play a necessary role in pinpointing the divergence of regional from national behavior.

The second important relationship is that among the endogenous variables themselves. Three basic types of models have been constructed. Since at least one of each type has been estimated for Michigan, these state models will serve as examples. In what Glickman terms a "simple" model,[10] regional activity is predicted solely on the basis of national variables. The Suits Michigan Model is such a construct.[11] It treats the components of gross state product (GSP), Michigan retail sales, and state employment as functions of national quantities: automobile expenditures, producer durables, and other private GNP. This is not really a model, but a group of independent equations, many of which should be directly related but are not, e.g., manufacturing employment and the manufacturing component of GSP. The Burton and Dyckman California study is another example of a simple model.[12]

In a recursive (unidirectional) model the variables are considered in a particular sequence. The first of the endogenous variables

is predicted only on the basis of the predetermined variables (exogenous and lagged endogenous). The second endogenous is predicted using (possibly) the forecast of the first in addition to the predetermined variables, and so on through the list of endogenous variables. An advantage of the recursive structure is that the equations often can be estimated in order using least squares throughout to yield consistent estimates. Simultaneous equation problems are avoided. The major drawback of recursive models is that variables near the end of the ordering do not affect those at the beginning. Not only is this lack of simultaneous (within period) feedback unrealistic as a representation of events in models based on annual or quarterly data, it severely constrains the types of policy simulations that can be carried out.

The Hymans-Shapiro model of the Michigan economy is recursive.[13] Personal income in Michigan is specified as a function of exogenous (to the state model) national aggregates. It is then used, along with exogenous variables, to predict employment in the government and distributive sectors. Manufacturing employment, like personal income, is wholly determined by outside factors. Current employment (or unemployment) plays no role in the determination of current income (except the weak indirect role as a component of the national aggregates upon which Michigan personal income depends). Other recursive models include the Chau Hawaii model[14] and the Bell Massachusetts model.[15]

The third, and most useful, type of model is the simultaneous model. Within this framework, the researcher is able to test for mutual interaction, the most general hypothesis about the relationship among the variables in the model. Most of the major regional models of the past few years have been of the simultaneous type.

Edward Robb estimated a simultaneous model of the Michigan economy.[16] In the Robb model the components of personal income are estimated and summed to obtain personal income. Personal income, in turn, is an independent variable in the equations predicting non-farm proprietors' income and wages and salaries in wholesale trade, retail trade, and services. This model is far from a complete picture of the Michigan economy, despite its title. It omits measures of employment, labor force, prices, and tax collections, to name a few. Thus further work remains to be done.

No discussion of regional modeling literature or the structure of regional models is complete without a reference to the article by L. R. Klein.[17] In this piece he outlines a general simultaneous structure (similar to that of many national models) for a regional macroeconomic model, including such variables as gross product, consumption, investment, imports, exports, government expenditures, and taxes. He also advocates constructing the regional models so specified as satellites of national models rather than summing regional models to produce a national one. Although data considerations have prevented many regional models from being constructed

in the Keynesian framework Klein described, his article was instrumental in distinguishing sub-national econometric models as worthwhile research projects and initiating their linkage with existing national models.

DATA PROBLEMS

The quality and variety of data available for regions often leave much to be desired. Certain series that are widely used on the national level do not exist for states, e.g., dividends, imports, exports, corporate profits, and non-manufacturing investment. Others are incomplete or available at too great a lag to be incorporated into a short-term forecasting model.

Constant definitional changes pose problems. This is more severe on the state than on the national level because new techniques are continually introduced to enable state data to more closely parallel their national analogues. Between July and December, 1974, for example, two major redefinitions have occurred in Michigan data. The labor force, total employment, and unemployment are now defined on a household rather than an establishment basis to bring Michigan Employment Security Commission calculations into agreement with Department of Labor population surveys. The series have been reestimated back only as far as 1970, leaving a small number of observations available for estimation. The series could not be taken further back than 1968 in any event, since the necessary state

household data do not exist for prior years. The second change is that the categories of state personal income are now estimated by the Department of Commerce on a place of employment rather than a place of residence basis, with revised data back only to 1971.[18]

In the best of all possible worlds, gross state product (GSP) accounts would be used to provide the framework for a state model in the same way GNP accounts structure a national model. GNP is usually computed in a model using one or more of three general approaches. The expenditure method sums consumption, investment, net exports, and government purchases to arrive at GNP. According to the income viewpoint, personal income is adjusted to produce national income which, in turn, leads to net national product. Capital consumption allowances are then included to produce a GNP figure. The third approach is value-added, whereby the components of GNP originating in each of the sectors of the economy are aggregated.[19]

Because import and export data are unavailable for most regions, while consumption estimates are weak (often based on state tax revenues which omit many categories of consumption), if they exist at all, the expenditure approach is not usually attempted. One exception to this statement is the model of the Alaskan economy estimated by Bradford Tuck.[20] If import and export data are available for any state, Alaska (or Hawaii) would be a likely candidate. Un-

fortunately, in the Alaska model both imports and exports are determined exogenously. For imports, Tuck states that "this has proved necessary because of the difficulty of obtaining a sufficient series of adequate length and reliability"[21]--an all too familiar problem.

Kendrick and Jaycox (K and J) were the first to suggest a simple method of constructing GSP using the value-added approach.[22] Since the most reliable data at the state level are personal income and its components (published by the Department of Commerce), the K and J method inflates these to obtain the corresponding gross state product components. K and J hypothesize that personal income in each private non-farm sector bears the same relation to GNP originating in that sector on both the national and state levels. This is expressed in the following relationship:

$$\frac{YP_i^{US}}{GNP_i^{US}} = \frac{YP_i^{ST}}{GSP_i^{ST}} \tag{2.1}$$

where YP represents personal income (wages and salaries) in sector i in either the United States (US) or the state in question (ST) and GNP_i^{US} or GSP_i^{ST} represents the part of gross product originating in sector i. This equation is solved for GSP_i^{ST} for each i and the sum $GSP^{ST} = \sum_i GSP_i^{ST}$ is computed.

There are three reasons why this approach is not optimal. The first is that using the process implicitly assumes that the state in question has a production and income pattern similar to that of the nation as a whole. This just is not true for many states, especially Michigan, as was discussed in Chapter I. In their Mississippi model, Adams and Brookings suggest that the procedure need not be carried out for manufacturing to get gross product in that sector.[23] They use the Survey of Manufactures as a source for total manufacturing output in Mississippi. This is a good idea for an annual model but cannot be used for a quarterly model, although it might provide a check on the four-quarter calendar year totals obtained by the K and J method. Adams and Brookings use the standard K and J procedure for the other private, non-farm sectors.

The second reason to eschew calculating GSP in this manner is that, even though there may be some payoff to generating a gross state product series for its own sake, less error is introduced into the model by explaining those variables for which we have better data.[24] The "noise" so introduced may be just sufficient to obscure some of the weaker relationships existing among segments of the economy.

The third, and possibly most important, criticism of the K and J framework is that it obscures the factors that cause the state in question to differ from other states and the nation as a whole. These factors are the very reason that time and effort are expended

in constructing state models. If the state variables are then regressed on their national counterparts, the R^2 is certainly biased upward.[25]

Many models do construct GSP using the K and J approach despite its drawbacks. The most well-known is the L'Esperance, Nestel and Fromm Ohio model.[26] The authors of this study state in a footnote that the assumption of equal factor shares within each industry for Ohio and the United States is reasonable due to the diversity of that state's economy.[27]

In his California model, Ratajczak attempts to parallel the income method of arriving at GNP.[28] Although this is a unique and interesting effort since it increases the scope of possible policy simulations, there is a large degree of arbitrariness in the data used to do it. Ratajczak adds corporate tax payments, retained earnings of corporations, indirect business taxes, capital consumption allowances, surplus or deficit of government enterprises, social insurance contributions, business transfers and statistical discrepancy to personal income while subtracting transfers and interest receipts. Much of these adjustment data are "derived from tax information which is available only on an annual basis, their quarterly profiles . . . arbitrarily determined by national profiles for comparable variables."[29] Even if one feels that this process does not introduce too much error, depreciation and retained earnings are still unreliable. The latter is computed as a residual item.

Ratajczak admits that the accuracy of his figure depends upon two assumptions: 1) that the California household sector receives the same amount in dividends as California corporations pay and 2) that multi-state corporations do not divert large amounts of income from high tax (e.g., California) to low tax states. Depreciation is difficult to estimate from tax data, especially on the state level, and constitutes a nonnegligible share of state product. Furthermore, many of these data are available with too much of a time lag to be useful in a quarterly model.

It is possible to construct regional models on an annual, quarterly, or even monthly basis.[30] Quarterly (or monthly) data are more sensitive to cyclical fluctuations. They allow the most up-to-date forecasts because recent values of the exogenous variables can be incorporated. The increased number of observations yields sufficient degrees of freedom to explore lag structures and to consider more than two or three explanatory variables. On the other hand, using annual observations, one has access to a much richer data base. This includes information that is only collected annually (e.g., U.S. Census of Manufactures) as well as data that are annual by nature (e.g., number of school children, tax collections, assessed property tax valuations).

A final data concern in a quarterly or monthly model is whether or not to seasonally adjust the data. Seasonally adjusted

data have two principal advantages in a regional model. First, they are more easily integrated with major national models that are normally estimated with seasonally adjusted data. Second, the output is more easily understood when movements can be clearly interpreted as non-seasonal variations. In a non-adjusted model, an increase may be less than the usual increase for that quarter and should be considered a decline.

While admitting that non-adjusted data are more difficult to interpret, proponents of non-adjusted data claim that these data are more useful. Forecasts can be directly compared to the unadjusted data produced by state agencies to determine their accuracy. Projected tax revenues and government expenditures are important in their absolute magnitude, not in their seasonally controlled level. They further assert that the seasonality factor can be duplicated by dummy variables (that have a time component if the seasonality factor seems to be increasing) in forecasting the unadjusted series. If the seasonal factors determined in this way are then subtracted from the unadjusted data, an adjusted series is produced. This method thus yields forecasts of both an adjusted and unadjusted series. The question in deciding if an adjusted series should be used is essentially whether or not dummy variables can replicate seasonal factors as well as packages such as the Census X-11 program.

EVALUATION OF THE MODEL

In evaluating an econometric model, one must consider both the fitting of the individual equations and the performance of the system of equations as a whole.

For a single equation, standard econometric criteria provide a rough means of comparison. In general, a high coefficient of determination (R^2) and a low standard error of estimate are preferred. The form of the equation must also be considered. A higher R^2 is expected on a time series equation estimated in levels, for instance, than for one estimated in differences.

Significant t-ratios (with correct sign, of course) are desirable, but in a complex equation derived from less-than-exact theory, it is difficult to say what transformation of the error term (if any) should be hypothesized as normal. Thus t-statistics are at best indicative. If theory suggests that a variable should have some effect, if the magnitude of the estimated coefficient seems reasonable, and if the coefficient is greater than its standard error, there is a case for inclusion.

Two further caveats are in order. The first is that the goal of the model is accurate forecasts and sometimes no amount of inspection of competing equations will choose the one which will predict best. The second is that an equation, taken alone, may appear reasonable but not function properly as part of a simultaneous equations system.

The best way to evaluate a model (and implicitly the forecaster operating it) is to look at its predictive accuracy. How well did the model foresee in the previous period what is taking place in the current period and what will occur in subsequent periods? Unfortunately, this sort of "track record" takes time to be accumulated.[31]

For a new model, the standard method of evaluation is through "forecasts" (static and dynamic) over the sample period and for any post-sample periods for which data are available. In static forecasts, correct values for the exogenous and lagged endogenous variables are used in each period. The predictions generated by the system are compared with the true values of the endogenous variables. Dynamic forecasting poses a more stringent test. For the first prediction period actual figures are entered for the exogenous and lagged endogenous variables as in the static forecast. In subsequent quarters, the values predicted by the model are used as the lagged endogenous variables. It is then possible to see whether the model corrects its own errors or becomes progressively less and less accurate. Regional models have an advantage over national models in dynamic forecasts because the exogenous (to the regional model) national variables are often in themselves powerful enough to keep the regional model "on track." In more self-sufficient national models, such controls are absent. Considering the model equation by equation exposes parts that need improvement in themselves while viewing the model as a system highlights parts that do not forecast

well when combined with others. If possible, improvements and re-estimations should be considered. At the very least, the forecaster develops a "feel" for the accuracy of his model. He notes which equations are least reliable and where there exist systematic tendencies to over- or under-predict, in which case adjustment constants can be used.

As Glickman points out,[32] there are no standardized statistical tests to evaluate model performance. Such statistics as mean absolute percentage error or root mean squared error may be computed and results compared among competing systems, but not against any absolute standard. These same statistics may be obtained for simple models such as $\Delta y_t = \Delta y_{t-1} + u_t$ or $y_t = y_{t-1} + u_t$ and the magnitudes noted. The very simplicity of such formulations makes it relatively easy to do better, setting the baseline quite low and reducing the usefulness of the comparison. Attempts have been made to evaluate econometric models relative to more sophisticated alternatives than the no change or constant change versions mentioned above. One such alternative has been Box-Jenkins models; more will be done in this area in the future.

MISCELLANEOUS COMMENTS

Although regional models suffer from many of the same defects as their national older brothers, they are more often the

targets of criticism for these failings. Possibly because macro-economic models of the United States have a proven record they are less vulnerable. Possibly, too, sub-national models display the common weaknesses to a greater degree. Whatever the reasons, regional econometric forecasting models have been widely criticized and commented upon.

A weakness of many econometric models is in their lack of precise theoretical justification for each equation. While theory may suggest variables and their interactions, it usually is not strong enough to specify the exact form or lag structure appropriate for the behavior being modeled. This must be left to trial and error and often depends as much upon peculiarities of the data as upon more substantive considerations. This theoretical gap is compounded in regional models by the unavailability of desired data series. Obtainable variables must be used as proxies for those missing, causing the theoretical linkage to appear even less compelling.

The role of the forecaster in using an econometric model is seldom mentioned explicitly[33] but should not be underestimated. The naive notion persists that it is sufficient to insert values for the exogenous variables, operate the computer, and read the (obviously correct) forecasts produced. The first problem is in obtaining the future values for the exogenous variables. Estimates differ from econometrician to econometrician and, of course, substantially

affect the values determined for the endogenous variables. In the case of regional models, the major exogenous variables are generated by a national model, itself subject to error.

A second modification performed by the forecaster is to adjust for prospective events that the model cannot be expected to incorporate on its own. If conditions vary in the post-estimation period from those of the sample period, the model must be told. Examples include non-linearities in functions previously assumed to be linear, the extraordinary price increases for petroleum products in 1974 being one such case, and structural shifts such as the change in coverage of a particular tax, that are not explicitly considered in the model. Adjustments can also be made in equations that are becoming systematically less accurate as time passes.

Once predictions are generated, the forecaster must decide if they seem reasonable, that is, do they reflect his view of what is likely to happen? This is especially crucial in the leadoff quarter (the first quarter to be forecast by the model) when the forecaster may have access to partial data on such variables as unemployment, interest rates, and industrial production. If the predictions of these key variables are not in close accord with their probable values, the adjustment constants are altered in selected equations and the whole system is re-solved. The model is then prepared to forecast more accurately in subsequent periods.

Other criticisms of econometric models are often aired, especially at the regional level.[34] These flaws include misspecification and lack of structural accuracy (the world is not "linear in the parameters"; the proper variables may not all be included; many standard econometric assumptions, e.g., serially independent residuals, remain unmet), trend dominance (almost any trended series is a minimally satisfactory independent variable; the R^2 is inflated due to a strong upward time trend), and omitted variables bias (multicollinearity precludes significance for more than one of a group of related independent variable). The critics, usually themselves professional economists, are not telling the empirical econometricians much of which they are not already painfully aware. In fact, it is most often the forecaster who has realistic expectations of what the model can and cannot do.

NOTES

[1] R. P. Burton and J. W. Dyckman, A Quarterly Economic Forecasting Model for the State of California (Berkeley, California: Center for Planning and Development Research, University of California, December, 1965). I have never actually seen this model; all references to it are via secondary sources.

[2] W. L. L'Esperance and A. E. King, "A Review of the State of the Art of Regional Econometric Model Building" (Columbus, Ohio: Midwest Econometrics, Inc., 1974).

[3] Almost every paper describing a regional model discusses other models to a certain extent. A good summary of ten of the more well-known models is Dean Chen, "A Tabular Survey of Selected Regional Econometric Models" (San Francisco: Federal Reserve Bank of San Francisco Working Paper No. 11, 1972).

[4] John Meyer, "Regional Economics: A Survey," American Economic Review, LIII (March, 1963), p. 22.

[5] A concise but informative reference for the more traditional methods of regional analysis is Harry W. Richardson, Elements of Regional Economics (Baltimore: Penguin Books, 1969).

[6] This is supported by political theorists who claim that the relevant time frame for a politician is from the present to the next election. Among those holding this view are Albert Breton, The Economic Theory of Representative Government (Chicago: Aldine Press, 1974), p. 124; Anthony Downs, An Economic Theory of Democracy (New York: Harper and Row, 1957), p. 52; and Jerome Rothenberg, "A Model of Economic and Political Decision Making," The Public Economy of Urban Communities, papers presented at the Second Conference on Urban Public Expenditure, February 21-22, 1964, under the sponsorship of the Committee on Urban Economics of Resources for the Future, Inc., Julius Margolis, editor (Baltimore: Johns Hopkins Press, 1965), p. 2.

[7] Richardson, op. cit., pp. 31-33, warns against indiscriminate use of multipliers obtained from economic base models.

[8] Briefly, the location quotient method computes the difference between actual regional employment in an industry and what employment would be if the region had its proportional share of the industry's national employment. For those industries where the difference is positive, the surplus workers are summed to yield an estimate of base employment.

[9]Michigan has the most volatile of the fifty state economies according to Robert B. Bretzfelder, "Sensitivity of State and Regional Income to National Business Cycles," Survey of Current Business, LIII (April, 1973), p. 22. He defines his measure of sensitivity, "cyclical swing," as the difference between the expansionary and recessionary increase in nonfarm personal income.

[10]Norman J. Glickman, "Regional Econometric Models: The Japanese and American Experience" (Philadelphia: University of Pennsylvania Institute for Environmental Studies, February, 1972), p. 4.

[11]Daniel B. Suits, Econometric Model of Michigan (Lansing, Michigan: State Resource Planning Program Technical Report No. 3, April, 1966).

[12]Glickman, op. cit., p. 5.

[13]Saul H. Hymans and Harold T. Shapiro, "The Michigan Economy in 1973," The Economic Outlook for 1973 (Ann Arbor, Michigan: Twentieth Anniversary Conference on the Economic Outlook, November 16-17, 1972), pp. 23-35. In fairness to the authors, this model was never billed as a finished or semifinished product. It was a tentative first step in a continuing program of research, of which this dissertation is a part.

[14]Laurence C. Chau, An Econometric Model for Forecasting Income and Employment in Hawaii (Honolulu: Economic Research Center, University of Hawaii, June, 1970).

[15]Frederick W. Bell, "An Economic Forecasting Model for a Region," Journal of Regional Science, VII (Winter, 1967), pp. 109-128.

[16]Edward H. Robb, "A Quarterly Econometric Model of Michigan" (unpublished Ph.D. dissertation, Michigan State University, Lansing, Michigan, 1971).

[17]Lawrence R. Klein, "The Specification of Regional Econometric Models," Papers and Proceedings of the Regional Science Association, XXIII (1969), pp. 105-115.

[18]Total personal income is still reported on a residence basis by including a residence adjustment component.

[19]A discussion of income and social accounting in a regional context is found in Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science (Cambridge, Massachusetts: M.I.T. Press, 1960), pp. 80-121.

[20]Bradford H. Tuck, "An Aggregate Income Model of a Semi-Autonomous Alaskan Economy" (Anchorage, Alaska: Federal Field Committee for Development Planning in Alaska, 1967).

[21]Ibid., p. 27.

[22]John W. Kendrick and C. Milton Jaycox, "The Concept and Estimation of Gross State Product," Southern Economic Journal, XXXII (October, 1965), pp. 153-163.

[23]F. Gerard Adams and Carl G. Brooking, "An Econometric Model of Mississippi" (Philadelphia: Wharton Economic Forecasting Associates, Inc., 1973), pp. 113-114. After obtaining gross manufacturing output, they disaggregate it into durables and nondurables by means of ten annual observations on the breakdown (1947, 1954, 1958, 1963-1967, 1969, 1970) and interpolate for the rest. This brings them back into the realm of "created" data they seem at first to be trying to avoid.

[24]This is not to deny that figures appearing in the Survey of Current Business, Business Conditions Digest, etc., are also extrapolations from benchmark series and/or estimates based upon sample data. The point is that in using K and J inflation one moves yet one degree further from the "real" information.

[25]Norman J. Glickman, "Son of 'The Specification of Regional Econometric Models' " (paper read at the 1973 North American Meetings of the Regional Science Association, Atlanta, Georgia, November 11, 1973), p. 10.

[26]W.L. L'Esperance, G. Nestel, and D. Fromm, "Gross State Product and an Econometric Model of a State," Journal of the American Statistical Association, LXIV (September, 1969), pp. 787-807.

[27]Ibid., p. 789.

[28]Donald Ratajczak, "A Quarterly Econometric Model for California" (Los Angeles: University of California, 1972). (Mimeographed.)

[29]Ibid., p. 22.

[30]T. C. Liu and Sidney Saltzman, in "A 'Live' System for Integrated Econometric Models for the Nation, New York State, and New York City" (Ithaca, New York: Cornell University, January, 1973), propose to integrate monthly state and city models with their monthly United States model.

[31]A number of national models have been producing forecasts regularly enough and for a sufficient period to evaluate their areas of strength and weakness. This can be said for very few regional models.

[32]Glickman, "Son of," op. cit., p. 15.

[33]Notable exceptions are models built by the Wharton School, e.g., Glickman, "Son of," op. cit., p. 23, and Adams and Brooking, op. cit., pp. 65-66.

[34]For a veritable laundry list of flaws present in econometric models, see Charles Richter, "An Econometric Model of the Coastal Plains States" (Chapel Hill: University of North Carolina, no date), pp. 36-39. (Mimeographed.)

CHAPTER III

THE MODEL: AN OVERVIEW

A simultaneous non-linear model is more than the sum of its individual equations. The equations must work together to reflect the operation of the economy upon which the model is based.

In this chapter the model of the State of Michigan is presented as an integrated whole. Emphasis is placed on the relationships among the endogenous variables and on the role of the exogenous ones. Exact specification of particular equations is not discussed until Chapter IV. The data used to estimate the model and the method of estimation are also described.

THE MODEL

The Michigan Model consists of 69 equations (69 endogenous variables) separated into a recursive block and a simultaneous block. The values of the thirteen variables in the recursive block are predicted on the basis of either predetermined variables or recursive ones earlier in the ordering.

Three of these recursive equations are linking equations, that is, they produce values of the United States variables the model

needs, using variables the Michigan Quarterly Econometric Model of the United States Economy (MQEM) actually predicts.[1] The United States consumer price index is obtained in this way from the personal consumption expenditures deflator, as is gross auto product from automobile consumption and the average production worker wage in United States manufacturing from total private non-farm compensation per man-hour. It simplifies the discussion that follows to treat these linking variables as exogenous (rather than recursive).

The simultaneous block contains 56 equations, 29 of which are econometrically estimated. The others are definitions or identities.

The model separates productive activity in the State of Michigan into nine principal sectors: manufacturing; transportation, communication, and utilities; wholesale and retail trade; finance, insurance, and real estate; services; mining; contract construction; farming; and government. Of these, manufacturing activity is clearly the most important and is a focal point of the model. The structure of the manufacturing sector is shown in Figure 3.1. A convention followed in the figures throughout this chapter is that exogenous United States variables are placed in parallelograms at the left of each diagram while endogenous Michigan variables are placed in rectangles at the center and right of the diagram. Ovals indicate exogenous Michigan variables.

The average hourly wage of production workers in Michigan manufacturing, the basic wage rate in the model, is predicted as a

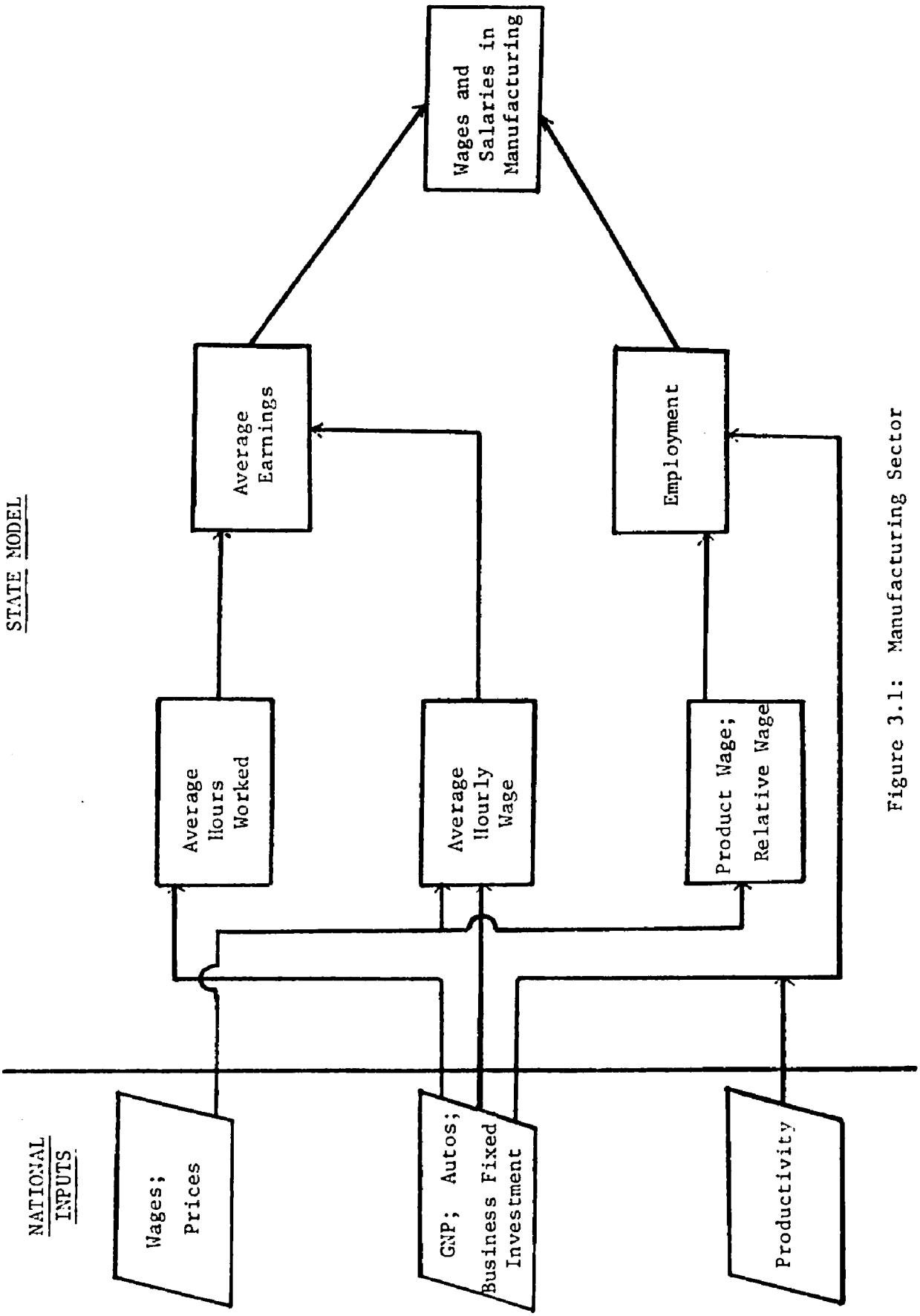


Figure 3.1: Manufacturing Sector

function of the analogous wage concept in the United States, the automobile expenditures share of gross national product, and prices in the Detroit area compared to those in the United States.

Average hours per worker in manufacturing are postulated to vary around some normal number, say forty hours per week, according to changes in automobile production and business fixed investment relative to GNP. The average wage is combined with the average number of hours worked to produce average earnings per quarter.

Employment in manufacturing is also determined by GNP and the shares of GNP accounted for by automobiles and business fixed investment. Wages in Michigan relative to those in the nation influence whether, other things equal, firms locate in Michigan. The product wage attempts to measure labor costs relative to the cost of output. If this ratio increases at an unacceptable rate, employers try to economize on labor inputs and employment declines. A negative time trend reflects increasing labor productivity. Employment is multiplied by average earnings per worker to yield wage and salary income attributable to manufacturing.

The non-manufacturing sectors, with the exception of farming,[2] are structured similarly but treated in less detail as can be seen in Figure 3.2. Average earnings per worker are determined as a function of the manufacturing wage mentioned previously and of the United States minimum wage in such sectors as trade, finance, and services,

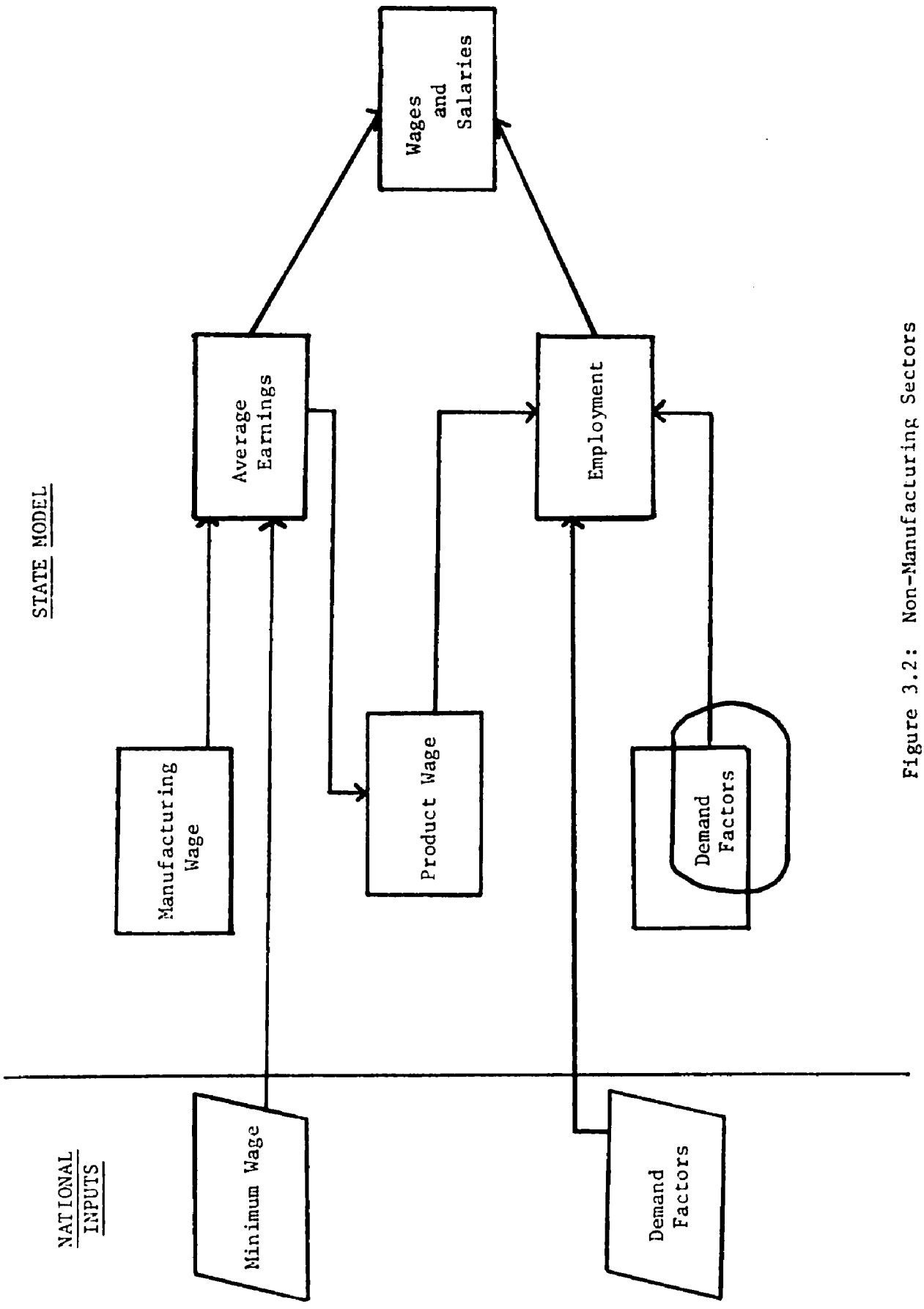


Figure 3.2: Non-Manufacturing Sectors

where much of the employment is at the lower end of the pay scale. Lagged dependent variables appear in these equations as a result of the Koyck transformation being performed on a geometric lag distribution of the independent variable.[3]

Since employment is treated as a derived demand for labor, the equations use endogenous and exogenous proxies for output demand in each sector. Endogenous demand factors include personal income in the government and transport sectors, disposable income in services, finance, and trade, and consumption, represented by sales tax collections, in the trade sector. Exogenous factors include GNP as a determinant of mining employment and business fixed investment and Michigan building permits affecting construction. In the employment equations, too, lagged dependent variables are often present.

As in manufacturing, average earnings and employment are multiplied to produce the figure for wages and salaries. Wages and salaries in each of the nine sectors are summed to obtain a total wages and salaries figure.

The non-wage and salary segment of personal income is diagrammed in Figure 3.3. It is composed of other labor income, proprietors' income, property income, and transfer payments minus contributions for social insurance. Transfers are further disaggregated into unemployment compensation, public assistance (both state and federally funded), Social Security benefits, and other transfers.

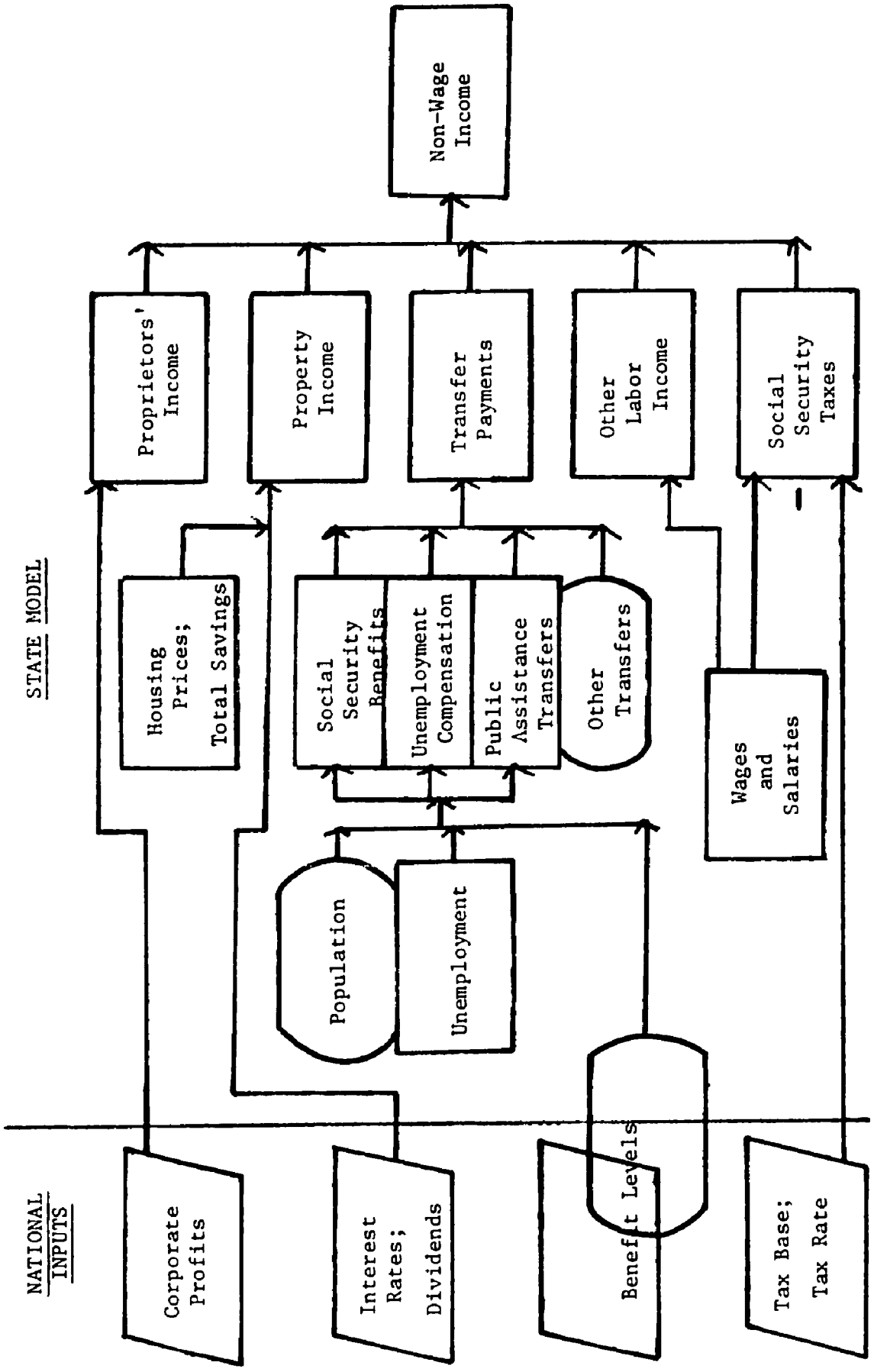


Figure 3.3: Non-Wage Income

The independent variables in these equations include unemployment, population, and benefit levels. Estimates of other labor income (fringe benefits) are based on wages and salaries while proprietors' income is a function of corporate profits in the United States. Property income (rent, interest, dividends) is dependent upon interest rates and dividend levels in the United States, the housing component of the Detroit consumer price index,[4] and total savings in Michigan. Contributions to Social Insurance are predicted as an interactive function of wages and salaries, the tax rate, and maximum taxable income under Social Security.

Figure 3.4 is a summary of the relationships among the principal variables of the model. The detail of the previous figures has been supressed; only aggregates are shown. As mentioned earlier, earnings and employment determine total wages and salaries. Adding non-wage and salary items yields personal income. Subtracting income taxes and other taxes[5] from personal income leaves disposable income. The consumer price index is used to convert nominal personal and disposable income to their constant dollar equivalents (real income in Figure 3.4). These real magnitudes are the variables that serve as demand proxies in the employment equations. Consumption is a function of real income and also affects employment. The Detroit consumer price index parallels the United States CPI for the most part. The strength of demand in Michigan

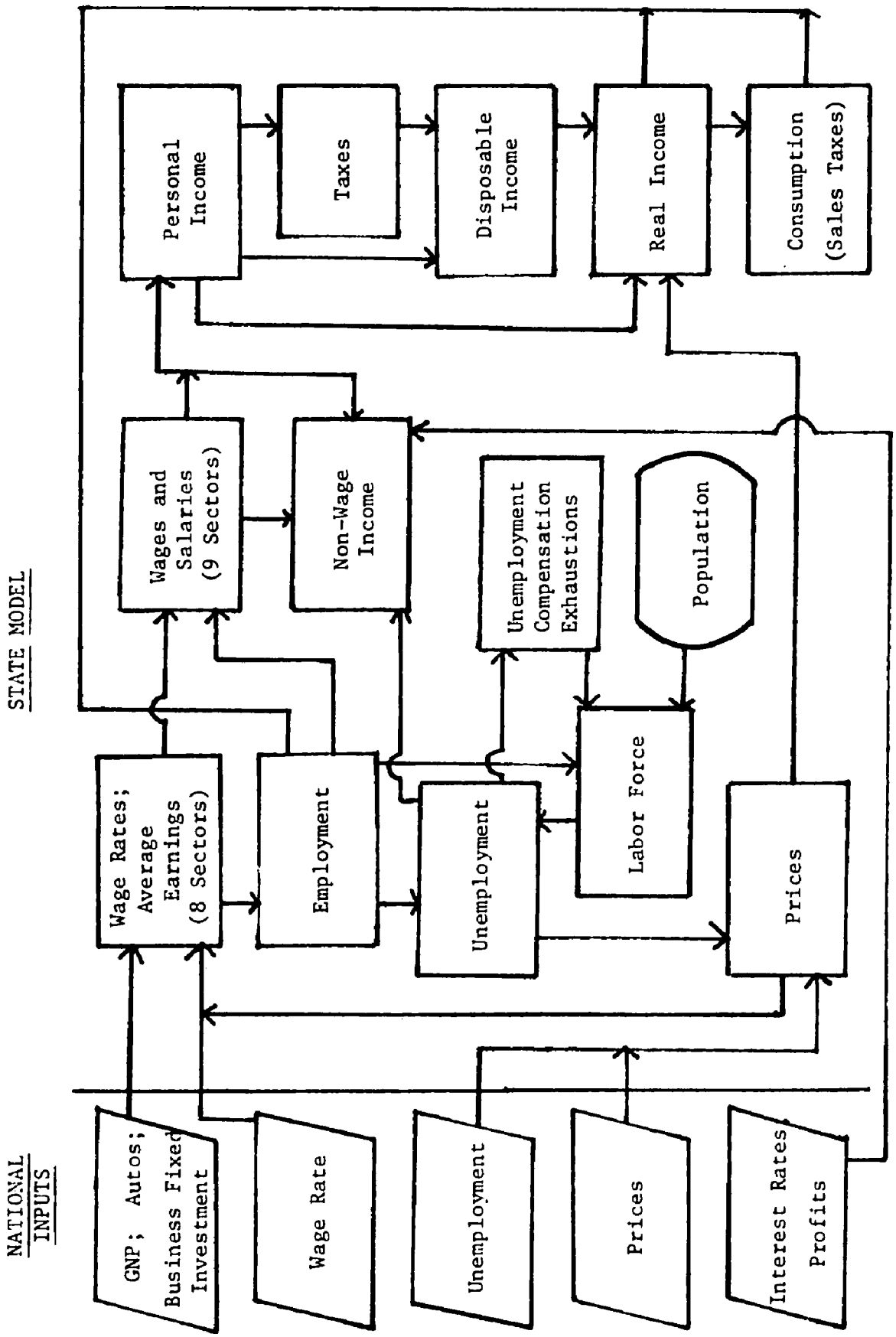


Figure 3.4: The Entire Model

relative to that in the U.S. enters the equation through the ratio of unemployment rates, Michigan to United States.

The supply side of the labor market is represented by a labor force equation, based on population, employment, and unemployment compensation exhaustions. Once the size of the labor force has been established, the number of unemployed persons is defined as the difference between the labor force and total employment. This unemployment helps determine the price level, unemployment compensation exhaustions and the transfer payment component of personal income.

As an example of how the model mirrors events in the economy, some of the effects of a hypothetical occurrence will be described. Suppose General Motors decides to reduce substantially automobile production in a given quarter. This would lead to a reduction in manufacturing employment and hours worked and a moderation in the rate of increase of the manufacturing wage.[6] There would be a slight (second order) countervailing increase in employment as the relative wage declined, but this would not be as great as the original effect. Total wages and salaries originating in manufacturing would decrease causing a reduction in personal income. Income tax collections would fall but not as much as personal income so disposable income would decline. Real income is lower, precipitating a fall in demand in the non-manufacturing sectors. Wages in these areas are

related to the manufacturing wage so their rate of increase is slowed. Both these effects reinforce the drop in wages and salaries.

Total employment drops, yielding a slightly smaller labor force (lower labor force participation rate), but an even more than offsetting increase in the number of unemployed. This unemployment lowers the rate of inflation, somewhat controlling the real income decline, and activates the automatic transfer payments mechanism.[7] Unemployment compensation and increased welfare rolls help pump purchasing power back into the economy. Discretionary government actions can also enter the model by means of such policy parameters as tax rates and transfer payment benefit levels.

THE DATA

The model was constructed using quarterly, seasonally adjusted data for both Michigan and United States variables. Where seasonally adjusted series could not be obtained directly, the quarterly version of the Bureau of the Census X-11 Seasonal Adjustment program (Program X-11Q)[8] was called upon to generate them.

The earliest period considered for any variable was 1956, first quarter (1956.1); the latest was 1973, fourth quarter[9] (a maximum of 72 observations). Where a complete series was unobtainable, the equations were estimated with the data at hand, but in no case were fewer than sixteen observations used. Accompanying each estimated equation is a number N, the number of cases in the shortest included series.

Appendix A lists the data series used in constructing the model. For each basic variable, the appendix contains the mnemonic, the source, the unit of measure, the frequency of the raw data (monthly, quarterly, annually), the period the data were available, and whether or not the Census X-11 program was used to deseasonalize. For each transformed variable, the mnemonic, unit of measure, and generating equation are listed.

ESTIMATION

Each equation of the model was originally estimated by ordinary least squares (OLS). The resulting coefficient estimates are not statistically consistent[10] (the system exhibits simultaneous equations bias) due to correlation between the error term of the equation and at least one right-hand-side variable. Even so, OLS was used initially to determine the independent variables in each equation because it is a relatively easy and inexpensive means to screen a large number of explanatory variables and functions of those variables. Appendix C contains the OLS predictive equations for the simultaneous variables.

Once the structure of the model had been determined by OLS regressions, an instrumental variables procedure was employed to remove the resulting inconsistency. An instrument was constructed for each simultaneous variable appearing on the right hand side. The

vector of predicted values generated by regressing the simultaneous variable on a set of exogenous variables served as the appropriate instrument. In a few cases where the simultaneous variable was part of a complex function used as an independent variable, the instrument was not obtained directly as the predicted values but as the corresponding function of the predicted values.

The set of exogenous variables determining each instrument was chosen using a procedure similar to that outlined by Fisher.[11] Briefly, the method proceeds as follows. One looks at the OLS equation to obtain the direct determinants of the variable for which an instrument is needed. These are called zero order causal variables. The determinants of the zero causal order variables are termed first causal order; those explaining the first causal order variables are of second causal order, etc. The exogenous (or sufficiently lagged endogenous) variables in these orders are arranged according to strength of causality, from strongest to weakest. The original variable is then regressed on this collection of variables (or the first T-2 of them if their number approaches the number of observations, T).[12] The least preferred (lowest) in the order of causality is then omitted and the regression re-run. If the R^2 drops perceptibly the variable is retained as making a significant contribution. If not, the variable is omitted. The procedure is repeated for the next to lowest variable, retaining the least preferred only if it passed the test. This continues

through the list of variables in order of increasing causality. The regression used to obtain the instrument includes all variables that pass the test. The independent variables used to estimate the equations generating the instruments are found in Appendix D.

Once the instruments had been constructed, instrumental variables (IV) estimation, rather than two stage least squares (as suggested by Fisher) was used on the 29 simultaneous stochastic equations of the model. Since actual t-statistics cannot be constructed, the rough significance criterion selected was that the absolute magnitude of a cofficient exceed its standard error. The coefficients in all but four of the equations were judged significant by this rule. In two of these cases the IV estimates were retained as they stood because the R^2 and other coefficients of the equation were not greatly changed from the OLS version and the coefficient/standard error ratio exceeded .7. In the other two cases, where the equations looked quite different and the standard error was huge in comparison to the coefficient, the least significant variable was omitted and IV tried again. This produced equations acceptable by the original criterion.

No attempt was made to use a full information (entire system) method such as three stage least squares or full information maximum likelihood to estimate the model. These methods are quite sensitive to specification error, since an error in one equation is spread

throughout the whole system and may do great damage.[13] In a single-equation method, e.g., instrumental variables or two stage least squares, the error is at least confined to the equation in which it occurs.

A few of the equations exhibited an unacceptable degree of first order autocorrelation so the parameter estimates needed to be adjusted.[14] In the case of an equation in the recursive block, lagged residuals from the OLS-estimated equation were employed as an additional explanatory variable and the equation reestimated by least squares. In the case of an equation in the simultaneous block, the IV procedure was first used to obtain a set of consistent residuals, the lagged values of which were employed as an additional explanatory variable in a second estimation, again using the IV procedure.[15] If the assumption that the autocorrelation process is of first order is correct, this procedure yields consistent parameter estimates which are of greater efficiency than those obtained without the autocorrelation correction. Further, the coefficient of the lagged residual variable serves as a consistent estimator of ρ, the first order autocorrelation parameter.[16]

The entire final model (recursive equations estimated by OLS, IV estimation for simultaneous variables, definitions, identities) is contained in Appendix B.

NOTES

[1]All United States exogenous variables used in the model are either predicted by MQEM or obtained as linking variables. MQEM is constructed and maintained by the Research Seminar in Quantitative Economics (RSQE).

[2]Since the Michigan Employment Security Commission revised its method of computing unemployment, employment data are no longer published for agriculture. Agricultural employment is included in the model's residual employment, while wages and salaries in this sector are exogenous.

[3]L. M. Koyck, Distributed Lags and Investment Analysis (Amsterdam: North Holland, 1954), pp. 19-24).

[4]This variable is included because a large part of the rent contribution to property income is imputed rental value of owner-occupied housing.

[5]Other taxes separating personal from disposable income include inheritance and estate taxes, gift taxes, hunting and fishing permits, and drivers' licenses.

[6]Since average hourly wage of production workers includes overtime hours, it might possibly fall. This is offset, however, by the fact that the workers laid off are, due to union rules, those with least seniority and consequently the lowest hourly wage.

[7]SUB benefits are not explicitly included here although they are part of other labor income according to James Haughey, economist for the State of Michigan Department of Management and Budget.

[8]Julius Shiskin, Allan H. Young, and John C. Musgrave, The X-11 Variant of the Census Method II Seasonal Adjustment Program, Bureau of the Census, United States Department of Commerce, Technical Report No. 15 (Washington: U. S. Government Printing Office, February, 1967). The Fortran source program, modified slightly to conform to requirements of the Michigan Terminal System, may be accessed in the file SDY1:X-11Q.S. The compiled (object) program is found in the file SDY1:X-11Q.0.

[9]More recent data are used in prediction and simulation as soon as they become available. The last figures contributing to the estimation are 1973.4.

[10]The OLS estimates of the recursive equations are consistent. The discussion refers to inconsistencies in the simultaneous block.

[11]Franklin M. Fisher, "The Choice of Instrumental Variables in the Estimation of Economy-Wide Econometric Models," International Economic Review, VI (September, 1965), pp. 245-274.

[12]The groups of regressors actually used initially contained between ten and fifteen variables.

[13]Ronald J. Wonnacott and Thomas H. Wonnacott Econometrics (New York: John Wiley and Sons, Inc., 1970), p. 397; Lawrence R. Klein, A Textbook of Econometrics (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1974), pp. 149-150.

[14]The Durbin-Watson statistic served as a measure of the degree of autocorrelation. The values listed in standard tables cannot be used, however, due to the stochastic nature of some of the regressors (including the use of lagged dependent variables).

[15]None of the simultaneous equations requiring autocorrelation corrections contained a lagged dependent variable.

[16]After all work was completed, an oversight was discovered. Equation 4 of Appendix B in the recursive block of the model exhibits first order autocorrelation and also contains a lagged dependent variable. The autocorrelation correction procedure should have recognized the existence of the lagged dependent variable in the equation but did not.

CHAPTER IV

THE MODEL: THE INDIVIDUAL EQUATIONS

The previous chapter presents the model as a collection of aggregates. The interactions among these aggregates determine how well the model functions as a replica of the actual economy. In this chapter the emphasis shifts from the model as an integrated unit to the individual equations that comprise the unit. Attention is focused on the independent variables in each equation and the theory relating them to the dependent variable.

Many independent variables and functional forms of these variables were tried and rejected in each of the equations. Space does not permit discussion of each of these unsuccessful attempts. Only in cases where an absent variable is an obvious candidate for inclusion is some comment made.

Appendix B lists the estimated equations of the final model in the approximate order they are described in this chapter, while Appendix C contains the ordinary least squares equations for those whose instrumental variables versions are found in Appendix B.

Particular estimated coefficients are discussed only when there was some a priori expectation as to their value. It is worth-

while to note whether or not the expectations were, in fact, met.

EMPLOYMENT

The first group of equations, the employment block, represent the demand side of the labor market. In each sector of the economy, the number employed[1] is viewed as a derived demand stemming from demand for the product produced by this labor.

Manufacturing Employment

Approximately 35 per cent of wage and salary workers in Michigan are employed in the manufacturing sector (compared to 25 per cent for the United States as a whole), where the primary outputs are transportation equipment, metals, and machinery. Besides being the largest single employment component, manufacturing is also the most volatile, accounting for most of the quarter-to-quarter variation in total employment. For these reasons, the manufacturing sector is treated in greater detail than the other parts of the economy.

The basic model for the manufacturing sector is

$$\text{(4.1)} \qquad EMFM = kGNP^{\left(a+b\frac{GAUTO}{GNP}+c\frac{IBF}{GNP}\right)},$$

where EMFM, GNP, GAUTO, and IBF represent employment in Michigan manufacturing, gross national product, gross auto product, and business fixed investment, respectively.[2,3]

As equation (4.1) reflects, real gross national product is the primary determinant of demand for Michigan's manufactured products and thus manufacturing employment. Its impact is affected by the share of automobile production and business fixed investment in that GNP; a given level of national output will lead to more Michigan jobs if that output is weighted towards automobile and machinery production.[4] It should be noted that these factors are all national in scope. This is not surprising since most of Michigan's manufactured output is sold in a national rather than a local market. Taking natural logarithms, equation (4.1) becomes

$$\ell n\ EMFM = k_1 + (a + b\frac{GAUTO}{GNP} + c\frac{IBF}{GNP})\ \ell n\ GNP \quad . \tag{4.2}$$

[5]

Increasing productivity enables the same output to be produced by fewer workers, decreasing employment demand for a given level of output. A time trend variable (DTIME), with a negative coefficient expected, is introduced to express this in the final equation (equation (4.3)). There are two additional influences on Michigan manufacturing employment, given national output. The first is the cost of hiring Michigan labor relative to labor elsewhere. If the average manufacturing wage in Michigan increases faster than its national counterpart, at the margin, employment will be diverted elsewhere. The second is the cost of hiring labor rather than more intensively utilizing capital. If wages rise too rapidly relative to capital cost,

there will be a shift towards greater capital use, even in the short run. These two effects are captured in the equation by the percentage change in the Michigan to United States wage ratio $(\Delta \ell n \frac{WM\$}{WUS\$})$ and the logarithm of the product wage $(\ell n \frac{AEQMFM\$}{PPNF})$, respectively.[6] A negative coefficient is anticipated in both cases. Since AEQMFM$ is a direct function of hours worked, the negative coefficient of $\ell n \frac{AEQMFM\$}{PPNF}$ may also be reinforced by the lack of an explicit hours variable in the equation. (Functions of average weekly hours worked in manufacturing were not significant.) If average hours worked increase for a given level of demand, employment decreases.

The Canadian Auto Pact might be expected to have a negative effect on manufacturing employment in Michigan as some automobile production takes place in Canada due to more favorable tariff treatment. A dummy variable reflecting the effect of the pact had no explanatory power in the equation. Possibly the effect of the pact simply fell outside Michigan. A more likely explanation is that automobile-related industries may have been attracted to Michigan as opposed to, say, a cheaper-labor Southern state, due to Michigan's nearness to Canadian production. Thus there may have been no net loss in manufacturing employment in Michigan due to the pact.

No strike variable is present in the manufacturing employment equation because the values of GAUTO and IBF adequately reflect

loss of production due to such work stoppages.

The final manufacturing employment equation is

$$(4.3) \qquad \ell n\, EMFM = k_1 + (k_2 + k_3 \frac{GAUTO}{GNP} + k_{4GNP} \frac{IBF}{}) \sum_{i=0}^{5} \lambda_i \ell n GNP_{-i}$$

$$+ k_5\, DTIME + k_6 \Delta \ell n \frac{WM\$}{WUS\$} + k_7 \ell n \frac{AEQMFM\$}{PPNF} + \epsilon^7$$

where the λ_i are the fixed lag weights on GNP.

Suppose $\frac{GAUTO}{GNP}$ and $\frac{IBF}{GNP}$ take their mean values (.044 and .103, respectively) in the estimated version of equation (4.3), Equation 1 of Appendix B. The steady state elasticity of Michigan manufacturing employment with respect to GNP is then 1.9965 + .6523(.0442) + .31788(.103) = 2.032. This says that, once all adjustments have taken place, a 1 per cent variation in GNP leads to an approximate 2 per cent change in manufacturing employment, again emphasizing the cyclical sensitivity of the Michigan economy. Since $\lambda_0 = .35$, 35 per cent of the ad justment is assumed to occur in the quarter where the change in GNP occurs. If $\frac{GAUTO}{GNP}$ and $\frac{IBF}{GNP}$ are taken at their relatively high values of the 1972-1973 period (.051 and .109), the elasticity increases to 2.064. Although not much greater than the average value of 2.032, this higher elasticity is likely to apply in just those periods when GNP itself is high and rising since total GNP and the automobile and investment shares of it exhibit strong positive correlation.

The estimated version of equation (4.3) can be evaluated in a manner not available for most other equations. Employment in manufacturing does not have the strong upward trend found in many of the other data series, so turning points are readily observable. Do the predictions generated by the equation capture these turning points? The answer is definitely yes. All major turnarounds are spotted, the 1960 peak, the 1961 trough, the 1966 peak, the 1967 trough, and the 1970 trough being pinpointed exactly. The 1958 trough is predicted only one quarter late while the equation is two periods early for the 1969 peak. This record increases confidence in the equation.

No attempt was made at this time to disaggregate manufacturing employment, although the data exist. This is a project that might be pursued in future development of the model.

Non-Manufacturing Employment

The other sectoral employment equations follow the general pattern

$$\ell n\, E_t = a + b\, \ell n\, E_{t-1} + c\, \ell n\, D + \epsilon \tag{4.4}$$

where E is the number of employees in the category and D is a variable or variables representing demand for the sector's output. Equation (4.4) may be derived from either of two views of the mechanism determining employment demand.

Employment in each sector may be viewed as gradually approaching a desired level E^*. That is,

$$(4.5) \qquad \frac{E_t}{E_{t-1}} = \left(\frac{E_t^*}{E_{t-1}}\right)^{\alpha} \qquad 0 \leq \alpha \leq 1$$

where α represents the speed of adjustment. $\alpha = 1$ indicates immediate adjustment while $\alpha = 0$ means no adjustment, i.e., $E_t = E_{t-1}$. Thus

$$(4.6) \qquad \ell n\, E_t - \ell n\, E_{t-1} = \alpha(\ell n\, E_t^* - \ell n\, E_{t-1}) \quad \text{or}$$

$$(4.7) \qquad \ell n\, E_t = (1 - \alpha)\, \ell n\, E_{t-1} + \alpha \ell n\, E_t^* \quad .$$

If the desired employment E_t^* is a function of demand variables, say kD_t^{β},

$$(4.8) \qquad \ell n\, E_t = \ell n\, k + (1 - \alpha)\, \ell n\, E_{t-1} + \alpha\beta\, \ell n\, D_t + \epsilon$$

is the form to be estimated. The estimated coefficient $1 - \alpha$ is actually close to one in most of the equations (α near 0). This indicates that the adjustment process postulated by the model occurs slowly.

The alternative explanation regards current employment as determined by a weighted average of current and past output demands,

$$(4.9) \qquad E_t = \alpha \sum_{i=0}^{\infty} w_i D_{t-i}$$

where the w_i are the weights.

This form is too general to be used in actual estimation because a large (infinite) number of parameters must be estimated. A standard approach in reducing the number of parameters is to assume the weights decline geometrically and to apply the Koyck transformation. That is, let $w_i = \lambda^{i+1}$, $|\lambda| < 1$, so that

$$E_t = \alpha \sum_{i=0}^{\infty} \lambda^{i+1} D_{t-i} = \alpha[\lambda D_t + \lambda^2 D_{t-1} + \lambda^3 D_{t-2} + \ldots] \quad . \tag{4.10}$$

Lagging equation (4.10) one period and multiplying by λ yields

$$\lambda E_{t-1} = \alpha [\lambda^2 D_{t-1} + \lambda^3 D_{t-2} + \lambda^4 D_{t-3} + \ldots] \tag{4.11}$$

Equation (4.11) is subtracted from (4.10) and the result rearranged to produce

$$E_t = \lambda E_{t-1} + \alpha\lambda D_t \quad . \tag{4.12}$$

If, in fact, the logarithm of employment is determined by a declining geometric weighting of the logarithm of demand, i.e.,

$$\ell n\, E_t = \alpha \sum_{i=0}^{\infty} \lambda^{i+1} \ell n\, kD_{t-i} \quad , \tag{4.13}$$

the corresponding form of equation (4.12) is

$$\ell n\, E_t = \lambda\, \ell n\, E_{t-1} + \alpha\lambda\ \ell n\, k + \alpha\lambda\ \ell n\, D_t + \epsilon \quad , \tag{4.14}$$

which, when estimated, cannot be distinguished from (4.8).

The variables represented by D_t in equations (4.8) and (4.14)

vary from sector to sector. The employment of workers in transportation, communication and utilities (TCU) reflects the general health of the economy; real state personal income is, therefore, used as an independent variable. For a given level of overall activity, manufacturing makes the greatest use of TCU output as large amounts of energy are used in producing manufactured goods and transport in moving them. Manufacturing employment (proxying manufacturing output) and the change in that employment represent this fact in the equation. The product wage is also important as substantial opportunity exists in TCU, as in manufacturing, to substitute capital for labor should relative prices so dictate. As in manufacturing, the negative coefficient of the product wage may also include variations in hours worked.

Population, real disposable income, and the product wage are the demand variables determining employment in wholesale and retail trade. Although the level of disposable income is important in itself, the proportion of this income that is actually spent also matters. The latter quantity is indexed by retail sales tax collections as a percentage of disposable income (both in real terms).[8,9]

Contract construction takes place for residential and non-residential purposes. Residential demand is measured in the model by an exogenous Michigan variable, the number of building permits

issued for residential purposes in the state. An attempt was made to estimate a predictive equation for building permits (endogenize the variable); results were uniformly poor and the effort was abandoned.

Non-residential demand is proxied by business fixed investment. Structures are only a part of total IBF, but predictions of the structures component alone are not generated by the Michigan Quarterly Econometric Model of the United States Economy (MQEM). Using total IBF does not present a serious problem because investment in producer durables is often accompanied by building construction or alteration to accommodate the machinery. The structures and non-structures components are highly correlated.

The estimated coefficients of ℓn IBF and ℓn BLDPERM are of interest. In constant dollar value, residential structures represent approximately half of construction, a six-year high of 56.4 per cent in 1972 and a low of 46.3 per cent in 1970.[10] Thus construction employment should have an elasticity near .5 for both IBF and BLDPERM. When Equation 4 of Appendix B is solved for its steady-state values, the figure .64 $\left(= \frac{.55}{1 - .14}\right)$ is reasonable for $\frac{\partial \ell n \text{ ECCM}}{\partial \ell n \text{ IBF}}$ while .07 is quite low for the elasticity with respect to residential building permits. The latter is an empirical result that is hard to explain.

The construction employment equation also contains a time trend variable to represent productivity increases and a strike dummy to adjust for the effects of the 1968 industry-wide strike. One would expect the product wage to be a successful predictor in the equation, but it was not. A possible explanation might be that local building codes and union regulations make it difficult to substitute prefabricated materials for on-site labor, despite increases in the cost of the latter.

The principal mineral products of Michigan include iron ore, petroleum, cement, copper, salt, sand, and gravel. Since the use of these occurs throughout the economy, real GNP was chosen as the demand variable. As in construction, productivity and strike variables are also present. Here, too, the product wage failed to affect employment.

Employment in services and finance, insurance, and real estate is the result of general activity in the economy. Thus real disposable and real personal income, respectively, are used to represent demand. Since greatly increased productivity over time and strong substitution effects are not present in these sectors, the variables representing such phenomena were not expected to be significant in the equations and, in fact, were not.

The last area to be considered is government employment in Michigan--federal, state, and local. Federal government

employment is beyond state control and is exogenous to the model. State and local government employment are functions of state population and real personal income. The latter, as usual, represents overall activity. On the state level it is also a rough indicator of the level of tax collections which provide the funds for government activity. Population may play a number of roles. It may reflect the simple fact that an increasing population demands more government services, leading to greater government hiring. Alternatively, population may function as a time trend variable to reflect the increase in the role of state and local governments at a rate exceeding the increase in personal income. Baumol,[11] for example, feels that this rapid rate of increase in government employment is due to the limited opportunities (relative to manufacturing, say) for government to increase productivity by substituting capital for labor. A third possibility is that the proper independent variable is some form of per capita personal income. As per capita income increases, citizens often wish to spend a larger share of that income on public rather than private goods.

Under the third justification alone, one would expect a negative coefficient for the population variable and a positive one for personal income. Although this is not the result obtained, the equation can be rearranged slightly to also support the third hypothesis. Suppose both population (POPM) and per capita personal income (YPM/POPM)

were to be used simultaneously as regressors. Since the equations are expressed in logarithmic form, this produces the same overall results as total income and population, i.e., $k_1 \ell n$ YPM + $k_2 \ell n$ POPM is equivalent to $k_1 \ell n(YPM/POPM) + (k_2 + k_1) \ell n$ POPM. Since k_1 and k_2 are both positive in the actual regressions (see Appendix B, Equations 8 and 9), both per capita income and population would have positive signs as the three reasons, taken together, would suggest.

The personal income variable in the state government employment equation is significant with a two period lag. This may simply be a statistical curiosity. It also may stem from the balanced budget constraint on state spending--officials are hesitant to commit themselves to new programs until they know the revenue will be available.

A number of other variables were considered for the government employment equations including functions of tax revenue, intergovernmental grants (both federal to state and state to local), and teaching employment. The results proved unsatisfactory and were not included in the model.

Residual Employment

Wage and salary employment is defined as the sum of employment in manufacturing, transport, trade, construction, mining, finance, services, and government. Separating wage and salary

employment from total employment is a variable termed residual employment. The residual has three principal components: agricultural workers, the self-employed, and a statistical discrepancy. The discrepancy arises because sectoral employment is surveyed on an establishment basis (place of work; a count of jobs) while total employment is on a household basis (place of residence; a count of workers). Employees who hold more than one job are double-counted in the sectoral statistics and make a negative contribution to the residual. The discrepancy is also due to those who live in Michigan while working out-of-state and vice-versa.

The employment residual is predicted as a linear function of wage and salary employment and (current and lagged) personal income. The estimated coefficient of the first is negative,[12] although, a priori, either sign could be justified. If self-employment (possibly farming, too) is an alternative to wage and salary employment when the latter is not available, a negative coefficient would be expected. If strength in the economy leads to both high wage and salary employment and good opportunities for starting one's own business, a positive relation is anticipated. It is likely that, in the actual equation, the positive personal income coefficient takes account of the increased opportunities while, for a given level of state personal income, salaried and self-employment are substitutes. Lagged personal income is significant because employment

changes tend to lag output changes throughout the business cycle.

The discrepancy portion of residual employment is viewed as essentially random. Although the number of multiple job holders and interstate commuters is affected by economic conditions, the relationship is hard to specify. YPM would capture any component that is cyclical, but the otherwise large random element makes the residual employment equation less satisfactory than the other employment equations in terms of proportion of explained variance. The actual residual employment equation is

$$(4.15) \qquad EMRESM = k_1 + k_2 EWSM + k_3 YPM + k_4 YPM_{-1} + k_5 YPM_{-2} + \epsilon$$

where EMRESM, EWSM, and YPM represent residual employment, wage and salary employment, and personal income, respectively.

WAGES, HOURS, AND EARNINGS

Average Hourly Earnings--Manufacturing

The basic wage in the model is the average hourly earnings of production workers in Michigan manufacturing, WM$. WM$ is not an index of the wage rate of all workers or any particular class of worker, but is a weighted average of the hourly wages actually received.[13] It is, therefore, affected by the amount of

overtime (compensated at higher rates) and the job mix of those employed.

Although WM$ exceeds its national analogue,[14] the average hourly earnings of production workers in United States manufacturing (WUS$), the patterns of increases in the two are similar. Changes in WUS$ reflect both cyclical and trend factors also present in WM$. The trend factors include new union agreements and the general upward drift of wages. Cyclical components refer to opportunities for overtime pay and advancement of the worker into higher job categories.

Interacting with the change in WUS$ are factors specifically affecting the Michigan wage. The most important of these is the percentage change in gross auto product as a component of GNP. When the automobile industry is healthy, the average wage in Michigan increases more than otherwise anticipated due to extensive overtime. How job mix is affected is not as clear cut because additional employees may be hired into lower-paying job categories as employment increases. On the other hand, workers may be promoted if the increased demand occurs at higher levels, increasing the average wage. The trend effect of a robust automobile industry is certainly positive because non-union employers are more likely to grant pay increases when demand and profits are high. On balance, a positive coefficient for $\Delta \ell n \frac{GAUTO}{GNP}$ is expected and is realized.

The second interactive, Michigan-specific factor is a relative price effect, the percentage change in the ratio of the Detroit consumer price index (PCPID) to its United States counterpart (PCPIUS). If Michigan prices are rising faster than the United States average, one would expect wages to do the same with a lag of, say, one or two quarters. The data support the price effect, but not the lag hypothesis. In the OLS model, the coefficient of the current value was the only one exceeding its standard error, while even the current value failed to pass this test in the IV model. A possible hypothesis is that the variable $\Delta \ell n$ WUS\$ $\cdot \Delta \ell n \frac{PCPID}{PCPIUS}$ is not a cause of changes in the Michigan wage but both are precipitated by a common factor. Likely candidates include $\Delta \ell n \frac{UM\%}{UUS\%}$, [15] $\Delta \ell n$ WUS\$ $\cdot \Delta \ell n \frac{UM\%}{UUS\%}$, or some other function of the employment rate since it is not unreasonable to expect an unemployment variable to be significant in a wage equation.

Actually, the three variables $\Delta \ell n \frac{UM\%}{UUS\%}$, $\Delta \ell n \frac{GAUTO}{GNP}$, and $\Delta \ell n \frac{PCPID}{PCPIUS}$ (each interacted with $\Delta \ell n$ WUS\$) were considered for the equation. The correlation coefficients for these variables are reproduced below. [16]

	$\Delta \ell n \frac{UM\%}{UUS\%}$	$\Delta \ell n \frac{GAUTO}{GNP}$	$\Delta \ell n \frac{PCPID}{PCPIUS}$
$\Delta \ell n \frac{UM\%}{UUS\%}$	1.0000	-.6299	.2467
$\Delta \ell n \frac{GAUTO}{GNP}$		1.0000	-.1410
$\Delta \ell n \frac{PCPID}{PCPIUS}$			1.0000

As expected, the first two variables exhibit strong negative correlation. This seems plausible since high unemployment in Michigan relative to that in the rest of the United States is often due to faltering automobile production. The effects, described previously, of $\Delta \ell n \frac{GAUTO}{GNP}$ on $\Delta \ell n$ WM$ could easily be re-expressed in terms of the unemployment variable.

In separate equations, $\Delta \ell n \frac{GAUTO}{GNP} \cdot \Delta \ell n$ WM$ and $\Delta \ell n \frac{UM\%}{UUS\%} \cdot \Delta \ell n$ WUS$ were used as explanatory variables (with $\Delta \ell n$ WUS$ and another variable to be discussed subsequently also present in the equations). Each proved highly significant (with the anticipated sign) although the R^2 of the equation with the automobile variable was higher (.755 vs. .688). When the variables were combined in a single equation, the coefficient of the unemployment variable was about half its standard error (with a positive sign rather than the theoretically predicted negative one) while the auto coefficient remained significant. The introduction of

$\Delta \ell n \frac{PCPID}{PCPIUS} \cdot \Delta \ell n$ WUS$ further reduced the coefficient of the employment variable relative to its standard error. Using the price and unemployment variables without the automobile variable also proved to be an inferior alternative. Thus, the final equation chosen contains the automobile and price variables but not the unemployment variable. In the equation, the means of $\Delta \ell n \frac{PCPID}{PCPIUS}$ and $\Delta \ell n \frac{GAUTO}{GNP}$, m_p and m_g, respectively, are subtracted before the interaction with $\Delta \ell n$ WUS$ to make the results more amenable to interpretation.

A final variable explaining wage increases is DAUCON, a dummy to represent major contract settlements in the automobile industry. The average manufacturing wage rises sharply in the quarter after a new contract is negotiated.

The final form[17] estimated for the wage equation is

$$\Delta \ell n \text{ WM\$} = k_1 + k_2 \text{ DAUCON} + [k_3 + k_4(\Delta \ell n \frac{GAUTO}{GNP} - m_g) + k_5(\Delta \ell n \frac{PCPID}{PCPIUS} - m_p)] \times \Delta \ell n \text{ WUS\$} + \epsilon \quad . \tag{4.16}$$

The estimated value of k_3 in equation (4.16) indicates that the average manufacturing wage in Michigan is increasing only 80 per cent as fast as that of the United States (see Equation 14, Appendix B) if $\Delta \ell n \frac{GAUTO}{GNP}$ and $\Delta \ell n \frac{PCPID}{PCPIUS}$ assume their mean values of

.0013687 and -.0020392, respectively. If these variables assume values only one standard deviation away from their means, the range of this elasticity becomes quite wide, from .31 to 1.29 [.80 - 2.6514(.142) - 34.432(.00352), .80 + 2.6514(.142) + 34.432(.00352)], since both percentage change variables have large variances relative to their means. Thus the relationship between the Michigan and United States wage, although stable over the long term, can exhibit great period to period variation.

Average Hours Worked--Manufacturing

Since total wages per person are the product of the average hourly wage and average hours worked, the model predicts the length of the average work week in Michigan manufacturing (HRSM). As with WM$, HRSM is an average rather than an index and is affected by the number of part-time workers, overtime, etc.

Average hours worked tends to have a cyclical pattern as employers use a longer or shorter work week as a buffer in adjusting employment to conditions in the economy.[18] When a downturn occurs, the work week is usually reduced for all employees in a group by eliminating overtime before layoffs begin. When it becomes evident that the downturn will continue, employment declines and the work week may increase slightly. At the beginning of the upturn, hours increase until the desirability of increased employment becomes certain and new workers can be found.

The model, therefore, determines HRSM by means of an adjustment process. Desired hours are postulated to return to a normal level, N, presumably in the neighborhood of 40, because overtime is costly while short work weeks are demoralizing and inefficient. Thus,

$$(4.17) \qquad \frac{HRSM^*}{HRSM_{-1}} = \left(\frac{N}{HRSM_{-1}}\right)^{\alpha} \qquad 0 \leq \alpha \leq 1$$

where * indicates a desired quantity and α is the speed of adjustment since the process does not take place immediately.

Actual and desired hours do not coincide because employers are slow in adjusting employment to changing demand conditions, as discussed above. If D indicates the change in demand

$$(4.18) \qquad \frac{HRSM}{HRSM^*} = e^{\gamma D} \quad .$$

This is a reasonable formulation because more severe changes will have more than proportional effects. If the change in demand is 0, $HRSM = HRSM^*$. Taking logarithms of both equations, solving (4.17) for $\ell n\, HRSM^*$, and substituting into (4.18) yields

$$(4.19) \qquad \ell n\, HRSM = \alpha\, \ell n\, N + (1 - \alpha)\, \ell n\, HRSM_{-1} + \gamma D \quad .$$[19]

A proxy for changes in demand is the percentage change in business fixed investment plus gross auto product as a fraction of GNP, $\Delta\, \ell n\, \frac{GAUTO + IBF}{GNP}$.

A check on this specification is to use the estimated equation to solve for the numerator N on the right hand side of equation (4.17) to see if it is near 40. From Appendix B, Equation 15, $1 - \alpha = .81803$ and $\alpha \ell n\, N = .67968$. Therefore, $\alpha = .18197$ and $\ell n\, N = \frac{.67968}{.18197} = 3.735$, which means $N = 41.9$, a reasonable value.

Average Earnings Per Quarter--Manufacturing

If average earnings per quarter in manufacturing (AEQMFM$), WM$, and HRSM all referred to the same group of workers, the identity

(4.20) $$AEQMFM\$ = WM\$ \cdot HRSM$$

could be used to arrive at AEQMFM$ for at least that group. The average earnings figure used in the model, obtained by dividing total manufacturing wages and salaries by total employment, however, includes all employees in the manufacturing sector (secretaries, executives, engineers, etc., as well as production workers) while HRSM and WM$ include only production workers. Because of this disparity, equation (4.20) is approximated by a regression equation

(4.21) $$\ell n\, AEQMFM\$ = k_1 + k_2\, \ell n\, HRSM + k_3\, \ell n\, WM\$ + k_4\, DADJRS + \epsilon\ .$$

In equation (4.21) a constant term has been added as well as a residence adjustment dummy (DADJRS), the latter to account for the fact that wages and salaries are computed on a place of residence

basis for the earlier part of the sample period and on a place of work basis subsequently.[20]

Since the equation is expressed in double logarithmic form, k_2 and k_3 are the elasticities of earnings with respect to hours worked and the wage rate. Both k_2 and k_3 are anticipated to have estimated values around one. The value of k_3 is in fact near one (1.02--see Appendix B, Equation 16), because increases in the wages of white collar workers in manufacturing tend to parallel those of their blue collar breathren. The value of k_2 is only .33, much lower than anticipated. This could be partially due to the fact that hours worked by non-production workers may be more or less stable and not follow the pattern of production hours, accounting for a coefficient less than one. Even so, .33 is a low value. The value of k_3 might also be less than one if non-production workers do not get raises when the average production worker hourly wage increases due to overtime.

Average Earnings Per Quarter--Other Sectors

Average earnings in transport, trade, construction, mining, and government are predicted by equations of form similar to equation (4.4). Again either an adjustment or distributed lag framework can be used to produce such a specification. The demand or desired wage variable used is the manufacturing wage, WM$. Earnings in the other sectors have a steady-state elasticity of

approximately one with respect to the manufacturing wage, i.e., proportionate wage increases are about the same in all the above sectors since the elasticity of AEQMFM$ to WM$ is also one. For instance, the steady state elasticity of average earnings per quarter in mining (AEQMIM$) with respect to WM$ is .986 $\frac{(=.53654)}{1 - .47119}$ from Equation 20 of Appendix B.

An interesting question is whether or not AEQMFM$ would be a better predictor than WM$ in these equations. If the hours-worked pattern is similar from sector to sector AEQMFM$ is likely to be superior.[21] In no equation did AEQMFM$ outperform WM$. The results of the two were most alike in the transportation, communication, and utilities area. This is not unexpected since transport demand stems from manufacturing demand, causing fluctuations in average hours to parallel one another.

Some of the average earnings equations contain other explanatory variables in addition to ℓn WM$. Trade earnings are affected by the minimum wage because much employment (especially in retail trade) is compensated at or near that level. Mining and construction contain the same strike dummies as their respective employment equations. The coefficients of both the dummies are positive. A priori, a negative sign would be expected since it is traditionally the more highly paid union workers who strike. Data errors are the likely explanation. In the quarters the strikes occur, wages and

salaries do not fall drastically in these areas (the probable error in the data) whereas employment does. Since average earnings are the quotient of wages and salaries divided by employment, the dummies proxy data errors rather than the strikes themselves. DADJRS is also present in the average earnings in construction equation.

Average earnings per quarter in services and finance, insurance, and real estate are treated differently from those of the other sectors. The variable ℓn WM$ failed to be significant in either equation so another approach was formulated. Average earnings in these sectors are generally a little above what they were the previous quarter and are also pulled upward by increases in the minimum wage (service industries, especially, have large numbers of employees earning only the minimum wage). A large increase in one quarter is offset to a degree by a lesser increase the next so the change in average earnings, lagged one quarter, appears with a negative coefficient. The equation is then

$$(4.22) \qquad \ell n\, AEQ = k_1 + k_2\, \ell n\, AEQ_{-1} + k_3 MINWUS\$ + k_4\, \Delta \ell n\, AEQ_{-1} + \epsilon$$

where AEQ are average earnings per quarter and MINWUS$ is the United States minimum wage.

Wages and Salaries

In each sector, wage and salary payments are the product of average earnings per quarter and employment. The 1000 in the

denominator of each of Equations 24-31 of Appendix B is present so the answer appears expressed in proper units. Total wages and salaries are the sum of wages and salaries in the eight estimated categories plus wages and salaries in the exogenous areas: agriculture and other.

NON-WAGE INCOME

The non-wage component of personal income is defined as the sum of other labor income, proprietors' (entrepreneurial) income, property income, and transfer payments less taxes for social insurance. Each of these is estimated using one or more equations of the model.

Other Labor Income

Other labor income (YLOM$) includes such items as employer payments for private pension, health, and welfare funds, compensation for injuries, directors' fees, and pay of the military reserves.[22] This form of income rises secularly over time and also increases as wages and salaries increase to yield the equation

$$(4.23) \qquad \ell n\, YLOM\$ = k_1 + k_2\, \ell n\, WSM\$ + k_3\, DTIME + \epsilon$$

where WSM$ represents total wages and salaries and DTIME is a time trend dummy.

Some care must be taken in interpreting the value of k_2, which turns out to be .31 (Equation 33, Appendix B). On the surface, the .31 would seem to be saying that, other things equal, fringe

benefits are only increasing 31 per cent as fast as wages and salaries, surely a low estimate. But, the time trend should not be included in the "other things equal." The equation actually says that, in addition to the increase represented by the time trend, fringe benefits increase a certain proportion of the increase in wages and salaries.

Proprietors' Income

Proprietors' (entrepreneurial) income (YENTM$) measures the earnings of unincorporated businesses (proprietorships, partnerships, producer cooperatives) from their current operations. It does not include capital gains and losses.[23] The pattern of such income bears a strong resemblance to that of corporate income; when corporations are maintaining healthy profit levels, so are unincorporated businesses. YENTM$ is thus postulated to be a function of a distributed lag on corporate profits. After applying the standard Koyck manipulation, the equation becomes

$$(4.24) \qquad \ell n\ YENTM\$ = k_1 + k_2\ \ell n\ YENTM\$_{-1} + k_3\ \ell n\ CPBTUS\$ + \epsilon$$

where CPBTUS$ represents United States corporate profits before tax, a Michigan figure being unavailable.

Property Income

Property Income (YPRM$) is the sum of three types of receipts: rents, interest, and dividends. All three refer to amounts received by persons as opposed to corporations or government. The rental

income category includes not only money earned from the use of property, but imputed net rental value of owner occupied non-farm dwellings and royalties received from patents, copyrights, and rights to natural resources.[24]

The equation used to predict property income attempts to account for all three major components. MQEM supplies predictions of total corporate dividends paid to United States citizens (YDIVUS$). There is no reason to suppose that the receipt of dividend income by Michigan residents should follow a pattern very different from that of Americans as a group, so the United States variable serves as a good predictor of the dividend portion.

The Detroit consumer price index for housing (PCPIDHSE) is used to predict the rent component. The housing rather than just rental housing component of the Detroit CPI is used because of the importance of imputed rental of owner-occupied housing in the total figure. PCPIDHSE is an endogenous variable, the prediction of which is discussed in the PRICES section of this chapter. No good indicator of royalty income was found. Hopefully, not much error is introduced by omitting any predictor of that segment of rental income from the equation.

An up-to-date measure of total interest-bearing assets of Michigan residents is unavailable so the total of time deposits, savings and loan shares, and credit union shares and deposits in Michigan

banks is used instead, henceforth referred to as total savings (SAVTOT$). Total savings bears a rough relationship to total interest earning assets, although the relationship fluctuates over the business cycle.[25] The prevailing rate of interest also affects the interest component of property income. The treasury bill rate (RTB%) is the basic interest rate predicted by MQEM and is used here as a proxy for the entire structure of rates in effect over a given quarter. Interest rates may also have a small effect on the rental component since most housing (apartment and single family) is built and/or purchased with borrowed money.

The form of the property income equation is, therefore,

$$(4.25) \quad YPRM\$ = k_1 + k_2\, YDIVUS\$ + k_3\, PCPIDHSE + k_4\, SAVTOT\$ + k_5\, RTB\% + \epsilon \quad .$$

The estimated value of k_2 in equation (4.25) is 13.3 (Appendix B, Equation 35). At first this may seem unreasonably large--how can one dollar of additional United States dividends yield $13.30 worth of property income (dividends) in Michigan alone? Two factors have not been considered. The first is that YPRM$ is in millions of dollars while YDIVUS$ is expressed in billions (see Appendix A). If both were in billions, the coefficient would be .013, a number that is too small. But YDIVUS$ is an MQEM variable and is thus expressed at annual rates rather than quarterly

values. If YPRM$ were also an annual rate, the coefficient would be .052. Since Michigan has 4.3 per cent of the United States population,[26] expecting 5.2 per cent of an additional dollar of dividend income is not unreasonable.

Predicting total savings, an important independent variable in the property income equation, poses a number of problems. The first is that the variable is a stock that has increased every year since 1956. This secular trend tends to dominate any other predictive variable. It was decided instead to try to predict total saving, the periodic flow element, rather than the stock. The next problem was that total saving data are available only on an annual basis; the quarterly figures used in the property income equation are interpolations. The computed quarter to quarter changes are meaningless. The dependent variable chosen, while possibly not ideal, is the difference between the value of SAVTOT$ at time t and at time t-4 (always a positive quantity).

What determines how much people save? The most powerful factor is income. As money income increases so does saving (a positive coefficient), but as prices increase, given money income, saving decreases (a negative coefficient), at least in the short run, as consumers attempt to maintain their accustomed standard of living. Both independent variables (personal income and prices--

YPM$ and PCPID, respectively) are used in the form of four quarter averages to correspond to the annual nature of the dependent variable.

Another determinant of saving, given income level, is how much people feel encouraged to spend on otherwise postponable purchases. This is measured by the index of consumer sentiment (ICS), also in the form of a four quarter average. Due to the manner in which the index is constructed, its value is high when consumers feel it is a good time to make major durable purchases, an alternative to saving. ICS, therefore, has a negative coefficient in the equation.

For a given level of real income and a given impetus to spend, there is a choice as to what form saving will assume. Will people make time deposits or put their money into stocks, bonds, and other money market instruments? When credit is tight and interest rates high (usually periods of economic prosperity) money flows into these alternative uses due to ceilings placed on the interest rates savings banks can pay on savings and commercial banks on time deposits. This process is referred to as "disintermediation."

The measure chosen in the model to represent credit tightness is the spread between long term (as represented by the corporate Aaa bond interest rate, RAAA%) and short term (as represented by the interest rate on four to six month commercial paper, RCP%) interest rates. This difference is a good measure of availability

of credit over the business cycle because short term rates rise relative to long term ones during booms and fall during recessions. This pattern is due to expectations about capital gains. In the short run, investors expect interest rates to remain at present levels or continue to move in the same direction, while in the long run they expect a return to some "normal" level. When interest rates are high and rising (boom), investors expect zero or negative capital gains on short term obligations but positive capital gains on long term ones. Long term securities are deemed more attractive and sell at relatively higher prices (equivalent to a relatively lower interest rate) than short term securities. Thus the long term minus short term interest rate differential decreases. During a recession investors buy short term securities to avoid a capital loss when rates return to their normal (higher) levels. This raises the price and lowers the relative yield of short term securities in comparison to long term ones.[27] In short, a positive relation is expected between the interest rate differential and saving.

These considerations yield the equation

$$(4.26) \quad SAVTOT\$ - SAVTOT\$_{-4} = k_1 + k_2 YPM\$_A + k_3 PCPID_A + k_4 ICS_A + k_5 (RAAA\% - RCP\%)_A + \epsilon$$

where the subscript A indicates a four quarter average.

Transfer Payments

The next part of personal income to be considered is transfer payments. Since the determinants of the various types of transfer payments differ, separate equations were used for Social Security payments, unemployment compensation, and public assistance. The remainder, termed "other transfer payments" (including, among others, veterans benefits and private pension), is exogenous to the model.

Social Security payments to Michigan residents comprise the largest segment of transfers, accounting for about 45 per cent of the total, and are increasing rapidly in absolute magnitude. This increase is likely to continue or even accelerate due to prolonged life expectancy and legal provisions tying benefit increases to the consumer price index. Because of the strong trend, a percentage change equation was specified. The percentage change in benefits ($\Delta \ell n$ SSTR$) is viewed as a function of the change in benefit level ($\Delta \ell n$ TSSBENLV) and the increase in population 65 and older. The last variable, however, is drawn from annual data, so, as with SAVTOT$, quarter-to-quarter change means little. A four quarter percentage change replaced the simple percentage change for this variable. The form of the equation is

$$(4.27) \qquad \Delta \ell n \, SSTR\$ = k_1 + k_2 \, \Delta \ell n \, TSSBENLV + k_3 (\ell n \, POP65+M - \ell n \, POP65+M_{-4}) + \epsilon$$

where TSSBENLV is an index of statutory changes in Social Security benefits.

It was anticipated that k_2 would have a value of approximately one. Its actual value of .55 (Equation 37, Appendix B) is surprisingly low. In contrast, the value of k_3 is quite large. Since the change in population aged 65 and over covers a year while the change in benefit payments refers to only one quarter, a coefficient of .25 would indicate that population and benefits change by the same proportion. The .70 seems to say, however, that a 1 per cent change in number of persons 65 and older yields a 2.8 per cent change in Social Security payments. This is not likely under normal circumstances.

The large value of k_3 includes two other effects not explicitly present in the equation. The first of these is the increase between 1956 and 1973 (the estimation period) in the proportion of the aged eligible for Social Security as the coverage of the system was gradually expanded. The second is that $\Delta \ell n$ TSSBENLV only measures one component of the increase in per capita Social Security transfers. The benefit a retiree receives depends upon his pre-retirement income subject to Social Security taxes. Once a person retires, that

income is, by definition, fixed. Thus for any given retiree $\Delta \ell n$ TSSBENLV (which reflects benefit changes for a given taxable income) accurately tracks the increases in his monthly check. However, for retirees as a group, the average Social Security payment has been rising faster than has TSSBENLV. This is due to the fact that as each new cohort retires, its benefit reflects not only the greater benefit on a given taxable base but increases in the base itself legislated while that group was still contributing. For benefits to increase, incomes must, of course, be high enough to reflect at least part of the larger maximum taxable base, which was indeed the situation. Since the change in POP65+M is an increasing variable (the number and proportion of aged persons in the United States is growing), it proxies the upward trends in both system coverage and income subject to tax as well, which partially explains the large coefficient.

The total unemployment compensation figure reflects average size of payment and the number of beneficiaries. The size of the average payment is represented by a benefit index (UCBENLV) similar in construction to TSSBENLV. The number of recipients differs from total unemployed because not all workers are covered by unemployment compensation and some of those otherwise eligible may have exhausted the benefits to which they were entitled. Nevertheless, the number unemployed is a useful indicator of the potential

number of recipients. The number of compensation exhaustions was tried as an additional explanatory variable but was not significant at any reasonable level.

As mentioned in Chapter II, unemployment data in the model were derived in two different ways. Until mid-1974 the unemployment figure was an estimate based on data collected by establishment, i.e., place of work. In 1974, the Michigan Employment Security Commission abandoned its previous methodology and began basing its unemployment estimate on population surveys. The older data were revised as far back as 1970. Since some of the revisions were quite large, the two series cannot be considered comparable. Thus the model has two unemployment variables: UOLDM based on the older procedure and used for observations from 1956.1 to 1969.4 and UM based on the newer method from 1970.1 forward. In order to have more than 16 observations to estimate the equation, both unemployment variables were used, the inapplicable variable being assigned a zero value for the quarter. The final equation is

$$\ell n\ UCTRM\$ = k_1 + k_2\ \ell n\ UCBENLV + k_3\ \ell n\ UOLDM + k_4\ \ell n\ UM + \epsilon \quad . \tag{4.28}$$

All three of the elasticities k_2, k_3, and k_4 should be in the neighborhood of one but are actually about 1.3 (Equation 38, Appendix B). There is a factor omitted from the equation that might

account for the large value of k_2. Over the years, the coverage of unemployment compensation has been broadened to include almost all non-farm workers (even government employees). If increases in coverage coincide with increases in benefits, the coefficient larger than one for UCBENLV is to be expected.

Public assistance transfers are defined in the model to include old-age assistance, aid to the blind, aid to the disabled, general assistance, and aid to families with dependent children. These five categories are grouped together because they are handled by the same social service agencies and separate figures are not always available.

Since the category is a mixed one, no benefit index was attempted; the average payment per recipient is exogenous. Number of individuals receiving aid (#PARECPM) is the dependent variable in the estimation. The equation finally adopted, after rejecting many unsuccessful specifications, is empirical and makes use of the continuity of the series. The variable #PARECPM is regressed on its two previous values to reflect the presence of a more complicated lag distribution than could be captured with only one lagged value. In addition, unemployment is a significant independent variable.[28] It is not so much the unemployed collecting this form of aid (although some of those not eligible for unemployment compensation might) but what unemployment indicates about other conditions in the economy. During hard times disability claims increase. Also, at

the margin, potential workers are discouraged about job prospects and may choose welfare over a continued job search. As in the unemployment compensation equation, both UOLDM and UM were used.

A third force in the equation is social rather than economic. Between January, 1967, and January, 1973, the number of public assistance recipients in Michigan rose steadily from about 270,000 monthly (its general level for the previous few years) to approximately 700,000. This sharp increase was due to changing views about welfare, especially among its recipients (actual and potential). Welfare was no longer to be regarded as a degrading expression of charity from the rest of society but as a deserved stipend from an economy that could not otherwise provide for all its members. By 1973 the increase had slowed, probably because most of those eligible for assistance had been brought into the system. This phenomenon, which may be thought of as the welfare revolution, is represented by the dummy DWELREV. DWELREV has the value zero until the fourth quarter of 1966, rises by one per quarter until the end of 1972 and remains at 24 thereafter.

This attitudinal change concerning welfare may also account for the differing coefficients of UOLDM and UM, the former being less than half the latter (See Appendix B, Equation 39). Although UOLDM and UM do differ, the disparity is not great enough to account for the size differential of the coefficients. A possible hypothesis is that people now see less of a social stigma attached

and are thus more willing, under the same economic circumstances, to accept welfare than they were in the earlier period.

The public assistance recipients equation is then

$$(4.29) \quad \#PARECPM = k_1 + k_2 \#PARECPM_{-1} + k_3 \#PARECPM_{-2} + k_4 DWELREV + k_5 UOLDM + k_6 UM + \epsilon \quad .$$

Public assistance transfers are obtained as the product of the number of recipients and average payment, and are added to the three previously mentioned transfer categories to obtain total transfer payments to Michigan residents.

Contributions to Social Insurance

To arrive at total personal income, employee contributions for social insurance (TSIM$) are subtracted from the other personal income components. Employer contributions, which, along with other labor income, comprise the Department of Commerce category Supplements to Wages and Salaries, are not included in personal income to begin with. (TSIM$ also includes the total Social Security contribution of the self-employed although no special account is taken of this minor component in the equation.)

Employee contributions are a percentage (TSSRATE) of total wages and salaries (WSM$) up to an annual limit on the income subject to tax (TSSBASE$). This amount is not collected uniformly throughout the year but is collected at the full percentage rate until

the base amount has been taxed, at which point contributions cease. Seasonal adjustment removes the problem of modeling declining contributions in the third and fourth quarters, but it is still important to determine what proportion of total wages and salaries are actually taxed.

The specification for this equation is

$$(4.30) \quad TSIM\$ = e^{k_1}\ TSSRATE^{k_2}\ WSM\$^{k_3} \left(\frac{WSM\$/EMPM}{TSSBASE\$}\right)^{k_4}$$

where $WSM\$/EMPM$ is the average (per worker) wage. It is assumed that the wage distribution remains relatively stable, at least in the short run, so that the ratio of the average wage to the Social Security base is a good relative indicator of the amount of wages and salaries subject to tax.[29] The coefficient k_4 is expected to be negative since the percentage taxable should decrease as the average wage rises, but should increase as $TSSBASE\$$ does.

The equation actually estimated is

$$(4.31) \quad \ell n\ TSIM\$ = k_1 + k_2\ \ell n\ TSSRATE + k_3\ \ell n\ WSM\$ + k_4\ \ell n \left(\frac{WSM\$ \cdot 4 \cdot 1000/EMPM}{TSSBASE\$}\right) + \epsilon \quad .$$

The 4 adjusts for the fact that $WSM\$$ is a quarterly figure while $TSSBASE$ is an annual one, while the 1000 compensates for differences in units of measure to make the coefficient easier to interpret.

PRICES

There are two Michigan price variables predicted by the model. Both exhibit strong upward trends and so are predicted in percentage change form.

The percentage increase in the Detroit consumer price index ($\Delta \ell n$ PCPID) follows the same general pattern as that of the United States consumer price index ($\Delta \ell n$ PCPIUS). $\Delta \ell n$ PCPIUS is, therefore, the primary independent variable in the equation. The other independent variable is a relative demand indicator, the relative (Michigan to United States) unemployment rate. When demand is high in Michigan relative to the rest of the country, unemployment will be low, and prices will increase at a relatively faster rate. This demand effect is expected to operate with a lag pattern, the approximate shape of which was empirically determined.

The form of the equation is

$$\ell n \text{ PCPID} = k_1 + k_2 \, \Delta \ell n \text{ PCPIUS} + k_3 \sum_{i=0}^{2} \lambda_i \, \ell n \left(\frac{\text{UOLDM\%}}{\text{UUS\%}} \right)_{-i} + k_4 \sum_{i=0}^{2} \lambda_i \, \ell n \left(\frac{\text{UM\%}}{\text{USS\%}} \right)_{-i} + \epsilon \tag{4.32}$$

where $\lambda_0 = .2$, $\lambda_1 = .35$, and $\lambda_2 = .45$.

When estimated, k_2 is approximately one (1.07 in Equation 43 of Appendix B), showing that Detroit and United States prices rise more or less at the same rate.

The major factor in determining the percentage increase in the housing component of the Detroit consumer price index (PCPIDHSE) is $\Delta \ell n$ PCPID. In addition, RAAA% - RCP% (as discussed in the total savings equation) measures the availability of funds for housing. As mentioned earlier, when the difference RAAA% - RCP% is high, funds are flowing into savings and loan associations, the principal mortage lending institutions, and are available to finance home purchases. This encourages more building and moderates price increases. The lag distribution here is not empirical but is the distribution used by the Department of Commerce to relate its housing starts figures to construction. An additional element present in this equation is the lagged dependent variable. The positive coefficient estimated for the lagged dependent variable reflects the fact that it takes a while for housing prices to adjust to a housing glut or shortage.

The equation described above is thus

$$(4.33) \quad \Delta \ell n \text{ PCPIDHSE} = k_1 + k_2 \Delta \ell n \text{ PCPIDHSE}_{-1} + k_3 \sum_{i=0}^{2} \lambda_i (\text{RAAA\% - RCP\%})_{-i} + k_4 \Delta \ell n \text{ PCPID} + \epsilon$$

where $\lambda_0 = .41$, $\lambda_1 = .49$, and $\lambda_2 = .1$.

LABOR FORCE AND UNEMPLOYMENT

This block consists of equations predicting the labor force and unemployment compensation exhaustions plus identities used to determine the number unemployed and the unemployment rate.

The labor force in Michigan (LFM) is a function of population (POPM)

$$(4.34) \qquad LFM = A + B\ POPM \quad .$$

B, the marginal proportion of the population who are members of the labor force, is not assumed to be constant, but is itself a function of other variables. Specifically,

$$(4.35) \qquad B = k_1 + k_2 \frac{EMPM}{POPM} + k_3 \left(\frac{UCEXM}{POPM}\right)_{-1} + k_4\ DTIME$$

where EMPM, UCEXM, and DTIME represent total employment, unemployment compensation exhaustions and a time trend dummy, respectively. The EMPM term has a positive coefficient, reflecting what has been termed the discouraged worker hypothesis.[30] When the unemployment rate is high (or employment low relative to population[31]), people are pessimistic about their prospects of finding a job. A larger number than if conditions were better discontinue their search, thus, by definition, dropping out of the labor force. Just the opposite happens in good times--additional workers enter the labor force upon hearing of good opportunities.

The exhaustions rate variable[32] measures a variation of the added worker hypothesis,[33] the entrance of secondary workers into the labor force when the primary worker is no longer employed. In this case, the hypothesis is that other family members begin the job search approximately one quarter before unemployment compensation benefits are scheduled to run out for the head of the household. Three months may be a little too long a lead time but the entrance and exhaustion are less accurately described by treating the variables as simultaneous.

The time dummy accounts for the observed trend in the labor force participation rate. The positive (although small) coefficient indicates that, other things equal, an increasing proportion of the population is seeking jobs. This may be due to the increased number of females, teenagers, and senior citizens who hold at least part-time jobs.

Substituting (4.35) for B into (4.34) yields

$$(4.36) \qquad LFM = A + k_2\, EMPM + k_3 \left(\frac{UCEXM}{POPM}\right)_{+1} \cdot POPM + k_4\, DTIME \cdot POPM + \epsilon$$

where k_1 POPM has been eliminated since k_1 was not significant in the actual estimation.

The number of persons exhausting unemployment compensation benefits is predicted as a distributed lag on unemployment.[34] A

first term-free Koyck pattern[35] is assumed to allow additional flexibility in the distributed lag, i.e.,

$$(4.37) \qquad Y = \alpha + \beta X_{-1} + \gamma \left(\sum_{i=2}^{\infty} \lambda^{i-2} X_{-i} \right) \quad .$$

Lag the equation one period and multiply by λ to obtain

$$(4.38) \qquad \lambda Y_{-1} = \alpha\lambda + \beta\lambda X_{-2} + \gamma \left(\sum_{i=3}^{\infty} \lambda^{i-2} X_{-i} \right) \quad .$$

Subtraction and rearrangement yield

$$(4.39) \qquad Y = \lambda(1 - \alpha) + \lambda Y_{-1} + \beta X_{-1} + (\gamma - \beta\lambda) X_{-2} \quad .$$

Even though β, γ, and λ are positive $\beta\lambda$ may exceed γ to produce a negative coefficient on X_{-2}.

If Y represents ℓn UCEXM and X the natural logarithm of unemployment, the equation to be estimated is

$$(4.40) \qquad \ell n \text{ UCEXM} = k_1 + k_2 \ell n \text{ UCEXM}_{-1} + k_3 \ell n \text{ UOLDM}_{-1} + k_4 \ell n \text{ UOLDM}_{-2} + k_5 \ell n \text{ UM}_{-1} + k_6 \ell n \text{ UM}_{-2} + \epsilon \quad .$$

The number unemployed is defined as the difference between the labor force and total employment, while the unemployment rate is 100 times the ratio of unemployment to the labor force.

TAXES

This group of equations includes those predicting the individual income tax, sales tax, and a residual tax variable. All taxes are

treated on an activity (when paid by citizens) rather than a collection (when actually received by the appropriate government unit) basis. This viewpoint is more accurate in establishing a disposable income figure, although not as useful in constructing a government budget.

Individual Income Tax

Michigan's personal income tax is levied at a flat rate (3.9 per cent in 1974, 4.6 per cent beginning May, 1975) on taxable income (essentially Federal Adjusted Gross Income) above a per-capita exemption ($1500 in 1974). Total taxes paid are the sum of withholding, quarterly declarations, annual payments, and penalties and interest, less refunds. The only two components treated endogenously are withholding and quarterly payments.

The equation predicting the withholding component (TYWM$) explicitly accounts for the effects of the exemption through inclusion of population (POPM) in the equation

$$(4.41) \qquad TYWM\$ = TYRTM\%(k_1 YPADJM\$ - k_2 \cdot E\$ \cdot POPM) + \epsilon \ .$$

where TYRTM% is the statuatory tax rate, YPADJM$ adjusted personal income, and E$ the statuatory per capita exemption. (Since E$ has remained constant over the sample period it is subsumed in k_2 in the estimated equation.) The coefficient k_2 would not be expected to have a value of one because not all potential taxpayers have income exceeding

their total exemption value. A constant value for k_2 is only approximate since its value depends on the (changing) relationship between incomes and the size of the exemption, but the constant is used nevertheless. Adjusted personal income is defined as personal income (YPM$) plus employee contributions for social insurance less transfer payments (see Equation 65, Appendix B). Adjusted personal income is a better variable to represent income subject to tax since most transfers are not counted as taxable income while contributions to social insurance are. The inclusion of k_1 is an attempt to recognize that YPADJM$ and taxable income are not exactly the same. If these variables bear an approximately stable relationship to one another, treating k_1 as constant introduces little error. Equation (4.41) is actually estimated with a constant term but that term (as expected) is smaller than its standard error (Equation 49, Appendix B).

Quarterly payments stem from estimates of tax liability required of those having taxable income not otherwise subject to witholding. Included are the self-employed and also persons with non-wage income (e.g., interest, rents, dividonds, capital gains) above a certain level. A logical model would adapt the identity that payments equal the base times the rate and regress the logarithm of quarterly payments on the logarithms of the tax rate, entrepreneurial income (YENTM$) and property income (YPRM$), the last two

representing the base. Unfortunately, the coefficient of TYRTM% is less than its standard error in this formulation. Better, although not altogether ideal, results were achieved by using the levels of the variables rather than their logarithms, even though the theoretical justification is weaker for such a specification.

In the equation actually used, YPRM$ is replaced by YPM$ (current dollar personal income) to yield greater sensitivity in simulations of the entire model. Over the period 1956.1 to 1973.4, the two variables (YPM$, YPRM$) exhibited a correlation coefficient of .996[36] so the two estimated equations have nearly identical forms, R^2's, and standard errors. Using correct variable values for the independent variables, the predicted values generated by the two equations are correlated .998. Why is YPM$ superior to YPRM$, then? As they are determined in the model, neither YENTM$ (derived totally from exogenous variables) nor YPRM$ (chiefly a function of exogenous variables) is sensitive to changes in the Michigan economy that do not mirror specific types of national changes (examples include Simulations I, III, IVA, and IVB of Table 5.5). When a simulation is run using the entire model, quarterly payments will be almost unaffected by such changes unless a more general Michigan-specific variable is included. Admittedly, more theoretically correct alternatives would be either to replace

YENTM$ (the variable likely to change due to changes in Michigan rather than United States economic conditions) by YPM$ or to estimate YENTM$ using Michigan variables, but both of these yield inferior estimates; the YPRM$ replacement does not.

Definitely one of the weaker equations in the model ($R^2 = .85$ for an equation estimated in levels), its final form is

$$(4.42) \quad TYQM\$ = k_1 + k_2 YENTM\$ + k_3 YPM\$ + k_4 TYRTM\% + \epsilon \quad .$$

Residual Tax

The residual tax variable (TRESM$) is the sum of all taxes except Michigan personal income tax that separate Michigan personal from disposable income.[37] The nine taxes that comprise the variable are Federal Income Tax (80 per cent of the total); Federal Estate Tax; Federal Gift Tax (all three refer to payments by Michigan residents); Michigan Inheritance Tax; Michigan Intangible Tax; Motor Vehicle Operator's, Chauffeur's and Driver's License Picture Fees; Michigan Weight Tax; Michigan Game and Fishing Permits; and local income tax payments in Michigan.

TRESM$ is predicted on the assumption that TRESM$/YPM$ bears a constant relation to TPUS$/YPUS$ where TPUS$ is the national total of tax and non-tax payments to government in the United States and YPUS$ is United States personal income. The Michigan to U.S. ratio will be less than one because TPUS$

includes state personal income taxes whereas TRESM$ does not. The estimated equation also includes a constant term:

$$(4.43) \qquad TRESM\$ = k_1 + k_2 \frac{YPM\$}{YPUS\$} \cdot TPUS\$ + \epsilon \quad .$$

Retail Sales Tax

Michigan retail sales tax payments[38] are estimated in three equations: automobiles and parts, foodstores, and other. The tax on automobiles is considered separately due to the extreme volatility of the series. Sales in foodstores are separated because the tax on (non-restaurant) food has been discontinued as of January, 1975, so the value of this variable will decrease by a substantial amount as of that date. As is implied by the above discussion, the "other" component of the sales tax consists of all levies except those on automobiles and parts and foodstores. There is no tax rate variable in any of the sales tax equations because the data for the short period when the tax was not 4 per cent have been revised to approximate the revenue that would have been collected had the 4 per cent rate been in effect. The approximation procedure is not entirely adequate since it ignores any possible difference in sales quantity due to the higher tax rate. All three sales tax equations are estimated as pseudo-consumption functions. That is, the dependent variable is treated as if it were sales (consumption) instead of taxes paid on those sales. The equations are then written as if they were predicting consumption in each of the three categories.

Retail sales tax payments on automobiles and parts (in real terms, TRSAUM) are predicted through a rational distributed lag mechanism similar to the one used in MQEM's automibile consumption equation.[40] The general form of such an equation is

$$C = k\frac{g(L)}{h(L)} \cdot f(Y, R, \ldots) \tag{4.44}$$

or

$$h(L) \cdot C = kg(L) \cdot f(Y, R, \ldots) \tag{4.45}$$

where C is a component of consumption expenditure, Y is an income variable, R an interest rate or rate differential, and $g(L)$ and $h(L)$ finite polynomial functions of the lag operator L. In this particular case, $g(L)$ was chosen to be L itself because such a specification seemed adequate empirically.

$$h(L) = 1 + \lambda_1 L + \lambda_2 L^2 \tag{4.46}$$

is chosen for the other distributed lag in order to encompass the following desired effects. When the $h(L)$ specification in (4.46) is applied to the variable C, the right hand side of the estimating equation will contain the expressions $-(\lambda_1 + \lambda_2)C_{-1} + \lambda_2 \Delta C_{-1}$, where it is assumed that $\lambda_2 < 0$ and $-(\lambda_1 + \lambda_2) > 0$. If auto sales are high in period $t-1$, they are also likely to be high in period t since overall conditions in the economy have not changed greatly. However, a large <u>increase</u> in period $t-1$ damps the value in period

t because an automobile is an infrequent purchase, the timing of which is at the discretion of the buyer. Thus a spurt in sales for a given set of economic conditions will be at least partially compensated for by fewer subsequent sales.

The income variable is separated into two parts, permanent (YPERM) and transitory (YTRANSTM) income, since the marginal propensity to purchase a major durable such as an automobile is higher for transitory than permanent income.[41] Permanent income is represented in the model by a six quarter declining-weight function of disposable income while transitory income is the difference between current and permanent income. These are more fully described in the INCOME section of this chapter.

R is chosen to be a three quarter average of the spread between short and long term interest rates. For the reasons detailed in the total savings and housing price equations, this variable indexes the availability of funds to likely lenders and is a better determinant of automobile borrowing than the interest rate itself.

The equation, rearranged and expressed in terms of the specific variables used, is

$$(4.47)\quad TRSAUM = k_1 + k_2\, TRSAUM_{-1} + k_3 \Delta TRSAUM_{-1} + k_4 YPERM_{-1} + k_5 YTRANSTM_{-1} + k_6 \sum_{i=1}^{3} \lambda_i (RAAA\% - RCP\%)_{-i} + \epsilon$$

where $\lambda_i = 1/3, \quad i = 1, 2, 3.$

Food consumption is assumed to follow a simple distributed lag pattern on current dollar[42] permanent income.[43] After performing the Koyck transformation, the equation becomes

$$(4.48)\quad TRSFM\$ = k_1 + k_2 TRSFM\$_{-1} + k_2 YPERM\$ + \epsilon$$

where TRSFM$ and YPERM$ represent the foodstores component of retail sales taxes and permanent income, respectively. The equation reflects the fact that food purchasing behavior is subject to habit formation so that income must change substantially before eating habits are altered.

Consumption of taxable non-automotive and non-food items is postulated to be a stock adjustment process.[44,45] If C represents consumption expenditure, S the actual stock of goods, S^* the desired stock, and δ the rate of depreciation,

$$(4.49)\quad C = \alpha (S^* - S_{-1}) + \delta S_{-1} \quad .$$

Equation (4.49) states that purchases serve two purposes--to replace worn out goods and to move towards an optimal stock. The stock is defined as the undepreciated part of previous stock plus new purchases so that

$$(4.50) \qquad S = (1 - \delta)S_{-1} + C$$

$$(4.51) \qquad = (1 - \delta)S_{-1} + \alpha(S^{*} - S_{-1}) + \delta S_{-1}$$

$$(4.52) \qquad = (1 - \alpha)S_{-1} + \alpha S^{*} \quad .$$

Multiplying (4.52) by $(1 - \delta)$, lagging it one quarter, and subtracting from (4.52) yields

$$(4.53) \qquad S - (1 - \delta)S_{-1} = (1 - \alpha)S_{-1} - (1 - \delta)(1 - \alpha)S_{-2} + \alpha S^{*} - \alpha(1 - \delta)S^{*}_{-1} \quad ,$$

or, substituting the value obtained for C in (4.50),

$$(4.54) \qquad C = (1 - \alpha)C_{-1} + \alpha S^{*} - \alpha(1 - \delta)S^{*}_{-1} \quad .$$

If the desired stock of possessions is a function of permanent income, say γ YPERM, the corresponding consumption equation is

$$(4.55) \qquad C = (1 - \alpha)C_{-1} + \alpha\gamma \text{YPERM} - \alpha(1 - \delta)\text{YPERM}_{-1} + \epsilon \quad .$$

For lack of an accurate deflator, the equation is again left in current dollars so YPERM\$ replaces YPERM in (4.55). The tax variable TRSOM\$ is substituted for consumption and a dummy DTSALES is added to account for a slight change in the coverage of the tax. The final equation is thus

$$(4.56) \qquad \text{TRSOM\$} = k_1 + k_2 \text{TRSOM\$}_{-1} + k_3 \text{YPERM\$} + k_4 \text{YPERM\$}_{-1} + k_5 \text{DTSALES} + \epsilon \quad .$$

INCOME

This block of equations consists of the definitions and identities used to determine the eight income variables present in the model. Personal income, the principal aggregate variable of the model, measures the overall health and performance of the Michigan economy. The current dollar value (YPM$) is the sum of its components: total wages and salaries, other labor income, proprietors' income, property income, transfer payments, and residence adjustment less contributions to social insurance. The Detroit consumer price index (PCPID) is used to convert YPM$ to its real equivalent (YPM).

Current dollar disposable income is defined in the model as current dollar personal income less state income taxes and the residual tax variable (discussed in the previous section entitled TAXES). YDM$ is also converted to constant dollars through deflation by PCPID. Disposable income approximates what is left for households to spend after taxes (other than retail sales tax, though) have been paid and thus determines demand for goods and services. Permanent income, defined in the model as a weighted average of current and past values of disposable income, is a more stable version of disposable income and is used in the model's consumption functions. Permanent income is based on six values of disposable income, the current quarter figure and five previous ones. The weights (see Appendix B, Equations 63 and 64) are constrained to sum to one while each is

approximately 80 per cent of the previous value. Real transitory income, the difference between constant dollar disposable and permanent income, highlights the difference between actual income this quarter and what past experience would predict income to be. If transitory income is high, money is available for discretionary spending.

Adjusted personal income, as was previously noted, is an approximation to the income tax base obtained by adding contributions to social insurance back to personal income while subtracting transfer payments.

LINKING VARIABLES

In three cases, MQEM does not predict the particular national variable needed by the state model. As Chapter III brought out, the United States variables actually used in the state model are termed linking variables and are determined from MQEM variables as the initial part of the state model.

Average United States Manufacturing Wage

The first of the linking variables is WUS$, the average production worker wage in United States manufacturing. It is well-predicted as a simple function of private non-farm compensation per manhour (CMHUS), even though the latter includes a much wider range of workers and non-wage compensation. The equation is

(4.57) $\ell n\ WUS\$ = k_1 + k_2\ \ell n\ CMHUS + \epsilon$,

where k_2 is anticipated to be, and is, somewhat less than one (.80 in Equation 67, Appendix B).

Gross Auto Product

The second linking variable, gross auto product, is separated from the MQEM variable, personal consumption expenditures for automobiles (CDAUS), by expenditures on automobiles as producer durables, net exports, and change in auto dealers' inventories. Therefore, along with CDAUS as independent variables in the equation are proxies for two of the others. Net exports are ignored for lack of a good method of representing them. IBF (total business fixed investment) describes the producer durables component under the assumption that investment in automobiles is an approximately constant percentage of total investment. The change in inventories is modeled through an expectations mechanism on the part of producers. If strong demand is anticipated, manufacturers expect inventories to be depleted. Planned production is increased to raise stocks to their normal levels. The index of consumer sentiment (ICS) is used to predict buyer demand. It is lagged one quarter because production decisions are usually made in advance.

An alternative way of viewing the inventory adjustment is as a function of the first and second differences of CDAUS. If sales are

increasing, further increases are expected so producers will want a larger inventory and will step up production. If the increases in sales come at an increasing rate, however, actual inventory will decline since additional production will not have been sufficient to meet the demand. This formulation was adequately supported by empirical evidence but not to the degree the ICS hypothesis is. The difference interpretation was then dropped from the equation.[46]

Two additional variables are an auto strike dummy (DAS) which accounts for dislocations in production due to major automobile strikes and the Canadian auto pact dummy (DAPM) which controls for changes in distribution of production between the United States and Canada. The equation is

$$(4.58) \qquad GAUTO = k_1 + k_2\, CDAUS + k_3\, IBF + k_4\, ICS_{-1} + k_5\, DAPM + k_6\, DAS + \epsilon \quad .$$

United States Consumer Price Index

The United States consumer price index (PCPIUS, used in the state model) differs from the implicit price deflator for personal consumption expenditure (PCE, predicted by MQEM) due to the employment of different weights in averaging expenditure components. PCPIUS uses base period weights (a Laspeyre index) while PCE uses the current period's market basket of goods (a Paasche index). Measures of changes in the composition of consumption were inserted

in the equation to try to isolate some of the effect of the change in weights. The percentage change in consumption of services (CSUS) and the consumption of durables (CDUS) relative to total consumption (CUS) were used. If services have been increasing as a component of total consumption and their price has been increasing faster than the index in general, PCE would be expected to increase slightly faster than PCPIUS. $\Delta \ell n$ CSUS/CUS would then have a negative coefficient in the $\Delta \ell n$ PCPIUS equation, which it does. The entire equation is

$$(4.59) \qquad \Delta \ell n \text{ PCPIUS} = k_1 + k_2 \Delta \ell n \text{ PCE} + k_3 \Delta \ell n \frac{\text{CSUS}}{\text{CUS}} + k_4 \Delta \ell n \frac{\text{CDUS}}{\text{CUS}} + \epsilon \quad .$$

As anticipated, the value of k_2 is approximately one (1.05 in Equation 69, Appendix B) since the two indices, given the weighting adjustment, are measuring the same price changes.

This concludes the presentation of the individual equations. Each is important in itself, but must also perform as part of the overall model. How well the equations interact in actual simulation is the subject of Chapter V.

NOTES

[1] Manhours are what are actually demanded rather than number of bodies. This could not be accounted for in the model for two reasons. "Average weekly hours" data are not available in all sectors. In addition, the data which are available, in manufacturing and construction, for instance, do not cover the same workers as the employment data so it is risky to multiply them to arrive at manhours. Differences in average hours worked absorb some of the variation that would otherwise show up in employment.

[2] All specific mnemonics used in the text correspond to those listed in Appendix A. The letters a, b, c, k, γ, α, etc., should, throughout this chapter, be interpreted as parameters whose values (either positive or negative) will be determined empirically.

[3] There is also an error term present which, in this case, is a multiplicative error.

$$EMFM = \epsilon \; k \; GNP^{\cdots}$$

The error term will sometimes not be explicitly expressed in preliminary versions of equations but is understood to be present in some form in all equations that are not definitions or identities.

[4] The terms of the tradeoff available between additional GNP and a decrease in the GAUTO and IBF component of it can be calculated. Suppose GAUTO and IBF together comprise p% of GNP (letting b = c for simplicity). Also suppose GNP increases by q% and let r% be the maximum allowable decrease in (GAUTO + IBF)/GNP to still maintain Michigan manufacturing employment. $EMFM_{old} = EMFM_{new}$ implies

$$kGNP^{\left\{a+\frac{bp}{100}\right\}} = k\left[\left(1+\frac{q}{100}\right)GNP\right]^{\left\{a+\frac{b(p-r)}{100}\right\}}$$

which yields, solving for r,

$$\frac{\left(\frac{100a}{b} + p\right)\left(\ell n\left(1+\frac{q}{100}\right)\right)}{\left(\ell n\left(1+\frac{q}{100}\right) - \ell n\, GNP\right)} = r \quad .$$

Unfortunately, this expression does not lend itself to a simple interpretation, indicating that the tradeoff is complex and depends on the absolute level of GNP.

[5] A distributed lag is actually used on GNP in the final equation because it takes time for increases in national output and income to express themselves in greater demand for manufacturing employment.

[6] There is certainly asymmetry here; one would expect both independent variables to appear in the same form, but they do not. The actual expressions used were determined empirically. Substituting $\Delta \ell n$ (WM$/WUS$) for ℓn(WM$/WUS$) substantially improved the fit, while $\Delta \ell n$(AEQMFM$/PPNF) was not significant in any of the trials.

[7] This error term is the logarithm of the ϵ in Note 3. ϵ is used throughout to indicate the error term in any form.

[8] This effect enters the equation in a form similar to that used in the manufacturing equation, i.e.,

$$\ell n\, ETRM = R + \ell n\, YDM^{(a+b\,\frac{TRSM}{YDM})}$$

where ETRM, YDM, TRSM and R represent trade employment in Michigan, Michigan real disposable income, Michigan sales tax collections in 1967 dollars and the rest of the equation, respectively.

[9] What is termed a retail sales tax in this dissertation is not strictly a tax on retail items because it includes some materials sold to businesses. It is called the retail sales tax in this paper because that is its reference title in the Michigan Department of Treasury Monthly Research and Statistical Bulletin. The retail sales tax will also be considered a consumption tax, although it covers items not usually considered a part of consumption and does not include some consumption items.

[10] U.S. Department of Commerce, Social and Economic Statistics Administration, Survey of Current Business (Washington, D.C.: U.S. Government Printing Office, July issues, 1972-1974), Table 1.2.

[11] William J. Baumol, "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis," American Economic Review, LVII (June, 1967), pp. 415-426.

[12] The fact that the data values for residual employment are obtained by subtracting wage and salary employment from total employment makes a significant negative coefficient almost certain. Equation (4.15) is the one equation of the model where the use of an

independent variable derived directly from the dependent variable or a factor in deriving the dependent variable could not be avoided. This is a practice that should not be encouraged.

[13] WM$ is an effective rather than a scale wage in the terminology of Robert E. Hall, "The Process of Inflation in the Labor Market," Brookings Papers on Economic Activity (2, 1974), p. 347.

[14] WM$ is higher than WUS$ for any or all of the following reasons: Michigan's labor force is more skilled, more unionized, or more heavily concentrated in traditionally high-wage industries than the American labor force generally.

[15] UM% is the Michigan unemployment rate while UUS% is the United States rate.

[16] A value of .306 is significant at the 1% level for normal variates.

[17] It should be noted that $\Delta \ell n \frac{GAUTO}{GNP} \neq \frac{\Delta \ell n\, GAUTO}{\Delta \ell n\, GNP}$ and $\Delta \ell n \frac{PCPID}{PCPIUS} \neq \frac{\Delta \ell n\, PCPID}{\Delta \ell n\, PCPIUS}$ so that dividing the equation by $\Delta \ell n$ WUS$ would not produce a uniform-appearing expression. The two expressions with Δ in the denominator could not be used as regressors because they involve division by zero in a few cases. As an experiment, the zero denominator cases (five of them) were omitted and these expressions were used in place of $\Delta \ell n$ (GAUTO/GNP) and $\Delta \ell n$ (PCPID/PCPIUS) for the remaining quarters. The amount of variation explained dropped sharply from that of equation (4.16).

[18] Beside the search and training costs of hiring new employees and the morale problems of layoffs, the "experience rating" factor in unemployment insurance makes it wise, up to a point, to adjust hours rather than bodies. The rate of an employer's contribution to the state unemployment insurance fund is based on the unemployment record of his employees.

When demand increases, the extra cost of overtime is offset somewhat by the fact that employer matching of Social Security contributions ceases after a certain level of earnings ($14,100 in 1975) and the costs of certain fringe benefits (e.g., employee health insurance) are not dependent upon the number of hours worked.

[19]One may be tempted to simplify the two equation model described above by compressing it into a single equation similar to that used to estimate employment demand, i.e.,

$$\frac{HRSM}{HRSM_{-1}} = \left(\frac{HRSM^{*}}{HRSM_{-1}}\right)^{\alpha}$$

and making a demand-proxy substitution for $HRSM^{*}$. The problem here is that actual hours or the relationship of actual to desired hours is the variable that depends on demand factors; $HRSM^{*}$, desired hours, does not.

[20]A residence adjustment dummy was present initially in each of the average earnings regression equations but was dropped if its coefficient did not differ significantly from zero.

[21]Also tried was ℓn HRSM, but it was not found to be significant in any of the average earnings equations.

[22]U.S. Department of Commerce, Dictionary of Economic and Statistical Terms (Washington: U.S. Government Printing Office, August, 1969), p. 10.

[23]Ibid., p. 11.

[24]Ibid.

[25]This is explained more fully in the discussion of the total savings equation below.

[26]Milliken, William G., Economic Report of the Governor, 1975. (Lansing, Michigan: March, 1975), Table B-43, p. 158.

[27]Michael K. Evans, Macroeconomic Activity--Theory, Forecasting, and Control (New York: Harper and Row, 1969), pp. 191-192.

[28]Unemployment, although significant in the presence of a lagged dependent variable, was not significant when used alone.

[29]It is not claimed that $\frac{WSM\$/EMP}{TSSBASE\$}$ is actually the percentage of wages subject to tax, merely that as the former rises, so does the latter.

[30]Albert Rees, The Economics of Work and Pay (New York: Harper and Row, 1973), pp. 13-14.

[31]The labor force is often used as the denominator here but population serves just as well.

[32]The idea of including compensation exhaustions in the labor force equation comes from Thomas Dernburg, Kenneth Strand, and Judith Dukler, "A Parametric Approach to Labor Force Participation," Industrial Relations, VI (October, 1966), pp. 49-50.

[33]Rees, op. cit., p. 13. The employment variable could also measure the added worker effect but the discouraged worker effect dominates.

[34]Current unemployment is not included because its presence would upset the working of the model. UCEXM is needed for period $t + 1$ when operating the model in period t. Therefore, requiring unemployment in period $t+1$ is not feasible.

[35]L. M. Koyck, Distributed Lags and Investment Analysis (Amsterdam: North Holland, 1954), p. 24. Koyck does not give this specification any particular name.

[36]The "true" values of the variables are not likely to be so well correlated, but the data values of YPRM$ are derived by the Bureau of Economic Analysis from those of YPM$. The latter fact yields the high correlation.

[37]James Haughey, Michigan Department of Management and Budget, created the disposable income variable used in the model by estimating the values of these taxes and subtracting them from personal income.

[38]See footnote 9 of this chapter.

[39]The sales tax-foodstores variable includes taxes collected on all sales of such stores, whether strictly food items or not. Many of these other items are household needs that people normally consider part of their food budgets, so viewing a food consumption equation is not far from the truth. Some food is also sold in non-food stores. Hopefully, this relatively small amount can be handled by an adjustment constant in the sales tax-other equation as will be the January, 1975, repeal of the 2 per cent sales tax on prescription drugs.

[40]Saul H. Hymans and Harold T. Shapiro, "The Structure and Properties of the Michigan Quarterly Econometric Model of the United States Economy," International Economic Review, XV (October, 1974), pp. 636-637.

[41]Hymans and Shapiro, Ibid., p. 637, found this empirically. This is also consistent with the theoretical findings of Milton Friedman, A Theory of the Consumption Function (Princeton: National Bureau of Economic Research, Princeton University Press, 1957), pp.28, 40, even though he would consider such a purchase saving rather than consumption.

[42]While real dollar magnitudes are theoretically desirable in the equation, the lack of a specific food deflator made attempted real variants of the equation less successful than the current dollar one. Also, if consumers are accustomed to spending a given amount (in current dollars) at the grocery store and if they temporarily reduce the quality or quantity of purchases when prices increase, then current dollar variables are called for in the equation.

[43]Disposable income was also a possibility here but permanent income (a six-quarter weighting of disposable income) performed more reliably.

[44]This derivation follows the general stock adjustment model described in Saul H. Hymans and Harold T. Shapiro, "The Michigan Quarterly Econometric Model of the United States Economy," The Economic Outlook for 1973 (Ann Arbor, Michigan: Twentieth Anniversary Conference on the Economic Outlook, November 16-17, 1972), p. 119.

[45]Some liberty has been taken in deriving the equation in this manner since the variable includes taxes on some non-durables of which a consumer would not have a depreciable stock.

[46]When the two were tried simultaneously, ICS_{-1} dominated.

CHAPTER V

EVALUATION OF THE MODEL

The first idea that comes to mind in evaluating a statistical model is a parametric test. Advance a hypothesis, construct the appropriate test statistic, compare it to a critical value, and objectively decide if the hypothesis should be accepted or rejected at a given significance level on the basis of the evidence. While this procedure works well for the parameters of a single equation and for the single equation itself, it has no general analogue in a multi-equation system.[1] The methodology has not been developed. A model of the type constructed here cannot be decisively termed "good" or "bad" or even "adequate" or "inadequate" on the basis of standardized tests.

The term "evaluation" in the title of this chapter has a more general meaning. The goal of the following discussion is to present evidence that will give a decision-maker enough confidence in the model actually to forecast with it. An additional purpose is to facilitate the intelligent use and future development of the model. These are done most directly by giving an indication of the magnitude of error that can be expected of the various equations in runs of differing lengths. Equations where the model is weak or areas where the

equations are not interacting properly are candidates for further work. Some attmpet is made at actual evaluation by comparing the results obtained to published results for other models and to the predictions of a naive, autoregressive model.

SAMPLE PERIOD SIMULATION

In this series of tests, a model, presented with the correct values of the exogenous variables, predicts the values of the endogenous variables over part of the sample period.[2] Before discussing the results, the models tested and the sample statistics calculated need to be described.

Three models are investigated in the sample period runs. In the first of these, ordinary least squares is used to estimate all the stochastic equations--it is henceforth referred to as the ordinary least squares (OLS) model. The equations of Appendix C replace the corresponding equations of Appendix B.

The second model is the principal one of the thesis, described in Chapters III and IV, in which instrumental variables estimation is used for the stochastic equations of the simultaneous block. It will be labeled the instrumental variables (IV) model.

The third model combines one new equation with elements of the previous two models. Referring to Equation 14 of Appendix B, the coefficient of the price variable is only 70 per cent of its standard

error when instrumental variables estimation is used. This is the weaker of the two cases where the instrumental variables estimate was allowed to remain even though it failed to meet the rejection criterion of Chapter III. If the price variable is omitted and the equation re-estimated (ordinary least squares suffices since there are no longer any endogenous right hand side variables), the resulting equation is, in the notation of Appendices A and B,

$$(5.1)\qquad \Delta \ell n\ WM\$ = \underset{(.83652)}{.0015058} + \underset{(5.2281)}{.020558}\ DAUCON + \left[\underset{(5.2281)}{.79576} + \underset{(4.8742)}{2.4174}\left(\Delta \ell n \frac{GAUTO}{GNP} - .0013687\right)\right] \Delta \ell n\ WM\$$$$

$$OLS\ R^2 = .75490\ \ SE = .0068367\ \ DW = 2.4636\ \ N = 67\ .$$

If this equation is substituted for Equation 14, the character of the model changes substantially because the dependent variables of Equations 1, 16-21, and 24 of Appendix B can now be predicted recursively (depend only upon exogenous, lagged endogenous, or previously recursive variables) for a total of 22 rather than 13 recursive equations.[3] Among the additional recursive equations is that predicting the important manufacturing employment variable. After arrangement in the proper order, the recursive equations, estimated by ordinary least squares (the same estimates as the OLS model), yield consistent predictions. Thus the alternative (ALT) model has its own manufacturing wage equation, the OLS model equations for

the augmented list of recursive variables, and the IV model equations for the remaining simultaneous variables. It is of interest to note how the ALT model compares in predictive accuracy with the IV one. Overall, though, the three models are quite similar and are expected to have the same areas of strength and weakness.

Two sample statistics are calculated for each of the 69 variables in each simulation. The first of these is the mean absolute percentage error (MAPE).[4] If Y_j is the observed value of the variable in quarter j and $\hat{Y}_j$ the estimate generated by the model,

$$\text{(5.2)} \qquad \text{MAPE} = \sum_{j=1}^{N} \left| \frac{Y_j - \hat{Y}_j}{Y_j} \right| \cdot \frac{100}{N}$$

where the average is taken over N quarters. The other statistic, the root mean squared error (RMSE), is defined by Equation (5.3):

$$\text{(5.3)} \qquad \text{RMSE} = \sqrt{\sum_{j=1}^{N} \frac{(Y_j - \hat{Y}_j)^2}{N}} \quad .$$

The RMSE is in the same units as the original variable, while the MAPE is in percentage points.

The two statistics are not directly comparable in that, when evaluating two equations over the same period of observation, the one with the larger MAPE need not have the larger RMSE. This is so because, by squaring the error, outlying observations are given greater

weight in the RMSE while the MAPE treats each percentage error equally. Since the errors are expressed as percentages of actual values in the MAPE, it does give heavier weight to a particular absolute error when the corresponding observed value is small. This should be noted when using the MAPE for a variable whose magnitude relative to its mean may differ substantially from period to period. In actual use, though, a model with a much larger MAPE for a given equation will probably have a larger RMSE, and vice versa.

The results of the sample period simulations are presented in Table 5.1. The variables are listed in the order of Appendix B. Obviously, time and space do not permit reporting the results of simulating every possible forecast length. It is hoped that those included constitute a representative group.[5]

Each simulation in the table is a dynamic overlap forecast of the length indicated. For example, the eight-period overlap statistics are based upon seven eight-quarter dynamic runs beginning in the quarters 1970.3, 1970.4, 1971.1, 1971.2, 1971.3, 1971.4 and 1972.1. The final period predictions and actual values are the raw data entering into the calculation of the MAPE and RMSE. The six-period overlap simulations consist of nine six-quarter dynamic runs to utilize the entire 14 quarters of data, and so on.

Comparing two values in Table 5.1 poses a statistical problem since the figures given are values of sample statistics whose

Table 5.1: Sample Period Simulations

		Static Simulation			4-Quarter Overlap			6-Quarter Overlap			8-Quarter Overlap		
		OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT
EMFM	MAPE	1.26%	1.25%	1.26%	1.40%	1.41%	1.40%	1.69%	1.71%	1.68%	2.22%	2.25%	2.19%
	RMSE	16.26	16.25	16.27	20.26	20.38	20.21	23.17	23.38	23.07	27.18	27.50	26.99
ETCM	MAPE	0.56%	0.68%	0.68%	1.24%	1.74%	1.70%	1.22%	2.48%	2.39%	1.13%	2.97%	2.84%
	RMSE	1.06	1.36	1.34	2.02	3.19	3.10	2.15	4.20	4.05	1.97	4.80	4.60
ETRM	MAPE	0.61%	0.67%	1.67%	0.97%	1.36%	1.32%	1.05%	1.55%	1.46%	1.39%	1.90%	1.77%
	RMSE	4.88	5.34	5.35	6.91	9.83	9.44	7.95	11.86	11.19	10.19	13.47	12.59
ECCM	MAPE	1.87%	1.87%	1.87%	2.38%	2.38%	2.38%	2.57%	2.57%	2.57%	3.24%	3.24%	3.24%
	RMSE	2.66	2.66	2.66	3.82	3.82	3.82	4.04	4.04	4.04	4.56	4.56	4.56
EMIM	MAPE	2.16%	2.16%	2.16%	4.69%	4.69%	4.69%	5.98%	5.98%	5.98%	5.56%	5.56%	5.56%
	RMSE	.39	.39	.39	.65	.65	.65	0.75	.75	.75	0.70	.70	.70
EFIM	MAPE	0.74%	0.74%	0.73%	1.44%	1.45%	1.42%	1.57%	1.57%	1.55%	1.11%	1.09%	1.06%
	RMSE	1.18	1.17	1.17	2.15	2.14	2.13	2.12	2.10	2.07	1.81	1.80	1.75
ESM	MAPE	0.96%	0.96%	0.97%	1.69%	1.73%	1.73%	1.84%	1.89%	1.90%	1.71%	1.55%	1.54%
	RMSE	5.67	5.66	5.66	10.40	10.56	10.57	10.51	10.65	10.69	10.29	9.95	9.89
EGLM	MAPE	0.87%	0.88%	0.88%	1.14%	1.19%	1.18%	1.18%	1.30%	1.29%	1.20%	1.21%	1.22%
	RMSE	5.56	3.59	3.59	5.09	5.19	5.14	5.32	5.64	5.59	4.91	5.11	5.11
EGSM	MAPE	1.22%	1.22%	1.22%	1.41%	1.40%	1.40%	1.61%	1.59%	1.58%	1.83%	1.80%	1.79%
	RMSE	1.96	1.96	1.96	2.41	2.40	2.40	2.56	2.55	2.52	3.08	3.05	3.02
EGM	MAPE	0.63%	0.64%	0.64%	1.00%	1.04%	1.05%	0.94%	1.05%	1.02%	1.05%	1.15%	1.13%
	RMSE	3.78	3.85	3.85	6.45	6.60	6.54	6.45	6.83	6.74	6.55	6.75	6.69
EWSM	MAPE	2.55%	0.56%	0.56%	0.65%	0.74%	0.71%	0.65%	0.82%	0.78%	0.89%	1.11%	1.06%
	RMSE	21.45	21.26	21.18	26.15	28.51	27.90	24.08	28.55	27.58	33.34	38.80	37.76
EMRESM	MAPE	4.81%	4.46%	4.40%	5.90%	5.12%	5.08%	6.15%	5.75%	5.50%	8.45%	8.11%	7.59%
	RMSE	20.99	20.61	20.56	24.74	23.80	22.82	26.04	26.69	25.48	31.56	31.60	29.44
EMPM	MAPE	0.47%	0.44%	0.44%	0.40%	0.58%	0.38%	0.49%	0.46%	0.46%	0.58%	0.57%	0.57%
	RMSE	19.67	18.87	18.84	18.65	18.27	17.99	20.06	19.57	19.68	25.55	26.44	26.38
WMS	MAPE	0.67%	0.67%	0.67%	1.07%	1.07%	1.57%	2.75%	2.75%	2.61%	3.60%	3.58%	3.41%
	RMSE	.04	.04	.04	.10	.10	.09	.14	.14	.11	.19	.19	.18
HRSM	MAPE	1.07%	1.07%	1.07%	1.97%	2.00%	2.00%	1.90%	1.90%	1.90%	2.34%	2.34%	2.34%
	RMSE	.57	.57	.57	1.00	1.00	1.00	1.01	1.01	1.01	1.08	1.08	1.08
AEQMFMS	MAPE	1.46%	1.44%	1.45%	1.98%	1.95%	1.95%	3.56%	3.53%	3.42%	5.01%	4.98%	4.82%
	RMSE	51.78	51.54	51.56	76.40	75.09	75.75	116.95	115.55	114.40	162.70	161.55	157.47
AEQTCMS	MAPE	1.35%	1.36%	1.36%	1.39%	1.38%	1.36%	2.40%	2.40%	2.27%	2.86%	2.80%	2.66%
	RMSE	47.76	48.08	47.80	48.41	48.28	47.28	85.19	82.75	79.55	88.84	87.25	83.02
AEQTRMS	MAPE	0.92%	0.92%	0.92%	1.34%	1.34%	1.29%	1.54%	1.55%	1.45%	1.92%	1.92%	1.76%
	RMSE	17.29	17.26	17.17	28.05	28.35	26.84	35.70	35.96	35.58	38.70	38.87	35.54
AEQCCMS	MAPE	1.86%	1.83%	1.85%	4.26%	4.25%	4.17%	5.88%	5.91%	5.78%	5.27%	5.30%	5.11%
	RMSE	71.61	70.57	71.39	154.05	155.16	150.07	153.59	153.91	148.42	125.46	126.56	117.47
AEQMIMS	MAPE	2.72%	2.69%	2.73%	2.91%	2.89%	2.95%	3.99%	3.95%	3.98%	4.80%	4.75%	4.73%
	RMSE	95.28	95.87	95.45	98.73	96.18	100.10	133.42	131.71	134.23	161.39	160.11	159.12

Table 5.1: Continued

		Static Simulation			4-Quarter Overlap			6-Quarter Overlap			8-Quarter Overlap		
		OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT
AEQFIMS	MAPE	1.59%	1.59%	1.59%	2.30%	2.30%	2.30%	2.38%	2.38%	2.38%	2.65%	2.65%	2.65%
	RMSE	39.99	39.99%	39.99%	56.91	56.91	56.91	64.90	64.90	64.90	76.09	76.09	76.09
AEQSMS	MAPE	1.25%	1.25%	1.25%	1.44%	1.44%	1.44%	0.98%	0.98%	0.98%	1.27%	1.27%	1.27%
	RMSE	25.96	25.96	25.96	34.07	34.07	34.07	27.91	27.91	27.91	32.18	32.18	32.18
AEQSMS	MAPE	0.93%	0.94%	0.93%	1.21%	1.25%	1.13%	1.37%	1.43%	1.24%	2.29%	2.38%	2.10%
	RMSE	26.24	26.02	26.17	36.25	36.89	34.52	36.53	37.94	33.66	57.55	59.70	52.92
WSMFMS	MAPE	1.68%	1.66%	1.67%	1.46%	1.42%	1.41%	2.25%	2.21%	2.16%	3.46%	3.40%	3.31%
	RMSE	76.38	75.99	76.21	69.55	68.04	69.75	102.55	99.66	101.09	142.69	139.66	138.69
WSTCMS	MAPE	1.30%	1.28%	1.28%	1.41%	1.62%	1.66%	2.00%	1.75%	1.80%	2.29%	1.40%	1.43%
	RMSE	7.61	7.79	7.79	7.62	7.95	8.19	11.83	10.27	10.55	12.90	10.40	10.57
WSTRMS	MAPE	0.91%	0.80%	0.80%	0.93%	0.58%	0.56%	0.86%	0.63%	0.63%	0.83%	0.42%	0.42%
	RMSE	11.99	11.14	11.09	15.02	12.00	11.71	13.70	9.88	9.71	11.05	6.54	6.42
WSCCMS	MAPE	2.79%	2.74%	2.78%	6.57%	6.54%	6.47%	6.47%	6.49%	6.36%	5.90%	5.94%	5.80%
	RMSE	15.17	15.02	15.14	28.42	28.33	28.07	27.50	27.60	27.04	25.23	28.42	24.61
WSMIMS	MAPE	3.37%	3.40%	3.37%	5.86%	5.91%	5.87%	8.13%	8.24%	8.00%	9.39%	9.45%	9.21%
	RMSE	1.57	1.57	1.57	2.51	2.51	2.51	3.25	3.24	3.21	3.80	3.80	3.75
WSPIMS	MAPE	1.51%	1.51%	1.50%	1.88%	1.87%	1.87%	2.17%	2.17%	2.16%	2.75%	2.74%	2.74%
	RMSE	4.74	4.74	4.74	6.01	6.00	5.99	7.31	7.29	7.29	9.35	9.34	9.35
WSSMS	MAPE	1.16%	1.18%	1.17%	1.36%	1.40%	1.42%	1.77%	1.88%	1.89%	1.75%	1.84%	1.85%
	RMSE	12.10	12.14	12.13	14.40	14.80	14.84	18.60	19.22	19.33	19.69	20.38	20.47
WSGMS	MAPE	0.97%	0.99%	0.99%	1.78%	1.95%	1.79%	1.74%	1.88%	1.67%	1.92%	2.07%	1.79%
	RMSE	13.26	13.64	13.49	24.51	26.25	24.59	24.87	26.79	24.26	30.17	32.44	28.30
WSMS	MAPE	0.87%	0.85%	0.84%	1.13%	1.02%	0.96%	1.41%	1.25%	1.16%	2.03%	1.87%	1.78%
	RMSE	95.19	93.68	93.41	94.80	88.69	86.39	135.04	125.20	120.49	188.83	174.36	167.37
YLOMS	MAPE	1.80%	1.81%	1.81%	2.21%	2.14%	2.12%	1.58%	1.51%	1.49%	1.54%	1.45%	1.41%
	RMSE	20.09	20.06	20.07	25.07	24.25	24.04	18.87	18.02	17.71	16.36	15.36	15.22
YENTMS	MAPE	3.14%	3.14%	3.14%	3.26%	3.26%	3.26%	2.90%	2.90%	2.90%	2.86%	2.86%	2.86%
	RMSE	25.82	25.82	25.82	25.38	25.38	25.38	24.25	24.25	24.25	25.95	25.95	25.95
YPRMS	MAPE	0.75%	0.79%	0.79%	0.62%	0.72%	0.72%	0.90%	1.02%	1.02%	0.84%	0.94%	0.94%
	RMSE	14.09	14.79	14.80	12.06	13.24	13.20	14.17	16.65	15.59	15.41	17.10	16.87
SAVTOTS	MAPE	1.09%	1.09%	1.09%	1.50%	1.51%	1.51%	2.23%	2.25%	2.25%	2.46%	2.48%	2.46%
	RMSE	.25	.25	.25	.35	.35	.35	.55	.55	.55	.64	.65	.64
SSTRS	MAPE	2.13%	2.13%	2.13%	2.86%	2.86%	2.86%	2.75%	2.75%	2.75%	2.40%	2.40%	2.40%
	RMSE	12.75	12.75	12.75	17.44	17.44	17.44	16.50	16.50	16.50	15.09	15.09	15.09
UCTRMS	MAPE	9.38%	8.93%	9.01%	9.19%	9.17%	9.22%	10.51%	9.24%	9.22%	14.22%	12.90%	12.88%
	RMSE	6.84	6.89	6.89	6.10	6.51	6.51	6.39	5.77	5.77	8.28	7.13	7.06
*PARECPM	MAPE	2.14%	2.12%	2.12%	2.03%	2.30%	2.31%	1.68%	1.98%	1.98%	1.52%	1.45%	1.45%
	RMSE	18.69	18.39	18.38	16.42	18.40	18.49	15.45	16.65	16.60	12.78	13.87	13.91
PATRMS	MAPE	2.14%	2.12%	2.12%	2.04%	2.30%	2.31%	1.68%	1.98%	1.98%	1.52%	1.45%	1.45%
	RMSE	3.55	3.51	3.51	3.50	3.88	3.90	3.40	3.62	3.61	2.85	3.08	3.09

Table 5.1: Continued

		Static Simulation			4-Quarter Overlap			6-Quarter Overlap			8-Quarter Overlap		
		OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT
YTRANSM$	MAPE	1.21%	1.28%	1.28%	1.15%	1.51%	1.50%	1.07%	1.20%	1.20%	1.24%	1.39%	1.37%
	RMSE	16.11	16.67	16.65	16.16	19.44	19.38	14.42	17.44	17.38	16.35	18.18	18.07
TSIM$	MAPE	1.39%	1.36%	1.36%	2.15%	2.18%	2.16%	1.90%	1.88%	1.86%	1.84%	1.86%	1.83%
	RMSE	6.[illegible]	6.70	6.69	10.85	10.65	10.55	9.82	9.81	9.72	9.55	9.88	9.86
PCPID	MAPE	0.54%	0.55%	0.55%	0.59%	0.54%	0.54%	0.58%	0.52%	0.52%	0.76%	0.62%	0.62%
	RMSE	.51	.51	.51	.89	.85	.85	.90	.79	.79	1.23	1.05	1.05
PCPIDHSE	MAPE	0.70%	0.70%	0.70%	2.08%	2.08%	2.08%	2.00%	2.14%	2.14%	2.29%	2.38%	2.38%
	RMSE	1.14	1.14	1.14	3.36	3.38	3.38	3.43	3.51	3.51	3.26	3.36	3.36
LFM	MAPE	0.42%	0.37%	0.37%	0.41%	0.42%	0.42%	0.46%	0.42%	0.43%	0.43%	0.44%	0.44%
	RMSE	18.86	17.44	17.50	17.50	18.42	18.48	20.60	19.44	19.50	21.17	19.61	19.64
UCEXM*1	MAPE	8.34%	9.32%	9.25%	9.23%	12.23%	12.05%	7.07%	10.27%	10.17%	5.96%	7.47%	7.42%
	RMSE	2.56	3.01	2.99	2.88	3.98	3.88	2.08	2.75	2.69	1.15	1.73	1.72
UM	MAPE	2.74%	3.81%	3.78%	5.77%	8.01%	7.92%	2.82%	5.91%	5.84%	3.59%	5.93%	5.92%
	RMSE	9.43	12.54	12.46	16.51	22.21	21.83	8.65	16.21	15.92	10.54	17.22	17.24
UM$	MAPE	2.75%	3.85%	3.79%	5.61%	7.68%	7.59%	2.78%	5.70%	5.65%	3.62%	5.84%	5.68%
	RMSE	.25	.33	.33	.43	.58	.56	.22	.42	.41	0.29	0.46	0.46
TYWM$	MAPE	2.11%	2.07%	2.07%	2.47%	2.49%	2.42%	1.70%	1.71%	1.59%	1.65%	1.46%	1.37%
	RMSE	5.11	5.09	5.09	6.67	6.67	6.54	5.11	5.06	4.85	5.27	5.00	4.70
TYQM$	MAPE	8.29%	8.30%	8.30%	8.85%	8.82%	8.80%	10.25%	10.17%	10.17%	9.00%	8.89%	8.82%
	RMSE	1.51	1.50	1.50	1.59	1.59	1.59	1.69	1.69	1.68	1.63	1.63	1.62
TYM$	MAPE	2.57%	2.55%	2.55%	2.78%	2.78%	2.77%	1.84%	1.78%	1.76%	1.96%	1.80%	1.70%
	RMSE	5.48	5.45	5.45	6.85	6.85	6.71	5.39	5.31	5.15	5.48	5.21	4.89
TRESM$	MAPE	3.19%	3.17%	3.17%	3.15%	3.14%	3.14%	3.36%	3.37%	3.38%	3.05%	3.00%	2.94%
	RMSE	59.17	59.13	59.09	65.18	64.92	64.86	70.26	69.80	69.84	70.39	69.78	68.62
TRSAUM	MAPE	2.62%	2.62%	2.62%	2.72%	2.73%	2.73%	2.82%	2.90%	2.92%	1.90%	1.91%	2.00%
	RMSE	1.37	1.37	1.37	1.45	1.45	1.46	1.55	1.56	1.56	1.20	1.22	1.23
TRSAUM$	MAPE	2.62%	2.62%	2.62%	2.72%	2.73%	2.73%	2.82%	2.90%	2.92%	1.90%	1.91%	2.00%
	RMSE	1.54	1.54	1.54	1.61	1.63	1.64	1.72	1.73	1.76	1.35	1.37	1.38
TRSTM$	MAPE	1.18%	1.24%	1.24%	1.28%	1.31%	1.32%	1.06%	1.13%	1.15%	1.24%	1.28%	1.32%
	RMSE	.62	.64	.64	.68	.70	.70	.64	.67	.69	0.79	0.81	0.82
TRSOM$	MAPE	0.95%	0.91%	0.91%	1.09%	1.05%	0.99%	1.32%	1.25%	1.22%	1.84%	1.79%	1.69%
	RMSE	1.48	1.50	1.50	1.75	1.70	1.65	2.16	2.06	2.00	2.95	2.91	2.78
TRSM$	MAPE	0.71%	0.72%	0.72%	0.79%	0.78%	0.78%	0.89%	0.84%	0.80%	1.31%	1.26%	1.17%
	RMSE	1.96	1.98	1.98	2.05	1.96	1.94	2.40	2.32	2.29	3.39	3.34	3.18
TRSM	MAPE	0.82%	0.85%	0.85%	1.12%	1.09%	1.10%	0.74%	0.78%	0.77%	0.64%	0.72%	0.62%
	RMSE	1.76	1.78	1.78	2.40	2.35	2.35	1.72	1.65	1.84	1.44	1.69	1.59
YPM$	MAPE	0.72%	0.70%	0.70%	0.79%	0.80%	0.83%	1.01%	0.92%	0.85%	1.33%	1.23%	1.17%
	RMSE	113.19	109.81	109.63	99.91	93.18	91.78	148.04	137.83	135.21	192.38	181.14	175.39
YPM	MAPE	0.85%	0.89%	0.88%	0.88%	0.84%	0.85%	1.02%	0.93%	0.92%	1.35%	1.28%	1.21%
	RMSE	106.82	105.57	105.37	97.43	92.69	91.18	107.07	105.27	104.99	132.96	133.57	128.27

Table 5.1: Continued

		Static Simulation			4-Quarter Overlap			6-Quarter Overlap			8-Quarter Overlap		
		OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT	OLS	IV	ALT
YDMS	MAPE	0.78%	0.77%	0.77%	0.87%	0.83%	0.82%	1.12%	1.01%	0.96%	1.33%	1.22%	1.13%
	RMSE	107.08	106.17	106.17	98.48	94.45	93.79	145.20	138.18	136.04	164.71	155.84	152.08
YDM	MAPE	0.97%	0.94%	0.93%	1.01%	0.94%	0.90%	0.85%	0.85%	0.82%	1.02%	0.98%	0.92%
	RMSE	97.72	96.75	96.71	94.52	92.20	91.57	98.51	99.15	97.97	100.57	103.41	101.17
YPERMS	MAPE	0.22%	0.22%	0.22%	0.38%	0.35%	0.31%	0.66%	0.56%	0.53%	1.03%	0.89%	0.81%
	RMSE	29.02	28.77	28.77	42.10	37.59	35.10	71.45	62.02	59.52	105.25	90.53	85.44
YPERM	MAPE	0.27%	0.26%	0.26%	0.55%	0.50%	0.48%	0.67%	0.65%	0.62%	0.69%	0.65%	0.61%
	RMSE	26.48	26.22	26.21	50.20	46.72	45.16	58.99	55.31	52.65	62.76	58.00	52.15
YPADJMS	MAPE	0.81%	0.80%	0.80%	0.99%	0.91%	0.87%	1.15%	1.05%	0.95%	1.49%	1.39%	1.31%
	RMSE	122.09	121.16	120.91	116.20	111.50	108.16	151.79	141.00	137.27	202.42	189.12	180.73
YTRANSIT	MAPE	48.12%	47.86%	47.60%	40.05%	40.16%	40.35%	38.82%	38.31%	38.76%	41.96%	41.01%	41.37%
	RMSE	71.25	70.53	70.50	69.13	69.85	70.42	72.55	74.02	74.87	71.97	74.49	75.73
WUSS	MAPE	0.50%	0.50%	0.50%	0.76%	0.76%	0.76%	1.18%	1.18%	1.18%	1.58%	1.58%	1.58%
	RMSE	.02	.02	.02	.04	.04	.04	.05	.05	.05	.07	.07	.07
GAUTO	MAPE	2.81%	2.81%	2.81%	3.17%	3.17%	3.17%	3.17%	3.17%	3.17%	3.10%	3.10%	3.10%
	RMSE	1.28	1.28	1.28	1.41	1.41	1.41	1.45	1.45	1.45	1.51	1.51	1.51
PCPIUS	MAPE	0.13%	0.13%	0.13%	0.15%	0.15%	0.15%	0.15%	0.15%	0.15%	0.20%	0.20%	0.20%
	RMSE	.21	.21	.21	.25	.25	.25	.25	.25	.25	.28	.28	.28

underlying distributions are unknown. Two statistics may differ, but the disparity could be due to sampling error rather than actual differences in the errors of the equations.[6] One expects the amount of error to increase somewhat as runs grow longer, but by how much before one will say the model is seriously misbehaving?

A crude test[7] can be constructed to compare RMSE's but it should be used, if at all, with utmost care. The mean squared error statistic (the square of the root mean squared error) divided by the theoretical variance has the form of a Chi-square variable (a sum of squares) divided by its degrees of freedom. The ratio of two of these estimates of the error in the same variable has the form of an F-statistic. Therefore, the square root of a tabulated F value is a rough critical value for judging whether two RMSE's can be considered significantly different.[8]

A few statistical considerations should indicate just how approximate a test this is. In the first place, the errors are probably not normally distributed and are certainly not independent for a given variable from quarter to quarter. The latter factor is usually accounted for by subtracting degrees of freedom but how many should be disallowed here? Since the two equations (models) are predicting over many of the same quarters, the two "Chi-squares" are not independent, another necessary condition for a valid F-test. A third consideration is that two tests performed on variables of the

same models are not independent of one another--a joint or conditional test is theoretically called for.

Given its theoretic weakness, the only use to be made of the pseudo-F test in this thesis is to determine approximate orders of magnitude to be considered significantly different. For instance, the 5% F-value for (7,9) degrees of freedom is 3.29. If the RMSE in an eight period overlap (seven observations) is about twice (RMSE comparison statistic of $\sqrt{3.29} = 1.81$) the value in a six period overlap (nine observations), one might venture to say that the former is significantly larger.

Table 5.1 indicates that, on the whole, all three models do well in static simulation over the sample period, judging from the MAPE statistics. Although no absolute levels of comparison have been set by other models,[9] a level of 3 or 4 per cent seems tolerable for most variables.[10] The statistics for the important total employment, price, and personal income variables show errors below 1 per cent.

The variables forecasted least accurately, according to MAPE values, are residual employment (EMRESM), unemployment compensation transfers (UCTRM$), unemployment compensation exhaustions (UCEXM+1), quarterly tax estimates (TYQM$), and transitory income (YTRANSTM), none of which is of crucial importance to the overall model. It is noteworthy though, that the errors in these five

variables do not increase very much (although remaining high) as the forecast period is lengthened.

The residual employment and quarterly payments equations were pinpointed as weak in Chapter IV and bear continual watching. The UCEXM+1 and UCTR$ values, also not the products of overly convincing equations, are very sensitive to errors in unemployment. The static simulation indicates that, even under the best of circumstances, these predictions should not be given a great deal of confidence.

As alluded to earlier, the MAPE is a very poor statistic to use in evaluating a variable such as transitory income. One reason is that YTRANSTM is defined (there is no error in the equation) as the difference between real disposable (YDM) and real permanent income (YPERM). These variables are large in relation to their difference so a small error in one yields an overwhelming percentage error in YTRANSTM. (This same reasoning also explains the large percentage errors in the number unemployed that begin to appear in some of the longer simulations.) Note that the RMSE is smaller for YTRANSTM than for YDM, although not for YPERM because the latter uses all the correct values for the lagged variables in static simulation. The second cause of the large MAPE is that YTRANSTM is the only endogenous variable that can have both positive and negative

values. Thus the denominator of the MAPE is small relative to the range of likely variation. For instance, the actual value of YTRANSTM in 1970.3 is 12.4. An absolute error of 25 (0.4% of YDM) would yield a 200 per cent input to the MAPE. The conclusion to be drawn is that the large MAPE for YTRANSTM is due to the nature of the variable and, although not a reassuring occurrence, is no cause for alarm, especially so since the variable only appears in one equation with a small coefficient.

All three models perform at a comparable level in static simulation. The largest differences are in unemployment and the related compensation exhaustions variable and in employment in transportation, communication, and utilities (ETCM), although these differences are almost certainly not significant.[11]

The fact that the OLS model yields a more accurate prediction of unemployment, the difference between the labor force and employment, is surprising since the IV and ALT models more accurately predict both the input variables. The explanation comes from the fact that the errors in LFM and EMPM are more often in the same direction in the OLS model over the sample period and cancel one another. Over a different time period, this higher positive correlation is unlikely.

The better OLS prediction of ETCM is due to the fact that the OLS equation differs from the IV and ALT one. Comparing

Equations 2 in Appendices B and C, it is evident that the B version omits ℓn EMFM (manufacturing employment). This is the result of its coefficient not exceeding its standard error when the equation was estimated by instrumental variables. Since the OLS equation seems superior, markedly so in the longer forecasts, a better course of action might have been to search for an improved instrument rather than eliminate the variable.

Turning to the longer simulations, the models seem to forecast well on the whole, although absolute comparison criteria are again lacking. The errors in total employment and consumer prices remain well below 1 per cent while the aggregate income variables have errors in the neighborhood of 1 per cent. Since error increases (at least does not decrease) as the forecast period is lengthened, declines in the RMSE and MAPE for a particular variable are indicators of the sampling error present. Unemployment remains an important thorn, although the increase from the static to the eight-period overlap error is probably not significant.

The five variables singled out as poor performers in the static forecast still do poorly although, as noted earlier, they do not seem to get appreciably worse.[12] Weakness begins to appear in the construction and mining sectors and in the more important manufacturing sector as the forecast period becomes longer. In manufacturing, the error seems to increase quite a bit from four to six quarters and again

from six to eight. Still, the error in total wages and salaries is under 3.5 per cent so it is difficult to know if there is cause for concern.

Looking across models, the differences become more apparent in the eight quarter overlap. OLS retains its edge in unemployment, compensation exhaustions, and transport employment. It also seems to be somewhat stronger in trade employment. Equations 3 of Appendices B and C show that the estimated coefficients change quite a bit from ordinary least squares to instrumental variables estimation. Here, as in transport, improving the instruments used might be worthwhile since the OLS model seems to do a better job over the sample period.

The analysis so far may seem to indicate that the OLS effort is the best of the three. This is an unwarranted conclusion. As the eight-period overlap indicates most clearly, the other two models, especially ALT, seem to do slightly better in the critical personal income, price, and total employment categories. These differences are definitely not significant, but are pervasive. In addition, the results of the post-sample forecasts have not yet been considered.

How does the Michigan model (IV version) compare in forecasting accuracy over the sample period to other econometric models? This is hard to answer since evidence is nonexistent about the performance of most regional models. One exception is Glickman's

Philadelphia IV model.[13] The author gives fairly detailed information about the MAPE statistics for a 17 observation (17 year) sample period simulation. His MAPE's are calculated by averaging the one period error, two period error, ..., 16 period error, and 17 period error of a dynamic forecast. In the interest of comparability, a dynamic IV forecast was produced for the 14 possible periods of the Michigan model and MAPE's noted. Table 5.2 compares the MAPE's for the two models both in individual variables where possible and overall distribution. The similarity of results in both the upper and lower halves of the table is evident. The errors in the sample period predictions of the Michigan model follow a pattern much like those of the Glickman model, with forecasting unemployment a problem in both. Although the comparisons favor the Michigan model because of its slightly shorter forecast length, the Michigan errors seem generally smaller and the distribution is slightly more favorable than Glickman's. Since the Philadelphia model has undergone much revision and improvement and is one of the Wharton group of models, it is encouraging that the Michigan model seems to do as well.

Glickman also reports MAPE statistics of principal variables for six other (seven, including Philadelphia IV) regional models over the same 17 year sample period.[14] Although the Michigan model does not predict some of the variables listed (e.g., population), there are three results that can be compared. For personal income,

Table 5.2: MAPE Statistics of the Michigan Model Compared to Those of Glickman's Philadelphia IV Model

Individual Variables

	Michigan	Philadelphia IV
Manufacturing Employment	1.51	1.42
Total Employment	.42	.66
Personal Income	1.48	1.55
Prices	.54	.61
Labor Force	.40	.59
Unemployment Rate	5.20	6.51
Retail Sales (Tax)	1.38	1.95

Distribution of Statistics for the Entire Model

MAPE Value	Michigan	Philadelphia IV
5% or more	11.6%	18.1%
4% - 4.99%	5.8%	10.2%
3% - 3.99%	8.7%	11.8%
2% - 2.99%	26.1%	31.5%
1% - 1.99%	34.8%	22.0%
Less than 1%	13.0%	6.3%
	100.0%	100.0%

the Michigan MAPE is third lowest of the eight, in total employment the second lowest and for manufacturing employment the second lowest. Since the same model was not best in each of these categories, the Michigan model fares well in the overall comparison. As Glickman suggests, other model builders should be encouraged to publish similar statistics to aid in model evaluation.

POST-SAMPLE SIMULATION

Before testing the models on post-sample (1974) data, adjustments were made for institutional changes the models could not otherwise be expected to take into account. Two such changes occurred in 1974--an increase in the per capita exemption of the Michigan personal income tax and an extension of the period of eligibility for unemployment compensation.

The first change affects the personal income tax withholding and quarterly payments equations. Since the exemption increased from $1200 to $1500 per person with a tax rate of 3.9 per cent, $11.70 (.039 times $300) less will be withheld annually ($2.925 per quarter) for each exemption claimed. If one assumes that half[15] the population is claimed as an exemption against a high enough income that is also subject to withholding, approximately $13.3 million less will be withheld per quarter (9,100,000 people times .5 times $2.925). This amount is subtracted from withholding by means of an adjustment

constant in Equation 49. A subtraction of $.5 is also made from the quarterly estimates equation. If a proportional subtraction (relative to withholding) were made, its value would be approximately $1.0 million. The full value is not used because many people making quarterly declarations also have income subject to withholding and have already made use of their increased exemption value.

The unemployment exhaustions-labor force segment of the model was altered in 1974 by the introduction in April of a maximum of 13 weeks extended unemployment compensation in addition to the normal 26 weeks. An unemployed worker is entitled to half the number of weeks of extended benefits as he received in regular benefits. A worker who collected 24 weeks of regular is eligible for 12 weeks of extended, for example. Two more 13 week extensions (65 weeks maximum) were granted in 1975, but do not affect 1974 model tests.

How, if at all, should these institutional changes be incorporated into the model for 1974 predictions? This is a problem since the unemployment compensation exhaustions equation predicts regular exhaustions while, presumably, the labor force equation is based on exhaustion of all benefits to which a family member is entitled. In 1974.1, workers did not know that an extension would be granted in April, so the first quarter labor force equation should see projected 1974.2 regular exhaustions as input (no adjustment to the model needed). In 1974.2, people should be looking at the exhaustion of the

first 13 week extension to determine their labor force behavior. By the second quarter of operation (July-September), extended benefit exhaustions should be almost as high as regular exhaustions would have been the previous quarter since people are just exhausting a maximum of 13 weeks later. Possibly the figure is somewhat smaller because workers have had an additional 13 weeks to find jobs or be recalled to their old ones. If the number of exhaustions is approximately constant, what the labor force equation should see in 1974.2 (1974.3 extended exhaustions) are not far from what the model predicts (1974.3 regular exhaustions).

In fact, with unemployment increasing (the increase prompted the extension of benefits in the first place), the figure the model sees (regular exhaustions) would be too high for its intended use in the labor force equation (regular exhaustions exceed extended exhaustions). It is not, though, due to an offsetting factor. As unemployment increases the predicted number of regular exhaustions according to the exhaustions equation is too small. This is so because there are more exhaustions per unit of unemployment as unemployment hits very high levels due to the difficulty of finding a job in periods of widespread unemployment (incentives for job search are also weakened by poor prospects). In other words, the model's coefficient on unemployment in the exhaustions equation is too low.

Thus, on balance, no adjustments were made for the control

run in either the labor force or exhaustions equation for fear of making the adjustment in the wrong direction, although there is a much larger degree of uncertainty in the operation of this part of the model in 1974 than over the sample period.

The extended unemployment compensation benefits will, however, affect what the model should predict for the dollar amount of unemployment compensation transfer payments. The average unemployment compensation benefit in Michigan is about $65 per week ($840 per quarter). The number of people collecting the extra money are those who would otherwise have exhausted their benefits. Estimating 30,000 such exhaustions in 1974.2 (when the program went into effect), 35,000 in 1974.3, and 40,000 in 1974.4, the adjustment constants used in Equation 38 are

1974.1	1974.2	1974.3	1974.4
0.0	25.2	29.4	33.6

The results of post-sample forecasts with the above adjustments are given in the left portion of Table 5.3. Each simulation is a four quarter overlap with dynamic runs ending in 1974.1 through 1974.4 (four runs). Even though this procedure involves some sample period simulation, it yields four fourth quarter values rather than the one (with its associated high variance) that would result from using strictly post sample data. The error statistics are surely worse than those of the four quarter overlap forecasts for the sample period, but no

Table 5.3: Additional Simulations

		Post Sample			Post Sample using Actual MQEM Predictions	Correct Values of Linking Variables Sample	Post-Sample
		OLS	IV	ALT	IV	IV	IV
EMFM	MAPE	3.70%	3.69%	3.70%	4.13%	1.10%	3.59%
	RMSE	50.97	50.52	50.98	49.12	17.31	46.18
ETCM	MAPE	2.93%	3.34%	3.35%	1.24%	1.68%	3.76%
	RMSE	4.71	5.33	5.34	2.25	2.88	5.97
ETRM	MAPE	1.54%	1.43%	1.41%	1.44%	1.16%	1.23%
	RMSE	11.57	10.63	10.46	10.36	7.94	9.07
ECCM	MAPE	7.25%	7.25%	7.25%	9.45%	2.38%	7.25%
	RMSE	9.80	9.80	9.80	12.44	3.82	9.80
EMIM	MAPE	10.35%	10.35%	10.35%	7.67%	4.69%	10.35%
	RMSE	1.36	1.36	1.36	1.00	0.64	1.36
EFIM	MAPE	0.65%	0.63%	0.63%	1.62%	1.48%	0.80%
	RMSE	.88	.85	.85	2.20	2.17	1.08
ESM	MAPE	1.39%	1.63%	1.63%	2.53%	1.77%	1.78%
	RMSE	7.98	9.24	9.24	14.24	10.75	10.17
EGLM	MAPE	2.83%	2.88%	2.89%	1.99%	1.22%	2.66%
	RMSE	15.72	15.90	15.90	12.45	5.34	15.21
EGSM	MAPE	1.60%	1.59%	1.59%	1.44%	1.39%	1.62%
	RMSE	2.13	2.13	2.13	2.03	2.40	2.16

Table 5.3--Continued

		Post Sample			Post Sample using Actual MQEM Predictions	Correct Values of Linking Variables Sample	Post-Sample
		OLS	IV	ALT	IV	IV	IV
EGM	MAPE	1.84%	1.88%	1.88%	1.41%	1.06%	1.75%
	RMSE	16.53	16.71	16.71	13.13	6.70	16.02
EWSM	MAPE	1.55%	1.57%	1.57%	1.86%	0.67%	1.27%
	RMSE	53.86	54.51	55.19	67.01	26.03	49.13
EMRESM	MAPE	16.74%	17.15%	17.35%	16.26%	4.78%	21.93%
	RMSE	59.99	59.51	60.26	55.13	19.00	73.35
EMPM	MAPE	0.55%	0.55%	0.54%	2.86%	0.39%	0.69%
	RMSE	22.76	24.30	23.78	104.70	17.39	28.80
WM$	MAPE	1.83%	1.87%	1.82%	2.13%	1.04%	2.45%
	RMSE	.11	.12	.11	.12	.07	.14
HRSM	MAPE	2.18%	2.18%	2.18%	3.00%	2.10%	1.94%
	RMSE	1.21	1.21	1.21	1.41	1.03	1.01
AEQMFM$	MAPE	3.19%	3.23%	3.18%	3.36%	1.58%	2.26%
	RMSE	122.65	123.48	122.09	121.34	61.73	82.39
AEQTCM$	MAPE	3.32%	3.35%	3.32%	3.23%	1.29%	4.74%
	RMSE	107.59	108.57	107.89	105.09	49.50	155.66
AEQTRM$	MAPE	1.04%	0.97%	1.05%	0.88%	1.06%	2.06%
	RMSE	28.09	26.68	28.45	23.21	12.56	52.34

Table 5.3--Continued

		Post Sample					
		OLS	IV	ALT	Post Sample using Actual MQEM Predictions IV	Correct Values of Linking Variables Sample IV	Post-Sample IV
AEQCCM$	MAPE	6.97%	6.78%	6.98%	6.65%	3.90%	8.36%
	RMSE	280.39	274.05	280.71	269.08	137.57	334.27
AEQMIM$	MAPE	4.72%	4.66%	4.74%	4.42%	3.24%	5.69%
	RMSE	159.14	157.17	159.99	150.45	102.73	194.38
AEQFIM$	MAPE	0.47%	0.47%	0.47%	0.47%	2.30%	0.47%
	RMSE	13.25	13.25	13.25	13.25	56.91	13.25
AEQSM$	MAPE	1.95%	1.95%	1.95%	1.95%	1.44%	1.95%
	RMSE	44.76	44.76	44.76	44.76	34.07	44.76
AEQGM$	MAPE	2.29%	2.26%	2.32%	2.10%	0.91%	3.26%
	RMSE	67.05	66.27	67.67	61.29	26.44	103.06
WSMFM$	MAPE	6.78%	6.81%	6.77%	4.57%	1.43%	3.32%
	RMSE	304.01	303.50	303.41	206.91	54.89	161.66
WSTCM$	MAPE	1.15%	1.17%	1.22%	1.95%	1.88%	1.61%
	RMSE	6.17	6.00	6.21	10.47	9.06	8.09
WSTRM$	MAPE	2.58%	2.23%	2.23%	0.80%	0.67%	2.32%
	RMSE	34.58	30.00	30.07	12.51	12.99	31.14
WSCCM$	MAPE	14.57%	14.35%	14.58%	16.70%	6.10%	16.06%
	RMSE	62.10	61.22	62.18	73.01	27.11	68.80

Table 5.3--Continued

		Post Sample			Post Sample using Actual MQEM Predictions	Correct Values of Linking Variables	
		OLS	IV	ALT	IV	Sample IV	Post-Sample IV
WSMIM$	MAPE	10.62%	10.61%	10.61%	8.03%	5.78%	9.07%
	RMSE	4.52	4.52	4.53	3.70	2.40	4.05
WSFIM$	MAPE	0.63%	0.63%	0.62%	1.48%	1.85%	0.74%
	RMSE	2.64	2.61	2.60	5.56	5.91	3.11
WSSM$	MAPE	1.71%	1.65%	1.65%	1.82%	1.45%	1.62%
	RMSE	20.79	21.41	21.44	27.16	15.37	22.37
WSGM$	MAPE	1.74%	1.70%	1.74%	1.88%	1.54%	2.05%
	RMSE	29.49	28.98	29.36	33.48	24.01	41.01
WSM$	MAPE	2.57%	2.60%	2.57%	2.69%	0.86%	0.86%
	RMSE	241.83	244.88	242.79	276.17	82.33	102.89
YLOM$	MAPE	7.41%	7.30%	7.29%	8.22%	2.06%	7.54%
	RMSE	84.04	82.84	82.76	89.52	23.50	83.42
YENTM$	MAPE	5.34%	5.34%	5.34%	1.84%	3.26%	5.34%
	RMSE	42.59	42.59	42.59	16.06	25.38	42.59
YPRM$	MAPE	1.87%	2.10%	2.10%	5.93%	0.75%	2.20%
	RMSE	35.80	39.80	39.81	104.37	13.46	41.20
SAVTOT$	MAPE	1.30%	1.14%	1.14%	1.40%	1.42%	1.05%
	RMSE	.34	.32	.31	.44	.34	.27

Table 5.3--Continued

		Post Sample			Post Sample using Actual MQEM Predictions	Correct Values of Linking Variables	
		OLS	IV	ALT	IV	Sample IV	Post-Sample IV
SSTR$	MAPE	1.34%	1.34%	1.34%	1.34%	2.86%	1.34%
	RMSE	11.22	11.22	11.22	11.22	17.44	11.22
UCTRM$	MAPE	23.29%	21.36%	21.24%	33.11%	8.28%	21.85%
	RMSE	33.04	28.93	28.77	52.99	5.44	29.28
#PARECPM	MAPE	0.78%	1.47%	1.48%	3.22%	2.06%	1.27%
	RMSE	6.71	15.10	15.11	27.20	16.47	12.46
PATRM$	MAPE	0.78%	1.47%	1.48%	3.22%	2.06%	1.27%
	RMSE	1.73	4.04	4.04	7.13	3.48	3.33
YTRANSM$	MAPE	2.09%	1.66%	1.65%	4.10%	1.44%	1.79%
	RMSE	35.20	27.50	27.25	65.44	18.95	28.95
TSIM$	MAPE	9.27%	9.20%	9.17%	12.07%	2.09%	9.23%
	RMSE	50.69	50.44	50.28	61.05	10.57	48.43
PCPID	MAPE	1.58%	1.55%	1.55%	5.00%	0.44%	0.49%
	RMSE	2.45	2.39	2.39	7.88	.71	.82
PCPIDHSE	MAPE	3.50%	3.36%	3.35%	3.35%	2.04%	2.32%
	RMSE	5.34	5.13	5.13	6.46	3.36	3.70
LFM	MAPE	0.92%	.61%	.61%	0.41%	0.41%	0.57%
	RMSE	36.82	26.08	25.92	20.64	18.00	25.35

Table 5.3--Continued

		Post Sample					
		OLS	IV	ALT	Post Sample using Actual MQEM Predictions IV	Correct Values of Linking Variables Sample IV	Post-Sample IV
UCEXM+1	MAPE	32.17%	15.07%	14.86%	44.45%	11.41%	14.34%
	RMSE	15.72	9.17	9.08	21.23	3.64	8.56
UM	MAPE	14.59%	9.78%	9.66%	31.33%	6.86%	10.32%
	RMSE	57.01	45.72	45.15	114.77	19.26	44.13
UM%	MAPE	13.80%	9.49%	9.37%	31.12%	6.55%	9.97%
	RMSE	1.40	1.14	1.13	2.95	.50	1.01
TYWM$	MAPE	2.17%	2.17%	2.14%	1.58%	2.38%	1.88%
	RMSE	6.56	6.52	6.46	4.73	6.22	4.71
TYQM$	MAPE	13.43%	13.48%	13.45%	15.21%	9.05%	12.35%
	RMSE	2.87	2.87	2.86	3.06	1.59	2.77
TYM$	MAPE	3.58%	3.55%	3.53%	2.67%	2.76%	0.66%
	RMSE	8.53	8.53	8.45	7.09	6.42	2.42
TRESM$	MAPE	1.65%	1.60%	1.58%	1.95%	3.08%	0.62%
	RMSE	30.68	29.51	29.27	38.94	63.83	13.73
TRSAUM	MAPE	8.13%	8.18%	8.20%	7.75%	2.50%	8.24%
	RMSE	4.99	5.00	5.00	3.86	1.39	4.80
TRSAUM$	MAPE	8.13%	8.18%	8.20%	7.22%	2.50%	8.24%
	RMSE	6.17	6.17	6.17	5.07	1.56	5.93

Table 5.3--Continued

		Post Sample			Post Sample using Actual MQEM Predictions	Correct Values of Linking Variables	
		OLS	IV	ALT	IV	Sample IV	Post-Sample IV
TRSFM$	MAPE	2.84%	3.00%	3.00%	2.89%	1.37%	2.96%
	RMSE	1.93	2.02	2.02	1.93	.69	1.98
TRSOM$	MAPE	4.08%	4.64%	4.65%	4.32%	0.86%	4.41%
	RMSE	7.30	8.16	8.17	7.88	1.55	7.86
TRSM$	MAPE	4.60%	4.96%	4.98%	4.08%	0.57%	4.61%
	RMSE	14.77	15.67	15.68	13.89	1.44	15.01
TRSM	MAPE	6.08%	6.41%	6.42%	2.25%	0.83%	5.07%
	RMSE	12.48	13.03	13.04	5.46	1.73	10.89
YPM$	MAPE	1.73%	1.67%	1.65%	1.30%	0.60%	0.64%
	RMSE	250.35	240.69	238.67	197.46	86.65	112.44
YPM	MAPE	1.95%	1.85%	1.83%	6.05%	0.65%	0.62%
	RMSE	234.03	221.61	220.88	553.03	70.93	60.46
YDM$	MAPE	1.73%	1.68%	1.66%	1.21%	0.84%	0.67%
	RMSE	214.92	206.41	204.74	161.05	95.41	101.92
YDM	MAPE	1.93%	1.80%	1.78%	5.90%	0.90%	0.64%
	RMSE	198.40	187.59	186.98	461.79	81.38	53.77
YPERM$	MAPE	0.19%	0.17%	0.16%	0.28%	0.31%	0.18%
	RMSE	27.03	25.32	24.56	41.34	35.65	25.68

Table 5.3--Continued

		Post Sample				Correct Values of Linking Variables	
		OLS	IV	ALT	Post Sample using Actual MQEM Predictions IV	Sample IV	Post-Sample IV
YPERM	MAPE	0.71%	0.70%	0.71%	2.89%	0.33%	0.12%
	RMSE	65.51	63.02	62.97	243.62	33.65	11.99
YPADJM$	MAPE	2.08%	2.11%	2.09%	2.01%	0.76%	1.07%
	RMSE	280.02	281.34	278.74	283.88	104.58	172.12
YTRANSIT	MAPE	281.01%	269.73%	269.95%	363.46%	39.59%	65.82%
	RMSE	140.20	132.82	132.66	238.29	62.31	57.22
WUS$	MAPE	1.96%	1.96%	1.96%	2.39%	-	-
	RMSE	.11	.11	.11	.12	-	-
GAUTO	MAPE	12.26%	12.26%	12.26%	24.08%	-	-
	RMSE	4.59	4.59	4.59	8.40	-	-
PCPIUS	MAPE	0.97%	0.97%	0.97%	5.32%	-	-
	RMSE	1.45	1.45	1.45	8.33	-	-

All results are for 4-quarter overlaps.

absolute judgment is possible.[16,17]

Not surprisingly, the error pattern remains similar to that of the sample period. Total employment, personal income, the labor force, and the price index are relatively well predicted; quarterly tax estimates, transitory income, unemployment compensation, compensation exhaustions, and residual employment are not. Construction, manufacturing, and mining show weakness as they did in the longer overlap forecasts of the sample period.

Two areas not previously mentioned do not fare well in the 1974 forecasts--contributions to social insurance and the automobile variables. The maximum income subject to Social Security taxation in 1974 jumped to $13,200 from $10,800 in 1973. This had a drastic effect on the proportion of wages and salaries that are taxed. The coefficient of the equation was not prepared to take this into account, leading to the 9 per cent MAPE's for the variable in Table 5.3. The year 1974 was a particularly poor year for the automobile industry, causing dislocations in traditional relationships. Even when presented with correct values of United States automobile consumption, gross auto product is badly forecast. Smaller MAPE's are observed for sales taxes on automobiles, but the RMSE's are about three times those of the sample period.

The OLS model does the worst job of the three in post sample simulation. Its poor prediction of the labor force leads to large

errors in unemployment. Unemployment errors cause problems with compensation exhaustions, which in turn affect the labor force. The fortuitous cancellation of errors in employment and the labor force is no longer present. The OLS trade employment equation is worse than its IV counterpart. These differences among models are large for runs of only four periods. Even the OLS edge in ETCM is narrowed. The ALT and IV models are extremely close with no differences of any magnitude appearing between them.

To further assess the IV model's predictive abilities, another experiment was performed involving a four quarter overlap forecast consisting of four runs ending in 1974.1 through 1974.4. Suppose it is November, 1973, and the Research Seminar in Quantitative Economics (RSQE) is making its 1974 predictions. Actual data are available for 1973.3 but not for 1973.4 or 1974. The Michigan Quarterly Econometric Model of the United States Economy (MQEM) is used to forecast the exogenous United States inputs to the state model[18] and then the state model is run. The error statistics are presented in the fourth data column of Table 5.3. The four quarter overlap format was used so the statistics can be compared to the IV ones in the same table.

The national forecast produced in late 1973 underestimated both the weakness in the economy and the increase in prices due to the Arab oil boycott and subsequent cartelization of the petroleum

industry. The underprediction of the non-farm price deflator by MQEM leads to low estimates for the United States consumer price index (PCPIUS) and the Michigan one (PCPID). Although a 5% MAPE is not excessively high in an absolute sense, considering the results for other variables, it is significantly larger than the errors one would come to expect for the price variable based on previous simulations. Naturally, gross auto product (GAUTO) is overpredicted as are manufacturing and most other employments except government. Note the large (relative to previous forecasts) error in total employment. This large error is due to the fact that almost all the errors in the employment components are in the same direction so the usual cancellation of errors does not occur. By the same token, unemployment and compensation exhaustions are underpredicted. The income predictions merit comment. Using RSQE predicted values (rather than actual values) for the exogenous variables produces slightly better results for current dollar personal and disposable income, but the problems with the deflator cause the constant dollar magnitudes to be well wide of the mark. Permanent income is worse in both cases using the predictions.

The conclusion to be drawn from this experiment is that correct values of the exogenous variables do matter. Any evaluation of the model (any model?) where correct exogenous variables are used underestimates the error likely to be produced in actually using the

model to forecast.

The linking variables (WUS$, GAUTO, and PCPIUS) occupy a special position in the model. They should be exogenous but are, of necessity, endogenous. How much better would the model predict given the correct values of these linking variables? The right hand columns of Table 5.3 list error statistics for four period overlap forecasts with correct linking variables for the sample and post sample periods. The first of these columns is to be compared with the fifth data column of Table 5.1. The errors are generally smaller with the correct linking variables, but not by a large amount. As should be repeated for all these comparisons, sampling error affects the computed statistics to an unknown degree. A forecast over a different time period might yield very different results.

The outcome is mixed when comparing results in the post sample period. Using correct linking variables improves the price and income, but not the employment estimates, though the last difference is not significant. What is especially surprising is that correct values of WUS$ and GAUTO do not lead to a better WM$ estimate in the post sample period. Again, the difference is probably not significant. The overall result of these two simulations is to increase confidence in the predictive powers of the linking equations; they are not making large contributions to the observed errors.

COMPARISON WITH AUTOREGRESSIVE MODELS

One simple, although not particularly powerful, way to evaluate a model is to compare it to an autogressive formulation. Autogressive equations were estimated over the sample period for five model variables: current dollar personal income (YPM$), constant dollar personal income (YPM), the Detroit consumer price index (PCPID), wage and salary employment (EWSM), and manufacturing employment (EMFM). YPM$, PCPID, and EWSM were chosen because they are highly trended variables that should put autoregressive prediction in its best light. YPM and EMFM are variables that seem less likely to do so.

The autoregressive equations were estimated by ordinary least squares regression. The dependent variable was first regressed on a constant term and its own lagged value. If the coefficient of the lagged value exceeded its standard error, the variable lagged twice was added. Adding lagged variables continued until the newly added term did not meet the criterion or removed the significance of a previous term. The five autoregressive equations are

$$\underset{(5.4)}{\text{YPM\$}} = \underset{(-2.7817)}{-128.21} + \underset{(6.5427)}{.77967}\ \text{YPM\$}_{-1} + \underset{(2.1350)}{.26290}\ \text{YPM\$}_{-2}$$

$$R^2 = .998$$

$$\underset{(5.5)}{\text{YPM}} = \underset{(-.14752)}{-11.248} + \underset{(7.2463)}{.87443}\ \text{YPM}_{-1} + \underset{(1.1295)}{.13833}\ \text{YPM}_{-2}$$

$$R^2 = .991$$

(5.6) $$PCPID = \underset{(-3.5962)}{-1.9669} + \underset{(13.061)}{1.4496}\ PCPID_{-1} - \underset{(-3.6888)}{.42507}\ PCPID_{-2}$$

$$R^2 = .999$$

(5.7) $$EWSM = \underset{(-.19990)}{-8.7256} + \underset{(10.179)}{1.2083}\ EWSM_{-1} - \underset{(-1.6597)}{.20149}\ EWSM_{-2}$$

$$R^2 = .984$$

(5.8) $$EMFM = \underset{(1.3719)}{62.612} + \underset{(21.756)}{.94105}\ EMFM_{-1} \qquad R^2 = .873$$

where the numbers in parenthesis are ratios of the estimated coefficients to their standard errors.

A series of four period runs were carried out for each of equations (5.4) to (5.8) with the same ending periods as the four period overlaps in Tables 5.1 and 5.3. The associated MAPE's and RMSE's were computed and are displayed in Table 5.4 along with comparable model statistics copied from Tables 5.1 and 5.3. In all cases but one, the simultaneous model does quite a bit better than the autoregressive models; the statistics are not even close. The exception is the manufacturing employment equation over the post sample period where the autoregressive specification does slightly, although probably not significantly, better. This is surprising since manufacturing employment in Michigan is not particularly trend dominated for a time series variable (note the relatively low R^2 in the autoregressive equation for manufacturing employment) and an autoregressive equation was expected to do poorly. The weak

Table 5.4: The Model versus Autoregressive Prediction

		Model		Autoregressive	
		Sample	Post Sample	Sample	Post Sample
YPM$	MAPE	0.69%	1.67%	1.54%	3.20%
	RMSE	93.48	240.69	198.08	450.08
YPM	MAPE	0.84%	1.85%	2.29%	7.50%
	RMSE	92.69	221.61	251.91	683.80
PCPID	MAPE	0.54%	1.55%	1.80%	2.99%
	RMSE	0.85	2.39	2.55	4.52
EWSM	MAPE	0.74%	1.57%	2.58%	3.17%
	RMSE	28.51	54.51	83.07	108.66
EMFM	MAPE	1.41%	3.69%	4.85%	3.40%
	RMSE	20.38	50.52	60.61	41.81

All statistics are computed for four period overlap simulations, eleven runs in the sample period and four runs in the post sample period.

showing of the model in general in 1974 is due to the unusual conditions in the automobile industry. It would seem, though, that the dislocation should have greater effect on an autoregressive equation.

Absolute evaluation is difficult here because analogous results of other models have not been published. A simultaneous equations model is expected to outperform a simple autoregressive one, but by how much? Hopefully the statistics presented in Table 5.4 will provide a baseline against which other econometric models can be compared.

ALTERNATIVE SCENARIOS

The multiplier aspects of the model have not yet been considered. To gauge the effect of changes in a particular exogenous or endogenous variable or group of variables on the rest of the model, four scenarios were envisioned. Besides facilitating the calculation of the appropriate multipliers,[19] these simulations help indicate what parts of the model are not functioning as they should be.

Since 1974 was such a poor year for the automobile industry, as well as being a recession year in general, the Michigan economy suffered badly. How much of this downturn was due to the weak economy as opposed to specific problems in the automobile industry? In the first alternative scenario, GNP, interest rates, etc., were assumed to remain as they were in 1974 while automobile consumption

(CDAUS, the exogenous automobile variable) was pegged at its average 1972-1973 percentage of GNP. In other words, non-automotive industries were assumed to have borne the effects of the national recession since the composition but not the level of GNP is being altered.

In quantitative terms CDAUS decreased from 5.5 per cent of GNP in 1972-1973 to 4.6 per cent in 1974. Thus the new CDAUS values would be 5.5/4.6 = 1.20 times the actual ones since GNP remains the same. Because IBF has an automobile component, it, too, needs to be adjusted. In 1972-1973, producer durable equipment - automobiles constituted 6.96 per cent of IBF.[20] Thus the simulation values of IBF are 1.36 per cent (20.0 % times 6.96%) higher than the previous ones. The actual and new values of CDAUS and IBF are given below.

	Actual Values				New Values			
	I	II	III	IV	I	II	III	IV
CDAUS	38.29	39.09	42.22	32.05	45.68	45.49	45.27	44.22
IBF	96.3	96.5	94.1	89.2	97.6	97.8	95.4	90.8

At first it was thought desirable to make some change in PCDA, the automobile price deflator, with the motivation that automobile prices might have increased more had demand been stronger. However, automobile prices increased so much in 1974 relative to 1972-1973 increases (which may have helped cause the decrease in demand) that any further inflation of PCDA seemed risky.

If automobile production had held at its 1972-1973 share of GNP, unemployment in Michigan would have been much lower, making extended unemployment compensation benefits unnecessary. Therefore, the 1974 changes in the adjustment constant for unemployment compensation transfers were omitted from this simulation.

Column I of Table 5.5 compares the results of this simulation to those of the control run.[21] All figures are for calendar year 1974. Had the automobile industry retained its 1972-1973 position in the economy, total employment in Michigan would have increased by 21,800, wages and salaries by $747.6 million. The unemployment rate would have dropped six tenths of 1 per cent while real personal and disposable income would have been up $408.5 and $342.9 million, respectively. These last figures account for approximately 25 per cent of the overall decline in income over the 1974 period.

In the manufacturing sector, the number of jobs would have been 36,400 higher, the hourly wage $0.03 higher, and the average number of weekly hours .5 higher. Other sectors also profited from the change but not nearly as much. The difference between the increases in total employment and wage and salary jobs (21,800 versus 42,200) is an unfortunate peculiarity of the model. As wage and salary employment (EWSM) is augmented, residual employment declines. To some extent this is a reflection of reality as people take second jobs or leave self-employment, but the model seems to

Table 5.5: Alternative Scenarios

Variable	Calendar 1974 Control	Changes from Control 1974 Values I	II	III	IVA	IVB
EMFM	1079.1	+36.4	+15.2	+7.5	-	-
ETCM	145.9	+1.8	+.6	+.4	+.1	-
ETRM	652.0	+.8	+.9	+1.0	-2.1	-2.5
ECCM	127.0	+1.1	+.9	-	-	-
EFIM	130.5	+.3	+.2	-	-	-
ESM	518.8	+.9	+.7	+.3	-.7	-.8
EGM	550.5	+.9	+1.6	+.3	+3.8	-
EMRES	326.3	-20.3	-5.0	-5.0	-.5	+2.0
EMPM	3541.3	+21.8	+12.8	+5.6	+.5	-1.3
WM$	5.66	+.03	-	-	-	-
WSM$	35838.5	+747.6	+290.2	+133.2	+20.4	-30.2
HRSM	42.1	+.5	-	-	-	-
YENTM$	3094.2	-	+42.5	-	-	-
YLOM$	4542.4	+28.7	+11.2	+4.7	+.8	-1.2
YPRM$	6843.0	+6.6	+26.3	+3.8	+.9	-.6
YTRANS$	5772.6	-186.4	-31.7	-12.0	-1.6	+3.5
TSIM$	2190.3	+38.5	+16.6	+7.5	+1.0	-2.1
PCPID	151.5	-.1	-	+.2	+.1	-
LFM	3859.4	-2.9	-2.1	-.7	-.1	+.3
UM%	8.24%	-.63%	-.38%	-.14%	-.01%	+.04%
TYM$	963.8	+22.6	+11.4	+4.2	+198.0	+196.2
TRSM$	1048.6	+9.3	+7.0	+2.5	-5.0	-5.9
YPM$	54103.2	+558.9	+322.9	+123.2	+19.4	-26.7
YPM	35724.1	+408.5	+219.2	+54.5	+5.4	-12.4
YDM	30530.9	+342.9	+178.8	+45.7	-126.0	-140.7

All units are those listed in Appendix A.

I: CDAUS as 1972-1973 percentage of GNP

II: $5 billion increase in non-defense federal spending

III: 5,000 new manufacturing jobs in Michigan

IV: 4.6% individual income tax rate

A. 3% increase in state government employment

B. No increase in state government employment

overpredict this effect. The personal income coefficients in the equation do not seem strong enough to outweigh the negative effect of EWSM. Thus a more reasonable figure for the increase in employment might be closer to 30,000 or 35,000, which would correspond to a total decrease of about 1.0 per cent in the unemployment rate. The other simulations to be described in this chapter obviously suffer from the same apparent defect in the model so the change in total employment may be underpredicted in those cases also.

Another shortcoming of the model, uncovered by the simulations, is in the labor force, unemployment, and unemployment compensation exhaustions loop. It is not reasonable that the increased opportunities of a healthier economy could cause a decrease in the labor force, although that is what the simulation predicts. What happens in the model is that the decrease in unemployment leads to fewer predicted compensation exhaustions and a smaller labor force, yielding lower unemployment, etc. The increase in employment does move the labor force prediction in the correct direction but its effect is not great enough. The original prediction of the unemployment rate, given the problems with the labor force equation, might not be too far wrong, with errors in total employment and the labor force tending to offset one another.

The second experiment attempts to gauge the effect of changes in federal policy on the Michigan economy. Suppose federal non-defense purchases are increased by five billion current

dollars at an annual rate beginning in 1973.1, with no compensating tax increases. In addition, assume the Federal Reserve carries out an accommodating monetary policy so that interest rates do not change and cause additional changes in expenditures. With MQEM, this is accomplished by exogenizing the treasury bill rate (RTB%) at its control level. The values produced by an MQEM run under these assumptions[22] serve as the exogenous inputs to a 1973.1-1974.4 dynamic simulation of the Michigan economy. Only one change was made in the exogenous variables not originating in MQEM; federal government employment in Michigan was increased. Since the five billion increase represents approximately a 1.9 per cent increase in 1973 total federal government expenditures,[23] federal government employment in Michigan was assumed to be 1.5 per cent higher than its control level in 1973-1974. The unemployment compensation transfers adjustment constant, removed in the previous simulation, was restored since the recession is assumed to have prompted the additional federal spending.

United States 1974 GNP increased by approximately $5 billion from the control to the simulation[24] while CDAUS and IBF increased by $.3 billion and $1.0 billion, respectively. The changes in Michigan variables are found in Column II of Table 5.5. The overall stimulus to the Michigan economy is roughtly 60 per cent of that of the previous simulation, although the distributions differ.

Entrepreneurial income (YENTM$) increases in Simulation II where it did not in Simulation I since YENTM$ is a recursive variable based upon United States corporate profits which (by assumption) did not change in Simulation I. Property income is also greater in Simulation II because the equation is principally based on United States variables which changed in that simulation. Wages and salaries did not increase by as much (relative to the increase in personal income) in Simulation II as in Simulation I while transfers declined a good deal less, even compensating for the extra adjustment constant.

The pattern followed by the other variables was much the same as in Simulation I with manufacturing, which showed the greatest recessionary decline, aided the most by the outside stimulus. Total employment and the labor force are probably underestimated for the same reasons given in the discussion of Simulation I.

One way that has been suggested for the state government to strengthen the Michigan economy is to encourage its growth and diversification, that is, to try to attract new non-automotive industry. The third simulation assumes that the state government has been successful, that early in 1973[25] a large non-automotive manufacturing plant, providing 5000 new jobs, began operation in Michigan. Assume that if the firm had not located in Michigan it would have located elsewhere so national variables remain unchanged. What are the

differences in the 1974 values of Michigan variables, allowing the model a year to adjust?

From Table 5.5., Column III, the number of jobs increases by 9500 for a multiplier of almost two. This is a large multiplier for an economy as open as that of Michigan. Total employment only increases by 5600, although this figure is too low due to problems in the model that have already been explored. The true figure is somewhere in between. The increase in transport employment is lower than might otherwise be expected. There is an initial increase in 1973 (due to dependence on the change in manufacturing employment) which has been smoothed out by 1974, as has the original increase in construction employment. As was mentioned earlier, a better instrument might have enabled the level of manufacturing employment to be retained in the transport employment equation so the 1974 level of such employment is probably underpredicted here, as well as in the two previous simulations. Otherwise, there are few surprises as the variables not mentioned behave more or less as the other two simulations would lead one to expect.

The fourth scenario explores the effects of a change in the state personal income tax rate. The individual income tax rate was actually increased from 3.9 to 4.6 per cent as of May 1, 1975. How would the Michigan economy have been affected had the increase occurred earlier? Suppose the rate increase had

taken effect January 1, 1973. The changes in selected variables are considered for 1974, by which time refunds and annual payments would be influenced by the new rate.

The new tax rate is .7/3.9 or about 18 per cent higher than the old one. The exogenous annual payments variable in 1974 (reflecting 1973 underwithholding or underestimation) was, therefore, assumed to increase by 18 per cent in Simulation IV. Approximately half the 1974 individual income tax refunds (by dollar value) were due to overwithholding; the rest of the items termed refunds were actually tax credits and similar adjustments.[26] Exogenous refunds were increased by 9 per cent to account for this. The penalties and interest figure was so small in 1974 that no changes were made. Annual payments and refunds in 1973 were not changed since they would be based on 1972 tax rates. The adjustment constant for each quarter of 1974 in the withholding equation was changed from -13.3 to -15.7 to reflect the added value of the $300 increase in the per capita exemption (.046 times $75 times 9,100,000 times .5 = 15.7).[27]

Two simulations (IVA and IVB in Table 5.5) were run under the above assumptions. In the first, government employment was allowed to increase as a result of additional government revenue. The individual income tax accounted for 29 per cent of total Department of Treasury revenues in fiscal 1973, while the Department of Treasury collected about 91 per cent of Michigan state taxes in that period.[28]

If the personal income tax yielded 18 per cent more money, total state revenue would increase by about .18 times .91 times .29 = 4.8 per cent. On the basis of this, state government employment was increased by 3 per cent in each quarter since not all the increased tax payments would generate new employment in Michigan.[29]

The combination of increased tax payments and additional government expenditure has a slight stimulative effect on the Michigan economy. (See Table 5.5, Column IVA.) The balanced budget multiplier concept would predict this result. Total employment increases (due to added government hiring), but those sectors dependent on disposable income (services, trade) show declines. Individual income tax collections increase by 198 million or 20.5 per cent. This result is certainly of the correct order of magnitude, increasing confidence in the tax equations and underlying assumptions of the simulation. Both money and real personal income increase by a very small amount while disposable income decreases as expected.

In Simulation IVB, no offsetting increase in state government employment is assumed. This situation could occur if the state needed the additional funds to cope with inflationary cost increases, for instance. The result of this simulation is a weaker 1974 economy than in IVA and the control run. Employment, wages and salaries, and personal income decline by small amounts. Again, the change in tax

payments is the approximate amount one would expect, as is the decline in disposable income.

TURNING POINTS

Another method of evaluating a model is to see how well it captures turning points in the economy. Unfortunately, the period over which the model can be tested (effectively 1970.3 through 1974.4) contains only one turning point--the peak in early 1974. The fourth quarter of 1970 was a poor quarter for the Michigan economy due to the automobile strike. However, the effects were so pronounced that all the major variables of the model record a decline for that period.

To make use of what limited information was available, an 18 quarter dynamic simulation was run over the interval 1970.3 to 1974.4. The behavior of a number of the more important variables was examined. Both current and constant dollar personal income actually declined in the first quarter of 1974, as did both disposable income variables. The model predicted the real income declines one quarter early but was three quarters late for both personal and disposable income in monetary terms. The downturns in manufacturing, total, and wage and salary employment were predicted one quarter too early. Average manufacturing hours began its decline as early as the second quarter of 1973, a fact which the model reflected exactly.

Figures 5.1 through 5.4 compare actual and predicted values for some of the above variables: current dollar personal income, real personal income, manufacturing employment, and average manufacturing hours, respectively. The predicted values are obtained from the 18 period sample and post-sample dynamic simulation of the preceeding paragraph.

In general, the simulations presented in this chapter have shown that the model behaves as it should, makes reasonable predictions, and has errors within a tolerable range. On the whole, it can be used with confidence. Certain specific areas, however, still need improvement. Chapter VI, the concluding chapter, recalls these areas once again and presents a guide for the further development of the model.

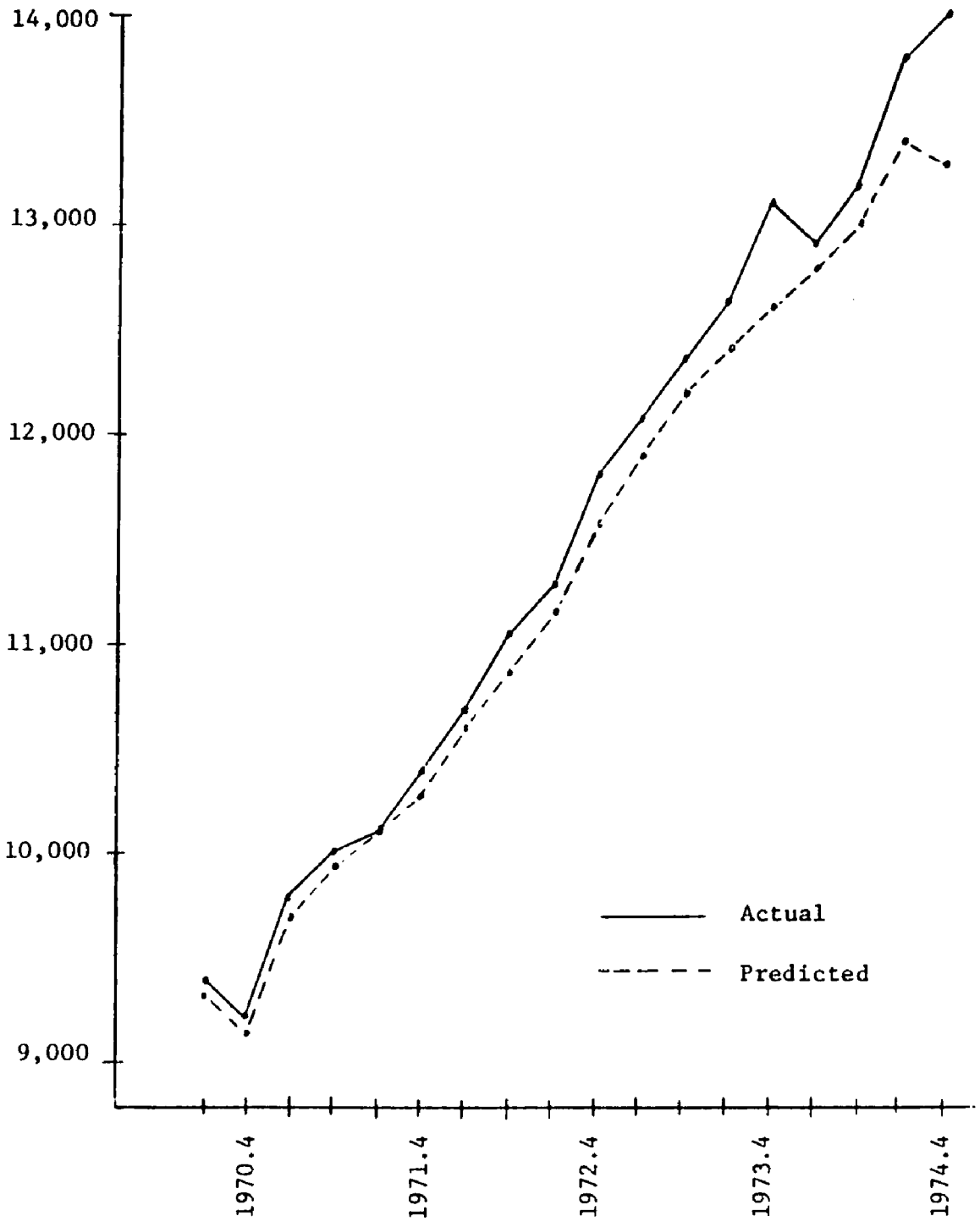


Figure 5.1: Actual and Predicted Values of Current Dollar Personal Income (YPM$), Millions of Dollars

Predicted values are determined by an 18 quarter dynamic simulation.

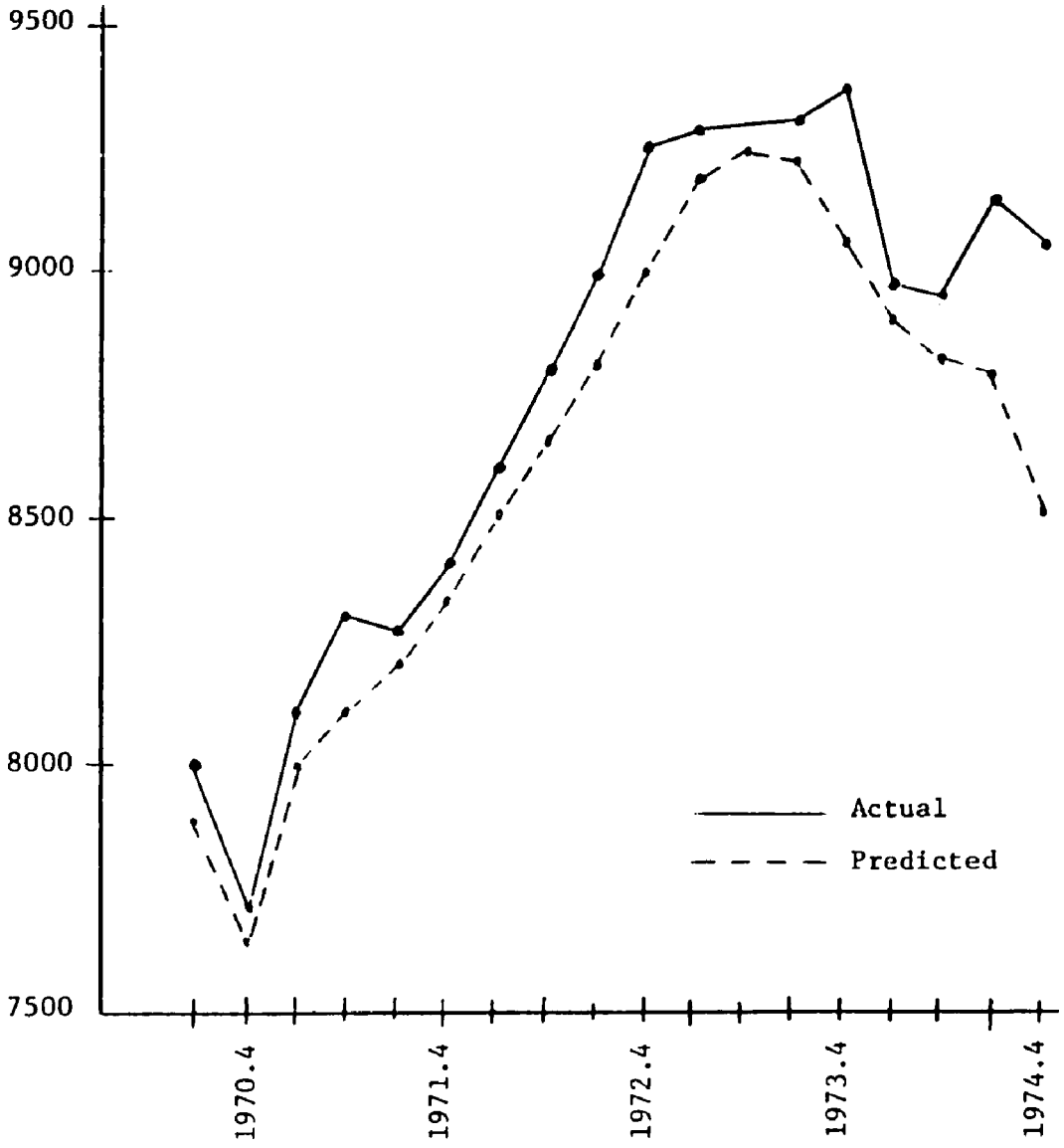


Figure 5.2: Actual and Predicted Values of Constant Dollar Personal Income (YPM), Millions of 1967 Dollars

Predicted values are determined by an 18 quarter dynamic simulation.

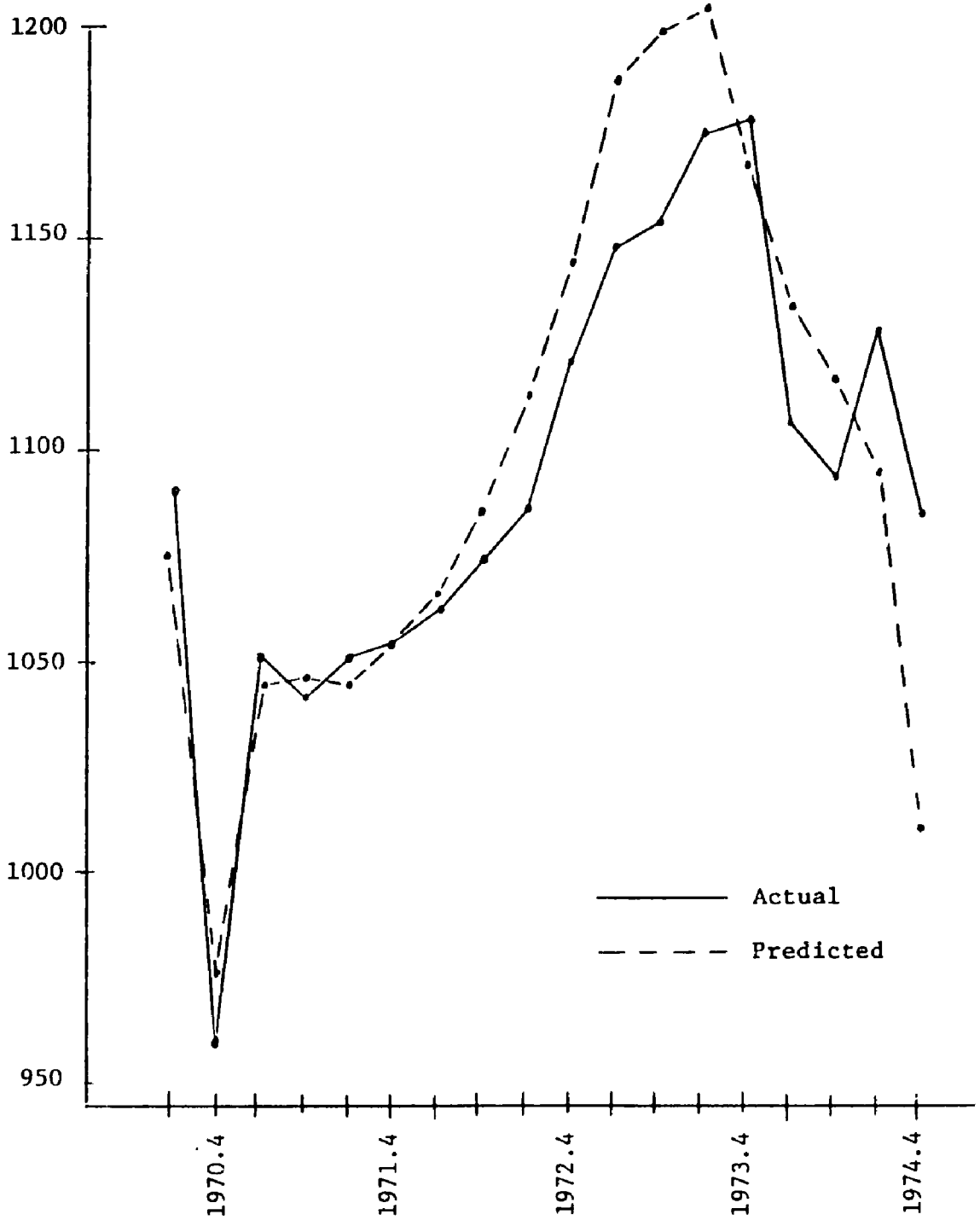


Figure 5.3: Actual and Predicted Values of Manufacturing Employment (EMFM), Thousands of Persons

Predicted values are determined by an 18 quarter dynamic simulation.

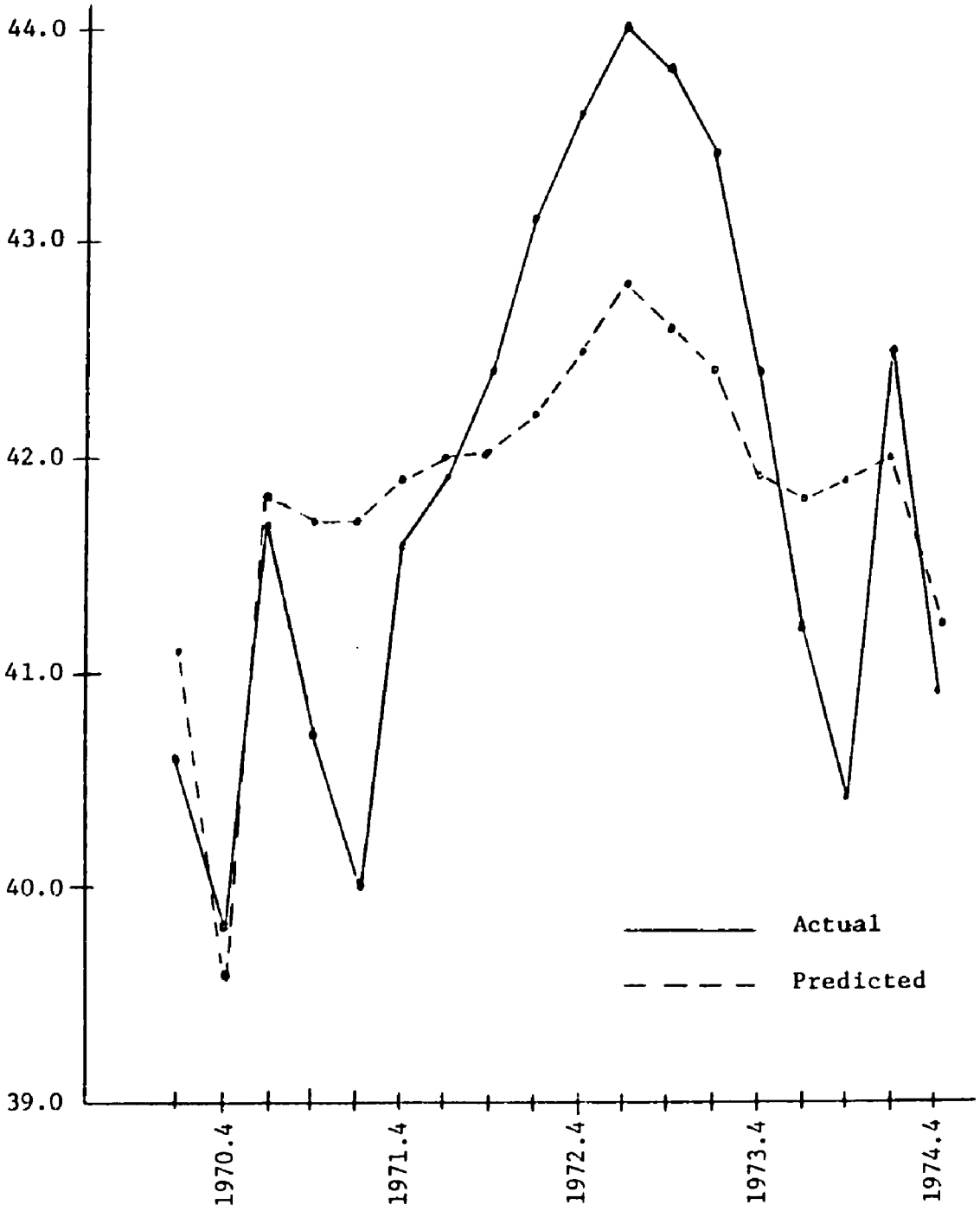


Figure 5.4: Actual and Predicted Values of Average Weekly Production Worker Hours in Manufacturing (HRSM)

Predicted values are determined by an 18 quarter dynamic simulation.

NOTES

[1]In Dhrymes, et al., "Criteria for Evaluation of Econometric Models," Annals of Economic and Social Measurement, I (July, 1972), pp. 307-308, the authors take a first step by describing a test for a static, multiequation model whose reduced form parameters are estimated by ordinary least squares and whose reduced form error terms meet certain requirements. This test is not valid for dynamic forecasts; its restrictions make it inapplicable to the model described in this thesis.

[2]It would be desirable to use the whole sample period from 1956.1 to 1973.4 for simulation. The majority of the individual equations were in fact estimated over this period. However, the entire model must be run in a simulation--data are necessary for all the variables. This means that the shortest series governs the simulation period, restricting the coverage to 1970.3 through 1973.4 in this case. Using the shorter period has the effect of increasing the variance of the estimates obtained.

[3]The 13 equations that are recursive in the IV model are Equations 4, 5, 9, 15, 21, 22, 34, 37, 53, 54, and 67-69 of Appendix B.

[4]The errors are computed for the actual level of the variable, not the form of the dependent variable the model predicts.

[5]There was some "method to the madness" in choosing forecast lengths for Table 5.1. Research Seminar in Quantitative Economics forecasts are generally made seven periods ahead so the six and eight represent a bracketing of the interval that the model will actually be called upon to forecast. The four quarter values are included in order to compare them to post-sample data. The static values are of interest as the best the model can do. The absence of a 14 period dynamic simulation (the longest possible given data constraints) is intentional. The model is not designed to be used for predictions of that length--it is too short term in outlook and conception. In addition, the statistics presented, to be comparable to the other overlap forecasts, would be the error values for only the 14th quarter. The variance of the one value would be so much larger than that of even the seven run average of the eight-period simulations (Relative variance is of the order of magnitude of the squared ratio of the number of observations.) that comparison is difficult, if not meaningless.

[6]Sampling error problems are especially acute when comparing simulations of different lengths over a fixed period as in Table 5.1. Since only final values for each dynamic run are averaged, eliminating one outlying quarter as a final value may markedly affect the results. For example, the nine six-quarter overlaps end in quarters 1971.4 to 1973.4 while the seven eight quarter ones end in 1972.2 to 1973.4. If 1972.1, say, were a particularly difficult quarter to forecast, the computed MAPE and/or RMSE would be smaller for the eight-period than the six-period simulation. Other runs covering the quarter would not be affected if observed values returned to their normal path in subsequent quarters since intermediate statistics are not calculated. The obvious suggestion is then to use only seven of the six quarter overlaps and end them in the same seven quarters as the eight quarter overlaps. By the time this is carried to the one period simulations, however, half the data are not used, greatly increasing the variance of the figures produced. It also means that the shorter forecasts have no contact at all with the earlier data. Since any comparisons between these sample statistics are quite risky to begin with, the decision was made to utilize as much information as possible in calculating the numbers presented in Table 5.1. At least the statistics themselves are as informative as possible under the circumstances.

[7]I owe the general idea for tests of this sort to E. Philip Howrey.

[8]The square root of the F-statistic will be referred to subsequently as the RMSE comparison statistic.

[9]Norman Glickman, in his "Son of 'The Specification of Regional Econometric Models' " (paper read at the 1973 North American Meetings of the Regional Science Association, Atlanta, Georgia, November 11, 1973), p. 15, suggests a sample period MAPE of 3 per cent as adequate. He does not state to what length run he refers, although on page 16 he uses the 3 per cent guideline for the average of all values over a 17 period in-sample simulation.

[10]Certain variables are easier to predict than others so smaller MAPE's are to be expected.

[11]The tabulated F-value for (14,14) d.f. is 2.48 for a RMSE comparison statistic of about 1.6.

[12]The RMSE comparison ratio for (7,14) d.f. is about 1.7 ($F = 2.77$).

[13]Glickman, op. cit., pp. 16, 18.

[14]Ibid., p. 17. The six other models are Wharton's Philadelphia I, Philadelphia III, Philadelphia IV, and Mississippi; Crow's Buffalo and Northeast Corridor; and Hall and Licari's Los Angeles.

[15]James Haughey, Department of Management and Budget, Revenue Division says the normal range is from 45 to 60 per cent. The fraction could not be one because some workers are not subject to withholding (the self-employed); other people do not earn sufficient income for the increased withholding to affect them (welfare recipients, many retirees, the "working poor") while certain workers with sufficient income subject to withholding do not claim the full number of exemptions to which they are entitled. The aged and the blind get two exemptions on their tax returns but only a relatively small number have income withheld.

[16]RMSE comparison statistic of 1.83 for (4, 11) d.f.

[17]The IV model is used in all subsequent tests. It is superior to the OLS one and almost indistinguishable in predictive accuracy from the ALT version.

[18]The actual MQEM predictions which were used in this experiment are available in Saul H. Hymans and Harold T. Shapiro, "The Economic Outlook for 1974," The Economic Outlook for 1974 (Ann Arbor, Michigan: Twenty-First Annual Conference on the Economic Outlook, November 15-16, 1972), pp. 20-22. In two ways the state predictions are not exactly as they would have been in November, 1973 (in addition to the fact that the model would not have existed or been the same). Actual state exogenous variables were used in all the periods although they would not have been known at that time. The simulation also incorporated present revisions of the 1973.3 and earlier national variables, also unavailable in November, 1973. It is not likely that these inconsistencies affect the general nature of the results.

[19]No actual multipliers are calculated, but the information present is sufficient for one to do so.

[20]The producer durables component of GAUTO is given in United States Department of Commerce, Social and Economic Statistics Administration, Survey of Current Business (Washington, D.C.: U.S. Government Printing Office, July, 1974), Table 1.15.

[21]To maintain comparability across the table, all runs begin in 1973.1 and are eight quarter dynamic forecasts, although variable values are presented for 1974 only.

[22]This corresponds to fiscal policy experiment F2 described in Saul H. Hymans and Harold T. Shapiro, "The Structure and Properties of the Michigan Quarterly Econometric Model of the United States Economy," International Economic Review, XV (October, 1974), pp. 645-646. The residuals of each equation in MQEM were used as adjustment constants so the predictions of this simulation differ from actual values only because of exogenous changes.

[23]Survey of Current Business, op. cit., Table 3.10, gives values for total government expenditures.

[24]The GNP increase is in real dollars while the federal government expenditure increase is in current dollars so the multiplier does exceed one.

[25]For the purposes of the simulation, on January 1, 1973.

[26]James Haughey, Michigan Department of Management and Budget, Revenue Analysis Division.

[27]Computed as described earlier in the discussion of the 1974 test simulations.

[28]Michigan Department of Treasury, Michigan Monthly Research and Statistical Bulletin, XXXVI (July 31, 1974), p. 2.

[29]Some of the new jobs would certainly be in local government and possibly also in other sectors if government purchase of goods increased, but the effect did not seem worth distributing for purposes of this simulation.

CHAPTER VI

BLUEPRINT FOR FURTHER DEVELOPMENT

The purpose of this project was to construct a model for the State of Michigan that would actually be used to generate forecasts. This underlying goal affects the types of data employed and thus the variables predicted. It also dictates that the model should never be considered final nor completed, but in a continual state of development.

To facilitate such development, this chapter brings together suggestions for the next steps to be taken. These ideas are of two types. The first group pinpoints areas where the model, as it is currently structured, could most profit from improvement. Although most of these weak spots have been mentioned in the previous two chapters, they are repeated here.[1] All areas of the model could, of course, profit from new ideas--the equations to be discussed seem to need the most attention. The second group is concerned with expanding the model in various directions to predict a larger number of variables.

CHANGES IN THE CURRENT MODEL

As the simulations of Chapter V showed quite clearly, the labor force equation does not react properly to changes in aggregate demand. Increased demand raises employment (although not as much as it should; see following material on residual employment) which, with the old labor force, would produce decreased value of unemployment. Decreased unemployment reduces the prediction of led unemployment compensation exhaustions (UCEXM+1) which, in turn, lowers the predicted size of the labor force, further lowering unemployment and so on. Increased employment helps increase the labor force estimate but not by enough. The coefficient of UCEXM+1 in the labor force equation is simply too big--the added worker effect is overestimated. The variable UCEXM+1 is also dangerous to use in the 1974-75 period (and possibly beyond) because of the various extensions of unemployment compensation, both in duration and scope of workers covered, due to the recession. The problem arises as to which exhaustions one should use. The suggestion here is to somehow replace exhaustions in the labor for equation or to restructure the labor force equation entirely. This will become easier to do as new observations are added to the relatively short (16 observation) labor force series.

The employment sector, more specifically the residual employment equation, does not seem to correctly capture demand changes

either. Residual employment decreases too much in response to an increase in wage and salary employment, i.e., -.71 is an overly large (in absolute magnitude) coefficient relative to the weaker effect of personal income in the opposite direction. The residual variable is not a particularly continuous series (even its own lagged value is not a significant predictor) and resists simple treatment.

It is beneficial for the model that the two above errors are positively correlated. A particular demand change causes both total employment and the labor force to be either over or underpredicted, reducing the error in predicting unemployment. This means that corrections should be made with care. A significant change in one of the two equations, even if it greatly improves forecasts of its own dependent variable, may have adverse effect on the overall model if the other variable continues to be poorly predicted.

Of the sectoral employment equations, transportation, communication and utilities, although not the worst, seems the most likely to be improved with a small amount of effort. As was noted in Chapter V, a variable (ℓn EMFM) was omitted when instrumental variables was used to refit the ordinary least squares equation. Simulation results seem to indicate that ℓn EMFM played a useful role. Better instruments for all four right-hand-side simultaneous variables in the equation might allow ℓn EMFM to be retained.

A further sore spot is the equation predicting quarterly estimates of individual income tax payments. Whether or not personal income replaces property income, the equation does poorly. This could be due to the fact that there is some amount of leeway in estimating the amount of income to declare. A lag structure of some sort may be helpful in reflecting the legal provision that this year's estimate need not be higher than what would be owed on last year's actual income. At any rate, improvement is called for. In a somewhat related area, entrepreneurial income, while not badly predicted, might be more responsive to Michigan activity if a Michigan specific variable were included.

Unemployment compensation transfers are another area that merits a second glance. Some of the problem with this variable is due to the poor predictions of unemployment, but not all, since residual run values also show considerable error. As hypothesized earlier, changes in coverage account for some of the unexplained variance if they do not coincide with changes in the benefit level. A comprehensive coverage index would help. With the 1974-75 benefit increase and extensions, this variable needs to be carefully reanalyzed.

A smaller item rounds out this group of suggestions. Transitory income, although not as badly predicted as standard statistics would indicate, is quite unstable. Rather than predict it by utilizing

its definition as the difference of two aggregate variables, a stochastic equation of some sort might be an improvement.

ADDITIONS TO THE MODEL

There are a number of ways the model could be expanded to yield useful information about the Michigan economy. The four sketched here are chosen because the necessary data, on first inspection, seem to be obtainable.

Manufacturing employment is treated in the model as if it were completely automobile or producer durable manufacture. These are the volatile elements, but not the entire total.[2] The Michigan Employment Security Commission provides data on manufacturing employment broken down into nine classes of durables and six of non-durables, so disaggregation is possible, although fifteen categories may be too many. Weekly hours and average hourly earnings data are also collected for a number of subcategories although total wages and salaries are not. Such a decomposition of the manufacturing sector will enable the model to respond more accurately to changes in the composition of manufacturing demand.

Another way to disaggregate the model would be on an area basis. Employment, average hours, and average earnings figures exist for thirteen SMSA's in Michigan. If the composition of output differs from city to city, such a disaggregated model could pinpoint

locales especially affected by particular economic conditions. This would be useful in government planning.

The government sector itself is a prime candidate for model development, both on the expenditure and revenue sides of the ledger. A state model that is fully integrated with predictions of items in a comprehensive government budget (including a budget constraint) would be an invaluable aid. This is a more ambitious undertaking than it may at first seem, especially on a quarterly basis. Attempts to predict tax revenues alone have occupied entire dissertations.[3] The data are messy and the laws change frequently so it is hard to judge, a priori, what sort of results are to be anticipated from such an attempt.

The fourth possible direction would be to expand the labor force block of equations to include endogenous predictions of population and migration. The Michigan labor force seems especially sensitive to migration patterns to and from Southern states as economic conditions vary. Whether these effects would show up in a short run model remains to be seen. Since the labor force segment of the model needs considerable work anyway, it might be wise to postulate a larger group of endogenous variables at the very beginning.

These are only a few of the ways the model could be expanded. If survey funds are available to generate additional data, consumption, investment, or gross product variables might also be predicted, to mention just a few.

Whatever additions are made, though, the core model must be continuously monitored. Forecast results and new observations should be utilized to assess the behavior of the system. Periodically, reestimations are necessary. Only in this way can the model retain its value as a predictive tool.

NOTES

[1]Few solutions to the problems are supplied. If there were obvious answers they would already be incorporated into the model.

[2]In 1974, transporation equipment accounted for 33.5 per cent of total manufacturing employment while machinery generated 19.0 per cent.

[3]Examples include Michael Zweig, "Forecasting State Tax Revenues" (unpublished Ph. D. dissertation, The University of Michigan, Ann Arbor, Michigan, 1967) and Fulton V. Clinkscales, Jr., "An Econometric Model of the South Carolina Tax Sector" (unpublished Ph. D. dissertation, Clemson University, Clemson, South Carolina, 1973).

APPENDIX A

DATA (MNEMONICS, SOURCES, AND RELATED INFORMATION)

The following rules were followed in assigning suggestive mnemonics to the variables of the model.

1. A mnemonic beginning with the letter Y always indicates an income variable.

2. A mnemonic beginning with the letter D always indicates a dummy variable.

3. A mnemonic beginning with the letter T indicates a tax variable, a tax rate, or a tax-related quantity.

4. A mnemonic beginning with the letter P often (not always) indicates a price deflator or price index. All price deflators begin with the letter P, though.

5. All mnemonics ending in $ represent variables measured in current dollars.

6. All mnemonics ending in % represent variables scaled in percentage point units.

7. In cases where confusion might arise, Michigan variables have the letter M appended (before the final $ or % if one occurs) while United States variables are indicated by US.

* indicates an endogenous variable.

** indicates a variable endogenous to MQEM (the Michigan Quarterly Econometric Model of the United States Economy); all such variables are expressed at annual rates .

*** indicates a linking variable.

A list of source and seasonal adjustment abbreviations used in the table is found at the end of this appendix.

Mnemonic	Name and Units	Source	Period[1] and Frequency	Seasonal Adjustment
ADJRS$	Adjustment factor for personal income by place of residence (millions of current $)	BEA	1971.1-1973.4 quarterly	AA
*AEQCCM$	Average earnings per quarter in Michigan construction (current $)	Transformation $\frac{WSCCM\$}{ECCM} * 1000$	--[2]	--[3]
*AEQFIM$	Average earnings per quarter in Michigan finance, insurance, and real estate (current $)	Transformation: $\frac{WSFIM\$}{EFIM} * 1000$	--	--
*AEQGM$	Average earnings per quarter in Michigan government (current $)	Transformation: $\frac{WSGM\$}{EGM} * 1000$	--	--
*AEQMFM$	Average earnings per quarter in Michigan manufacturing (current $)	Transformation: $\frac{WSMFM\$}{EMFM} * 1000$	--	--
*AEQMIM$	Average earnings per quarter in Michigan mining (current $)	Transformation: $\frac{WSMIM\$}{EMIM} * 1000$	--	--

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*AEQSM$	Average earnings per quarter in Michigan service industries (current $)	Transformation: $\frac{WSSM\$}{ESM} * 1000$	--	--
*AEQTCM$	Average earnings per quarter in Michigan transportation, communication and utilities (current $)	Transformation: $\frac{WSTCM\$}{ETCM} * 1000$	--	--
*AEQTRM$	Average earnings per quarter in Michigan wholesale and retail trade (current $)	Transformation: $\frac{WSTRM\$}{ETRM} * 1000$	--	--
BLDPERM	Building permits issued for residential construction in Michigan (thousands)	DMB	1963.1-1973.4 monthly	AA
**CDAUS	Personal consumption expenditures for autos and parts, excluding mobile homes (billions of 1958 $)	RSQE	1956.1-1973.4 quarterly	AA
**CDFEUS	Personal consumption expenditures for furniture and household equipment (billions of 1958 $)	RSQE	1956.1-1973.4 quarterly	AA

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
**CDOUS	Personal consumption expenditures for other durables (billions of 1958 $)	RSQE	1956.1-1973.4 quarterly	AA
**CMHUS	Compensation per man hour in United States private non-farm sector (Index: 1967=100)	E & E	1956.1-1973.4 quarterly	AA
**CPBTUS$	United States corporate profits before tax (billions of current $)	SCB Table 1.10	1956.1-1973.4 quarterly	AA
**CSUS	Personal consumption expenditures for services (billions of 1958 $)	SCB Table 1.2	1956.1-1973.4 quarterly	AA
**CUS	Total personal consumption expenditures (billions of 1958 $)	SCB Table 1.2	1956.1-1973.4 quarterly	AA
DADJRS	Dummy variable for income components on a place of work basis 1956.1 to 1970.4 = 0.0 1971.1 to 1973.4 = 1.0	RSQE	1956.1-1973.4 quarterly	NN

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
DAPM	Dummy variable reflecting Canadian Auto Pact	RSQE	1956.1-1973.4 quarterly	NN
DAS	Dummy variable for major automobile strikes: -2 in 1964.4, +1.2 in 1965.1, +.8 in 1965.2, -1 in 1967.4, .75 in 1968.1, +.25 in 1968.2, -.36 in 1970.4, +2.4 in 1971.1, +1.2 in 1971.2, zero otherwise	RSQE	1956.1-1973.4 quarterly	NN
DAUCON	Dummy variable reflecting large wage increases granted in connection with automobile contract renewals: 1.0 in 1965.1, 1968.1, and 1971.1, 0.0 otherwise	RSQE	1956.1-1973.4 quarterly	NN
DCS	Dummy variable reflecting major construction strike: 1.0 in 1968.2, 0.5 in 1968.3, 0.0 otherwise	RSQE	1956.1-1973.4 quarterly	NN

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
DMIS	Dummy variable reflecting major mining strike: 1.0 in 1971.3, 0.0 otherwise	RSQE	1956.1-1973.4 quarterly	NN
DTIME	Time trend dummy: 1.0 in 1956.1 and increasing by 1.0 per quarter	RSQE	1956.1-1973.4 quarterly	NN
DTSALES	Dummy variable reflecting change in the coverage of Michigan's retail sales tax: 0.0 from 1956.1 to 1970.2, 1.0 from 1970.3 onward	RSQE	1956.1-1973.4 quarterly	NN
DWELREV	Dummy reflecting increase in public assistance rolls due to the "welfare revolution": 0.0 from 1956.1 to 1966.4, 1.0 in 1967.1 and increasing by 1.0 per quarter to 1972.4, 24.0 from 1973.1 onward	RSQE	1956.1-1973.4 quarterly	NN

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*ECCM	Employment in Michigan construction (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*EFIM	Employment in Michigan finance, insurance and real estate (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
EGFM	Federal government employment in Michigan (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*EGLM	Local government employment in Michigan (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*EGM	Total government employment in Michigan (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*EGSM	State government employment in Michigan (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*EMFM	Employment in Michigan manufacturing (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11

Mnemonics	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*EMIM	Employment in Michigan mining (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*EMPM	Total employment in Michigan (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*EMRESM	Residual employment (agriculture, self-employed, household vs. establishment discrepancy) (thousands of persons)	Transformation: EMPM-EWSM	--	--
*ESM	Employment in Michigan service industries (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*ETCM	Employment in transportation, communication, and utilities (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
*ETRM	Employment in Michigan wholesale and retail trade (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*EWSM	Total wage and salary employment in Michigan (thousands of persons)	MLMR	1956.1-1973.4 monthly	X-11
***GAUTO	Gross auto product (billions of 1958 $)	SCB Table 1.16	1956.1-1973.4 quarterly	AA
**GNP	Gross national product (billions of 1958 $)	SCB Table 1.2	1956.1-1973.4 quarterly	AA
*HRSM	Average weekly hours of production workers in Michigan manufacturing (number of hours)	MLMR	1957.1-1973.4 monthly	X-11
**IBF	United States business fixed investment (billions of 1958 $)	SCB Table 1.2	1956.1-1973.4 quarterly	AA
ICS	Index of Consumer Sentiment (Index 1966.1 = 100)	BCD # 435	1956.1-1973.4 quarterly	NN
*LFM	Michigan labor force (population survey basis) (thousands of persons)	MLMR	1970.1-1973.4 monthly	X-11

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
MINWUS$	Minimum hourly wage in the United States (current $)	DMB	1956.1-1973.4 quarterly	NN
OTRM$	Other transfer payments in Michigan (millions of current $)	Transformation: YTRANSM$ - SSTRM$ - PATRM$ - UCTRM$	--	--
*# PARECPM	Number of recipients of public assistance transfer payments in Michigan (thousands of persons)	SSB	1956.1-1973.4 monthly	X-11
PATRAVM$	Average quarterly public assistance transfer payment in Michigan (current $)	Transformation: $\frac{\text{PATRM\$}}{\text{\# PARECPM}}$	--	--
*PATRM$	Public assistance transfer payments to Michigan residents (millions of current $)	SSB	1956.1-1973.4 monthly	X-11
PCDA	Personal consumption expenditures implicit deflator: autos and parts (Index: 1958=100)	DC	1956.1-1973.4 quarterly	AA

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
**PCE	Personal consumption expenditures implicit deflation (Index: 1958 = 100)	SCB Table 8.1	1956.1-1973.4 quarterly	AA
*PCPID	Detroit consumer price index (Index: 1967 = 100)	MLR	1956.1-1973.4 monthly	NN
*PCPIDHSE	Detroit consumer price index: housing component (Index: 1967 = 100)	DMB	1956.1-1973.4 monthly	NN
***PCPIUS	United States Consumer Price Index (Index: 1967 = 100)	MLR	1956.1-1973.4 monthly	NN
POPM	Michigan population (thousands of persons)	ERG	1956.1-1973.4 annually	NN
POP65+M	Michigan population 65 and over (thousands of persons)	DMB	1956.1-1973.4 quarterly	NN
**PPNF	Private non-farm GNP implicit deflator (Index: 1958 = 100)	SCB Table 8.4	1956.1-1973.4 quarterly	AA
**RAAA%	Corporate Aaa interest rate (per cent)	FRB	1956.1-1973.4 monthly	NN

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
**RCP%	Interest rate on 4-6 month prime commercial paper (per cent)	FRB	1956.1-1973.4 monthly	NN
RES_{-1}	Lagged residual to correct for auto-correlation	--	--	--
**RTB%	90-day treasury bill rate, daily average of market yield (per cent)	FRB	1956.1-1973.4 monthly	NN
*SAVTOT$	Total savings in Michigan banks, savings and loans, and credit unions (billions of current $)	ERG	1956.1-1973.4 annually	NN
SSTRM$	Social Security transfer payments to Michigan residents (millions of current $)	SSB	1956.1-1973.4 monthly	X-11
**TPUS$	United States personal tax and non-tax payments (billions of current $)	SCB Table 2.1	1956.1-1973.4 quarterly	AA

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*TRESM	Taxes (other than Michigan personal income tax) separating personal from disposable income (millions of current $)	DMB	1956.1-1973.4 quarterly	X-11
*TRSAUM	Michigan retail sales tax on new and used automobile and parts (millions of 1958 $)	Transformation: $\frac{\text{TRSAUM\$}}{\text{PCDA}} * 100$	--	--
*TRSAUM$	Michigan retail sales tax on new and used automobiles and parts (millions of current $)	RSB	1956.1-1973.4 monthly	X-11
*TRSFM$	Michigan retail sales tax on food purchased in food stores (millions of current $)	RSB	1969.1-1973.4 monthly	X-11
*TRSM	Michigan retail sales tax (millions of 1967 $)	Transformation: $\frac{\text{TRSM\$}}{\text{PCPID}} * 1000$	--	--
*TRSM$	Michigan retail sales tax (millions of current $)	RSB	1956.1-1973.4 monthly	X-11

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*TRSOM$	Michigan retail sales tax--non-food, non-automotive (millions of current $)	Transformation: TRSM$ - TRSFM$ - TRSAUM$	--	--
*TSIM$	Contributions of Michigan residents to social insurance (millions of current $)	SSB; RSQE	1956.1-1973.4 annually	X-11
*TSSBASE$	Maximum annual income subject to Social Security Tax (current $)	SSB	1956.1-1973.4 annually	NN
TSSBENLV	Social Security benefit level (Index: 1956 = 100)	RSQE	1956.1-1973.4 quarterly	NN
TSSRATE	Employee Social Security tax rate (fraction)	SSB	1956.1-1973.4 annually	NN
TYAM$	Michigan personal income tax--annual payments (millions of current $)	DMB	1967.4-1973.4 quarterly	X-11
*TYM$	Michigan personal income tax (millions of current $)	DMB	1967.4-1973.4 quarterly	X-11

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*TYQM$	Michigan personal income tax,quarterly payments (millions of current $)	DMB	1968.1-1973.4 quarterly	X-11
TYP&IM$	Michigan personal income tax,penalty and interest payments (millions of current $)	DMB	1967.4-1973.4 quarterly	X-11
TYRM$	Michigan personal income tax,refunds (millions of current $)	DMB	1968.1-1973.4 quarterly	X-11
TYRTM%	Michigan personal income tax rate (per cent)	DMB	1967.4-1973.4 quarterly	X-11
*TYWM$	Michigan personal income tax,withholding (millions of current $)	DMB	1967.4-1973.4 quarterly	X-11
UCBENLV	Unemployment compensation benefit level (Index: 1956 = 100)	RSQE	1956.1-1973.4 quarterly	NN

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*UCEXM	Number of persons in Michigan exhausting their unemployment compensation benefits (thousands of persons)	SSB	1956.1-1973.4 monthly	X-11
*UCTRMS	Unemployment compensation payments to Michigan residents (millions of current $)	SSB	1956.1-1973.4 monthly	X-11
*UM	Number of unemployed in Michigan (population survey basis) (thousands of persons)	MLMR	1970.1-1973.4 monthly	X-11
*UM%	Unemployment rate in Michigan (population survey basis) (per cent)	MLMR	1970.1-1973.4 monthly	X-11
UOLDM	Number of unemployed in Michigan (establishment survey basis) (thousands of persons)	MLMR	1956.1-1969.4 monthly	X-11
UOLDM%	Unemployment rate in Michigan (establishment survey basis) (per cent)	MLMR	1956.1-1969.4 monthly	X-11

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*UUS%	United States unemployment rate (per cent)	E & E	1956.1-1973.4 monthly	AA
*WM$	Average hourly earnings of production workers in Michigan manufacturing (current $)	MLMR	1957.1-1973.4 monthly	X-11
WSAGM$	Wage and salary disbursements in Michigan agriculture (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*WSCCM$	Wage and salary disbursements in Michigan construction (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*WSFIM$	Wage and salary disbursements in Michigan finance, insurance and real estate (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*WSMFM$	Wage and salary disbursements in Michigan manufacturing (millions of current $)	BEA	1956.1-1973.4 quarterly	AA

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*WSGM$	Wage and salary disbursements of governments in Michigan (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*WSMIM$	Wage and salary disbursements in Michigan mining (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*WSM$	Total wage and salary disbursements in Michigan (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
WSOM$	Other wage and salary disbursements in Michigan (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*WSSM$	Wage and salary disbursements in Michigan service industries (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*WSTCM$	Wage and salary disbursements in Michigan transportation, communication, and utilities (millions of current $)	BEA	1956.1-1973.4 quarterly	AA

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
WSTRM$	Wage and salary disbursements in Michigan wholesale and retail trade (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
***WUS$	Average hourly earnings of production workers in United States manufacturing (current $)	E & E	1956.-1-1973.4 monthly	X-11
**YDIVUS$	Corporate dividend payments (billions of current $)	SCB Table 1.9	1956.1-1973.4 quarterly	AA
*YDM	Michigan disposable income (millions of 1967 $)	Transformation: $\frac{YDM\$}{PCPID} * 100$	--	--
*YDM$	Michigan disposable income (millions of current $)	Transformation: YPM$ - TYM$ - TRESM$	--	--
*YENTM$	Proprietors' income in Michigan (millions of current $)	BEA	1956.1-1973.4 quarterly	AA

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
YLOM$	Other labor income in Michigan (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*YPADJM$	"Adjusted" Michigan personal income (millions of current $)	Transformation: YPM$ + TSIM$ - YTRANSM$	--	--
*YPERM	"Permanent" income in Michigan (millions of 1967 $)	Transformation: $\sum_{i=0}^{5} \lambda_i YDM_{-i}$	--	--
*YPERM$	"Permanent" income in Michigan (millions of current $)	Transformation: $\sum_{i=0}^{5} \lambda_i YDM\$_{-i}$ $\lambda_0=.271$, $\lambda_1=.217$, $\lambda_2=.173$, $\lambda_3=.139$, $\lambda_4=.111$, $\lambda_5=.089$	--	--
*YPM	Michigan personal income (millions of 1967 $)	Transformation: $\frac{YPM\$}{PCPID}*100$	--	--

Mnemonic	Name and Units	Source	Period and Frequency	Seasonal Adjustment
*YPM$	Michigan personal income (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*YPRM$	Michigan property income (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
**YPUS$	United States personal income (billions of current $)	SCB Table 1.9	1956.1-1973.4 quarterly	AA
*YTRANSM$	Transfer payments to Michigan residents (millions of current $)	BEA	1956.1-1973.4 quarterly	AA
*YTRANSTM	Transitory income in Michigan (millions of 1967 $)	Transformation: YDM - YPERM	--	--

NOTES

[1]The period is given in quarters regardless of the original units of the data. Frequency refers to the raw data.

[2]For transformed variables, the period corresponds to the intersection of the periods of the variables entering into the transformation.

[3]Transformations are performed on data that are already seasonally adjusted, if such adjustment is necessary.

LIST OF ABBREVIATIONS USED

I. Seasonal Adjustment
- AA: already adjusted
- NN: no adjustment necessary
- X-11: adjusted by Census X-11 Q program

II. Sources of Data
- BCD: U.S. Department of Commerce, Social and Economic Statistics Administration. Business Conditions Digest. Washington: U.S. Government Printing Office.
- BEA: Unpublished data supplied by Department of Commerce, Bureau of Economic Analysis, Regional Economics Division.
- DC: Unpublished data supplied by Department of Commerce.
- DMB: Unpublished data supplied by the State of Michigan, Department of Management and Budget
- E&E: U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings. Washington: U.S. Government Printing Office.
- ERG: Milliken, William G. Economic Report of the Governor. Lansing, Michigan.
- FRB: Board of Governors of the Federal Reserve System. Federal Reserve Bulletin. Washington.
- MLMR: Michigan Department of Labor, Michigan Employment Security Commission. Michigan Labor Market Review (formerly Michigan Manpower Review). Detroit, Michigan.

MLR: U.S. Department of Labor, Bureau of Labor Statistics. Monthly Labor Review. Washington, U.S. Government Printing Office.

RSB: Michigan Department of Treasury. Monthly Research and Statistical Bulletin. Lansing, Michigan.

RSQE: Private series prepared by the Research Seminar in Quantitative Economics.

SCB: U.S. Department of Commerce, Social and Economic Statistics of Administration. Survey of Current Business. Washington: U.S. Government Printing Office.

SSB: U.S. Department of Health, Education, and Welfare, Social Security Administration. Social Security Bulletin. Washington: U.S. Government Printing Office.

APPENDIX B

EQUATIONS OF THE FINAL MODEL

The equations are presented in the approximate order that they are discussed in Chapter IV. The mnemonics correspond to the listing of Appendix A. Following each estimated equation are five types of information: the method of estimation (ordinary least squares--OLS or instrumental variables--IV); the coefficient of multiple determination, R^2, unadjusted for degrees of freedom; the standard error of estimate, S.E.; the Durbin-Watson statistic, D.W.; and the number of observations, N, upon which the equation is estimated. The values in parentheses are the ratios of the estimated coefficients to their standard errors.

I. Employment

Employment-Manufacturing

$$-1- \quad \ell n\, EMFM = \underset{(-5.6711)}{-5.1880} - \underset{(-1.3185)}{.28966}\, \Delta \ell n \frac{WM\$}{WUS\$} - \underset{(-1.2302)}{.11502}\, \ell n \frac{AEQMFM\$}{PPNF}$$

$$+ \left\{ \underset{(12.470)}{1.9965} + \underset{(8.7967)}{.65230} \frac{GAUTO}{GNP} + \underset{(2.9212)}{.31788} \frac{IBF}{GNP} \right\} \sum_{i=0}^{5} \lambda_i \ell n\, GNP_{-i}$$

$$- \underset{(12.798)}{.017838}\, DTIME + \underset{(2.7876)}{.35687}\, RES_{-1}$$

$$\lambda_0 = .35 \quad \lambda_1 = .25 \quad \lambda_2 = .2 \quad \lambda_3 = .1 \quad \lambda_4 = .05 \quad \lambda_5 = .05 \quad \sum_{i=0}^{5} \lambda_i = 1$$

IV $R^2 = .98374$ SE = .013423 DW = 1.9805 N = 66

Employment--Transportation, Communication, and Utilities

$$-2- \quad \ell n\, ETCM = \underset{(-2.4248)}{-.38750} + \underset{(29.7223)}{.96874}\, \ell n\, ETCM_{-1} + \underset{(2.9206)}{.11257}\, \ell n\, YPM$$

$$- \underset{(-2.6176)}{.15905}\, \ell n \frac{AEQTCM\$}{PPNF} + \underset{(6.5338)}{.30390}\, \Delta \ell n\, EMFM$$

IV $R^2 = .97128$ SE = .010578 DW = 1.8952 N = 68

Employment--Wholesale and Retail Trade

$$-3- \quad \ell n\,ETRM = \underset{(-1.8448)}{-\,7.5668} + \underset{(4.3568)}{.60763}\,\ell n\,ETRM_{-1} + \underset{(1.7688)}{.97608}\,\ell n\,POPM$$

$$+\left\{\underset{(2.9552)}{.23634} + \underset{(2.9908)}{1.7862}\sum_{i=0}^{1}\lambda_i\left(\frac{TRSM}{YDM}\right)_{-i}\right\}\ell n\,YDM$$

$$\underset{(-1.6193)}{-\,.48318}\,\ell n\left(\frac{AEQTRM\$}{PCPID}\right)$$

$$\lambda_0 = .67 \quad \lambda_1 = .33 \quad \sum_{i=0}^{1}\lambda_i = 1$$

IV R^2 = .99707 SE = .0080294 DW = 1.9568 N = 68

Employment--Contract Construction

$$-4- \quad \ell n\,ECCM = \underset{(5.4394)}{1.6445} + \underset{(1.5978)}{.14086}\,\ell n\,ECCM_{-1} + \underset{(2.6888)}{.063828}\,\ell n\,BLDPERM$$

$$+ \underset{(6.3540)}{.55001}\,\ell n\,IBF - \underset{(-2.2042)}{.0018020}\,DTIME - \underset{(-9.5631)}{.23919}\,DCS2$$

$$+ \underset{(3.0924)}{.51876}\,RES_{-1}$$

OLS R^2 = .93713 SE = .026736 DW = 2.0593 N = 43

Employment--Mining

-5- $\ell n\ EMIM = \underset{(-1.4625)}{-1.7101} + \underset{(6.4284)}{.55900}\ \ell n\ EMIM_{-1} - \underset{(-2.9734)}{.0064997}\ DTIME + \underset{(2.3903)}{.48362}\ \ell n\ GNP - \underset{(-4.0938)}{.18293}\ DMIS$

OLS $R^2 = .85815$ SE $= .043276$ DW $= 1.6746$ N $= 71$

Employment--Finance, Insurance, and Real Estate

-6- $\ell n\ EFIM = \underset{(-3.5468)}{-.19258} + \underset{(39.417)}{.91847}\ \ell n\ EFIM_{-1} + \underset{(3.7424)}{.065122}\ \ell n\ YPM$

IV $R^2 = .99826$ SE $= .0071601$ DW $= 2.0363$ N $= 71$

Employment--Services

-7- $\ell n\ ESM = \underset{(-2.9342)}{-.25561} + \underset{(41.550)}{.95681}\ \ell n\ ESM_{-1} + \underset{(2.4114)}{.059686}\ \ell n\ YDM$

IV $R^2 = .99870$ SE $= .0085417$ DW $= 1.6431$ N $= 71$

Employment--Local Government

-8- $\ell n\ EGLM = \underset{(-1.8937)}{-1.4283} + \underset{(28.548)}{.85496}\ \ell n\ EGLM_{-1} + \underset{(1.4614)}{.15871}\ \ell n\ POPM + \underset{(3.3861)}{.092425}\ \ell n\ YPM$

IV $R^2 = .99845$ SE $= .0081262$ DW $= 1.8512$ N $= 71$

Employment--State Government

-9- $\ell n\ EGSM = \underset{(-2.2230)}{-4.0615} + \underset{(14.279)}{.78398}\ \ell n\ EGSM_{-1} + \underset{(1.6160)}{.090930}\ \ell n\ YPM_{-2}$

$$+ \underset{(1.8612)}{.46923}\ \ell n\ POPM$$

OLS $R^2 = .99399$ SE = .018002 DW = 2.2927 N = 70

Employment--Total Government

-10- EGM = EGSM + EGLM + EGFM

Employment--Wage and Salary (Non-farm)

-11- EWSM = EMFM + ETCM + ETRM + EFIM + ESM + ECCM + EMIM + EGM

Residual Employment

-12- $EMRESM = \underset{(6.5366)}{1473.8} - \underset{(-4.4121)}{.71312}\ EWSM + \underset{(1.3217)}{.036069}\ YPM + \underset{(1.9049)}{.060842}\ YPM_{-1}$

$$+ \underset{(.91536)}{.029320}\ YPM_{-2}$$

IV $R^2 = .86023$ SE = 17.690 DW = 1.7620 N = 16

Total Employment

-13- EMPM = EWSM + EMRESM

II. Wages, Hours, and Earnings

Average Hourly Wage in Manufacturing--Michigan

-14- $$\Delta \ell n\, WM\$ = \underset{(.84516)}{.0015168} + \underset{(3.3060)}{.019094}\ DAUCON + \left\{ \underset{(5.2499)}{.79667} + \underset{(4.4296)}{2.6514}\left(\Delta \ell n \frac{GAUTO}{GNP} - .0013687\right) + \underset{(.69356)}{34.432}\left(\Delta \ell n \frac{PCPID}{PCPIUS} + .00020392\right)\right\} \Delta \ell n\, WUS\$$$

IV $R^2 = .76026$ SE = .0068159 DW = 2.4183 N = 67

Average Weekly Hours in Manufacturing--Michigan

-15- $$\ell n\, HRSM = \underset{(3.5742)}{.67968} + \underset{(16.062)}{.81803}\ \ell n\, HRSM_{-1} + \underset{(7.0498)}{.28008}\ \Delta \ell n\left(\frac{IBF+GAUTO}{GNP}\right)$$

OLS $R^2 = .83387$ SE = .015383 DW = 2.3093 N = 67

Average Earnings Per Quarter--Manufacturing

-16- $$\ell n\, AEQMFM\$ = \underset{(21.212)}{5.1414} + \underset{(4.9644)}{.33343}\ \ell n\, HRSM + \underset{(61.910)}{1.0212}\ \ell n\, WM\$ - \underset{(-2.4416)}{.022200}\ DADJRS$$

IV $R^2 = .99456$ SE = .017732 DW = 1.9864 N = 68

Average Earnings Per Quarter-- Transportation, Communication, and Utilities

-17- $\ell n\ AEQTCM\$ = \underset{(3.8973)}{2.1283} + \underset{(7.5243)}{.65776}\ \ell n\ AEQTCM\$_{-1} + \underset{(4.1032)}{.38145}\ \ell n\ WM\$$

IV $R^2 = .99705$ SE = .013735 DW = 2.0995 N = 68

Average Earnings Per Quarter--Trade

-18- $\ell n\ AEQTRM\$ = \underset{(4.0204)}{2.0705} + \underset{(7.6805)}{.65745}\ \ell n\ AEQTRM\$_{-1} + \underset{(3.8542)}{.30307}\ \ell n\ WM\$ + \underset{(2.8541)}{.061237}\ \ell n\ MINWUS\$$

IV $R^2 = .99782$ SE = .010968 DW = 2.0507 N = 68

Average Earnings Per Quarter--Construction

-19- $\ell n\ AEQCCM\$ = \underset{(4.2030)}{1.5024} + \underset{(10.935)}{.74258}\ \ell n\ AEQCCM\$_{-1} + \underset{(4.2499)}{.39088}\ \ell n\ WM\$ + \underset{(4.9473)}{.12674}\ DC52 - \underset{(-2.3578)}{.038136}\ DADJRS$

IV $R^2 = .99258$ SE = .027351 DW = 1.9685 N = 68

Average Earnings Per Quarter--Mining

-20- $\ell n\ AEQMIM\$ = \underset{(5.5741)}{3.3399} + \underset{(4.9903)}{.47119}\ \ell n\ AEQMIM\$_{-1} + \underset{(5.7155)}{.53654}\ \ell n\ WM\$ + \underset{(3.9468)}{.12579}\ DMIS$

IV $R^2 = .98336$ SE = .031009 DW = 1.8429 N = 68

Average Earnings Per Quarter--Finance, etc.

-21- $\ell n\ AEQFIM\$ = \underset{(.47902)}{.066662} + \underset{(49.888)}{.99178}\ \ell n\ AEQFIM\$_{-1} + \underset{(1.6658)}{.040404}\ \ell n\ MINWUS\$ - \underset{(-3.8143)}{.44352}\ \Delta \ell n\ AEQFIM\$_{-1}$

OLS $R^2 = .99708$ SE = .013365 DW = 1.9019 N = 70

Average Earnings Per Quarter--Services

-22- $\ell n\ AEQSM\$ = \underset{(2.7721)}{.68642} + \underset{(25.220)}{.90135}\ \ell n\ AEQSM\$_{-1} + \underset{(3.8676)}{.11784}\ \ell n\ MINWUS\$ - \underset{(-2.2697)}{.24498}\ \Delta \ell n\ AEQSM\$_{-1} + \underset{(1.8781)}{.018027}\ DADJRS$

OLS $R^2 = .99480$ SE = .016184 DW = 2.1060 N = 70

Average Earnings Per Quarter--Government

-23- $\ell n\ AEQGM\$ = \underset{(3.6442)}{1.7918} + \underset{(8.5433)}{.69990}\ \ell n\ AEQGM\$_{-1} + \underset{(3.8470)}{.34270}\ \ell n\ WM\$$

IV $R^2 = .99582$ SE = .016702 DW = 1.6402 N = 68

Wages and Salaries

-24- Manufacturing WSMFM$ = AEQMFM$ * EMFM/1000

-25- Transport, etc. WSTCM$ = AEQTCM$ * ETCM/1000

-26- Trade WSTRM$ = AEQTRM$ * ETRM/1000

-27- Construction WSCCM$ = AEQCCM$ * ECCM/1000

-28- Mining WSMIM$ = AEQMIM$ * EMIM/1000

-29- Finance, etc. WSFIM$ = AEQFIM$ * EFIM/1000

-30- Services WSSM$ = AEQSM$ * ESM/1000

-31- Government WSGM$ = AEQGM$ * EGM/1000

-32- Total WSM$ = WSMFM$ + WSTCM$ + WSTRM$ + WSFIM$ + WSSM$
+ WSCCM$ + WSMIM$ + WSGM$ + WSAGM$ + WSOM$

III. Non-Wage Income

Other Labor Income

-33- $\ell n\ YLOM\$ = \underset{(4.9393)}{2.3337} + \underset{(5.0371)}{.30583}\ \ell n\ WSM\$ + \underset{(24.729)}{.025720}\ DTIME + \underset{(8.7898)}{.73253}\ RES_{-1}$

IV $R^2 = .99698$ SE = .035931 DW = 1.9476 N = 71

Entrepreneurial Income

-34- $\ell n\ YENTM\$ = \underset{(3.7324)}{.93313} + \underset{(12.375)}{.75021}\ \ell n\ YENTM\$_{-1} + \underset{(4.4966)}{.15058}\ \ell n\ CPBTUS\$$

OLS $R^2 = .97316$ SE = .028327 DW = 2.0665 N = 71

Property Income

-35- $YPRMS = \underset{(2.3686)}{-122.72} + \underset{(6.3327)}{2.6425}\ PCPIDHSE + \underset{(7.8864)}{14.824}\ RTB\% + \underset{(4.0799)}{13.331}\ YDIVUS\$ + \underset{(8.9095)}{35.294}\ SAUTOT\$ + \underset{(4.1444)}{.47482}\ RES_{-1}$

IV $R^2 = .99916$ SE = 10.210 DW = 1.7410 N = 70

Total Saving in Michigan

$$-36- \quad SAVTOT\$ - SAVTOT\$_{-4} = \underset{(2.6803)}{4.7951} + \underset{(7.4876)}{.26954} \sum_{i=0}^{3} \lambda_i (RAAA\% - RCP\%)_{-i}$$

$$- \underset{(-1.3050)}{.0096929} \sum_{i=0}^{3} \lambda_i ICS_{-i} + \underset{(6.0333)}{.00014311} * 4 * \sum_{i=0}^{3} \lambda_i YPM\$_{-i}$$

$$- \underset{(3.7858)}{.069137} \sum_{i=0}^{3} \lambda_i PCPID_{-i} + \underset{(10.308)}{.85603} RES_{-1}$$

$$\lambda_i = .25, \quad i = 0, 1, 2, 3, \quad \sum_{i=0}^{3} \lambda_i = 1$$

IV $R^2 = .93112$ SE = .16250 DW = 1.7146 N = 67

Social Security Transfer Payments

$$-37- \quad \Delta \ell n\, SSTR\$ = \underset{(1.2840)}{.011443} + \underset{(10.210)}{.55071} \Delta \ell n\, TSSBENLV$$

$$+ \underset{(1.5794)}{.70120} (\ell n\, POP65+ - \ell n\, POP65+_{-4} - \underset{(-2.3528)}{.28606} RES_{-1}$$

OLS $R^2 = .63513$ SE = .026575 DW = 1.7113 N = 67

Unemployment Compensation Transfer Payments

-38- $\ell n\ UCTRM\$ = \underset{(-8.1202)}{-9.6566} + \underset{(6.4117)}{1.3369}\ \ell n\ UCBENLV + \underset{(21.256)}{1.2919}\ \ell n\ UOLDM + \underset{(24.277)}{1.2771}\ \ell n\ UM + \underset{(5.1913)}{.55387}\ RES_{-1}$

IV $R^2 = .93886$ SE = .12841 DW = 2.2224 N = 71

Number of Public Assistance Recipients

-39- $\#PARECPM = \underset{(5.1087)}{42.748} + \underset{(4.7140)}{.51401}\ \#PARECPM_{-1} + \underset{(2.6562)}{.25817}\ \#PARECPM_{-2} + \underset{(5.0605)}{.11422}\ UOLDM + \underset{(7.2515)}{.27447}\ UM + \underset{(4.7862)}{2.9283}\ DWELREV$

IV $R^2 = .99476$ SE = 11.834 DW = 1.8749 N = 70

Public Assistance Transfers

-40- PATRM$ = #PARECPM * PATRAVM$

Total Transfer Payments

-41- YTRANSM$ = SSTRM$ + PATRM$ + UCTRM$ + OTRM$

Contributions to Social Insurance

-42- $$\ell n\ TSIM\$ = \underset{(-3.5300)}{-.94057} + \underset{(31.393)}{.75893}\ \ell n\ TSSRATE + \underset{(45.542)}{1.0235}\ \ell n\ WSM\$ - \underset{(-17.011)}{.52353}\ \ell n \frac{\left(\frac{WSM\$ * 4 * 1000}{EMPM}\right)}{TSSBASE\$} + \underset{(9.2970)}{.73837}\ RES_{-1}$$

IV $R^2 = .99902$ SE = .020006 DW = 1.7714 N = 71

IV. Prices

Detroit Consumer Price Index

-43- $$\Delta \ell n\ PCPID = \underset{(1.2544)}{.0011243} + \underset{(12.673)}{1.0668}\ \Delta \ell n\ PCPIUS - \underset{(3.7265)}{.0090163} \sum_{i=0}^{2} \lambda_i \ell n \left(\frac{UOLDM\%}{UUS\%}\right)_{-i} - \underset{(1.7218)}{.0090187} \sum_{i=0}^{2} \lambda_i \ell n \left(\frac{UM\%}{UUS\%}\right)_{-i}$$

$\lambda_0 = .2$ $\lambda_1 = .35$ $\lambda_2 = .45$ $\sum_{i=0}^{2} \lambda_i = 1$

IV $R^2 = .79394$ SE = .0031685 DW = 2.0858 N = 68

Detroit Consumer Price Index--Housing Component

-44- $$\Delta \ell n\ PCPIDHSE = \underset{(.039905)}{.000049869} + \underset{(3.8557)}{.33159}\ \Delta \ell n\ PCPIDHSE_{-1}$$

$$- \underset{(1.8007)}{.0013824} \sum_{i=0}^{2} \lambda_i (RAAA\% - RCP\%)_{-i} + \underset{(5.9220)}{.72971}\ \Delta \ell n\ PCPID$$

$$\lambda_0 = .41 \quad \lambda_1 = .49 \quad \lambda_2 = .1 \quad \sum_{i=0}^{2} \lambda_i = 1$$

IV $R^2 = .69790$ SE = .0052115 DW = 2.0247 N = 70

V. Labor Force and Unemployment

Labor Force

-45- $$LFM = \underset{(1.4211)}{1240.6} + \underset{(1.5773)}{.55440}\ EMPM + \underset{(1.2656)}{3.1822}\ \left(\frac{UCEXM}{POPM}\right)_{+1} * POPM$$

$$+ \underset{(1.1478)}{.00079149}\ DTIME*POPM$$

IV $R^2 = .97907$ SE = 13.500 DW = 1.6206 N = 15

Unemployment Compensation Exhaustions

-46 $$\ell n\ UCEXM = \underset{(-2.2372)}{-3.5305} + \underset{(1.8539)}{.41391}\ \ell n\ UCEXM_{-1} + \underset{(4.6295)}{1.5602}\ \ell n\ UMOLD_{-1} - \underset{(-2.8295)}{.57617}\ \ell n\ UMOLD_{-2} + \underset{(4.7543)}{1.5457}\ \ell n\ UM_{-1} - \underset{(-2.7692)}{.56220}\ \ell n\ UM_{-2}$$

IV $R^2 = .91980$ SE = .17905 DW = 2.0263 N = 70

Unemployment

-47- UM = LFM - EMPM

Unemployment Rate

-48- $$UM\% = \frac{UM}{LFM} * 100$$

VI. Taxes

Michigan Personal Income Tax--Withholding

-49- $$TYWM\$ = \underset{(-.63300)}{-6.7661} + \underset{(13.385)}{.0071253}\ TYRTM\% * YPADJM\$ - \underset{(1.5206)}{.0014228}\ POPM * TYRTM\% + \underset{(1.3277)}{.30870}\ RES_{-1}$$

IV $R^2 = .99477$ SE = 5.1254 DW = 2.0098 N = 24

Michigan Personal Income Tax--Quarterly Payments

-50- $$TYQM\$ = \underset{(-4.0084)}{-17.297} + \underset{(1.7351)}{.014070}\ YENTM\$ + \underset{(1.4487)}{.0014715}\ YPM\$ + \underset{(1.1767)}{1.6521}\ TYRTM\%$$

IV $R^2 = .85250$ SE = 1.6094 DW = 2.2058 N = 24

Total Income Tax Collections

-51- $$TYM\$ = TYWM\$ + TYQM\$ + TYAM\$ + TYP\&IM\$ - TYRM\$$$

Residual Taxes

-52- $$TRESM\$ = \underset{(5.2669)}{73.252} + \underset{(60.072)}{.82269}\ \frac{YPM\$}{YPUS\$} * TPUS\$$$

IV $R^2 = .98099$ SE = 48.858 DW = 1.7392 N = 72

Retail Sales Tax--Automobiles

$$-53- \quad TRSAUM = \underset{(-2.8362)}{-3.6696} + \underset{(5.0322)}{.50122}\ TRSAUM_{-1} - \underset{(-3.0287)}{.31325}\ \Delta TRSAUM_{-1}$$

$$+ \underset{(3.4543)}{.0082999}\ YTRANSIT_{-1} + \underset{(3.3310)}{1.1796}\ DAS$$

$$+ \underset{(4.2870)}{1.2274} \sum_{i=1}^{3} \lambda_i\ (RAAA\% - RCP\%)_{-i} + \underset{(4.8821)}{.0032271}\ VPERM_{-1}$$

$$\lambda_1 = \lambda_2 = \lambda_3 = .333 \qquad \sum_{i=1}^{3} \lambda_i = 1$$

OLS $R^2 = .95661$ SE = 1.8197 DW = 1.9817 N = 66

$$-54- \quad TRSAUM\$ = TRSAUM * PCDA/100$$

Retail Sales Tax--Foodstores

$$-55- \quad TRSFM\$ = \underset{(1.1945)}{3.0814} + \underset{(1.1566)}{.28703}\ TRSFM\$_{-1} + \underset{(3.2688)}{.0033354}\ YPERMS$$

IV $R^2 = .97721$ SE = .75255 DW = 1.7699 N = 19

Retail Sales Tax--Other (Non-food, non-automobile)

-56- $$TRSOM\$ = \underset{(1.3221)}{10.336} + \underset{(5.3215)}{.83761}\ TRSOM\$_{-1} + \underset{(3.0213)}{3.7682}\ DTSALES + \underset{(1.8736)}{.027208}\ YPERM\$ - \underset{(1.7644)}{.026700}\ YPERM\$_{-1}$$

IV $R^2 = .99345$ SE = 1.5616 DW = 2.0163 N = 19

Retail Sales Tax--Total

-57- TRSM$ = TRSAUM$ + TRSFM$ + TRSOM$

-58- TRSM = TRSM$ * 100/PCPID

VII. Income

Personal Income

-59- YPM$ = WSM$ + YLOM$ + YENTM$ + YPRM$ + YTRANSM$ - TSIM$ + ADJRS$

-60- YPM = YPM$ * 100/PCPID

Disposable Income

-61- YDM$ = YPM$ - TYM$ - TRESM$

-62- YDM = YDM$ * 100/PCPID

Permanent Income

-63,64- $YPERMS = \sum_{i=0}^{5} \lambda_i YDMS_{-i}$ $\quad YPERM = \sum_{i=0}^{5} \lambda_i YDM_{-i}$

$\lambda_0 = .271 \quad \lambda_1 = .217 \quad \lambda_2 = .173 \quad \lambda_3 = .139 \quad \lambda_4 = .111 \quad \lambda_5 = .089 \quad \sum_{i=0}^{5} \lambda_i = 1$

Adjusted Personal Income

-65- YPADJM$ = YPM$ - YTRANSM$ + TSIM$

Transitory Income

-66- YTRANSIT = YDM - YPERM

VIII. Linking Variables

Average Hourly Wage in Manufacturing--United States

-67- $\ell n\ WUS\$ = \underset{(-317.96)}{-2.6472} + \underset{(437.66)}{.80364}\ \ell n\ CMHUS + \underset{(13.718)}{.91647}\ RES_{-1}$

OLS $R^2 = .99965$ SE = .0040619 DW = 2.4134 N = 71

Gross Auto Product

$$-68- \quad GAUTO = \underset{(-3.5297)}{-9.0937} + \underset{(11.642)}{.79300}\ CDAUS + \underset{(3.0218)}{.12112}\ IBF + \underset{(5.3390)}{1.4615}\ DAS - \underset{(-2.2206)}{.66652}\ DAPM + \underset{(2.8641)}{.086865}\ ICS_{-1}$$

OLS $R^2 = .97693$ SE = 1.3328 DW = 1.8449 N = 71

United States Consumer Price Index

$$-69- \quad \Delta \ell n\ PCPIUS = \underset{(1.5468)}{.00073068} + \underset{(17.991)}{1.0475}\ \Delta \ell n\ PCE - \underset{(-1.9279)}{.010616}\ \Delta \ell n \frac{CSUS}{CUS} - \underset{(-1.8207)}{.025401}\ \Delta \ell n \left(\frac{CDAUS + CDFEUS + CDOUS}{CUS} \right)$$

OLS $R^2 = .84668$ SE = .0021504 DW = 2.1754 N = 71

APPENDIX C

ORDINARY LEAST SQUARES EQUATIONS

This appendix contains the ordinary least squares estimation of only those equations whose instrumental variables versions are found in Appendix B. The equation is given the same identification number in both appendices. Unchanged equations are not repeated and block headings have been eliminated. The information provided for each equation is the same as in Appendix B. The mnemonics are again listed in Appendix A.

Employment--Manufacturing

$$-1- \quad \ell n\, EMFM = \underset{(-5.7243)}{-5.1962} - \underset{(-1.8418)}{.30482}\, \Delta\, \ell n \frac{WM\$}{WUS\$} - \underset{(-1.4598)}{.10891}\, \ell n \frac{AEQMFM\$}{PPNF}$$

$$+ \left\{ \underset{(12.514)}{1.9951} + \underset{(9.7496)}{.65250} \frac{GAUTO}{GNP} + \underset{(2.9469)}{.31789} \frac{IBF}{GNP} \right\} \sum_{i=0}^{5} \lambda_i\, GNP_{-i}$$

$$- \underset{(-13.024)}{.017862}\, DTIME + \underset{(2.8588)}{.35998}\, RES_{-1}$$

$$\lambda_0 = .35 \quad \lambda_1 = .25 \quad \lambda_2 = .2 \quad \lambda_3 = .1 \quad \lambda_4 = .05 \quad \lambda_5 = .05 \quad \sum_{i=0}^{5} \lambda_i = 1$$

OLS $R^2 = .98376$ SE = .013412 DW = 1.9787

Employment--Transportation, Communication, and Utilities

$$-2- \quad \ell n\, ETCM = \underset{(-2.9096)}{-.40047} + \underset{(31.553)}{.94237}\, \ell n\, ETCM_{-1} + \underset{(1.7892)}{.082002}\, \ell n\, YPM$$

$$- \underset{(-1.8936)}{.12386}\, \ell n \frac{AEQTCM\$}{PPNF} + \underset{(1.6194)}{.045062}\, \ell n\, EMFM + \underset{(5.7502)}{.23907}\, \Delta\, \ell n\, EMFM$$

OLS $R^2 = .97236$ SE = .010321 DW = 1.7998 N = 71

Employment--Wholesale and Retail Trade

-3- $$\ell n\ ETRM = \underset{(-3.2258)}{-4.5288} + \underset{(14.927)}{.69776}\ \ell n\ ETRM_{-1} + \underset{(2.9872)}{.56802}\ \ell n\ POPM$$

$$+\left\{\underset{(5.5876)}{.21485} + \underset{(4.5060)}{1.2009} \sum_{i=0}^{1} \left(\frac{TRSM}{YDM}\right)_{-i}\right\} \ell n\ YDM$$

$$- \underset{(-3.2230)}{.32686}\ \ell n \frac{AEQTRM\$}{PCPID}$$

$$\lambda_0 = .67 \quad \lambda_1 = .33 \quad \sum_{i=0}^{1} \lambda_i = 1$$

OLS $R^2 = .99699$ SE = .0080174 DW = 1.9880 N = 71

Employment--Finance, Insurance, and Real Estate

-6- $$\ell n\ EFIM = \underset{(-3.5785)}{-.18884} + \underset{(40.832)}{.92020}\ \ell n\ EFIM_{-1} + \underset{(3.7971)}{.063798}\ \ell n\ YPM$$

OLS $R^2 = .99826$ SE = .0071597 DW = 2.0384 N = 71

Employment--Services

-7- $$\ell n\ ESM = \underset{(-3.3851)}{-.27865} + \underset{(43.823)}{.95055}\ \ell n\ ESM_{-1} + \underset{(2.8607)}{.066535}\ \ell n\ YDM$$

OLS $R^2 = .99871$ SE = .0085363 DW = 1.6285 N = 71

Employment--Local Government

-8- $$\ell n\ EGLM = \underset{(-2.1798)}{-1.6130} + \underset{(29.057)}{.86041}\ \ell n\ EGLM_{-1} + \underset{(1.7802)}{.18877}\ \ell n\ POPM + \underset{(3.0504)}{.079125}\ \ell n\ YPM$$

OLS $R^2 = .99846$ SE = .0081103 DW = 1.8519 N = 71

Residual Employment

-12- $$EMRESM = \underset{(10.621)}{1712.2} - \underset{(-7.9775)}{.89260}\ EWSM + \underset{(2.8115)}{.061400}\ YPM + \underset{(1.9374)}{.052941}\ YPM_{-1} + \underset{(1.8764)}{.04918}\ YPM_{-2}$$

OLS $R^2 = .87379$ SE = 15.642 DW = 1.8478 N = 16

Average Hourly Wage in Manufacturing--Michigan

-14- $$\Delta \ell n\ WMS = \underset{(.84464)}{.0015143} + \underset{(3.5634)}{.019420}\ DAUCON + \left\{\underset{(5.2539)}{.79647} + \underset{(5.0411)}{2.5992}\left(\Delta \ell n \frac{GAUTO}{GNP} - .0013687\right) + \underset{(1.2298)}{26.755}\left(\Delta \ell n \frac{PCPID}{PCPIUS} + .00020392\right)\right\} \Delta \ell n\ WUS\$$$

OLS $R^2 = .76074$ SE = .0068090 DW = 2.4319 N = 67

Average Earnings Per Quarter--Manufacturing

-16- $\ell n\ AEQMFM\$ = \underset{(21.176)}{5.1313} + \underset{(5.0141)}{.33664}\ \ell n\ HRSM + \underset{(61.891)}{1.0195}\ \ell n\ WM\$ - \underset{(-2.3643)}{.021479}\ DADJRS$

OLS $R^2 = .99456$ SE = .017730 DW = 1.9888 N = 68

Average Earnings Per Quarter--Transport, etc.

-17- $\ell n\ AEQTCM\$ = \underset{(4.4245)}{2.2522} + \underset{(7.8303)}{.63789}\ \ell n\ AEQTCM\$_{-1} + \underset{(4.6498)}{.40264}\ \ell n\ WM\$$

OLS $R^2 = .99705$ SE = .013728 DW = 2.0533 N = 68

Average Earnings Per Quarter--Trade

-18- $\ell n\ AEQTRM\$ = \underset{(4.4665)}{2.1440} + \underset{(8.0947)}{.64516}\ \ell n\ AEQTRM\$_{-1} + \underset{(4.3119)}{.31461}\ \ell n\ WM\$ + \underset{(2.8979)}{.061945}\ \ell n\ MINWUS$

OLS $R^2 = .99782$ SE = .010966 DW = 2.0230 N = 68

Average Earnings Per Quarter--Construction

-19- $\ell n\ AEQCCM\$ = \underset{(4.3951)}{1.5518} + \underset{(12.231)}{.73400}\ \ell n\ AEQCCM\$_{-1} + \underset{(4.4565)}{.40429}\ \ell n\ WM\$ + \underset{(4.9556)}{.12693}\ DCS2 - \underset{(-2.3518)}{.039729}\ DADJRS$

OLS $R^2 = .99258$ SE = .027346 DW = 1.9486 N = 68

Average Earnings Per Quarter--Mining

-20- $\ell n\ AEQMIM\$ = \underset{(5.3338)}{3.1468} + \underset{(5.3990)}{.50183}\ \ell n\ AEQMIM\$ + \underset{(5.4737)}{.50559}\ \ell n\ WM\$ + \underset{(3.9968)}{.12723}\ DMIS$

OLS $R^2 = .98339$ SE = .030981 DW = 1.9124 N = 68

Average Earnings Per Quarter--Government

-23- $\ell n\ AEQGM\$ = \underset{(3.4618)}{1.6250} + \underset{(9.3076)}{.72777}\ \ell n\ AEQGM\$_{-1} + \underset{(3.6742)}{.31224}\ \ell n\ WM\$$

OLS $R^2 = .99583$ SE = .016685 DW = 1.6938 N = 68

Other Labor Income

-33- $\ell n\ YLOM\$ = \underset{(4.6601)}{2.1382} + \underset{(5.6130)}{.33096}\ \ell n\ WSM\$ + \underset{(25.017)}{.025297}\ DTIME + \underset{(8.8280)}{.73340}\ RES_{-1}$

OLS $R^2 = .99700$ SE = .035825 DW = 1.9394 N = 71

Property Income

-35- $YPRM\$ = \underset{(-3.7808)}{-148.94} + \underset{(8.7816)}{2.8573}\ PCPIDHSE + \underset{(8.4887)}{14.185}\ RTB\% + \underset{(5.9486)}{14.958}\ YDIVUS\$ + \underset{(11.044)}{33.182}\ SAVTOT\$ + \underset{(4.2644)}{.48073}\ RES_{-1}$

OLS $R^2 = .99918$ SE = 10.126 DW = 1.7473 N = 71

Total Savings in Michigan

$$-36- \quad SAVTOT\$ - SAVTOT\$_{-4} = \underset{(3.1113)}{5.3739} + \underset{(7.9057)}{.27836} \sum_{i=0}^{3} \lambda_i (RAAA\% - RCP\%)$$

$$- \underset{(-1.6472)}{.011913} \sum_{i=0}^{3} \lambda_i ICS_{-i} + \underset{(6.5815)}{.00015039} * 4 * \sum_{i=0}^{3} \lambda_i YPM\$_{-i}$$

$$- \underset{(-4.2631)}{.074971} \sum_{i=0}^{3} PCPID_{-i} + \underset{(10.294)}{.85099} RES_{-1}$$

$$\lambda_i = .25 \quad i = 0, 1, 2, 3 \qquad \sum_{i=0}^{3} \lambda_i = 1$$

OLS $R^2 = .93096$ SE = .16299 DW = 1.7003 N = 67

Unemployment Compensation Transfer Payments

$$-38- \quad \ell n\ UCTRM\$ = \underset{(-8.6150)}{-9.9151} + \underset{(6.7049)}{1.3711}\ \ell n\ UCBENLV + \underset{(22.968)}{1.3105}\ \ell n\ UOLDM$$

$$+ \underset{(26.099)}{1.2929}\ \ell n\ UM + \underset{(5.1892)}{.55064}\ RES_{-1}$$

OLS $R^2 = .93907$ SE = .12816 DW = 2.2165 N = 71

Number of Public Assistance Recipients

-39- $$\#\,PARECPM = \underset{(5.0853)}{42.479} + \underset{(4.6894)}{.50930}\ \#\,PARECPM_{-1} + \underset{(2.7046)}{.26200}\ \#\,PARECPM_{-2} + \underset{(5.2887)}{.11672}\ UOLDM + \underset{(7.3192)}{.27591}\ UM + \underset{(4.8458)}{2.9554}\ DWELREV$$

OLS $R^2 = .99476$ SE = 11.883 DW = 1.8606 N = 70

Contributions to Social Insurance

-42- $$\ell n\ TSIM = \underset{(-3.332)}{-.87176} + \underset{(32.076)}{.76448}\ \ell n\ TSSRATE + \underset{(46.174)}{1.0176}\ \ell n\ WSM\$ - \underset{(-17.517)}{.52917}\ \ell n \frac{\left(\frac{WSM\$ * 4 * 1000}{EMPM}\right)}{TSSBASE\$} + \underset{(9.3451)}{.74035}\ RES_{-1}$$

OLS $R^2 = .99902$ SE = .019957 DW = 1.7890 N = 71

Detroit Consumer Price Index

-43- $$\Delta\,\ell n\ PCPID = \underset{(.85858)}{.00067541} + \underset{(13.766)}{1.0880}\ \Delta\,\ell n\ PCPIUS - \underset{(-4.1236)}{.0072442} \sum_{i=0}^{2} \lambda_i\, \ell n \left(\frac{UOLDM\%}{UUS\%}\right)_{-i} - .0091925 \sum_{i=0}^{2} \lambda_i\, \ell n \left(\frac{UM\%}{UUS\%}\right)_{-i}$$

$\lambda_0 = .2 \quad \lambda_1 = .35 \quad \lambda_2 = .45 \quad \sum_{i=0}^{2} \lambda_i = 1$

OLS $R^2 = .79725$ SE = .0031407 DW = 2.1498 N = 68

Detroit Consumer Price Index--Housing Component

-44- $$\Delta \ell n\ PCPIDHSE = \underset{(-.012011)}{-.000014302} + \underset{(3.9231)}{.32823}\ \Delta \ell n\ PCPIDHSE_{-1}$$

$$- \underset{(-1.7937)}{.0013662} \sum_{i=0}^{2} \lambda_i\ (RAAA\% - RCP\%)_{-i} + \underset{(6.9383)}{.74014}\ \Delta \ell n\ PCPID$$

OLS $R^2 = .69793$ SE = .0052111 DW = 2.0177 N = 70

Labor Force

-45- $$LFM = \underset{(2.4434)}{1439.1} + \underset{(1.9918)}{.47479}\ EMPM + \underset{(1.5636)}{2.6082}\ \left(\frac{UCEXM}{POPM}\right)_{+1}\ POPM$$

$$+ \underset{(1.9991)}{.00094608}\ DTIME * POPM$$

OLS $R^2 = .97930$ SE = 13.426 DW = 1.6963 N = 15

Unemployment Compensation Exhaustions

-46- $\ell n\ UCEXM = \underset{(-.29948)}{-.32703} + \underset{(5.5212)}{.84468}\ \ell n\ UCEXM_{-1} + \underset{(4.0378)}{.79031}\ \ell n\ UOLDM_{-1}$

$$- \underset{(-1.9689)}{.41786}\ \ell n\ UOLDM_{-2} - \underset{(-1.7099)}{.22946}\ \ell n\ UOLDM_{-3}$$

$$+ \underset{(4.2168)}{.80445}\ \ell n\ UM_{-1} - \underset{(-1.9492)}{.40823}\ \ell n\ UM_{-2} - \underset{(-1.8971)}{.24661}\ \ell n\ UM_{-3}$$

OLS $R^2 = .93678$ SE = .16124 DW = 1.7209 N = 69

Michigan Personal Income Tax--Withholding

-49- $TYWM\$ = \underset{(-.87335)}{-9.1879} + \underset{(13.319)}{.0069874}\ TYRTM\% * YPADJM\$$

$$- \underset{(-1.2866)}{.0011846}\ POPM * TYRTM\% + \underset{(1.2962)}{.29652}\ RES_{-1}$$

OLS $R^2 = .99479$ SE = 5.1137 DW = 2.0224 N = 24

Michigan Income Tax--Quarterly Payments

-50- $TYQM\$ = \underset{(-4.0195)}{-17.340} + \underset{(1.7201)}{.013942}\ YENTM\$ + \underset{(3.0526)}{.0015020}\ YPM\$ + \underset{(1.4021)}{1.5924}\ TYMRT\%$

OLS $R^2 = .85252$ SE = 1.6092 DW = 2.2027 N = 24

Residual Taxes

-52- $$TRESM\$ = \underset{(5.2524)}{73.035} + \underset{(60.105)}{.82292}\ \frac{YPM\$}{YPUS\$} * TPUS\$$$

OLS $R^2 = .98099$ SE = 48.857 DW = 1.7392 N = 72

Retail Sales Tax--Food

-55 $$TRSFM\$ = \underset{(1.0271)}{2.6295} + \underset{(1.4192)}{.34768}\ TRSFM\$_{-1} + \underset{(3.0611)}{.0030824}\ YPERM\$$$

OLS $R^2 = .97730$ SE = .75106 DW = 1.9080 N = 19

Retail Sales Tax--Other (Non-food, non-automotive)

-56- $$TRSOM\$ = \underset{(1.3807)}{9.0768} + \underset{(5.5464)}{.85377}\ TRSOM\$_{-1} + \underset{(2.1841)}{.023812}\ YPERM\$ - \underset{(-2.0535)}{.023307}\ YPERM\$_{-1} + \underset{(3.0780)}{3.6759}\ DTSALES$$

OLS $R^2 = .99349$ SE = 1.5562 DW = 2.0072 N = 19

APPENDIX D

INSTRUMENTS

This appendix lists the dependent variable and independent variables in each regression equation used to create the instruments. The actual instrument consists of the predicted values obtained from the regression or a function of these values. The equation or equations in which the instrument or a function of it are employed are also indicated--equation numbers are those of Appendix B. Individual regression coefficients are unimportant in this context and are omitted. Mnemonics are those of Appendix A.

Dependent Variable	Independent Variables	Equations in Which Used
ℓn AEQMFM $	ℓn HRSM DADJRS ℓn WUS$ ℓn IBF ℓn YPUS$ ℓn GAUTO	1
Δ ℓn WM$	Δ ℓn WUS$ DAUCON Δ ℓn WUS$*Δ ℓn GAUTO/GNP	1
Δ ℓn EMFM	Δ ℓn YPUS$ Δ ℓn GAUTO/GNP Δ ℓn IBF/GNP Δ ℓn WUS $ Δ ℓn PCPIUS	2
ℓn AEQTCM$	ℓn HRSM ℓn WUS$ ℓn YPUS$ ℓn GAUTO DADJRS	2
ℓn YPM	ℓn YPUS $ ℓn UUS % ℓn PCPIUS GAUTO/GNP IBF/GNP	2, 6, 8

Dependent Variable	Independent Variables	Equations in Which Used
$\left\{.67\,\frac{TRSM}{YDM} + .33\left(\frac{TRSM}{YDM}\right)_{-1}\right\}$ YDM	YPUS$	3
	IBF	
	$\frac{GAUTO}{GNP}$	
	$\left(\frac{GAUTO}{GNP}\right)_{-1}$	
	$\left(\frac{GAUTO}{GNP}\right)_{-2}$	
	$\frac{IBF}{GNP}$	
	$\left(\frac{IBF}{GNP}\right)_{-1}$	
	$\left(\frac{IBF}{GNP}\right)_{-2}$	
	ℓn PCPIUS	
	ℓn WUS%	
$\ell n \frac{AEQTRM\$}{PCPID}$	ℓn HRSM	
	ℓn WUS$	
	ℓn YPUS$	
	$\ell n \frac{IBF}{GNP}$	
	ℓn PCPIUS	
	DADJRS	

Dependent Variable	Independent Variables	Equations in Which Used
ℓn YDM	ℓn YPUS$ ℓn PCPIUS $\frac{GAUTO}{GNP}$ $\frac{IBF}{GNP}$ TPUS$	3, 7
YPM	$\frac{GAUTO}{GNP}$ $\frac{IBF}{GNP}$ GNP IBF GAUTO WUS$	12
EWSM	DTIME PCPIUS $\sum_{i=0}^{5} \lambda_i GNP_{-i}$ $(\sum_{i=0}^{5} \lambda_i GNP_{-i}) \frac{GAUTO}{GNP}$ $(\sum_{i=0}^{5} \lambda_i GNP_{-i}) \frac{IBF}{GNP}$ $\lambda_0 = .35 \quad \lambda_1 = .25 \quad \lambda_2 = .2$ $\lambda_3 = .1 \quad \lambda_4 = \lambda_5 = .05$	12

Dependent Variable	Independent Variables	Equations in Which Used
Δ ℓn PCPID	Δ ℓn PCPIUS Δ ℓn WUS$ ℓn UUS% ℓn YPUS$ ℓn GAUTO / GNP ℓn IBF / GNP	14, 44
ℓn WMS	ℓn UUS% ℓn WUS$ DAUCON GAUTO / GNP IBF / GNP	16, 17, 18, 19, 20, 23
ℓn WSM	ℓn IBF ℓn GAUTO ℓn YPUS$ ℓn UUS% ℓn WUS$ ℓn PCPIUS	33, 42
SAVTOT$	RAAA% - RCP% YPUS$ PCPIUS	35

Dependent Variable	Independent Variables	Equations in Which Used
PCPIDHSE	PCPIUS GNP$ IBF YPUS$ GAUTO $\frac{GAUTO}{GNP}$ $\frac{IBF}{GNP}$ WUS$ UUS% $\sum_{i=0}^{2} \lambda_i (RAAA\% - RCP\%)_{-i}$ $\lambda_0 = .41 \quad \lambda_1 = .49 \quad \lambda_2 = .1$	35
PCPID	PCPIUS WUS$ IBF GAUTO GNP$ UUS% $\frac{GAUTO}{GNP}$ $\frac{IBF}{GNP}$	36

Dependent Variable	Independent Variables	Equations in Which Used
YPM$	YPUS$ GAUTO / GNP IBF / GNP GNP$ IBF GAUTO PCPIUS WUS$	36, 50, 52
ℓn UOLDM	ℓn PCPIUS ℓn WUS$ ℓn UUS% ℓn IBF ℓn GAUTO ℓn YPUS$	38, 46
ℓn UM	ℓn PCPIUS ℓn WUS$ ℓn UUS% ℓn IBF ℓn GAUTO ℓn YPUS$	38, 46
UOLDM	POPM WUS$ GNP IBF	39

Dependent Variable	Independent Variables	Equations in Which Used
UOLDM	↓	
	YPUS$	
	GAUTO	
	UUS%	
	$UUS\%_{-1}$	
	GAUTO/GNP	
	$(GAUTO/GNP)_{-1}$	
	IBF/GNP	
	$(IBF/GNP)_{-1}$	
UM	POPM	39
	UUS%	
	GNP	
	IBF	
	YPUS$	
	GAUTO	
	IBF/GNP	
	PCPIUS	
	WUS$	
ℓn WSM$/EMPM	GAUTO/GNP	42
	ℓn PCPIUS	
	ℓn WUS $	
	ℓn GNP	
	ℓn YPUS $	

Dependent Variable	Independent Variables	Equations in Which Used
ℓn UOLDM%	ℓn IBF ℓn GAUTO ℓn UUS% ℓn WUS$ ℓn PCPIUS	43
ℓn UM%	ℓn IBF ℓn YPUS$ ℓn GAUTO ℓn PCPIUS ℓn UUS% ℓn WUS$	43
EMPM	$\frac{\text{GAUTO}}{\text{GNP}}$ PCPIUS$ WUS$ UUS%	45
YPADJM$	GNP$ IBF YPUS$ GAUTO UUS% $\frac{\text{GAUTO}}{\text{GNP}}$ $\frac{\text{IBF}}{\text{GNP}}$ WUS$	49

Dependent Variable	Independent Variables	Equations in Which Used
YDM$	TPUS$ YPUS$ GNP$ IBF GAUTO $\frac{\text{GAUTO}}{\text{GNP}}$ $\frac{\text{IBF}}{\text{GNP}}$ WUS$	55, 56

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