A Model of Macroeconomic Activity

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Volume II: The Empirical Model

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To My Parents

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Preface

The work described in this volume is a continuation of my effort to try to improve the specification of macroeconomic models. The model presented in this volume is an empirical version of the theoretical model developed in Volume I. Three important features of the theoretical model that distinguish it from earlier models are that it is based on solid microeconomic foundations, it accounts explicitly for disequilibrium effects, and it accounts for all flows of funds in the system. These three features have been carried over to the empirical model.

The methodology of this study is unusual enough to require some explanation. There is, first of all, no unique way to specify an empirical version of the theoretical model; the model is simply too abstract for this to be possible. Thus, although I have been guided closely by the theoretical model in my empirical specification, it will be clear in what follows that my particular specification is not the only one that could be said to be consistent with the theoretical model.

If there is no unique empirical version of the theoretical model, the question immediately arises as to how the theoretical model is to be judged. My answer to this question occurs on page 16 of Volume I:

> The author looks on a theoretical model of the sort developed in this study as not so much true or false as useful or not useful. The model is useful if it aids in the specification of empirical relationships that one would not already have thought of from a simpler model and that are in turn confirmed by the data. It is not useful if it either does

not aid in the specification of empirical relationships that one would not have thought of from a simpler model or aids in the specification of empirical relationships that are in turn refuted by the data.

I argue in Chapter Eight that the present empirical model is confirmed by the data in the sense of its being more accurate than other models. It is also the case that I do not think that I would have been led to the present empirical specifications had I not had the theoretical model as a guide. Consequently, my conclusion is that as of this writing the theoretical model is useful. Whether this conclusion holds up as new models are developed, new tests performed, and new data collected is, of course, unknown. One can never rule out the possibility that a more accurate empirical model will be developed that is based on a different theoretical model.

One of the key assumptions of the theoretical model is that economic agents engage in maximizing behavior. In particular, each of the main behavioral units in the model makes its decisions on the basis of the solution to an optimal control problem. This is what is meant by the statement that the model is based on solid microeconomic foundations. It is true, of course, that economic agents do not actually solve optimal control problems explicitly in making their decisions. The assumption that they do so is used here as it is used in most of microeconomics: as a possibly useful approximation. As just mentioned, my way of testing whether assumptions such as this are useful for macroeconomic model building is to specify a theoretical model based on them, use the theoretical model as a guide to the specification of an empirical model, and then test the empirical model in standard ways. The results that I have obtained so far suggest that the maximizing assumption is useful for the specification of macroeconomic models. Additional tests are needed, however, before one can place too much confidence on this conclusion.

Another basic feature of the theoretical model is that expectations play an important role in influencing people's decisions (i.e., in influencing the solutions to the optimal control problems). For the simulation work in Volume I, most of these expectations were assumed to be formed in simple ways on the basis of past data. This is also true for the work in this volume, in the sense that lagged endogenous and lagged exogenous variables are used as explanatory variables in the stochastic equations to try to capture expectational effects.

It would have been possible for the simulation work in Volume I to use more sophisticated mechanisms of expectation formation. It could have been assumed, for example, that each behavioral unit estimates its own relevant econometric model each period, and uses this model to forecast the future values of the variables that it needs to know in order to solve its control problem. Assumptions similar to this were in fact made for some of

the expectations formed by the banks, the firms, and the bond dealer. (See in particular the discussion on pages 205, 208, and 209 in Volume I.) Banks, firms, and the bond dealer were assumed to estimate from past data some of the key parameters that influence their expectations. Although I have not carried out such experiments, I doubt that the properties of the theoretical model would be changed very much if more of these types of assumptions were made. What is a crucial characteristic of the model, however, is the assumption that behavioral units do not have perfect foresight. This is one of the four characteristics listed on page 3 of Volume I that the model was deliberately designed to have.

Even if more sophisticated mechanisms of expectation formation had been postulated in Volume I, expectations would still have been based on past data. Consequently, I would probably still have been led to use lagged values in the empirical model to try to capture expectational effects. It is true, however, that if expectations of behavioral units are fairly accurate, one might expect actual future values to be better proxies for these expectations than are current and lagged values. I did in fact do some experimentation in the initial development of the empirical model to see if future values of some of the key explanatory variables (e.g., prices, wage rates, and interest rates) explained the current values of the decision variables better than did the current and lagged values of the explanatory variables. This empirical work did not support the use of future values, however, and in the end no future values were used as explanatory variables in any of the equations of the empirical model. The treatment of expectations in the empirical model is discussed in section 1.2 of Chapter One of this volume.

In a model building effort of this sort there are a number of detailed decisions that have to be made about how certain variables are to be treated and about what kinds of data are to be used. Realizing that not everyone is as interested in these details as I am, I have tried to write this volume so that the discussion of these details can be easily skipped or skimmed. In particular, I have relegated most of this discussion to section 1.3 of Chapter One and to Chapter Two. Most of the discussion of econometric issues is contained in Chapter Three, and this material can also be easily skipped or skimmed by readers who are not particularly interested in such things.

The first section of Chapter One, section 1.1, contains a summary of the central features and properties of the empirical model and of the major conclusions reached in this study. For those who are primarily interested in getting a general ideal of the properties of the model and of how it differs from other models, reading this section should be enough. Section 1.2 contains a discussion of some of the basic principles that guided the empirical specification, and section 1.3 contains a discussion of the linking of the national income accounts with the flow-of-funds accounts by sector. Although the details in section 1.3 can be skipped without much loss of continuity, it

should be stressed that the linking of the two accounts is an important part of the present empirical work and has an important effect on the properties of the model.

The complete model is presented in Chapter Two, except for the discussion of the individual stochastic equations. The stochastic equations are explained in Chapters Four, Five, Six, and Seven. These latter four chapters are important in understanding the model, and by considering most of the data and econometric issues in Chapters Two and Three, I have tried to keep Chapters Four through Seven relatively free from discussion other than that directly related to the specification of the stochastic equations. The complete model is presented in tabular form in Tables 2-1, 2-2, and 2-3 in Chapter Two, and these tables are used for reference purposes throughout the rest of the text.

The predictive accuracy of the model is examined in Chapter Eight, and the properties of the model are examined in detail in Chapters Nine and Ten. The properties of the model are examined in Chapter Ten via the computation of optimal controls. Chapter Eleven contains some brief concluding remarks.

This volume can be read without a detailed knowledge of Volume I. One should, however, have some understanding of the theoretical model before reading this volume. At a minimum, Chapters One and Eight (Introduction and Conclusion) in Volume I should be read to get a general idea of the theoretical model.

I would like to stress that the empirical model presented here is not in any direct sense an expanded or revised version of my earlier forecasting model [14]. My interest in developing the forecasting model was to see if an econometric model could be developed that produced reasonably accurate forecasts when used in as mechanical a way as possible. My interest in Volume I, on the other hand, was theoretical and was to develop a general, dynamic macroeconomic model that was based on solid microeconomic foundations and that was not based on the restrictive assumptions of perfect information and the existence of tâtonnement processes that clear markets every period. My interest in this volume, although empirical, is more of an extension of my interest in Volume I than of my interest in the forecasting model. (The forecasting model does, however, provide a good basis of comparison for other models in terms of prediction accuracy, and it has been used for this purpose in Chapter Eight.)

Although my earlier work with the forecasting model has not had a direct effect on the specification of the present model, some of my work with monthly three-digit industry data has. This work is described in references [23], [21], and [15]. The results in these three studies have had an influence on my specification of both the theoretical and empirical models. Some of the links between my work with the monthly three-digit industry data and my work here are discussed in Chapter Five.

I am indebted to a number of people who have commented on my model building effort during the past few years. I would particularly like to thank Gregory Chow, Robert Hall, Donald Hester, Sharon Oster, and James Tobin for comments that led to important additions to this volume. I reluctantly assume responsibility for any errors. Most of this study was financed by grants from the National Science Foundation and the Ford Foundation to the Cowles Foundation for Research in Economics at Yale University.

Ray C. Fair
October 1975

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References

[1] Amemiya, Takeshi, "A Note on a Fair and Jaffee Model," *Econometrica*, XLII (July 1974): 759–762.

[2] Amemiya, Takeshi, "The Nonlinear Two-Stage Least-Squares Estimator," *Journal of Econometrics*, II (July 1974): 105–110.

[3] Board of Governors of the Federal Reserve System, Division of Research and Statistics, *Flow of Funds Table Codes*, July 1975.

[4] Brainard, William C., and James Tobin, "Pitfalls in Financial Model Building," *The American Economic Review*, LVIII (May 1968): 99–122.

[5] Brayton, Robert K., Fred G. Gustavson, and Ralph A. Willoughby, "Some Results on Sparse Matrices," *Mathematics of Computation*, XXIV (October 1970): 937–954.

[6] Brittain, John A., "The Incidence of Social Security Payroll Taxes," *The American Economic Review*, LXI (March 1971): 110–125.

[7] Chow, Gregory C., "A Comparison of Alternative Estimators for Simultaneous Equations," *Econometrica*, XXXII (October 1964): 532–553.

[8] Chow, Gregory C., "On the Computation of Full-Information Maximum Likelihood Estimates for Nonlinear Equation Systems," *The Review o, Economics and Statistics*, LV (February 1973): 104–109.

[9] Chow, Gregory C., and Ray C. Fair, "Maximum Likelihood Estimation of Linear Equation Systems with Auto-Regressive Residuals," *Annals of Economic and Social Measurement*, II (January 1973): 17–28.

[10] Cochrane, D., and G. H. Orcutt, "Application of Least Squares Regression to Relationships Containing Auto-Correlated Error Terms," *Journal of the American Statistical Association*, XLIV (March 1949): 32–61.

[11] Cooper, Richard N., "Implications of the Euro-Dollar for Monetary Policy and the U.S. Balance-of-Payments Deficit," in Robert Z. Aliber, ed., *National Monetary Policies and the International Financial System* (Chicago: University of Chicago Press, 1974): 139–151.

[12] Fair, Ray C., "A Comparison of Alternative Estimators of Macroeconomic Models," *International Economic Review*, XIV (June 1973): 261–277.

[13] Fair, Ray C., "An Evaluation of a Short-Run Forecasting Model," *International Economic Review*, XV (June 1974): 285–303.

[14] Fair, Ray C., *A Short-Run Forecasting Model of the United States Economy* (Lexington, Mass.: D. C. Heath and Co., 1971).

[15] Fair, Ray C., "A Test of Capital-Labor Substitution Using Capacity Data," 1974 (mimeo).

[16] Fair, Ray C., "Disequilibrium in Housing Models," *The Journal of Finance*, XXVII (May 1972): 207–221.

[17] Fair, Ray C., "Efficient Estimation of Simultaneous Equations with Auto-Regressive Errors by Instrumental Variables," *The Review of Economics and Statistics*, LIV (November 1972): 444–449.

[18] Fair, Ray C., "Labor Force Participation, Wage Rates, and Money Illusion," *The Review of Economics and Statistics*, LIII (May 1971): 164–168.

[19] Fair, Ray C., "On the Robust Estimation of Econometric Models," *Annals of Economic and Social Measurement*, III (October 1974): 667–677.

[20] Fair, Ray C., "On the Solution of Optimal Control Problems as Maximization Problems," *Annals of Economic and Social Measurement*, III (January 1974): 135–154.

[21] Fair, Ray C., "Sales Expectations and Short-Run Production Decisions," *The Southern Economic Journal*, XXXVII (January 1971): 267–275.

[22] Fair, Ray C., "The Estimation of Simultaneous Equation Models with Lagged Endogenous Variables and First Order Serially Correlated Errors," *Econometrica*, XXXVIII (May 1970): 507–516.

[23] Fair, Ray C., *The Short-Run Demand for Workers and Hours* (Amsterdam: North-Holland Publishing Co., 1969).

[24] Fair, Ray C., and Dwight M. Jaffee, "Methods of Estimation for Markets in Disequilibrium," *Econometrica*, XL (May 1972): 497–514.

[25] Fair, Ray C., and Harry H. Kelejian, "Methods of Estimation for Markets in Disequilibrium: A Further Study," *Econometrica*, XLII (January 1974): 177–190.

[26] Fromm, Gary, and Lawrence R. Klein, "A Comparison of Eleven Econometric Models of the United States," *The American Economic Review*, LXIII (May 1973): 385–393.

[27] Howrey, E. Philip, and Harry H. Kelejian, "Simulation versus Analytical Solutions: The Case of Econometric Models," Chapter 12, in Thomas H. Naylor, ed., *Computer Simulation Experiments with Models of Economic Systems* (New York: John Wiley and Sons, 1971).

[28] Huang, H. Y., "Unified Approach to Quadratically Convergent Algorithms for Function Minimization," *Journal of Optimization Theory and Applications*, V (June 1970): 405–423.

[29] IBM, *SL-MATH, User's Guide*, First Edition (November 1971).

[30] Klein, Lawrence R., *An Essay on the Theory of Economic Prediction* (Chicago: Markham Publishing Co., 1971).

[31] Loftus, Shirley F., "Stocks of Business Inventories in the United States, 1928–71," *Survey of Current Business*, LII (December 1972): 29–32.

[32] Maddala, G. S., and Forrest D. Nelson, "Maximum Likelihood

Methods for Models of Markets in Disequilibrium," *Econometrica*, XLII (November 1974): 1013–1030.

[33] Malinvaud, E., *Statistical Methods of Econometrics*, second revised edition (Amsterdam: North-Holland Publishing Co., 1970).

[34] McNees, Stephen K., "How Accurate Are Economic Forecasts?" *New England Economic Review* (November/December 1974): 2–19.

[35] McNees, Stephen K., "The Predictive Accuracy of Econometric Forecasts," *New England Economic Review* (September/October 1973): 3–27.

[36] Nordhaus, William, and John Shoven, "Inflation 1973: The Year of Infancy," *Challenge*, XVII (May-June 1974): 14–22.

[37] Powell, M. J. D., "An Efficient Method for Finding the Minimum of a Function of Several Variables without Calculating Derivatives," *Computer Journal*, VII (July 1964): 155–162.

[38] Shavell, Henry, "The Stock of Durable Goods in the Hands of Consumers, 1946–1969," *1970 Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, 241–246.

[39] Young, Allan H., John C. Musgrave, and Claudia Harkins, "Residential Capital in the United States, 1925–70," *Survey of Current Business*, LI (November 1971): 16–27.

[40] U.S. Bureau of Economic Analysis, *Fixed Nonresidential Business Capital in the United States*, 1925–73, reproduced by National Technical Information Service, U.S. Department of Commerce, 1974.

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