AN EVALUATION OF THE LEADING ECONOMIC INDICATORS IN AN ALTERNATIVE MONETARY TRANSMISSION MECHANISM

JOHN E. TRIANTIS

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AN EVALUATION OF THE LEADING ECONOMIC INDICATORS
IN AN ALTERNATIVE MONETARY TRANSMISSION MECHANISM

BY

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M.A., University of New Hampshire, 1976

A DISSERTATION
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in
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August 1, 1978
Date
To my parents
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The purpose of this dissertation is twofold: First, it constructs an alternative transmission mechanism of monetary impulses to real GNP, based on twelve NBER leading indicators, within a general portfolio balance framework. Second, it evaluates the role of the indicators in this mechanism by a contemporaneous and a distributed lag version of the alternative transmission model.

Changes in the leading indicators are transfused to the coincident indicators. Furthermore, monetary changes consistently precede changes in the leading indicators and are strongly related to them. Subsequently, this study sets out to test the hypothesis that the leading indicators constitute important linkages in the process through which monetary impulses are channeled to income via wealth and substitution effects.

It is widely accepted that monetary changes affect income with a lag. To understand the monetary transmission mechanism, it is necessary to understand the monetary lag. This, in turn, necessitates the analysis of the linkages through which monetary impulses affect the economy. While others have used GNP components as the channels through which monetary
impulses are transmitted, our approach employs leading indicators in the transmission process. However, in view of efficient markets hypothesis considerations and the theory of rational expectations, a model using the contemporaneous values of the explanatory variables is also tested.

Our model tests the strength of the postulated linkages by using monthly data for the 1966 to 1976 period and taking the average NBER lags as the correct lag lengths. Based on the experience of time it takes for effects to pass through each channel, most of the linkages provided by the leading indicators are found statistically significant.

The results of the two forms of our model lead us to reject the null hypothesis that the postulated relationships are statistically insignificant. It is not clear, though, that the distributed lag model performs better than the concurrent hypothesis model. It appears that a model with variables combining both contemporaneous and distributed lag forms would be superior to either a pure contemporaneous or lagged model.

The Friedman hypothesis concerning lag relationships between indicators maintains that monetary changes initiate portfolio adjustments, which affect new plant and equipment investment commitments, inventory buying, and the new business formation. Using leading indicators within a general portfolio balance approach, this study elaborates on the nature of the links that connect monetary changes to the leading indicators that eventually effect income. In developing that elaboration and obtaining statistical estimates of these relationships, this study fills some existing voids in the Friedman hypothesis.

This investigation provides support for the monetarist position by constructing an alternative monthly model of the transmission mechanism. However, since the unpredictability of the monetary lag is confirmed,
the policy implication of this study is that a steady growth in the stock of money may be superior to attempts of fine-tuning the economy.
ACKNOWLEDGEMENTS

My interest in monetary theory and policy dates back to 1972 when I was engaged in empirical studies of the demand for money and inflation in several countries. I am very grateful to my former advisor and friend, Professor Elizabeth Bogan, for having guided my first steps in that direction.

When I came to the University of New Hampshire in 1975, this interest was further stimulated by discussions on portfolio and wealth adjustments with Professors Dwayne Wrightsman and William Hosek. Also, my participation in the Finance Workshop provided me the opportunity to work in an ideally suited environment. At this point, economics is an integral part of my being and it is difficult to be certain where or from whom I have learned. I would like, however, to thank the faculty members of the Finance Workshop from whom I learned a great deal about how economists think and should think.

The topic of this dissertation was the product of my own groping for a disaggregated and alternative mechanism to the conventional mechanisms of monetary impulses to the real sector of the economy. I am deeply indebted to my advisor Professor William Hosek for the guidance, advice, and encouragement he so kindly offered me in the pursuit of this research project.

The comments and suggestions of Professor Larry Cole on the empirical part of the dissertation are acknowledged and appreciated. Many thanks are due to Professors James Horrigan, Fred Kaen, and Dwayne Wrightsman for their valuable comments and criticisms and, in
particular, for helping me overcome my ignorance on some topics in the area of finance and for reminding me that an empirical dissertation, if it is not to be a futile exercise in data mining, has to be consistent with widely accepted theories. I also wish to acknowledge Professor Sam Rosen's sound advice on economic methodology and Professor Evangelos Simos' valuable comments concerning the specification of the model.

This study has required a substantial amount of statistical computation which was made possible with the assistance of Jane Clark who obtained the necessary computer program. The editorial comments of Professor James Horrigan are also acknowledged and appreciated. Finally, I wish to thank Fran Hamblin, Val Harrington, and Pat Prescott for their expert typing which they did with such great friendliness and strong sense of humor, often under the most trying of circumstances.

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Durham, New Hampshire   May 30, 1978
CHAPTER 1
INTRODUCTION

Monetary theory has developed two major channels through which changes in the stock of money affect the economy: wealth and substitution (or relative price) effects, though the availability doctrine is often invoked to explain monetary policy influences. Regardless of the analytical framework used, wealth and/or relative price changes are the transmitting instruments of monetary impulses which lead to spending changes and those changes eventually affect income.¹ When a disequilibrium develops between the stock of money in existence and the quantity demanded, wealth and/or relative prices changes and this sets off both substitution and wealth effects.

Changes in relative prices involve changes in the rates of return on real capital and financial assets as well as changes in the prices of goods and services. Some examples of wealth changes that can affect spending are movements in real cash balances or changes in the market value of equities. However, monetary influences may operate through channels that have not yet been identified; in fact, it may not be possible to trace monetary impulses through any particular channel because they may be transmitted to the real sector through an immensely diverse and complicated process of portfolio adjustments.

¹For an excellent survey on the development of monetary theory and policy, see H.G. Johnson (1962) and for a survey of equal quality on the channels of monetary influence, see R.W. Spencer (1974).
Interest in disaggregation subsided more than two decades ago as Keynesian analysis, with its aggregative approach and its prescriptions for stabilizing the economy, superceded Institutionalism. However, extensive NBER studies of business cycles led to two conclusions accepted by all economists: First, business fluctuations arise in a money economy; and, second, business cycles are not merely fluctuations in aggregative activity but are fluctuations that are widely diffused throughout the economy. Furthermore, statistical records produced by the NBER have revealed the consistent and systematic leads of changes in the money supply over other leading economic indicators relative to the turning points of several cycles.

Quasi-monetarist explanations of the business cycle can be traced as far back as John Stuart Mills' Principles of Political Economy. More recently, Milton Friedman and his associates have developed a monetary theory of the business cycle which, together with the evidence assembled, leads them to conclude that ".....there is an extremely strong case for the proposition that sizable changes in the rate of change in the money stock are a necessary and sufficient condition for sizable changes in the rate of change in the money income" (M. Friedman and A.J. Schwartz, [1963, p. 63]). Julius Shiskin (1970) argued for the first time that the three stage patterns of movement in the leading indicators, followed by a similar change in the coincident indicators, which is confirmed, in turn, by the behavior of lagging indicators, could be integrated into the monetarist explanation of business and fluctuations.

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2For a comprehensive historical account on the development of theories on money, credit, and cycles, see Chapter 7, part III; and Chapter 8, part IV in J.A. Schumpeter (1974).
In his examination of the 1920-1967 period, Shiskin concluded that the change in the money supply reached its turns earlier than the index of leading indicators. No cases were found where the leads in money supply changes crossed opposite turning points in the index of leading indicators. Furthermore, no additional cycles in the money supply series were found when it was compared with the leading indicator index. In his conclusion, Julius Shiskin (1970, p. 28) points out that:

...the statistical record is sufficiently clear to support the statement that the change in the money supply leads the leading indicators and does so more consistently and systematically than it leads the business cycle generally. These results are consistent with a causal sequence running from changes in the money supply to the leading indicators to the coincident indicators. Just how this process works is still to be explained.

Whereas some monetarists contend that the channels of monetary influence are diverse and complicated, thus making their identification and measurement impossible to estimate with structural models, J. Shiskin (1970, p. 28) reiterates Friedman's suggestion that:

...changes in the money supply stimulate portfolio readjustments, which affect new investment commitments for plant and equipment, inventory buying, and establishment of new business. In turn, these movements in these leading indicators bring about changes in output and employment. An elaboration of this hypothesis would be highly desirable.

The lead of monetary changes over the NBER's leading economic indicators has been firmly established and the effects of monetary changes on common stock prices -- one of the leading indicators -- have been studied widely. Also, scattered attempts have been made to explain

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3 See, for example, Y.C. Park (1972, p. 39)

the behavior of disaggregated variables, and some of the leading indicators, in terms of real and monetary variables. But, the investigations of the connection between changes in the money supply, or its rate of growth, and the leading indicators cease here. No monetarist explanations have been offered on how changes in the leading indicators affect the coincident indicators and, more specifically, real GNP.

Changes in the leading indicators are eventually transfused to the coincident indicators. However, since monetary changes precede changes in the leading indicators and a strong relationship is shown to exist between turning points in the series of percentage changes in the money supply and the leading indicators, the premise of this study suggests that the leading economic indicators, in and of themselves, constitute a neglected apparatus in the transmission mechanism through which monetary impulses are channeled to income and the other coincident indicators via wealth and substitution effects. That is, this study suggests that the leading indicators not only register and depict the performance of the economy at a particular point on the business cycle, but they also constitute a mechanism through which fluctuations in economic activity can be dampened or accentuated because of expectational effects, in addition to the wealth and substitution effects. Thus, the focus of this research project is to evaluate the role of the leading indicators in the alternative monetary transmission mechanism that we develop.

The evaluation of the leading indicators' role in the monetary process during the 1966 to 1976 period necessitates the construction of an appropriate econometric model. The purpose of the model is to capture the essential features of a monetary transmission mechanism which uses leading indicators as the transmitting linkages that respond to
wealth and relative price changes, as well as to changing expectations of economic units.

In more explicit terms, the intent of this study is to specify and investigate the causal paths from money to the leading indicators, the interactions between them, and their subsequent effects on income. By building upon existing macroeconomic theory, this study will put forth and test hypotheses linking changes in the stock of money to changes in the leading indicators and their eventual effects on real GNP. In doing that, this study will fill the existing void in regard to the Friedman hypothesis mentioned above.

To be worthy of serious attention, this investigation of the role of the leading indicators in the alternative transmission mechanism that we propose should embody a definite and reasonable point of view. Accordingly, the investigation will be conducted within a general portfolio balance framework. Also, whenever appropriate, the influence of one leading indicator on other indicators or real GNP will be based on generally accepted macroeconomic theory.

Monetarists widely accept the hypothesis that monetary changes affect income with a lag. To understand the lag, however, one must examine the channels through which monetary changes affect the economy. This, in turn, necessitates evaluation of the lag in the effect of monetary changes on the basis of experience of the time period required for those effects to pass through each channel of influence. While other investigators have used GNP components as the channels through which monetary impulses are transmitted, this study uses twelve leading economic indicators as the channels or linkages in the transmission process.
The theory and/or hypotheses that are advanced in the construction of the alternative mechanism are centered around percentage changes in the money supply narrowly defined and twelve leading indicators. Once the model explaining the linkages and the workings of this mechanism is constructed, statistical estimation of the parameters and hypothesis testing can be conducted. The NBER ordering of turning points in the series for these leading indicators provides us with a system of distributed lag equations to be tested.

However, the empirical results of the efficient markets hypothesis and the theory of rational expectations imply that there should be no lagged adjustments in the endogenous variables. That is, the adjustment of the dependent variables is realized within the time period of the observations, regardless of the length of the time period, because market participants use all the information currently available and that information is reflected in current market prices and quantities. Thus, in our model, the adjustment of any indicator due to changes in the growth rate of the money supply or other indicators is realized contemporaneously with the changes that cause the adjustment.

Therefore, in view of these two different perspectives of our economic system, two versions of the alternative monetary transmission mechanism are tested in this study: First, the concurrent hypothesis model, which is the model implied by the efficient markets hypothesis and the theory of rational expectations, is tested. Second, the distributed lag hypothesis model, which is implied by the NBER lag structure of turning points in the series of the leading indicators, is also tested.

The construction of the alternative monetary transmission mechanism hinges on a general portfolio balance adjustment process. This framework
can be used to evaluate the role of the leading indicators in our monetary transmission mechanism because the behavior of these indicators is consistent with predictions of the general portfolio balance model. Furthermore, leading indicators not only reflect changes in relative prices, but adjustment to such changes as well.

Since our mechanism uses twelve leading economic indicators to describe the transmission of monetary impulses to income, both versions of our model are only impressionistic approximations of the actual sequence of events that take place. However, the hypotheses we advance cannot be considered unsatisfactory simply because some less important linkages in the transmission mechanism are omitted. As Karl Brunner (1968, p. 102) put it, "If a hypothesis were judged unsatisfactory because some aspects are omitted, all hypotheses are unsatisfactory."

Fiscal policy influences on the leading indicators are omitted primarily because the lead of fiscal variables over the business cycle is unclear, although their potential effects are not explicitly denied. Interest rates and the general price level are not shown in this chain of events because they are not indicators of monetary policy or of economic activity, although their impact on the various indicators is discussed at length. Feedback effects from the coincident indicators, other than real GNP, and from the lagging indicators are simply ignored in order to keep the scope of this project within reasonable limits. Certain other factors, such as recent international monetary developments, are considered external to the system and are omitted for the same reason.

The maintained hypothesis of our model consists of accepting as correct the behavioral assumptions underlying the general portfolio balance framework. The set of the thirteen equations that constitute
our model of the alternative transmission mechanism are not part of the
maintained hypothesis; they are to be tested. For each explanatory
variable in the concurrent influence model, the null hypothesis is that
the coefficient of that explanatory variable is not significantly
different from zero. For each explanatory variable in the distributed
lag hypothesis model, the null hypothesis is that the sum of the weights
of the lag structure adopted from the NBER implied lag structure is not
significantly different from zero. In both cases, the alternative
hypothesis is that the coefficient (or sum of the lag coefficients) is
significantly different from zero and of the expected sign. Thus, a
one-tail t-test with a five percent probability of committing a type-I
error is used throughout.

The importance of this research project includes the following
novelties as well as the statistical findings:

1. The synthesis of theories and the development of hypotheses
   that link monetary changes with the leading indicators and
   their eventual effect on real GNP.

2. The construction of an alternative monetary transmission
   mechanism that uses leading economic indicators as the
   apparatus by which expectations and wealth and relative
   price changes are transmitted to income.

3. The construction of a monthly monetarist model that
   employs institutionalist variables.

This study develops a new transmission mechanism employing leading
indicators as the linkages in that mechanism, and it raises numerous new
questions concerning the specification of such a model. Thus, this
research project lays the foundations for possible future work in a
large area of investigation which is outlined in the concluding chapter.
Chapter Two surveys the literature relevant to the construction of our alternative transmission mechanism. The first section of this chapter reviews the literature on leading indicators. This review examines the timely ordering of the indicators according to median leads over the NBER benchmarks, the rationale behind the indicators, uses of the indicators in predicting turning points in economic activity, and attempts to integrate the monetary change indicator in the body of economic theory that deals with income determination. The second section of this chapter examines some of the characteristics of the leading indicators, such as the definitions for each of the indicators and the statistical properties of these series. The third section presents a brief discussion of different lag structures, while a more extensive treatment of this topic is found in Appendix A. Also, a brief account of the efficient markets hypothesis and of the theory of rational expectations is given. Finally, the fourth section reviews the transmission mechanisms in the portfolio balance approach, the quantity theory, and the wealth adjustment models and the general portfolio balance approach used in this study is outlined.

Chapter Three opens with a short introduction, and then the second section develops the necessary hypotheses and appropriate assumptions for the model of the alternative monetary transmission mechanism. For each linkage, consisting of the individual indicators as the dependent variables, a separate model is advanced in order to explain and evaluate the role of the leading indicators in our mechanism. The thirteen equations that purport to explain the structure of the alternative mechanism are stated in implicit form, with the particular lag structures deferred until the following chapter. This chapter ends with a summary
statement of our model in Section III. The discussion of the various
econometric problems introduced by the specification of our model is
presented in Appendix B.

In Chapter Four, the equations of our model are given specific
functional forms, and the implied NBER lag structure is adopted as the
appropriate lag structure for the transmission of monetary impulses to
real GNP. Also, several rules concerning the estimation of the model are
adopted in this chapter in order to eliminate ad hoc empiricism and "data
mining." The particular functional forms of the concurrent and the
distributed lag hypothesis versions of the model to be estimated are
stated; and finally the null hypothesis, the alternative hypothesis,
and the criterion used for testing the null hypothesis are presented.

In the introduction of Chapter Five, the time period of the study
and the data used in the estimation of our model are discussed in brief,
and the advantages of using a monthly model are given. The second section
presents the statistical results of the concurrent and the distributed lag
versions of the model and gives a brief explanation for each of the
estimated equations. (For the distributed lag equations, the sum of
the coefficients is presented and the weight distributions of the
variables for each equation are tabulated in Appendix C.) Also, the
relative performance of the contemporaneous versus the distributed lag
form of the explanatory variables is discussed. The last section of
this chapter proceeds with the conclusion that, in the absence of a
robust statistical test, the relative performance of either version of
our model cannot be judged superior to that of the other on the basis
of existing statistics.
Chapter Six contains a summary of this study. Some general conclusions are drawn, and the relevance of the results of this study and its implications are discussed. The chapter ends with an outline of perspectives on future research needed for improving the alternative monetary transmission mechanism.
CHAPTER TWO

LEADING ECONOMIC INDICATORS: REVIEW OF THE LITERATURE, CHARACTERISTICS, LAG STRUCTURES, CAUSATION

I. Literature Review of the Leading Indicators

Business cycle indicators have been used to identify and appraise business cycles, as defined by the NBER. Although the economic indicators are extremely valuable for such purposes, it is not clear that they can satisfy the necessary conditions for analytical or policy purposes. According to John Merriam (1973, p. 73) "An ideal indicator is one which both meets the pragmatic test of accurate ex-ante forecasting and is also grounded in a theoretical process of causation within the business cycle." However, the NBER's approach to the study of the economic indicators has been pragmatic and is not directed by adherence to any branch of economic theory.

The present set of economic indicators grew out of earlier work by W.C. Mitchell and A. Burns and by G. Moore and J. Shiskin. Recent work in this area has been carried forward by V. Zarnowitz and C. Boschan (1975). The NBER's work has been a product of the desire to test several business cycle theories against the statistical evidence of

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economic history. Nonetheless, several economists have voiced reservations about the economic theory underlying the NBER's work on business cycles and statistical indicators.  

The leading economic indicators contained in the 1966 short list have been ordered according to their median lead relationship with respect to the NBER's turning point benchmarks as follows:

- Percentage change in the money supply narrowly defined (M1): - 15 months
- Change in consumer installment debt: - 10 months
- Change in manufacturing and trade inventories: - 8 months
- Index of net business formation: - 7 months
- Layoff rate in manufacturing industries: - 6.5 months
- Contracts and orders for plant and equipment: - 6 months
- Housing permits for private housing units: - 6 months
- Average workweek, manufacturing industries: - 5 months
- New Orders for durable goods: - 4 months
- Stock price index, 500 common stocks: - 4 months
- Price per unit labor cost index: - 3 months
- Industrial materials prices: - 2 months
- Corporate profits after taxes: - 2 months

2See, for example, the article by T.J. Koopmans (1947).

3The series used to estimate the reference dates of peaks and troughs of the business cycle include comprehensive input and output measures, such as total employment, real GNP, and industrial production as well as related nominal indicators such as national income and manufacturing and trade sales (V. Zarnowitz and C. Boschan [1975, p. 1]).

4The lead of this indicator is obtained from the revised 1975 short list contained in V. Zarnowitz and C. Boschan (1975).
However, due to changing economic developments, the 1966 NBER was appraised and revised in 1975 by the Bureau of Economic Analysis and a new ordering of leading indicators was obtained. The latest revision of the indicators was as follows:

- Housing permits for private housing units: - 9.5 months
- Percentage change in the money supply narrowly defined (M1): - 9 months
- Average weekly unemployment insurance claims: - 8 months
- Change in consumer installment debt: - 7 months
- Layoff rate in manufacturing industries: - 6.5 months
- Contracts and orders for plant and equipment: - 6 months
- Change in manufacturing and trade inventories: - 6 months
- Stock price index, 500 common stocks: - 5.5 months
- Corporate profits after taxes: - 5.5 months
- Average workweek, manufacturing industries: - 5 months
- Price per unit labor cost index: - 5 months
- New Orders for durable goods: - 3.5 months
- Index of net business formation: - 3 months

Victor Zarnowitz and Charlotte Boschan (1975, p. 1) maintain that the criteria used for selecting the leading indicators provide a direct link between indicator analysis and economic theories bearing on business cycles. The main factors of these theories can be classified in three groups:

1. The interaction between investment and final demand which includes models employing accelerator-multiplier variables, hypotheses emphasizing lags and nonlinearities in investment

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and saving functions, and views stressing the role of innovations and investment opportunities in particular industries;

2. Changes in the money supply, bank credit, interest rates, and the burden of private debt, including both the older credit theories and the current monetarist theories; and

3. Changes in price-cost relations, profit margins and totals, and business expectations that cover the concept of horizontal maladjustments that result in price-cost imbalances as well as the concept of businessmen's errors of overoptimism and pessimism.  

Leading indicators have been ordered in terms of median monthly leads to test causal hypotheses concerning business cycles against the statistical record. However, the usefulness of the leading indicators lies with the intended property of these series to forecast not only turning points in economic activity, but also the amplitude and duration of business downturns. Another function of the leading indicators series is to aid in the ex-ante predictive performance of econometric models. Since the record of ex-ante forecasting with leading indicators has been poor, several other constructs have been created from them in order to improve their predictive capacity.

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6 For a good survey of business cycle theory and research, see V. Zarnowitz (1972).

7 See, for example, D.J. Daly's article and the discussions by O.J. Firestone and H.I. Liebling, in B.G. Hickman (1972).

While L.H. Lempert (1966, p. 38) maintains that leading indicators are "...nothing more than the product of a particular way of looking at the economy we live in," E.C. Bratt (1961) makes a good case for the economic rationale of the series included in the 1966 NBER short list. Bratt defends the usefulness of the leading indicators employed in the derivation of composite and diffusion indexes on the basis that such series refer to indicators of activity rather than to an economically significant total: "...these indicators all pertain to general economic conditions, but do not comprise an economically significant group" [p. 390].

The leading economic indicators exhibit price and quantity changes, represent the investment decision-making stages, reflect the profitability of business firms, and measure labor adjustments in the economy. However, composite indexes, diffusion indexes, and several other types have been constructed to maximize the use of the turning point information contained in the individual series in the business cycle and may given an excessive number of false signals.

The composite leading indicator index is constructed by dividing the monthly rate of change in each series that enters the index by its absolute average rate of change over a given time period. Then, weighted averages of these standardized rates are cumulated over time to form the composite index. The diffusion index, on the other hand, is constructed by adding the number of indicators rising at a given time and taking this number as a percentage of the total indicators entering the index. While

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9This definition is from K.H. Moore (1971).

these and other indexes constructed from the leading indicators may exhibit a lower false-signal rate than the individual indicators, they display a somewhat poorer lead time performance. That is, at times they fail to predict a turning point in advance.

The quantitative predictions of the various indexes constructed from the leading economic indicators have, in most cases, proven superior to those of autoregressions. Also, forecasting business cycle turning points with these indexes has more often than not been more accurate than forecasting with econometric models. Nonetheless, the overall performance of such indexes cannot be judged as adequately reliable for policy actions. And, individual leading indicators are considered unreliable forecasting instruments because of their many false signals and the variable lead time over cycles. At this juncture, we are reminded of Maurice Lee's dictum that: "The trail to sound methods of economic forecasting is littered with the bones of half-right and largely wrong techniques, to say nothing of the bones of those who have tried to use them" (M.W. Lee [1971, p. 576]).

Every leading indicator has been given some rationale for its behavior and economic significance, although the rationale may not fit into a particular theoretical framework. However, the importance of some leading indicators relating to new investment commitments, such as new contracts and orders, housing permits, and housing starts is non-

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11See, for instance, H.O. Stekler and M. Schepsman (1963) and J.E. Maher (1957).


13See, for example, Part two in G.H. Moore (1961, volume1).
controversial. These indicators, in conjunction with surveys of capital expenditure plans, may be used by economists of a Keynesian persuasion in appraising the investment area.\(^\text{14}\)

While the rationale of the influence of monetary factors in economic activity may be traced as far back as John Stuart Mill, Milton Friedman and his associates have provided the theoretical framework and convincing empirical evidence about the role of the rate of the change in the money supply as a leading indicator.\(^\text{15}\) However, as we shall see later, non-monetarists dispute the role of monetary changes as the primary causal agent of cyclical movements in economic activity and the role of the lags in effect of monetary policy.

Clark Warburton (1946) and Beryl Sprinkel (1959) argued that changes in the growth rate of the money supply affect economic activity in a predictable manner and that the relation between this monetary variable and economic activity is stable enough so that cyclical predictions based upon it are possible. In addition to recognizing the importance of the rate of change in the money supply as a leading indicator, Clark Warburton (1950) investigated the role of changes in bank reserves and the income velocity of money. As expected, he found changes in bank reserves leading changes in the money supply which, in turn, lead changes in the velocity of circulation of money.

Most of the work with economic indicators has been carried forward in the United States. However, several other industrial countries have adopted lists of NBER indicators to measure business cycles and for

\(^{14}\)D.J. Daly (1972, p. 1163).

forecasting purposes. Although the behavior of individual leading indicators and indexes constructed from them corresponds to those of the U.S. indicators and indexes, their forecasting record has not proven superior to that in the U.S.\footnote{See, for example, E.J. Chambers (1957), W.A. Beckett (1961), G. Macesich (1962), M.G. Bush and A.M. Cohen (1968), OECD (1969), Japanese Economic Planning Agency (1969), and K.H. Moore (1971).}

Milton Friedman and Anna Schwartz (1963) have presented a monetary theory of the business cycle, and their evidence leads them to conclude that "...there is an extremely strong case for the proposition that sizable changes in the rate of change in the money stock are a necessary and sufficient condition for sizeable changes in the rate of change in money income" [p. 63]. However, Julius Shiskin (1970) argued for the first time that the three stage pattern of movement in the leading indicators, followed by a similar change in the coincident indicators which is confirmed by the lagging indicators' behavior, could be integrated into the monetarist explanation of business fluctuations.

Upon examination of the statistical evidence for the 1920-1967 period, Shiskin found that the change in the money supply reached its turns earlier than the index of leading indicators. He found no cases where the leads in money supply (M1) changes crossed opposite turning points in the index of leading indicators. Furthermore, there were no additional cycles in the money supply series when it was compared with the leading indicator index. Concluding his study, Shiskin points out that:

...the statistical record is sufficiently clear to support the statement that the change in the money supply leads the leading indicators and does so more consistently and systematically than it leads the business cycle generally. These
results are consistent with a causal sequence running from changes in the money supply to the leading indicators to the coincident indicators. Just how this process works is still to be explained (J. Shiskin [1970, p. 28]).

The major purpose of this paper is to model the process suggested by Shiskin. But before we proceed to that task, a detailed examination of the relevant indicators is in order. Thus, in Part A of the following section we shall look at the definitions of the indicators used in this study, while in Part B we shall examine the statistical properties of these series.

II. Characteristics of the Indicators

A. Definitions of the Indicators

Leading economic indicators are usually classified under seven categories that are recognized as strategic processes in business cycles:

1. Employment and unemployment (18 series)
2. Production and income (10 series)
3. Consumption, trade, orders, and deliveries (13 series)
4. Fixed capital investment (18 series)
5. Inventories and inventory investment (9 series)
6. Prices, costs, and profits (17 series)
7. Money and credit (26 series)

All the indicators used for business conditions analysis and forecasts have been evaluated on the basis of six major characteristics. Namely, economic significance, statistical adequacy, consistency of timing at cycle peaks and troughs, conformity to business expansions and contrac-
tions, smoothness, and prompt availability. The leading indicators used in this study received the highest scores and are contained in the 1966 NBER short list, with the exception of the layoff rate series that was selected from the 1975 revised list of indicators to replace the indicator of non-agricultural placements that was eliminated from the short list.

Let us now turn to the definitions of the leading indicators used in this study and their importance in the ebbs and flows of economic activity.

1. Change in U.S. Money Supply (M1); M. Annual rate, percent.

Seasonally adjusted by FRB. This series measures the month to month percent change, at annual rates, in the money supply consisting of the total of the non-bank public's holdings of coins, currency, and demand deposits in commercial banks.

M1 is the money stock narrowly defined to be the sum of (1) demand deposits at all commercial banks other than those due to domestic commercial banks and the US government, less cash items in the process of collection and Federal Reserve float; (2) foreign demand balances at the Federal Reserve Banks; and (3) currency outside the Treasury, Federal Reserve Banks, and vaults of all commercial banks.

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17 For a scoring system that evaluates business cycle indicators for the years 1948-1966 that are contained in the 1966 NBER short list, see J. Shiskin and G. Moore (1967), pp. 3-33.

Source: Board of Governors of the Federal Reserve System, Banking Section.

2. **Net Change in Consumer Installment Debt; (Y1).** Unit: billion dollars, annual rate. Seasonally adjusted by FRB. Consumer installment debt is short and intermediate term credit used to finance the purchase of commodities and services for personal consumption or to refinance debts originally incurred for such purposes. Installment credit includes all consumer credit held by financial institutions and retail outlets that is scheduled to be repaid in two or more installments. Revolving credit and budget and coupon accounts are classified as installment credit.

Specific categories of consumer installment credit include automobile paper, other consumer goods paper, personal loans, and home repair and modernization loans, but it does not include home mortgages. Thus, this series measures the change in the amount of consumer installment debt outstanding during the month. Each monthly change is determined by subtracting the consumer credit repaid during the month from the new credit extended.

Source: Board of Governors of the Federal Reserve System.

3. **Change in Book Value of Manufacturing and Trade Inventories; (Y2).** Unit: billion dollars, annual rate. Seasonally adjusted by BEA. This series measures the month to month change, at annual rate, in the dollar value of inventories held by manufacturing, merchant wholesalers', and retail trade establishments at the end of the period. That is, it measures the difference between inventories held at the end of the current month and the end of the previous month. Changes in the book value of business inventories reflect
movements of replacement costs as well as changes in physical volume. In measuring inventory investment as part of the gross national product, the data are adjusted to remove the effect of changes in replacement costs.


4. Index of Net Business Formation, 1967=100; (Y3). Seasonally adjusted by the Bureau of Census and NBER. This series measures the change in total population of non-farm business concerns in operation. It is equivalent to the difference between the number of new businesses started and the number of businesses discontinued. Business transfers, which reflect only a change in ownership or legal form of organization, have no effect on the figures.

The basic data relate to the entire private economy of the U.S., excluding agricultural activities and professional services. Units counted are "firms" rather than "establishments" and are defined as any business organization, regardless of size, under one management. A concern carrying on a variety of activities is counted only once.

Source: Dun and Bradstreet, Inc., and Bureau of Census

5. Layoff Rate, Manufacturing; (Y4). Unit: number per 100 employees. Seasonally adjusted by NBER. This series is one of a number of turnover rates compiled to measure the flow of workers into and out of employment with individual establishments. The statistics cover all employees on the payroll of an establishment; i.e., they include full- and part-time, permanent and temporary wage and salary workers. Layoffs are unpaid job terminations during the calendar month lasting or expected to last for more than seven consecutive calendar
days. The terminations are initiated by the management without prejudice to the worker and for such reasons as the shortage of orders or materials, the conversion of a plant to a new product, or the introduction of labor saving machinery or process. Layoff rates are estimates of the ratio of the cumulated monthly amounts of the respective turnover items to the total number of employees on the payrolls of the reporting establishments.


6. Value of Contracts and Orders for Plant and Equipment; (Y5). Unit: billion dollars. Seasonal adjustments are made by the Census Bureau. This series measures the dollar value of new contract awards to building and public works and utilities contractors and of new orders received by manufacturers in heavy machinery and equipment industries. It is the sum of (1) value of commercial and industrial contracts, (2) value of privately owned public works and utilities contracts, and (3) value of new orders of manufacturing machinery and equipment industries.

The first component measures the value of contracts for work about to get underway on commercial buildings and manufacturing buildings. The second component measures the value of public works and utilities contracts awarded by private individuals and agencies. The third component of this series measures the volume, in current dollars, of: a) the monthly net new orders received by all durable goods manufacturers, b) manufacturers' new orders of machinery and equipment, c) manufacturers' new orders of defense products, and d) the end of the month orders backlogs of durable goods manufacturers and the change in these backlogs.

7. **Index of New Private Housing Units; (Y6).** Authorized by local building permits, 1967=100. Seasonally adjusted data by the Bureau of Census. A housing unit is defined as a room or groups of rooms intended for occupancy as separate living quarters by a family and containing provision for installed cooking facilities. Each apartment unit in an apartment building is counted as one housing unit. Excluded from the data are group quarters and transient accommodations. Mobile homes are also excluded.

The index of housing units authorized by building permits pertains to all of the approximately 13,000 places in the U.S. which were identified in 1967 as having local building permit systems. For the U.S. as a whole, about 87 percent of all private housing units are currently constructed in permit issuing places. These data relate to the issuance of a permit and not to the actual start of construction. Frequently, several months may pass between the issuance of a permit and the start of construction.


8. **Average Workweek, Manufacturing Industries; (Y7).** Unit: Hours per week. Seasonally adjusted by NBER. This series is derived by dividing the man-hours paid for per week in manufacturing production by the number of production workers employed. The figures cover both full and part-time production and related workers who received pay for any part of the pay period ending nearest the 15th of the month.

This series reflects the effects of shifts in industrial composition (shifts from short-hour industries to long-hour industries and vice versa) as well as such factors as strikes, overtime and part-time work, labor turnover, and accidents. Since the early 1960's the
figures have to an increasing degree, exceeded the number of hours actually worked because of the increasing amount of paid sick leave, holidays, and vacation.


9. **Value of New Orders for Durable Goods; (Y8)**. Placed with manufacturing industries. Unit: billion dollars. Seasonal adjustment of the data by BEA. This series represents the total volume, in current dollars, of new business placed with durable goods manufacturers. New orders are defined as commitments to buy, which are received and accepted by a company, involving either the immediate or future delivery of goods. In the case of durable goods producers, a lag normally exists between the receipt of an order and the shipment of the goods, and this lag gives rise to order backlogs. Since the change in unfilled orders during the month is equivalent to new orders less sales and cancellations, net new orders are computed by adding net sales to the change in unfilled orders during the month.


10. **Index of Stock Prices, 500 Common Stocks; (Y9)**. Industrials, rails, and utilities, Standard and Poor's; 1941-43=10. No seasonal adjustment is considered necessary for this series. This monthly common stock price index is an average of Standard and Poor's weekly composite stock price index, a base-weighted aggregate expressed in relatives, the price of each component stock being weighted by the number of shares outstanding. The aggregate market value is divided by the average weekly values for the period 1941-43, and the quotient multiplied by 10. The index formula is modified to offset arbitrary price changes caused by the issuance of rights, stock dividends,
split ups, and mergers. Use of the 1941-43=10 base permits the level of all stocks listed on the New York Stock Exchange.

Source: Standard and Poor's Corporation.

11. **Price per Unit Labor Cost Index, 1967=100; (Y10).** This series is the ratio of the index of wholesale prices of manufactured goods to the index of compensation of employees per unit of output. The compensation of employees component (labor cost) measures the income received by persons in an employee status as remuneration for their work, including wage and salary disbursements and supplements to wages and salaries - or fringe benefits. Seasonally adjusted data on compensation of employees are converted to an index by the BEA.

The wholesale price index for manufactured goods is designed to measure the direction and the rate of change of the prices of manufactured commodities. The prices used in this index are transaction prices as obtained from manufacturers, taking into account trade and quantity discounts. Normal or published prices are used when they are considered indicative of the market situation or when no other price is available.


12. **Index of Industrial Materials Prices, 1967=100; (Y11).** No seasonal adjustment is considered necessary for this series which measures the spot market price movements of thirteen raw industrial materials on commodity markets and organized exchanges. It is one of two major groupings (the other being foodstuffs) of the BLS index of spot market prices for twenty two basic commodities whose markets
are presumed to be among the first to be influenced by changes in economic conditions. The commodities used in this index are those which are:

1. In wide use for further processing (basic);
2. Freely traded in an open market;
3. Sensitive to changing conditions significant in those markets; and
4. Sufficiently homogeneous or standardized so that uniform and representative price quotations can be obtained over a period of time.

Some commodities (such as crude rubber, tin, etc.) which are important in international trade, are also taken into account in order to reflect the influence of international markets on the economy. Note, however, that this index is an unweighted geometric mean of the individual commodity price relatives, i.e., the ratio of the current price to the base period price. Equal percentage changes in the price of each commodity have the same effect on the index.


13. Corporate Profits After Taxes; (Y12). Unit: billion dollars, annual rate. Seasonally adjusted by BEA. This series is available on a quarterly basis and these figures are obtained by extrapolating the latest benchmark estimates based upon IRS tabulations. The indicator of corporate profits after taxes shows the volume of earnings net of corporate tax liability (federal and state income and excess profits taxes), originating in US Corporations organized for profit. Profits include depletion and exclude domestic dividends received and capital gains and losses, conforming thereby to the national income accounts. Adjustments are made for international flows that affect profits. Monthly figures are obtained from a simple interpolation of the quarterly data.

14. **Gross National Product in Constant (1972) Dollars; (Y13).** Unit: billion dollars, annual rate. GNP is the most comprehensive single measure of aggregate economic output. It represents the market value of the total output of goods and services produced by the nation's economy, before deduction of depreciation charges and other allowances for business and institutional consumption of capital goods. Output is measured by summing the expenditures involved in obtaining final goods and services by the ultimate investors or consumers. Thus, GNP is the total of personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government purchases of goods and services.

GNP measures the output resulting from the labor and property supplied by the nation's residents. Although these factors of production are usually located in this country, GNP also includes profits repatriated from foreign branches of US businesses, earnings of American employees of foreign governments and international agencies stationed in the U.S., and excludes profits repatriated from U.S. branches of foreign businesses and interest dividends paid by Americans to foreigners.

The constant dollar GNP series is derived by dividing components of the seasonally adjusted current dollar series by appropriate price indexes and then summing them to the constant-dollar total. This eliminates the effects of price changes and results in a series which measures the physical volume of output. The monthly series is obtained by a simple interpolation of the quarterly figures.

B. Statistical Properties of the Series

The time range covered by this study spans the 1966 to 1976 period. This time interval covers different phases of the U.S. economy which, during these years, was far from being stationary or anywhere near the steady state growth path. In Table 1, the simple correlation matrix of the variables to be used in our model is presented, while Table 2 exhibits the covariance matrix of the same variables. The statistical analysis of the series involved is presented in Table 3 where, in addition to the mean, standard deviation, kurtosis, and skewness, trend values are presented along with the results of autoregressions.

In Table 1, values of the correlation coefficient, R, greater than .17496 are significant at the 95 percent level of significance. It should be noted, however, that the test based on the statistic \( \frac{1}{2} \ln \left( \frac{1 + R}{1 - R} \right) \) is only approximate and that it is assumed that the given series can be looked upon as a random sample from a bivariate normal population. Nonetheless, most of the correlation coefficients are significant at the 95 percent level and the covariances indicate dependence on the variables. These results are not surprising, since practically all economic time series are interrelated. However, significant correlation coefficients, or non-zero covariances, may introduce problems in the estimation of our model. The nature of these potential problems will be discussed in Appendix B and possible solutions will be offered.

The wide fluctuations of some of the series is evidenced by high standard deviations, while the positively skewed distributions of most of the variables is exhibited by positive Pearsonian coefficients of skewness. In Table 3 positive coefficients of skewness imply that the means of the distributions are higher than their medians and modes and that the tail of the distributions is at the right. Since all coefficients
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Values of R > .17496 are significant at the 95% level.
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<td>20.69</td>
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<td>599.81</td>
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<td>Y13</td>
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<td>545.07</td>
<td>461.86</td>
<td>0.06</td>
<td>254.97</td>
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<td>716.08</td>
<td>264.70</td>
<td>688.09</td>
<td>3213.18</td>
<td>1146.93</td>
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Table 2. Covariance Matrix
### Table 3. Analysis of the Variables

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<th></th>
<th>M</th>
<th>Y1</th>
<th>Y2</th>
<th>Y3</th>
<th>Y4</th>
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<th>Y9</th>
<th>Y10</th>
<th>Y11</th>
<th>Y12</th>
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<tbody>
<tr>
<td>Mean</td>
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<td>15.94</td>
<td>110.64</td>
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<td>34.46</td>
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<td>107.04</td>
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<td>Trend values&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>.11&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Autoregressive constant and t-value</td>
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<td>1.07</td>
<td>3.26</td>
<td>2.59</td>
<td>.11</td>
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<td></td>
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<td>2.72</td>
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<td>Autoregressive coefficient and t-value</td>
<td>.45</td>
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<td>.97</td>
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<td>.98</td>
<td>.90</td>
<td>.98</td>
<td>.99</td>
<td>.98</td>
<td>.99</td>
</tr>
</tbody>
</table>

<sup>a</sup>Origin: June 1971; x-units, 1 month; y-units, values of each variable.

<sup>b</sup>Values are insignificant at the 5 percent level.
of kurtosis are less than 3, all the distributions are platykurtic, which means that the distributions of these variables are rather flat in the middle and have relatively thin tails.

Whereas all indicators display cyclical fluctuations, most of the series exhibit some secular trend. This trend is evident in the series of the price per unit labor cost ratio, the industrial materials prices index, the corporate profits after taxes, and the real GNP series. With no exception, the results of autoregressions indicate strong positive autocorrelation in the series. However, the presence of autocorrelation in the series does not necessarily imply that the residuals obtained from regressions involving other explanatory variables will be autocorrelated. Although serial correlation in the residuals does not affect consistency, it will bias OLS estimates of the parameters unless steps are taken to correct for it.

III. Discussion of Lag Structures

The simple equation, univariate, static linear econometric model of the form

\[ Y_t = a + bX_t \quad ; \quad t = 1, 2, \ldots, n \quad (A.3.1) \]

is a special case of a multivariate dynamic economic model and for empirical purposes may be a poor analogue of real economic behavior. Having specified the regression equation in this manner, we assume that, in fact, the current values of the dependent variable depend on current values, but not on any past values, of the explanatory variable. This implies that the model is an operative depiction of economic behavior

\[ ^{19} \text{Although the discussion of distributed lag models centers around a simple distributed lag model, all results can be generalized when more than one explanatory variable is included.} \]
whereby perfect knowledge is freely available, markets are functioning perfectly, and all adjustments are made instantaneously.

However, as Allen Sinai (1974, pp. 7-8) has pointed out,

When one admits the real world frictions of uncertainty, expectations, search, transaction costs, adjustment costs, institutional restrictions, gestation lags, decision making inertia, hedged reactions, etc., into economic models, lags in economic behavior are almost certain to result.

J. Johnston (1972, p. 379) agrees that it is difficult to find examples of markets where equilibrium values are determined instantaneously and maintains that some adjustment mechanism must be specified in order to advance the realism of the model. Taking a more definite position, Christopher Sims (1973, p. 1) maintains that: "A time series regression model arising in econometric research ought in nearly every case to be regarded as a distributed lag model until proven otherwise."

The pattern of leads in the leading indicators implies that, if changes in the growth rate of the money supply cause changes in the indicators, such changes occur with a lag. As such, the lag pattern of change in the leading indicators provides us with a hypothesis to be tested about the lag in effect of monetary change. Thus, a brief discussion of lags in economic behavior at this point will help set the stage for the tests to follow.

Most economic behavior is characterized by delayed adjustment processes; however, lagged reactions are more prominent in some kinds of economic behavior than in others. For example, consumer patterns, investment behavior, portfolio balance, labor market adjustments and production processes are subject to different costs of search and adjustment, varying transaction delays and gestation periods, and different
inertia and market imperfections. As a result of these frictional restrictions, different adjustment patterns occur.

The history of economic models dealing with lagged adjustments in the dependent variable originated with the work of Irving Fisher and Jan Tinbergen and dates back to the 1930's.\(^{20}\) In the business cycle literature, under the guise of "dynamic multipliers," "flexible accelerator," and "habit persistence," similar topics were also discussed. However, the recent popularity of distributed lags as an operative econometric technique is attributed to the work of L.M. Koyck (1954), P. Cagan (1956), M. Nerlove (1956) and (1958), and S. Almon (1965).

One of the most popular distributed lag models in applied econometrics is Koyck's geometric lag scheme. As the name indicates, the distributed lag coefficients are assumed to be declining continuously according to some geometric series:

\[ b_t = \lambda^t b_0, \quad 0 < \lambda < 1 \]

Starting with a model of the form

\[ Y_t = a + b_0 X_t + b_1 X_{t-1} + \ldots + U_t \]

(2.3.3)

where all the usual assumptions about the error terms are satisfied, this technique obtains

\[ Y_t = a(1-\lambda) + b_0 X_t + \lambda Y_{t-1} + V_t \]

(2.3.4)

as the equation to be estimated. Equation (2.3.4) is an autoregressive lag scheme known as Koyck's transformation.\(^{21}\)

\(^{20}\)For summary accounts of the early development of this subject, see F.K. Alt (1942) and M. Nerlove (1958).

\(^{21}\)For the derivation of this transformation and the other lag structures discussed here, as well as their properties, see Appendix A.
Phillip Cagan (1956) suggested the adaptive expectations model whereby expectations are revised in proportion to the error connected with the previous levels of expectations. This model is based on the hypothesis that the value of $Y_t$ depends not on the actual value of the explanatory variable $X_t$, but, rather, on the expected or permanent level of $X_t$, denoted by $X_t^*$. Since $X_t^*$ cannot be observed directly, we postulate that expectations concerning its value are formed by the rule

$$X_t^* - X_{t-1}^* = \rho (X_t - X_{t-1}^*), \ 0 < \rho \leq 1 \quad (A.3.5)$$

Expectations are revised each period on the basis of the most recent experience and $X_t^* - X_{t-1}^*$ is the change in current expectations. However, expectations are rarely realized in full and realized and expected values are usually different. Thus, $X_t^*$ is partly determined by past expectations and partly by the desire of economic units to eliminate the above difference, by adjusting their expectations in view of the immediate experience. By solving the original form of the model

$$Y_t = a + bX_t^* + U_t \quad (2.3.6)$$

for $X_t^*$ and $X_{t-1}^*$ and substituting in the rule of adaptive expectations (2.3.5), we get that

$$Y_t = ap + (bp) X_t + (1 - \rho) Y_{t-1} + V_t \quad (2.3.7)$$

Equation (2.3.7) is similar to the Koyck transformation model and the similarity between the two models is a direct result of the geometrically declining weight scheme.

Cagan's adaptive expectations model attributes the lags to uncertainty of the future and delay in the process of adjustment between anticipation and realization, while another model is due to the partial adjustment hypothesis. Marc Nerlove (1958) combined the adaptive expectations model with the Koyck transformation procedure to provide a rationale and a simple estimation technique applicable to a wide range
of problems. Nerlove's partial adjustment model uses a lag structure to explain technological, institutional, and/or psychological barriers to making adjustment to a change instantaneously. According to M. Dutta (1975, p. 192), the same model can also be used to express the desire to phase out the increasing costs of rapid changes.

In Nerlove's model, current values of the independent variables determine the desired or "target" value of the dependent variable; hence, the initial model is:

\[ Y_t^* = aX_t + U_t \] \hspace{1cm} (2.3.8)

However, since only some fixed fraction of the desired adjustment is completed within any one particular time period, we obtain:

\[ Y_t - Y_{t-1} = \delta (Y_t^* - Y_{t-1}^*) \] \hspace{1cm} (2.3.9)

Combining equations (2.3.8) and (2.3.9) we get that:

\[ Y_t = a\delta X_t + (1-\delta)Y_{t-1} + \delta U_t \] \hspace{1cm} (2.3.10)

which is the equation of the partial adjustment model. This is an improvement over the previous models, but an obvious limitation of the partial adjustment model is that it is usually unreasonable to assume that the desired value of Y depends only on the contemporaneous value of X.

In several instances, distributed lag models, where the weights of the lag distribution follow a geometrically declining scheme from the present time period into the past, may not be appropriate. The weights of the distribution may be increasing initially and then decline, instead of falling in all successive time periods. This form of lag pattern is specified to be of the "inverted V" type and was suggested by Robert Solow (1960). The values of the weights of this lag distribution are not arbitrarily specified, but are defined by the Pascal function - or Pascal probability function when its variable is regarded as random.
Whereas all autoregressive models assume a scheme of geometrically declining weights, the Almon Lag technique – due to Shirley Almon (1965) – does not assume such a rigid relationship between the distributed lag coefficients. Instead, it assumes that whatever the pattern of successive weights may be, it can be approximated by a polynomial. Thus, the Almon lag technique is a flexible and powerful finite lag specification developed to deal with a wide spectrum of lag forms.

One of the major advantages of the Almon lag technique is its flexibility in the case where the best-fitting lag structure is sought. Also, this is the only model that allows bimodal forms in the distribution of weights. And, in those cases where lag distributions follow such a pattern, it is the only technique that can detect and pick it up. More importantly, however, the serial correlation that plagues the lagged endogenous variable models, the Pascal distribution model, and the rational lag model is less likely to present a problem in the Almon lag technique. Finally, the multicollinearity problem, which is almost always present in models dealing with time series, is of a lower degree here than in the general distributed lag model of the form shown in equation (2.3.3).

In the large U.S. econometric models, monetary impulses are transmitted to the real sector through changes in interest rates, wealth, and credit availability. Nevertheless, all these models show that the monetary influence is realized with a long lag.22 The lag in the effect of monetary policy is of extreme importance in the transmission mechanism.

22For detailed accounts of the various large U.S. econometric models, see B.G. Hickman (1972) and the references to earlier works on these models contained therein.
not only because it bears on the Fed's decisions as to the kind of policy actions it should pursue at a given point in the business cycle, but also because the magnitude, variability, asymmetry, and unpredictability of the monetary lag holds an important role in the rules versus authorities debate. In view of this, let us consider the concept of the lag, since there are at least four different notions of a monetary lag:

1. The time period involved between the change in monetary policy and the time at which monetary effects have been fully absorbed by the economy.

2. The time period elapsing between the change in monetary policy and the date at which a certain proportion of the full effect is realized.

3. A distributed lag that bypasses the problem of the cut-off date at which a given percentage of the full monetary effect is captured.

4. The average length of time between turning points in the money supply series and the ensuing business cycle turning points.

The lag structure implied by the timely ordering of the NBER leading economic indicators according to median leads over the NBER benchmark turning points refers to the average number of months by which the turning points of one series lags behind the turning points of another series.

23 For a detailed statement of the monetary rule position, see M. Friedman (1960); a typical account of the position in favor of discretionary monetary policy can be found in F. Modigliani (1964); and for a criticism of the two views, see T. Mayer (1967). A strong, dogmatic criticism of monetary and fiscal policy actions in elucidated in J.M. Buchanan and R.E. Wagner (1977).

24 These definitions of a lag are due to T. Mayer. For a summary of the various lags estimated, see Tables 1 and 2 in T. Mayer (1967).
The first thing that should be noted about the NBER lag structure is the lack of causality and specification of the paths of influence among the leading indicators. Secondly, the turning point concept of a lag is different from the one envisioned in distributed lag models where the length of the lag can be varied, so as to capture whatever amount of influence on the dependent variable is desired.

Assuming that the NBER lags are correct and that causation among the indicators is correctly specified, the application of distributed lag models to NBER implied lags still presents a limitation. That is, we have no idea what proportion of the total effect involved in the turning point lags the distributed lags will be able to capture. However, if paths of influence are appropriately specified and the implied NBER lag lengths are correct, distributed lag coefficients should be statistically significant. Polynomial distributed lags can accommodate any shape of adjustment patterns in the dependent variable, regardless of what theoretical model generates the adjustment. Hence, the choice of the Almon lag technique to be used in the estimation of a model designed to evaluate the role of the leading economic indicators in the monetary transmission mechanism is dictated by the property of this scheme to present the least damaging econometric problems.

Most expectation models in existing empirical work are of the autoregressive expectations variety including static expectations, adaptive expectations, extrapolative expectations, and error-learning mechanisms. These models in which expectations of a series are based only on the information content of past values of that series are referred to as weak-form hypothesis of forecast formation. Thus, every distributed lag model

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is a special case of the general category of weak-form hypothesis concerning forecast information. Semi-strong and strong-form forecast formations utilize all information available at the present time, including forecasts of the exogenous variables. Eugene Fama (1970) developed the concepts of weak-form, semistrong-form, and strong-form hypothesis tests in the closely related context of efficient markets.\textsuperscript{26} Stated heuristically, a market is efficient if the price fully reflects a certain subset of information available to market participants.

John Rutledge (1974, p. 23) points out that the possibility that economic units may find it beneficial to gather other types of information to produce more accurate forecasts is rarely explored in distributed lag models. However, the idea that market participants have incentives to gather and process information about the economic structure so as to increase the accuracy of their forecasts was advanced by John Muth (1961) who suggests that: "...expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory...we call such expectations 'rational'." [p. 316]. Since one of the major assumptions underlying economic theory is rational behavior, the plausibility of rational expectations is apparent.

Muth's concept of a rational expectation is that it is equal to the prediction of the relevant economic theory. In other words, "An expectations measure that reflects current information more fully than another measure is 'rational' in that it produces more accurate predictions than other alternatives" (J. Elliott [1977, p. 430]). While most studies on the theory of rational expectations treat the world as if information

\textsuperscript{26}For an account of the relationship of these hypotheses to rational expectations, see W. Poole (1976).
costs were zero, one of the insights of this theory is that economists and economic agents collect information for the same reasons and they use the same analytical framework. Furthermore, A. Walters (1971) maintains that if expectations held by economic units are consistent with the data being observed, they will alter the expectations formation mechanism so that their predictions will coincide with observed values.

In order for predictions to be altered so as to coincide with actual observations at a given time period, a rapid adjustment process is necessary. While prices may adjust instantaneously, quantities adjust slower—especially in the case of plant, equipment, and durable goods production. Nonetheless, one possible empirical implication of the rational expectations hypothesis is that the lag operator is carried forward in time, thus generating leads instead of lags. This simply means that the value of the dependent variable is a function of the expected values of the explanatory variables and these expected values are the same as the observed values forward in time. Therefore, distributed leads may be appropriate in testing the rational expectations hypothesis within the theoretical framework using leading indicators as the channels through which monetary impulses are transmitted to income. This, however, lies beyond the scope of this research project.

IV. The General Portfolio Balance Model

Monetarists, like non-monetarists, base their views on the functioning of the economic system upon the assumption they make regarding the real and monetary sectors of the economy. However, prior to examining

\[\text{\textsuperscript{27}}\] For more on this topic, the interested reader is referred to J. Rutledge (1974), especially Chapter 4.
the manner in which monetary impulses are channeled and the assumptions regarding the instruments of influence, consider what is meant by the notion of a monetary transmission mechanism. As Fred Glahe (1973, pp. 270-71) defines it, "The monetary transmission mechanism is the manner in which changes in the money supply produce effects that interact with the real sector to bring about changes in income and the price level."

The essence of the monetary transmission process being set in motion consists of the creation of a monetary disequilibrium which results in changes in relative prices and/or changes in wealth. These changes, in turn, initiate substitution and wealth effects. Substitution effects are triggered through changes in prices of financial assets, real assets, and non-price credit rationing. On the other hand, wealth effects are realized via changes in real cash balances and equity values. Wealth and substitution effects influence spending, but changes in expenditures may result in relative price and/or wealth changes through feedback effects.28

The idea that monetary impulses are transmitted to income is quite picturesquely described by Irving Fisher (1923) who termed business fluctuations as "a dance of the dollar." The importance of money was recognized by Keynes and elements of portfolio adjustment theory are contained in The General Theory, where "the" rate of interest determines how the public apportions its financial wealth between bonds and cash balances. However, modern versions of monetary transmission mechanisms which are based on portfolio and wealth adjustments are primarily due to

28This is adopted from the diagramatic exposition of the monetary transmission process contained in R.W. Spencer (1974, p. 9). For an alternative view of the channels of monetary influence, see F. DeLeeuw and E.M. Gramlich (1969).
the work of Milton Friedman, James Tobin, and Karl Brunner and Allan Meltzer.\textsuperscript{29}

The portfolio balance approach to the monetary transmission mechanism is an extension of Keynesian analysis in design and is also known as the Neo-Keynesian View. Developed in large part by Tobin, this approach has been termed as the eclectic view because it selects those theoretical parts from Keynesian and Monetarist analyses that appear to be best suited to interpreting the effect of monetary impulses on the real sector of the economy. In this approach, it is assumed that there are only three assets; namely, existing capital stock, government bonds, and money, once the private subsectors are subsumed into a single unit and private debt nets out. The crux of the advance in realism in this approach over earlier work consists in that not all nonmoney assets are perfect substitutes for one another and in that other rates of return have to be determined, in addition to the market interest rate. The supply price of capital is the strategic variable in the portfolio balance framework. James Tobin (1961, p. 35) defines the supply price of capital as the required rate of return that induces holders of wealth to absorb the existing stock of capital valued at current prices. The supply price of capital is also considered as the most reliable indicator of monetary policy in this framework. If the marginal productivity of capital is higher than the supply price of capital, an excess demand for real capital goods is created that stimulates price increases of these goods and higher production of real capital.

\textsuperscript{29}For an extensive list of Milton Friedman's contributions to monetary theory, see the bibliography in N. Thygesen (1977). Tobin's most important works on this topic are: J. Tobin (1961), (1965), (1970), (1972), (1974), and D.D. Hester and J. Tobin (1967). Accounts of the work by Brunner and Meltzer are found in K. Brunner (1968), (1970), and (1971) and in K. Brunner and A. Meltzer (1963), (1972), and (1973).
The demand for any asset varies directly with its own yield and inversely with the yield of substitute assets; thus, the composition of portfolios is determined by relative yields and is for Tobin, invariant with respect to the existing stock of wealth in the economy. In this framework, monetary changes work through altering the yield structure on these assets; that is, the effective structure of interest rates can be changed only by changing the relative stocks of assets. While changes in the money supply can alter relative yields and the composition of portfolios, they are by no means unique in that respect. The composition of portfolios and relative yields depend on the relative supplies of all the assets in the community.

The essence of the monetary transmission mechanism in the portfolio balance approach is that changes in the money supply affect relative yields which lead to impacts on the demand for real capital and, hence, on the rate of economic expansion. However, unlike the Quantity Theory or the Keynesian framework where monetary changes lead to unambiguous income changes, the direction of the impact of a change in the money supply - or the supply of securities, for that matter - depends on the degree of substitutability among the various assets held in the portfolios of the private sector. Nonetheless, any action which tends to increase the demand for capital is unambiguously expansionary.

The Quantity Theory approach to the monetary transmission mechanism accepts the permanent income hypothesis and assumes that the portfolios affected by monetary changes contain a wide spectrum of assets. In addition to government securities, various grades of corporate bonds, and equity stocks, portfolios include a variety of other assets that range all

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30 For examples whereby increases in the money supply result in a decrease in income see D. Wrightsman (1976, pp. 199-201) and W. Hosek and F. Zahn (1977, pp. 192-95).
the way down to consumer durables, clothing, skills obtained by
training, and so forth. The purchase of assets is determined by "the
rate of interest;" however, quantity theorists take a wide view of
interest rates. When discussing "the interest rate," quantity theorists
are referring to a construct that includes implicit and explicit yields
or rates of return on all the assets contained in the portfolios of
the community (M. Freidman and D. Meiselman [1963, p. 218]).

An increase in the money supply through, say, open market purchases
of government securities finds commercial banks accumulating excess
reserves and the public holding redundant cash balances. Since there is
no explicit return on additional money holdings, banks and non-bank
holders of newly acquired money will invest in financial securities of
higher yields which are close substitutes for government securities.
Such securities are low-risk corporate bonds, quality mortgages, and,
perhaps, municipals. However, since the short-tun supply of these assets
is assumed fixed in this framework, their prices are pushed up by the
attempt of banks and the public to acquire more of these securities.
With the increase in the price of these assets, a decrease in their
yields results and investors turn to high-risk (low-grade) bonds and
corporate stocks.

As prices of low-grade bonds and corporate stocks rise, investors
acquire non-marketable securities and real assets. However, the adjustment
process towards equalization between desired and actual stocks of assets
does not terminate here: Price increases are diffused throughout the
whole spectrum of assets. That is, price increases for real capital,
stocks of consumer durable goods, and even services occur. The price
increases of all the assets affected result in a higher price level that
decreases the real value of the newly introduced stock of money by
reducing its purchasing power. A new equilibrium is attained and monetary
effects diminish when prices and income have increased sufficiently to
equate the supply of the money stock with the demand for it. According
to the Quantity Theory view, income increases come about by the process
of bidding up prices of real assets. That is, as prices of existing
real assets increase, it becomes more profitable to engage in the
production of new real assets. Increased production of such goods means
a rise in the derived demand for the factors employed in the production
of real capital goods. Also, greater quantities of services are used
as inputs in the increased production of real assets. Thus, a rise in
the growth rate of the money supply results in increased incomes for the
owners of factors of production.31

Introduced and refined by Brunner and Meltzer, the wealth adjustment
approach to explaining the transmission of monetary impulses to the real
sector of the economy is based on a general portfolio balance framework.
While this view considers money as one of the assets included in the
portfolios of the community, it holds that monetary changes are the
dominant cause of changes in income and general economic activity.
In the words of the founders of this approach:

...the interrelation of money with current activity appears
as part of a general wealth adjustment process. The public
adjusts the composition of its balance sheet in response to
relative prices — including interest rates — to achieve a
desired balance sheet position. Variations in output emerge
from this process, particularly in response to the public's
decision to adjust its real capital (K. Brunner and A.
Meltzer [1963, p. 372-73]).

31 For a sample of the analytical aspects of a monetarist transmission
mechanism, see D. Fand (1970) and M. Darby (1976).
In addition to interest rates affecting the demand for money, the stock of wealth is a major determinant of money holdings in individual portfolios, although money balances are not proportional to the total wealth stock, relative to other assets, as was the case in the portfolio balance approach. In the Brunner and Meltzer framework, there are four markets: the money market, the bond (or securities) market, the market for existing capital goods, and the market for current output. Thus, three prices are determined by the wealth adjustment model; namely, the yield on bonds, the yield on existing capital, and the price of current output. The bond yield can be considered as determined by supply and demand conditions in the securities market. The yield on existing capital is determined by forces in the capital goods market that set the price of real capital. Lastly, the price of current output is influenced by the factors underlying aggregate demand and supply conditions in the market for current output.

Starting from a state of equilibrium, let an increase in the money supply take place through open market purchases of government securities. Further, let us assume that money, bonds, and real capital are substitutes, though neither poor nor perfect. In the process of inducing holders to part with them and reduce security holdings from private portfolios, the Fed increases their prices and security yields decline. At the same time, the price of existing capital goods rises, since their relative yield falls. That is, with lower bond yields, or higher bond prices, the yield of existing capital falls and its price rises. Thus far, the effect of an increase in the money supply is to lower the market interest rate and reduce the yield of existing capital relative to newly produced capital goods. In order to assure a definite direction of influence on the price of existing capital goods, the wealth adjustment framework assumes that
the price of existing capital is more closely connected to demand and supply conditions in the money market than it is influenced by supply and demand factors in the securities market.

Once we adopt the Brunner and Meltzer postulate that the price of existing capital is proximately determined by the money market, then, the increase in the money supply has to lead to an increase in the price of existing capital. Changes in the market interest rate and the price of existing capital exert influences on the current output market. Namely, the demand for current output increases as the decrease in the interest rate takes effect. Furthermore, as the price of existing capital goods is bid up, their yield declines relative to newly produced capital goods whose demand shifts out. As the demand for new capital goods rises, the output market responds and moves towards equilibrium once production of capital goods begins accelerating. Increased production of new capital goods also results in higher prices for goods and services that enter into the production of such goods and, therefore, to an increase in income.

The theoretical approach used in the construction of a transmission mechanism from monetary impulses to real GNP is a general portfolio balance approach, similar to the wealth adjustment framework, in which monetary changes are considered the prime causal agent. However, unlike the wealth adjustment approach, our framework does not specify the number of markets or the degree of substitutability among the various assets in the economy. To advance the degree of realism, the supply of assets in the economy is allowed to vary and in contrast to the Quantity Theory, our approach does not assume the existence of the ripple effect from government securities to high-grade bonds, to low-grade bonds, to corporate stocks, to real assets, to consumer non-durables and services.
In our approach, an increase in the growth rate of the money supply affects the yields of all assets. However, our framework does not specify only price changes because quantity changes in all assets — especially financial assets — are possible. Thus, prices and quantities of all assets in the economy are influenced by monetary changes and in the process, the real sector is affected by adjustments in prices and quantities of the assets held in the portfolios of the public. In view of this, our transmission mechanism examines the effect of monetary disturbances on the series of leading economic indicators purporting to measure price and quantity developments in both the financial and the real sectors of the economy. That is, monetary impulses are traced through series whose behavior is incorporated in the general portfolio balance approach.
I. Introduction

The principles of scientific methodology dictate that hypotheses or theories attempting to show the relation of causation to recurrent change must be, among other things, skeptical and undogmatic. Employing an argument that abstracts from the empiricist tradition to establish the independence of causal laws from patterns of events, Christopher Sims (1973) argues that the causal connection between money and income is necessary, actual, and real. While it is generally accepted that economic fluctuations arise only in money economies, this does not imply that money alone is the sole factor generating business fluctuations, although changes in the stock of money may initiate impulses that result in changes in prices, output, and income.

The variables affected by a monetary change are many and may include the leading economic indicators. However, the construction of a monetary transmission mechanism within a general portfolio balance approach based on Institutionalist variables and median lags of indexes requires the integration of the leading economic indicators in the corpus of monetary theory. Restricting the linkages from monetary changes to real GNP to a set of twelve leading indicators may introduce misspecification in the form of the model but, as Kenneth Wallis (1969, p. 784) has indicated,

Unless at some stage one is prepared to neglect the errors induced by regarding as exogenous - for the purpose of the study - variables which may really be endogenous in some more extensive system, one is inexorably led toward construction of a complete macro-economic model.
The integration of the leading indicators in the main body of monetary theory is a difficult task because the conventional monetary transmission mechanisms are based on relative wealth and/or relative price changes. While some of the indicators used here are price indexes themselves and others reflect changes in prices, there are some indicators that simply show developments in particular markets, such as average workweek, for example. Wealth and implicit yields measured on a monthly basis are not available and the effects of changes of these variables on the economy cannot be assessed directly.\(^1\) Furthermore, indicators like the stock price index are only approximations, in this case of the market valuation of the existing capital stock.

Despite these difficulties, a monetary transmission mechanism based on the leading economic indicators can be constructed. What makes the hypothetical notion of linkages provided by these indicators part of a monetary transmission mechanism is not only the observed regularity with which leading indicators follow monetary changes but also their consistent behavior with portfolio and wealth adjustment theories. In view of this, the purpose of this chapter is to develop a theoretical framework and advance hypotheses linking changes in the money stock with changes in the leading indicators. Hypotheses about the relationships among the leading indicators are also advanced. Since the linkages between money and the leading indicators and among the indicators can be stated as a system of equations, the following section specifies the relevant variables entering the implicit and general functional form of the equations con-

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\(^1\) Although yearly estimates of wealth are now available for the U.S. economy, implicit yields on assets cannot be measured.
stituting that system. For organizational purposes, the discussion of the particular lag structures appropriate for our analysis is deferred until Chapter Four. This Chapter ends with a summary statement about the developed system of equations and will mention potential econometric problems involved in its estimation.

II. An Alternative Transmission Mechanism

Starting from a position of general equilibrium - where differences in asset yields reflect characteristics such as time to maturity, default risk, and the variance of expected returns - let us assume that an increase in the money supply takes place through open market purchases of government securities from the public and/or the banking system. To induce holders of government securities to sell, the Fed has to offer those holders higher prices. As a consequence of increased prices, the yield of the securities purchased by the Fed is reduced relative to the yields of other assets in the portfolios of the community. ^2

The change in the relative yield structure in the public's portfolios sets in motion an adjustment process that alters the composition of assets in these portfolios. The degree of substitutability between assets and their relative supplies determine the sequence of the adjustment process between high-grade private securities, lower-grade private securities, equities, and real assets. Moreover, the increase in the money supply implies an initial accumulation of additional excess reserves that induces the commercial banking sector to increase its loans and investments in

^2 Usually, increases in the growth rate of the money supply through printing new money, reduction in reserve requirements, inflow of dollars from abroad, or through any other means have, approximately, the same effect on asset yields through their influence on the implicit yield of reserves.
assets other than government securities it exchanged for money. One of the assets that the commercial banking sector will increase its investments in is commercial paper, since its yield is now higher than the yield of assets already affected by the substitution process.

Starting with the net change in consumer installment debt, we will now construct the linkages of the alternative monetary transmission mechanism and follow hypothetically how the impact of changes in the stock of money is transmitted through the leading indicators to income.

1. Net Change in Consumer Installment Debt: $Y_1$

This series measures the change in the amount of consumer installment debt outstanding during the month. Consumer installment debt is all short and intermediate term credit used to finance the purchase of commodities and services for personal consumption or to refinance debt originally incurred for such purposes. This type of credit includes automobile paper, other consumer goods paper, personal loans, and home improvement loans, but it excludes home mortgages.

The net change in consumer installment debt is a variable quantity which is determined in the market for such debt. Net changes in the supply of consumer installment debt by households can be expressed as:

$$Y_1^S = f(t) [i_{y1}, Y_{13}]$$  \hspace{1cm} (3.1.1)

where, \( \delta Y_1^S / \delta i_{y1} < 0 \) \hspace{1cm} and \hspace{1cm} \( \delta Y_1^S / \delta Y_{13} > 0 \),  \hspace{1cm} (3.1.2)

and where \( i_{y1} \) is the "effective" interest rate which contains, in addition to the explicit interest rate, the costs associated with the amount of down payments, repayment terms of consumer installment debt, etc., and \( Y_{13} \) is GNP in constant dollars. \( f(t) \) is a function intended to approximate any composite lag distribution that may be applicable. In the case of real GNP, for instance, a lag structure on this variable may be interpreted
as a response of consumer installment debt to a real income change that
is perceived to be long lasting. Although the influence of real GNP
on net changes in consumer installment debt is initially positive and
increasing, after some time period the positive influence is diminishing.
This happens because consumer wants may be satiated, and also because
enough savings may have been generated to purchase goods on a cash basis.
The purpose of functions like $f(t)$ is to capture any such type of res-
ponse. The expressions of (3.1.2) tell us that as the "effective" interest
rate rises, households will supply less of this debt, while as real GNP
rises, households tend to increase the amount of consumer installment
debt they are willing to supply.

Net changes in the demand for consumer installment debt by financial
institutions and retail trade concerns can be shown as:

$$\Delta Y_1^d = g(t) [i_{Y_1}, \dot{M}] \quad (3.1.3)$$

where, $\partial Y_1^d/\partial Y_1 > 0$ and $\partial Y_1^d/\partial M > 0 \quad (3.1.4)$

and where $i_{Y_1}$ is defined as before and $\dot{M}$ is the growth rate of the money
supply narrowly defined. The expressions of (3.1.4) indicate that as
the effective interest rate on consumer installment debt rises, more
consumer installment debt is demanded. With an increase in the growth
rate of the money supply through open market purchases of government
securities, the yield on government securities declines and the relative

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3 The notion of real permanent income is closely related to the idea
of applying a distributed lag on real GNP. Permanent income variables
constructed on the basis of different schemes are - in the monetarist
tradition - superior explanatory variables for consumer behavior than
measured real GNP.
yield on consumer installment debt becomes higher. This means that as
financial institutions shift out of government securities, they will
increase their demand for instruments whose relative yields have risen.
Consumer installment debt is one such instrument and financial institu-
tions will demand more of it; that is, they will attempt to increase the
difference between the amount of credit extended and the amount of credit
repaid. This results in a net increase in consumer installment debt.

In order for the consumer installment debt market to be in equilibrium,
we must have:

\[ Y_1^S = Y_1^d \]  \hspace{1cm} (3.1.5)

Solving (3.1.1) and (3.1.3) for \( Y_1 \), setting them equal to each other and
using the equilibrium condition (3.1.5) we obtain:

\[ Y_1 = H[g(t)M, f(t)Y_{13}] \]  \hspace{1cm} (3.1.6)

where, \( \frac{3Y_1}{3M} = g(t)M, f(t)Y_{13} > 0, g' > 0 \) \hspace{1cm} (3.1.7)
and \( \frac{3Y_1}{3Y_{13}} = f(t)Y_{13}, f(t)Y_{13} > 0, f' > 0 \) \hspace{1cm} (3.1.8)

Equation (3.1.6) is the implicit form of the postulated linkage from
monetary changes to net changes in consumer installment debt, with real
GNP as another factor contributing to the determination of the dependent
variable. Although the "effective" interest rate appears in both demand
and supply functions for net consumer installment debt, it is not
measurable as such and it is not critical for our purpose since it does
not enter the reduced form equation.

2. Change in Value of Manufacturing and Trade Inventories: \( Y_2 \)

This series measures the month to month change in the dollar value
of inventories held by manufacturing, wholesale, and retail trade estab-
lishments at the end of the period; i.e., the difference between inventories
held at the end of the current month and the end of the previous month. Changes in the book value of business inventories reflect movements of replacement costs as well as changes in physical volume.

Inventory investment functions have been developed through stock adjustment, flexible accelerator, variable accelerator, and buffer-stock models. Although it is an ex-post realization relationship, the change in the value of manufacturing and trade inventories model is here based on expected sales as its determinant. That is,

\[ Y_2 = g(t)[S^*] \quad (3.2.1) \]

where expected sales \( S^* \) are determined by demand and supply conditions in the economy and

\[ g'(t) > 0 \quad (3.2.2) \]

Demand conditions are approximated by consumption, while supply conditions are determined by what may be called production adaption during a period. Production adaption refers to the adjustment of output according to the availability of input materials, since in the midst of uncertainty about output prices, capital and labor inputs are chosen before actual output prices are observed. When dealing with monthly data, however, production adaption is primarily determined by industrial materials prices. The functional forms of the demand and supply for

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4 For a review of inventory investment models, see M. K. Evans (1969, Chapter 8).

5 For studies using materials input as another factor of production see, for example, M. Denny and D. May (1977), L. Sahling (1977) and the references therein.
expected sales are the following:

\[ S^d = d(C) \]  
and \[ S^s = h(t)[Y_{II}] \]

where \( d' > 0, \partial S^s/\partial Y_{II} > 0, \) and \( h'(t) > 0, \)  

and where \( Y_{II} \) is the index of industrial materials prices.

When an increase in industrial materials prices takes place, the firms affected by this change wish expansion of expected sales so that these price increases may be passed on to buyers of their products. Changes in the value of manufacturing and trade inventories are affected by changes in industrial materials prices via expectations of further price increases of industrial materials, in which case manufacturing and trade related firms want to increase their inventories at prevailing prices rather than at higher prices in the future.

Consumption is postulated to be positively related to net changes in consumer installment debt, to real GNP, and to the growth rate of the money supply. That is,

\[ C = C[a(t)Y_1, b(t)Y_{II3}, c(t)\dot{M}] \]

where \( \partial C/\partial Y_1 > 0, \partial C/\partial Y_{II3} > 0, \partial C/\partial \dot{M} > 0. \)

A rise in the net change of consumer installment debt reflects easier credit availability and/or better terms of credit which facilitates higher demand for consumer goods. When net changes in consumer installment debt show an increase, this implies an increase in the demand for durable and non-durable goods. Responding to the rise in consumer demand, manufacturing and trade related firms increase the physical volume of their inventories, consisting not only of finished goods, but raw materials, and goods in process as well.
Real GNP increases of a permanent nature have a direct and positive effect on consumption, which, in turn affects directly actual sales and indirectly desired sales. Since desired sales affect changes in the value of manufacturing and trade inventories, real GNP has a positive effect on the change in inventories variable. Finally, a rise in the growth rate of the money stock results in portfolio adjustments on the part of households from government securities to other assets, among which are consumer goods. Another channel through which monetary changes affect consumption is the wealth effect. Thus, as the growth rate in the money supply increases, consumption rises, sales rise, the level of desired sales rises, and an increase in the change of value of manufacturing and trade inventories takes place.

Combining equations (3.2.3), (3.2.4), and (3.2.6) we get that:

\[ S^* = F[e(t)Y1, f(t)Y11, h(t)Y13, k(t)\dot{M}] . \]  \quad (3.2.8)

Substituting (3.2.7) into (3.2.1) we obtain:

\[ Y2 = H[e(t)Y1, f(t)Y11, h(t)Y13, k(t)\dot{M}] . \]  \quad (3.2.9)

From (3.2.4), (3.2.6), and (3.2.8) we have:

\[ \frac{\partial Y2}{\partial Y1} = e(t)H_Y1 [e(t)Y1, f(t)Y11, h(t)Y13, k(t)\dot{M}] > 0, e' > 0 \]  \quad (3.2.10)

\[ \frac{\partial Y2}{\partial Y11} = f(t)H_{Y11} [e(t)Y1, f(t)Y11, h(t)Y13, k(t)\dot{M}] > 0, f' > 0 \]  \quad (3.2.11)

\[ \frac{\partial Y2}{\partial Y13} = h(t)H_{Y13} [e(t)Y1, f(t)Y11, h(t)Y13, k(t)\dot{M}] > 0, h' > 0 \]  \quad (3.2.12)

\[ \frac{\partial Y2}{\partial \dot{M}} = k(t)H_{\dot{M}} [e(t)Y1, f(t)Y11, h(t)Y13, k(t)\dot{M}] > 0, k' > 0 \]  \quad (3.2.13)

Equation (3.2.9) is the functional form of the second hypothesized linkage in our mechanism to be estimated.
3. Index of Net Business Formation: Y3

This series measures the change in total population of non-farm business concerns in operation. It is equivalent to the difference between the number of new businesses started and the number of businesses discontinued. The data relate to the entire private U.S. economy, excluding agricultural activities and professional services.

The decision to form a new business concern is, usually, based on long-run considerations such as growth of the economy, profit margins in the particular industries, institutional restrictions, and expected earnings on the investments made. The index of net business formation, on the other hand, is primarily determined by the prevailing climate of optimism of pessimism. In practical terms, optimism or lack thereof is translated into profits; more specifically, expected profits, \( \Pi^* \). Thus, our starting equation is:

\[
Y3 = f(t)[\Pi^*] \quad (3.3.1)
\]

where \( f'(t) > 0 \) \quad (3.3.2)

Abstracting from other considerations, we postulate that expected profits depend on liquidity, \( L \), and demand conditions, \( D \), in the economy. That is,

\[
\Pi^* = g(t) [L,D] \quad (3.3.3)
\]

The reason for this is that increased liquidity facilitates substitution between labor and capital so as to increase actual and expected profits. Also changing demand conditions affect sales which influence actual and expected profits. In our model, liquidity is approximated by the growth rate of the money supply and demand conditions by real GNP, which includes changes in manufacturing and trade inventories. Equation (3.3.3)
now becomes:

\[ \Pi^* = G[a(t)\dot{M}, b(t)Y_{13}] \]  \hspace{1cm} (3.3.4)

where, \( \partial \Pi^*/\partial \dot{M}>0 \) and \( \partial \Pi^*/\partial Y_{13}>0 \) \hspace{1cm} (3.3.5)

An increase in the growth rate of the money supply results in an increase in the index of net business formation primarily through its effect on expected profits. An additional effect of sustained increases in the growth rate of the money supply is channeled to the index of net business formation through substitution effects. That is, as relative yields on financial assets decline, the yield on investments in real assets increases. As a result, successful business firms may establish new subsidiaries, or private investors may very well initiate the formation of new productive units. Furthermore, since peaks in the money supply growth usually occur during economic slowdowns, they result in lower interest rates. With lower interest rates and more readily available credit, the number of business failures is reduced, while new business formation is stimulated. This amounts to an increase in the index of net business formation, which is of a temporary nature because, as economic activity is stimulated, inflation follows and interest rates rise, which lead to a relative decline in the positive effect of the monetary change on the index of net business formation.

The effect of real GNP on the index of net business formation is obvious: as the economy grows, the need for additional firms and resources becomes apparent, although capacity utilization moves upwards during periods of expansion. A sustained rise in real GNP implies a higher corporate profits component. Thus, as profits tend to rise, new business concerns may enter into the various industries in which barriers to entry are not prohibitive. More important, however, is the impact of
increasing real GNP on marginal firms: as aggregate demand increases, prices rise and marginal firms are now able to sell their products in markets in which they previously had difficulty competing.

From equations (3.3.1) and (3.3.4) and the expressions of (3.3.5) we have that:

\[ Y_3 = F[a(t)M, b(t)Y_{13}] \]  
(3.3.6)

where, \( \frac{\partial Y_3}{\partial M} = a(t)F_{a(t)M}, b(t)Y_{13} > 0, a' > 0 \)
(3.3.7)

\[ \frac{\partial Y_3}{\partial Y_{13}} = b(t)F_{b(t)Y_{13}} [a(t)M, b(t)Y_{13}] > 0, b' > 0 \]
(3.3.8)

Equation (3.3.6) is the general form of the third linkage in our mechanism whereby changes in the growth rate of the money supply and real GNP determine the index of net business formation.

4. Layoff Rate, Manufacturing: Y4

This series is one of a number of turnover rates compiled to measure the flow of workers into and out of employment with individual establishments. Layoffs are unpaid job terminations during the calendar month lasting or expected to last for more than seven consecutive calendar days. The terminations are initiated by management for such reasons as the shortage of orders or materials, the conversion of a plant to a new product, or the introduction of labor saving machinery or process.

In postwar business cycles, unemployment has tended to move to higher levels in each cycle, both in numbers and as a proportion of the U.S. labor force.\(^6\) While unemployment is not the same concept as the

\[^6\text{The behavior of unemployment in recent business cycles can be found in a study by G. Cloos (1975).}\]
layoff rate, they are closely related. However, during the period under study, the layoff rate in manufacturing industries displays a very mild trend and generally fluctuates with economic conditions.

The linkage of the layoff rate in our transmission mechanism is developed around the adaptive expectations model:

\[ Y_4 = h(t) [L_t^* - L_{t-1}^*] \]  

(3.4.1)

where, \( L^* \) is the optimum labor input in man-hours per month. According to this model if \( L_t^* - L_{t-1}^* > 0 \), the layoff rate falls and if \( L_t^* - L_{t-1}^* < 0 \), the layoff rate rises. From the general form of the production function \( Q = g(k, L) \) we have that:

\[ L^* = f(Q, K) \]  

(3.4.2)

where, \( \partial L^*/\partial Q > 0 \), and \( \partial L/\partial K < 0 \) \( \) \( (3.4.3) \)

Equation (3.4.2) says that the optimum labor input is a function of output and the capital stock employed. As output rises, optimum labor input increases to facilitate the rise in output. On the other hand, as the stock of capital rises optimum labor input may increase or decrease depending on whether the increase in capital embodies labor saving techniques.

Some of the indicators are components of capital employed or measure changes in its amount. Inventories can be considered a form of capital investment which will generate revenue for a firm in following periods. However, as the change in manufacturing and trade inventories is observed to increase, desired output declines. As output declines, \( L_t^* \) decreases, the difference \( L_t^* - L_{t-1}^* \) declines and the layoff rate increases. That is, when desired output falls, workers on the payrolls of manufacturing industries are laid off to affect the decrease in output.
Net additions to business formation imply higher output which results in a decrease in the unemployment and the layoff rate because more business firms in operation—properly weighted by their relative share of output—means a lower layoff rate and a higher hiring rate. In terms of equation (3.4.2), as the index of net business formation, \( Y_3 \), rises, the gap \( L_t^* - L_{t-1}^* \) becomes positive and the layoff rate declines.

When monetary impulses are diffused throughout the economy, the value of contracts and orders for plant and equipment, \( Y_5 \), is affected. As this variable increases, the layoff rate is expected to fall unless, of course, a rise in \( Y_5 \) is part of a capital intensive technological change aimed at reducing labor costs. An increase in the value of contracts and orders for plant and equipment, \( Y_5 \), is equivalent to an increase in capital investment. As capital increases, \( L_t^* \) increases and the difference \( L_t^* - L_{t-1}^* \) rises and the layoff rate declines. However, if new contracts and orders for plant and equipment involve labor saving techniques, then, as \( Y_5 \) rises \( L_t^* \) declines, the gap \( L_t^* - L_{t-1}^* \) decreases, and the layoff rate increases.

In view of the arguments presented, we obtain that:

\[
Y_4 = H[a(t)Y_2, b(t)Y_3, c(t)Y_5]
\]

where,

\[
\frac{\partial Y_4}{\partial Y_2} = a(t)H_{Y_2}[a(t)Y_2, b(t)Y_3, c(t)Y_5] > 0, \quad a' > 0
\]

\[
\frac{\partial Y_4}{\partial Y_3} = b(t)H_{Y_3}[a(t)Y_2, b(t)Y_3, c(t)Y_5] < 0, \quad b' < 0
\]

\[
\frac{\partial Y_4}{\partial Y_5} = c(t)H_{Y_5}[a(t)Y_2, b(t)Y_3, c(t)Y_5] < 0, \quad c' < 0
\]

Equation (3.4.4) is the fourth linkage of our mechanism to be estimated, whereby the layoff rate is determined by changes in manufacturing and
trade inventories, by the index of net business formation, and by the value of contracts and orders for plant and equipment. Notice that the influence of the value of orders for new durable goods is channeled through indirectly on the layoff rate via the other explanatory variables.

5. Value of Contracts and Orders for Plant and Equipment, Y5

This series is the sum of the value of commercial and industrial contracts, the value of privately owned public works and utilities contracts, and the value of manufacturers', new orders, machinery, and equipment industries. Defined as such and properly adjusted, this series measures approximately the volume of new private investment commitments in current dollars by summing selected new orders and contract-awards data.

Using a stock adjustment model we have:

\[ Y5 = g(t)K_t^* - K_{t-1}^*, \quad g(t) > 0 \]  \hspace{1cm} (3.5.1)

where, \( K_t^* \) is the desired capital stock in the present time period and \( K_{t-1} \) is the actual stock of capital in the previous time period. According to this model, if \( K_t^* - K_{t-1}^* > 0 \), \( Y5 \) rises and if \( K_t^* - K_{t-1}^* < 0 \), \( Y5 \) falls.

From the Cobb-Douglas production function \( Q = AL^aK^b \), we have the following profit maximizing condition:

\[ K^* = \frac{\beta Q}{r} \]  \hspace{1cm} (3.5.2)

where, \( r \) is the nominal user cost of capital. It consists of (a) the opportunity cost of using capital (the market interest rate), plus (b) depreciation of capital over the period of use, minus (c) any capital gains received by the owner over the period.\(^7\)

\(^7\)For a discussion of the shadow price called nominal user cost of capital, see F. Wycoff (1976, pp. 186-187).
As the growth rate of the money supply increases, \( r \) declines by virtue of the decline in the market interest rate, \( K^* \) rises, and \( Y_5 \) increases. That is,
\[
\frac{\partial K^*}{\partial M} > 0 \tag{3.5.3}
\]
Contracts and orders for plant and equipment as a component of investment \((\Delta K)\) are influenced by changes in the stock of money in the following manner. With an increase in the growth rate of the stock of money, relative yield structures are altered and the well known portfolio adjustments on the part of business firms take place. As they move out of government securities to other financial assets and to investment in real assets, they depress their yields successively by bidding up their prices. Yields on existing capital goods - of which plants and equipment are the major part - are depressed as well, which means that the relative yield of newly constructed plants and equipment is now higher.

The indicator of contracts and orders for plant and equipment represents one form of investment that is affected by price expectation changes which originate with monetary changes and which have a broad impact upon total investment:

Since to anticipate a general inflation of prices is also to anticipate a depreciation in the value of money, the expectation of a rising price level heightens the value of all real assets (including newly produced real assets) relative to money and other assets the value of which is fixed in terms of money. The marginal efficiency of capital schedule is shifted upward. (J. P. Lewis and R. G. Turner [1967, p. 205]).

However, this does not necessarily mean that inflationary expectations will invariably stimulate investment in real assets because the same expectation that raises the marginal efficiency of capital schedule may prompt lenders to demand higher premiums for parting with their liquidity.
In the face of expectations of general inflation, both the nominal market interest rate and the rate of change in the price of capital increase and the effect on the nominal user cost of capital is ambiguous. Also, given the corporate tax structure, an increase in the rate of inflation can lower the after tax real rate of return and, therefore, induce a reduction in real investment. Thus, while in times of price stability monetary changes have a positive influence on the desire capital stock, during inflationary periods the relation shown in (3.5.3) may be violated and the possibility that $\frac{\partial K^*}{\partial M} < 0$ must be admitted.

Net new business formation is an obvious factor influencing output; that is, as $Y_3$ increases output rises. However, in order for output to rise, $K^*$ must also rise, as seen from (3.5.2). That is,

$$\frac{\partial K^*}{\partial Y_3} = \frac{\partial K^*}{\partial Q} \frac{\partial Q}{\partial Y_3} > 0$$

(3.5.4)

Also, an increase in household investment in new durable goods results in higher desired output. To meet an increased demand for durables, manufacturing industries first increase their capacity utilization and then increase their productive capacity by expanding their desired capital stock. Thus, we have:

$$\frac{\partial K^*}{\partial Y_8} = \frac{\partial K^*}{\partial Q} \frac{\partial Q}{\partial Y_8} > 0$$

(3.5.5)

As a result of the arguments presented above, the functional form of (3.5.1) now becomes:

$$Y_5 = h(t)[a(t)Y_3, b(t)Y_8, c(t)M]$$

(3.5.6)

or,

$$Y_5 = H[a(t)Y_3, b(t)Y_8, c(t)M]$$

(3.5.7)

Equation (3.5.7) constitutes the fifth linkage to be estimated in our
mechanism, where we have that:

\[
\frac{\Delta Y_5}{\Delta Y_3} = a(t)H_{Y_3}(a(t)Y_3, b(t)Y_8, c(t)\dot{M}) > 0, \ a' > 0 \tag{3.5.8}
\]

\[
\frac{\Delta Y_5}{\Delta Y_8} = b(t)H_{Y_8}(a(t)Y_3, b(t)Y_8, c(t)\dot{M}) > 0, \ b' > 0 \tag{3.5.9}
\]

\[
\frac{\Delta Y_5}{\Delta \dot{M}} = c(t)H_{\dot{M}}(a(t)Y_3, b(t)Y_8, c(t)\dot{M}) < 0, \ c' < 0 \tag{3.5.10}
\]

6. Index of Housing Permits, Private Units: \( Y_6 \)

The index of housing units authorized by building permits pertains to all of the approximately 13,000 places in the U.S. which were identified in 1967 as having local building permit systems. For the nation as a whole, about 85 percent of all private housing units are currently constructed in permit issuing places. These data relate to the issuance of permits and not to the actual start of construction. Frequently, several months may pass between the issuance of a permit and the start of construction.

Dynamic models used in studies of the demand for housing units and durable goods are essentially partial wealth adjustment or stock adjustment models. In our model, the index of housing permits for private units as a measure of housing demand is based on a wealth adjustment model of the form:

\[
Y_6 = f(t)[W^*_t - W^*_t-1, f'(t) > 0 \tag{3.6.1}
\]

where \( W^* \) is the optimum stock of wealth defined as \( W^* = aw_{NM} + bM \). \( w_{NM} \) is the non-monetary component of wealth which includes real assets held by the private sector and government bonds and \( M \) is the component of wealth consisting of the stock of money narrowly defined.

---

\( ^8 \)See, for example, the studies contained in A. Harberger (1960).
This definition of wealth differs from the conventional definition which includes only capital assets and "outside" financial assets, i.e., government bonds and the monetary base. The difference in our definition consists of the inclusion of demand deposits, which are "inside" assets, as part of wealth. Since the index of housing permits is a quantity variable, price changes are not included explicitly in (3.6.1); however, the effect of price changes on each of the wealth components is reflected in the coefficients $a$ and $b$ which may be different than one. Thus, in addition to indirect wealth effects, our definition of wealth allows monetary policy changes to affect direct wealth effects on the economy.

In the absence of a reliable monthly measure of non-monetary wealth, permanent income, $Y^p$, is used as an approximation and the definition of wealth becomes:

$$W^*_t = aY^p_t + bM_t$$  \hspace{1cm} (3.6.2)

also,

$$W^*_{t-1} = aY^p_{t-1} + bM_{t-1}$$  \hspace{1cm} (3.6.3)

Subtracting (3.6.3) from (3.6.2) we obtain:

$$W^*_t - W^*_{t-1} = a(Y^p_t - Y^p_{t-1}) + b(M_t - M_{t-1})$$  \hspace{1cm} (3.6.4)

---

10 For a good summary of the wealth effects of monetary and fiscal policies, see L. H. Meyer (1974).

11 The use of permanent income as a proxy for wealth originated with M. Friedman (1956, Chapter I) and 1957). For a recent study following such use see, for example, B. Klein (1977).
But, since permanent (or normal) income grows at a constant rate, c, over the short run, we have:

\[ W_t^* - W_{t-1}^* = a c Y_t^p + b(M_t - M_{t-1}) \]  (3.6.5)

Hence, \( Y6 = f(t)[eY_t^P + b(M_t - M_{t-1})] \), (3.6.6)

where \( e = ac \).

The effect of permanent income on the index of housing permits for private units is mostly realized through changes in wealth. That is, as permanent income increases, wealth increases and the decision of households is affected in the direction of channeling their past savings into investment in private housing units. A sustained increase income generates or reinforces household confidence concerning their ability to meet mortgage payments. Thus, the role of permanent income may also be expectational in the sense that it influences the extent to which planned investments in new private housing units are initiated.

It is an empirically established fact that the housing sector of the economy displays the most elastic response to changes in monetary policy. As the stock of money increases, interest rates fall due to increased liquidity in the commercial banking sector and the always lagging mortgage loan rates decline, thus resulting to an increase in housing permits applied for and received. Another route through which housing permits and the subsequent housing construction are affected by monetary changes in through portfolio adjustments that occur on the part of individual household units. A third path through which changes in the money supply can influence or induce household units to invest in new housing is the incidence of a direct wealth effect. That is, as the money supply increases wealth increases which, in turn, results in a rise in the index of housing permits for private units.
Because the difference \((M_t - M_{t-1})\) is not an economic indicator and because the first logarithmic difference follows closely the level difference, we can use \(\log M_t - \log M_{t-1}\) to approximate the effects of monetary changes on the index of housing permits. Equation (3.6.6) now becomes:

\[
Y_6 = f(t)[e(t)Y^P_t, g(\log M_t - \log M_{t-1})]
\]

(3.6.7)

But, \(\log M_t - \log M_{t-1} = M\) so (3.6.7) becomes:

\[
Y_6 = f(t)[eY^P, hM]
\]

(3.6.8)

Since, empirically, \(Y^P\) is a distributed lag of \(Y_{13}\), equation (3.6.8) becomes:

\[
Y_6 = H[k(t)Y_{13}, q(t)M]
\]

(3.6.9)

where

\[
\frac{\partial Y_6}{\partial Y_{13}} = k(t)H_{y_{13}}[k(t)Y_{13}, q(t)M]>0, k'>0
\]

(3.6.10)

\[
\frac{\partial Y_6}{\partial M} = q(t)H_{m}[k(t)Y_{13}, q(t)M]>0, q'>0
\]

(3.6.11)

The functional form (3.6.9) of the index of housing permits for private units is the linkage of new housing demand in our mechanism.

7. Average Workweek, Manufacturing Production Workers: \(Y_7\)

This series is derived by dividing the paid man-hours per week in manufacturing production by the number of production workers employed. The figures cover both full and part-time production and related workers who received pay for any part of the pay period ending nearest the 15th of the month. This series reflects the effects of shifts in industrial composition (shifts from short-hour industries to long-hour industries and vice versa) as well as such factors as labor turnover and overtime and part-time work.

From the production function \(Q = F(K, L)\), we obtain that the demand for labor is determined by the profit maximizing condition that the
marginal product of labor equals the real wage rate. For a given capital stock, the demand for labor is a function of real wage rate:

\[ L^d = f(t) \left[ \frac{W}{P} ; K \right] \]  

(3.7.1)

where

\[ \frac{\partial L^d}{\partial (W/P)} < 0 \quad \text{and} \quad \frac{\partial L^d}{\partial K} > 0 \]  

(3.7.2)

The theory of choice between work and leisure assumes that individuals maximize their welfare and that the amount of labor supplied depends on the real wage rate. That is,

\[ L^s = g(t) \left[ \frac{W}{P} \right], \quad g'(t) > 0 \]  

(3.7.3)

But labor input, \( L \), can be disaggregated as follows:

\[ L = chN \]  

(3.7.4)

where \( c \) is the number of weeks per month, \( h \) is the average workweek, and \( N \) is the number of workers employed.

From (3.7.1) - (3.7.4) we get that:

\[ h^d = \frac{1}{CN} f(t) \left[ \frac{W}{P} ; K \right] = F(t) \left[ CN, \frac{W}{P} ; K \right] \]  

(3.7.5)

and

\[ h^s = \frac{1}{CN} g(t) \left[ \frac{W}{P} \right] = G(t) \left[ CN, \frac{W}{P} \right] \]  

(3.7.6)

Solving (3.7.5) and (3.7.6) for the real wage rate we obtain:

\[ \frac{W}{P}^d = F(t) [h, CN, K] \]  

(3.7.7)

\[ \frac{W}{P}^s = G(t) [h, CN] \]  

(3.7.8)

Setting equations (3.7.7) and (3.7.8) equal to each other, by virtue of the equilibrium condition \( \left( \frac{W}{P} \right)^d = \left( \frac{W}{P} \right)^s \), and solving for the average workweek, \( h \), we obtain:

\[ h = f(t) [CN, K] \]  

(3.7.9)

or

\[ Y7 = f(t) [N, K] \]  

(3.7.10)
since c is a constant. Taking the total differential of equation (3.7.10) we get:

\[ dY_7 = f_1(t)dN + f_2(t)dK \]  \hspace{1cm} (3.7.11)

which can be approximated by:

\[ \Delta Y_7 = f_1(t)\Delta N + f_2(t)\Delta K \]  \hspace{1cm} (3.7.12)

Equation (3.7.12) can be written as:

\[ Y_7t = f_1(t)AN_t + f_2(t)AK_t + Y_7t-1 \]  \hspace{1cm} (3.7.13)

Imposing the restriction that the coefficient of \( Y_7t-1 \) is equal to one and assuming that in monthly data the partial derivatives are approximately constant, equation (3.7.13) can be written as:

\[ Y_7 = H(t) [AN, AK, Y_7(t-1)] \]  \hspace{1cm} (3.7.14)

However, since the factors that affect the average workweek also influence the number of workers employed, the explanatory variable \( N \) may be omitted and (3.7.14) becomes:

\[ Y_7 = H(t) [AK, Y_7(t-1)] \]  \hspace{1cm} (3.7.15)

In our system, capital changes are affected by changes in manufacturing and trade inventories, \( Y_2 \), by net business formation, \( Y_3 \), and by contracts and orders for plant and equipment, \( Y_5 \), all of which are some form of investment. As these components of investment increase, average workweek is expected to rise due to pressures in labor markets. The effects of monetary changes on the average workweek can be approximated by the effect of changes in the growth rate of the money supply on the \( K \) variable. As this growth rate increases and economic activity is stimulated, investment rises which results in an increase in the average workweek.
In view of these considerations, equation (3.7.15) becomes:

\[ Y_7 = H(t) \{ Y_2, Y_3, Y_5, Y_7_{t-1} \} \quad (3.7.16) \]

or,

\[ Y_7 = H \{ a(t)Y_2, b(t)Y_3, c(t)Y_5, e(t)H, Y_7_{t-1} \} \quad (3.7.17) \]

where,

\[ \frac{\partial Y_7}{\partial Y_2} = a(t)H \{ a(t)Y_2, b(t)Y_3, c(t)Y_5, e(t)H, Y_7_{t-1} \} > 0, \quad a' > 0 \quad (3.7.18) \]

\[ \frac{\partial Y_7}{\partial Y_3} = b(t)H \{ a(t)Y_2, b(t)Y_3, c(t)Y_5, e(t)H, Y_7_{t-1} \} > 0, \quad b' > 0 \quad (3.7.19) \]

\[ \frac{\partial Y_7}{\partial Y_5} = c(t)H \{ a(t)Y_2, b(t)Y_3, c(t)Y_5, e(t)H, Y_7_{t-1} \} > 0, \quad c' > 0 \quad (3.7.20) \]

\[ \frac{\partial Y_7}{\partial H} = e(t)H \{ a(t)Y_2, b(t)Y_3, c(t)Y_5, e(t)H, Y_7_{t-1} \} > 0, \quad e' > 0 \quad (3.7.21) \]

and \( \frac{\partial Y_7}{\partial Y_7_{t-1}} = 1. \quad (3.7.22) \)

Average workweek of production workers in manufacturing industries is the seventh indicator providing a linkage in our mechanism and equation (3.7.17) is the functional form to be estimated statistically.

8. Value of New Orders for Durable Goods: \( Y_8 \)

This series represents the total volume in current dollars, of new business placed with durable goods manufacturers. New orders are defined as commitments to buy, received and accepted by a company, involving either the immediate or future delivery of goods. Since the change in unfilled orders during the month is equivalent to new orders less sales and cancellations, net new orders are computed by adding net sales to the change in unfilled orders during the month.

Using a wealth adjustment model as our starting point, the value of new orders for durable goods can be expressed as:

\[ Y_8 = f(t) \{ W_t^* - W_{t-1}^* \} + g(t)P \quad (3.8.1) \]

where, \( \frac{\partial Y_8}{\partial g(t)P} > 0 \) \quad (3.8.2)
and where $W^*$ is now defined as: $W^* = W^M + M$ and $g(t)P$ is a cost considerations function involving materials prices. Price considerations enter explicitly equation (3.8.1) because the coefficients of the components of wealth are one. This means that effects, other than indirect wealth effects, of price changes on the dependent variable will be captured by $g(t)P$. Use of the cost consideration function in (3.8.1) is deemed appropriate because the dependent variable measures value and not simply quantity, as was the case with the index of housing permits.

Following the analysis of Section 6, equation (3.8.1) reduces to:

$$Y_8 = h(t)[Y_{13}, M] + g(t)P$$  \hspace{1cm} (3.8.3)

where the effects of real income and monetary changes on the indicator of new orders for durable goods are realized through changes in wealth as shown in the case of housing permits for private units. However, when a change in the growth rate of the money supply takes place, both output and prices are affected by the adjustment process set off. When variables such as net business formation, housing starts, and contracts and orders for plant and equipment increase, as a result of a monetary change, industrial materials prices are pushed upward. There is evidence suggesting that the demand for consumer durables is more responsive to income changes rather than to price changes,\(^{12}\) while other studies show that the demand for durable goods is very sensitive to price changes.\(^{13}\) While unexpected increases in industrial materials prices may have a retarding effect on the demand for durable goods, sustained increases of these prices are associated with a higher value for durable goods. Furthermore, the effects

\(^{12}\)See, for example, the study by M. Hamburger (1967).

\(^{13}\)For such studies of the factors influencing consumer spending on durables, see J. Miner (1960) or J. Lansing, E. Maynes, and M. Kreinin (1957, pp. 487-545).
of inflationary expectations may outweigh the negative effects of price increases on the demand side for durable goods, while increases in industrial materials prices raise the value of the orders for these goods.

Since industrial materials prices, Y11, dominate the cost considerations function, we have that:

\[ g(t)P = c(t)Y11 \]  \hspace{1cm} (3.8.4)

Substituting (3.8.4) into (3.8.3) we obtain:

\[ Y8 = h(t) [a(t)Y13, b(t)Y13] + k(t)Y11 \]  \hspace{1cm} (3.8.5)

or, \[ Y8 = H [a(t)Y13, b(t)Y13, k(t)Y11] \]  \hspace{1cm} (3.8.6)

where,

\[ \frac{\partial Y8}{\partial Y13} = a(t)H_{Y13} [a(t)Y13, b(t)Y13, k(t)Y11] > 0, \ a' > 0 \]  \hspace{1cm} (3.8.7)

\[ \frac{\partial Y8}{\partial M} = b(t)H_{M} [a(t)Y13, b(t)Y13, k(t)Y11] > 0, \ b' > 0 \]  \hspace{1cm} (3.8.8)

and

\[ \frac{\partial Y8}{\partial Y11} = k(t)H_{Y11} [a(t)Y13, b(t)Y13, k(t)Y11] > 0, \ k' > 0 \]  \hspace{1cm} (3.8.9)

Equation (3.8.6) constitutes another linkage in our transmission mechanism, whereby the value of new orders for durable goods is hypothesized to be determined by real GNP, the growth rate of the money supply, and by the industrial materials prices index. Notice, however, that the influence of net changes in consumer installment debt does not appear in this equation because its determinants are included as explanatory variables in the same equation.


This monthly common stock price index is an average of Standard and Poor's weekly composite stock price index, a base weighted aggregative expressed in relatives, the price of each component stock being weighted
by the number of shares outstanding. The index formula is modified to offset arbitrary price changes caused by the issuance of rights, splits, and mergers. This is one of the series where no seasonal adjustment is considered necessary.

According to the equity pricing model used by Hamburger and Kochin, the current price of an equity can be expressed as:

\[ P = \frac{E_t}{(1+i_t+r_t)} \]  

(3.9.1)

where, \( E_t \) are expected earnings, \( i_t \) the risk free rate to time \( t \), and \( r_t \) the risk premium to time \( t \). However, since "Changes in the stock of money affect in different ways all of the determinants of equity prices: the risk free yield, earnings expectations and the risk premium,"\(^{14}\) equation (3.9.1) reduces to the implicit form:

\[ P = f(t) \]  

(3.9.2)

The general form of F. Bell's model (1974) of the structure of stock prices is the following:

\[ P = h(D,E,r,g) \]  

(3.9.3)

where, \( D \) represents dividends per share, \( r \) the rate of discount, \( E \), the earnings per share, and \( g \) the constant rate of growth of dividends. Since \( g \) is constant and \( r \) and \( E \) are influenced by changes in the growth rate of the stock of money, combining the two models we get that:

\[ P = h(t)[D, a(t) \bar{M}] \]  

(3.9.4)

or

\[ Y_9 = h(t)[D, a(t)\bar{M}] \]  

(3.9.5)

but,

\[ D = d(t)[\bar{M}] \]  

(3.9.6)

where \( \bar{M} \) is some appropriate profits variable. In our system, \( \bar{M} \) can be approximated by corporate profits after taxes, \( Y_{12} \), and (3.9.6) can be

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\(^{14}\) M. Hamburger and L. Kochin (1972, p. 232).
written as:

\[ D = e(t)[Y_{12}] \quad (3.9.7) \]

Substituting (3.9.7) into (3.9.5) we get that:

\[ Y_9 = h(t)[a(t)\hat{M}, e(t)Y_{12}] \quad (3.9.8) \]

where

\[ \frac{\partial Y_9}{\partial \hat{M}} = a(t)H_{\hat{M}} [a(t)\hat{M}, e(t)Y_{12}] > 0, \quad a' > 0 \quad (3.9.9) \]

and

\[ \frac{\partial Y_9}{\partial Y_{12}} = e(t)H_{Y_{12}} [a(t)\hat{M}, e(t)Y_{12}] > 0, \quad e' > 0 \quad (3.9.10) \]

Stock prices are assumed to provide an important linkage in the model of our transmission mechanism; the index of stock prices being determined by changes in the growth rate of the money supply and by corporate profits after taxes, as shown in equation (3.9.8). The significance of the stock price index in our mechanism lies with its property of reflecting the market valuation of the existing capital stock in the economy. This is an important indicator not only because of the impacts it has on the economy through expectational effects, but also, because common stocks are the securities at the one end of the spectrum of interest bearing financial assets; at the other end of the spectrum are short-term U. S. government securities. Any portfolio adjustments beyond common stocks involve investment in real assets and result in the production of new real capital. In addition to the impact of stock prices through substitution effects, wealth effects are present in changes of stock prices. As stock prices rise, capital gains are realized which affect, primarily, consumer spending in the positive direction.

The direct relationship between money and stock prices and the indirect influence of monetary changes on the stock price index through interest rate and price level changes have been shown to hold under widely different
models. Viewed from a general portfolio balance approach, an increase in the money supply creates a disequilibrium between actual and desired cash holdings in the portfolios of the private sector. Attempts to correct this discrepancy alter relative yield structures of the assets contained in the portfolios and initiate portfolio adjustments that influence the public's desire to substitute money for other financial assets, including common stocks.

An increase of the growth rate in the money supply adds to the total wealth in the economy, (or the rate of which it grows) if prices remain constant. Monetary changes, however, have other significant wealth effects. As a Neo-Keynesian put it:

An expansionary monetary policy lowers the capitalization rates employed in valuing expected income streams, thereby raising the market value of outstanding bonds as well as real wealth and equity claims thereto. In part, this strengthens the impact on economic activity of the portfolio adjustments... by increasing the size of the net portfolios for allocation. In addition, the increase in household wealth may significantly stimulate consumption. (W. Smith [1969, p. 107]).

One effect of an increase in stock prices, therefore, is to increase consumption via the wealth effect. But, if money is theorized to be a proxy variable for the interest rate and expected earnings, monetary increases can stir up expectations of further stock price increases.\(^{16}\)

Further stock price increases may be interpreted by some investors as reflecting strengthened confidence in the economy and a sign of improving business conditions. Also, the increase in stock prices reinforces the sequence of portfolio adjustments, initiated earlier in the process, and


\(^{16}\)Money was hypothesized to be a proxy variable for interest rates and expected earnings in the study by M. Keran (1971).
results in decreased relative yields on existing capital goods, while making the relative yield of newly produced capital goods higher. All these factors influence investment spending which affects real GNP and the other coincident indicators.

The positive effect of the corporate profits after taxes variable (Y12) on the index of stock prices is realized through dividends per share and also through expected earnings. That is, as net corporate profits rise, dividends per share tend to rise and so do stock prices. Similarly, as net profits show an upward trend, expected earnings tend to display an increase which, other things being equal will cause a rise in stock prices. However, during times in which corporations invest in expanding their productive capacity or modernizing their plants and equipment, increasing corporate profits after taxes may have no significant effect on stock prices. This is so because profits are channeled away from dividends and expected earnings may not be forthcoming in the immediate time horizon.

10. Price per Unit Labor Cost, Index: Y10

This series is the ratio of the index of wholesale prices of manufactured goods to the index of compensation of employees per unit of output. The compensation of employees component (labor cost) measures the income received by persons in an employee status as remuneration for their work, including wage and salary disbursements and supplements to wages and salaries - or fringe benefits. The manufactured goods wholesale price index is designed to measure the direction and rate of change of prices for these goods. The prices used in this index are transaction prices as obtained from manufacturers taking into account trade and quantity discounts.
From the economic version of Euler's theorem,\textsuperscript{17} as applied to production, we have that:

\[ QP = WL + rK \]

where \( Q \) is output, \( P \) is the price of output, \( W \) is the nominal wage rate, \( L \) is labor input, \( r \) is the nominal rental rate of capital (or profit) and \( K \) is capital input. Dividing (3.10.1) by \( Q \) we obtain:

\[ P = \frac{WL}{Q} + \frac{rK}{Q} \]  
(3.10.2)

Dividing equation (3.10.2) through by \( \frac{WL}{Q} \) we get:

\[ \frac{P}{(WL/Q)} = 1 + \left( \frac{r}{W} \right) \left( \frac{K}{L} \right) \]

(3.10.3)

But, \( \frac{P}{(WL/Q)} \) is nothing more than the price of output to per unit labor cost ratio. Therefore,

\[ Y_{10} = 1 + \left( \frac{r}{W} \right) \left( \frac{K}{L} \right) \]  
(3.10.4)

Assuming that the ratio \( (r/W) \) is stable within monthly observations, the price to unit labor cost ratio is a function of the capital to labor ratio; that is,

\[ Y_{10} = f(t) \left[ \frac{K}{L} \right] \]  
(3.10.5)

With an increase in contracts and orders for plant and equipment, the stock of capital rises and labor also rises. However, if we make the reasonable assumption of technological improvement of the capital stock

\textsuperscript{17}Euler's theorem applied to production states that under conditions of competition and constant returns to scale, each input factor is paid the value of its marginal product and the total product is exhausted exactly by the distributive shares of all the input factors.
and ex-ante substitution between capital and labor, capital will rise by more than labor. Thus, an increase in contracts and orders for plant and equipment leads to an increase in the ratio of price to unit labor cost. For a given capital stock, there is no ex-post substitutability between capital and labor. Thus, as the layoff rate increases, labor input in man-hours falls and the capital to labor ratio rises, which results in an increase in the price per unit labor cost index. An increase in the growth rate of the money supply results in an increase in the productivity of the labor employed. This implies that less labor can now produce the same output; that is, the capital to labor ratio rises and the price to labor unit cost ratio also rises.

As a result of these arguments, equation (3.10.5) can be written as:

\[ Y_{10} = H[a(t)Y_4, b(t)Y_5, c(t)M] \] (3.10.6)

where,

\[ \frac{\partial Y_{10}}{\partial Y_4} = a(t)Y_4[a(t)Y_4, b(t)Y_5, c(t)M] > 0, a' > 0 \] (3.10.7)

\[ \frac{\partial Y_{10}}{\partial Y_5} = b(t)Y_5[a(t)Y_4, b(t)Y_5, c(t)M] > 0, b' > 0 \] (3.10.8)

and,

\[ \frac{\partial Y_{10}}{\partial M} = c(t)Y_M[a(t)Y_4, b(t)Y_5, c(t)M] > 0, c' > 0 \] (3.10.9)

Equation (3.10.6) provides another linkage in our mechanism for the index of price of output to unit labor cost which measures the relative shares of labor and capital. A rise in this index may, in one sense, be interpreted as an improvement in the share of capital owners. On the other hand, a decrease in the index of this ratio indicates an increase in the labor's claim to total output.

One of the significant aspects of this indicator's behavior in our transmission mechanism is the impact it has not only on the corporate profits after taxes indicator, but on total output as well. That is, as the price of output increases, relative to increases in unit labor costs, profit margins are widened and total corporate profits after taxes rise. Since profits is one of the major determinants of investment, an increase in profits usually results in higher investment expenditures which are translated into increased income and employment.

11. Index of Industrial Materials Prices: Yll

This series measures the spot market price movements of thirteen raw industrial materials on commodity markets and organized exchanges. It is one of two major groupings (the other being foodstuffs) of the BLS index of spot market prices for twenty-two basic commodities whose markets are presumed to be among the first to be influenced by changes in economic conditions. The commodities used in this index are those which are:

1. In wide use for further processing (basic);
2. Freely traded in an open market;
3. Sensitive to changing conditions significant in those markets; and
4. Sufficiently homogeneous or standardized so that uniform and representative price quotations of this series is considered necessary.

The demand for industrial materials can be expressed as follows:

\[ IM^d = f(t)P_M; Y5, Y6, Y8 \]  \hspace{1cm} (3.11.1)

where \( IM^d \) is the quantity of industrial materials demanded, \( P_M \) is the price of industrial materials, and the other variables as defined earlier.
and where
\[
\frac{\partial IM^d}{\partial P_M} < 0, \quad \frac{\partial IM^d}{\partial Y_5} > 0, \quad \frac{\partial IM^d}{\partial Y_6} > 0, \quad \text{and} \quad \frac{\partial IM^d}{\partial Y_8} > 0. \tag{3.11.2}
\]

As an increase in the growth rate of the money supply takes place and portfolio adjustments are initiated, wealth and substitution effects take hold and result or induce changes in contracts and orders for plant and equipment, in housing permits for private units, and in new orders for durable goods. As a result of these changes, the demand for industrial materials is affected in the same direction.

Increases in contracts and orders for plant and equipment and in new orders for durable goods are expected to show a great deal of influence on the demand for industrial materials. Housing permits for private units actually have no direct effect on the demand for industrial materials, but housing construction does. As housing construction rises, an increase in the demand for industrial materials develops. Increased housing construction also results in an increased demand for equipment and durable goods whose manufacturing requires use of industrial materials.

In our model, the supply of industrial materials is determined by their domestic prices only. The effects of price changes of commodities that are important in international trade are taken into account in the index of industrial materials prices in order to reflect the influence of international markets on the economy. That is,
\[
IM^S = g(t)[P_M], \quad g'(t) > 0 \tag{3.11.3}
\]
The equilibrium condition for the industrial materials market is:
\[
IM^d = IM^S \tag{3.11.4}
\]
Substituting (3.11.1) and (3.11.3) in (3.11.4) and solving for \( P_M \), we obtain:
\[
P_M = h(t)[Y_5, Y_6, Y_8] \tag{3.11.5}
\]
But $P_\text{M}$ is approximated by $Y_{11}$ in our system; hence:

$$Y_{11} = h(t) [Y_5, Y_6, Y_8]$$  \hspace{1cm} (3.11.6)

or

$$Y_{11} = H [a(t)Y_5, b(t)Y_6, c(t)Y_8]$$  \hspace{1cm} (3.11.7)

where,

$$\frac{\partial Y_{11}}{\partial Y_5} = a(t)H_{Y_5} [a(t)Y_5, b(t)Y_6, c(t)Y_8] > 0, \quad a' > 0$$  \hspace{1cm} (3.11.8)

$$\frac{\partial Y_{11}}{\partial Y_6} = b(t)H_{Y_6} [a(t)Y_5, b(t)Y_6, c(t)Y_8] > 0, \quad b' > 0$$  \hspace{1cm} (3.11.9)

$$\frac{\partial Y_{11}}{\partial Y_8} = c(t)H_{Y_8} [a(t)Y_5, b(t)Y_6, c(t)Y_8] > 0, \quad c' > 0$$  \hspace{1cm} (3.11.10)

Equation (3.11.7) for the industrial materials prices index is the eleventh in our series of linkages through which the effect of monetary impulses are channeled to income. This indicator is important in the transmission of monetary impulses to real GNP because it influences the value of manufacturing and trade inventories, the value of new orders for durable goods, and the price to unit labor cost ratio, and therefore, it influences industrial production through the supply side. This indicator affects real GNP through output and the GNP deflator, in which it is assigned a considerable amount of weight. Increases in the index of industrial materials affect adversely corporate profits after taxes as well. The destabilizing influence of abrupt increases in industrial materials prices affects not only production but, more importantly, investment decisions and the entire economic system. Proof of this was provided by the painful adjustments of the world economies to higher energy prices after the oil embargo of 1973.

12. Corporate Profits After Taxes: $Y_{12}$

This series shows the volume of earnings net of corporate tax liability (federal and state income and excess profits taxes) originating in
U.S. corporations organized for profit. Profits include depletion and exclude domestic dividends received and capital gains and losses, conforming thereby to the national income concept. Adjustments are made for international flows which affect profits. Quarterly figures are obtained by extrapolating the latest benchmark estimated based upon IRS tabulations and monthly figures are derived by simple interpolation of the quarterly estimates.

From Euler's theorem which states that \( PQ = WL + rK \) we obtain that the profit rate, \( r \), is:

\[
r = \frac{PQ}{K} - \frac{WL}{K}
\]  

(3.12.1)

Multiplying and dividing by \( (WL) \) the first term of the right hand side, we get:

\[
r = \frac{PQ}{WL} \left( \frac{WL}{K} - \frac{WL}{K} \right)
\]  

(3.12.2)

or

\[
r = \frac{WL}{K} \left( \frac{PQ}{WL} - 1 \right)
\]  

(3.12.3)

But earlier, in section 10, we found that \( PQ \) is the price per unit labor cost ratio \( Y_{10} \). Thus (3.12.3) becomes:

\[
r = \frac{WL}{K} \left( Y_{10} - 1 \right)
\]  

(3.12.4)

As contracts and orders for plant and equipment rise, capital increases and the profit rate, \( r \), declines; i.e.,

\[
\frac{\partial r}{\partial Y_{5}} < 0 .
\]  

(3.12.5)

When the average workweek increases, labor input increases and the profit rate (return on capital) also increases; that is,

\[
\frac{\partial r}{\partial Y_{7}} > 0 .
\]  

(3.12.6)

With an increase in new orders for durable goods capital increases and so does labor. However, ex-post capital is fixed and, therefore, as
labor increases $r$ also increases. This means that:

$$\frac{\partial r}{\partial Y_5} > 0.$$  (3.12.7)

Finally, as the ratio of price to unit labor cost rises, $r$ also rises. Thus:

$$\frac{\partial r}{\partial Y_{10}} > 0.$$  (3.12.8)

Corporate profits after taxes are a function of the profit rate, $r$, and the corporate tax rate structure, $T$:

$$Y_{12} = f(t)[r, T]$$  (3.12.9)

However, since the corporate tax rate structure has been stable over the period under study, $T$ can be omitted from (3.12.9) without loss of any valuable information concerning the determination of $Y_{12}$. Thus, equation (3.12.9) now becomes:

$$Y_{12} = g(t) [r]$$  (3.12.10)

where $g'(t) > 0$  (3.12.11)

From the arguments above, we get that (3.12.10) can be expressed as:

$$Y_{12} = h(t)[Y_5, Y_7, Y_8, Y_{10}]$$  (3.12.12)

or,  $$Y_{12} = h[a(t)Y_5, b(t)Y_7, c(t)Y_8, e(t)Y_{10}]$$  (3.12.13)

From (3.12.5) - (3.12.8) and (3.12.10) we get that:

$$\frac{\partial Y_{12}}{\partial Y_5} = a(t)H_{Y_5} [a(t)Y_5, b(t)Y_7, c(t)Y_8, e(t)Y_{10}] < 0, a' < 0$$  (3.12.14)

$$\frac{\partial Y_{12}}{\partial Y_7} = b(t)H_{Y_7} [a(t)Y_5, b(t)Y_7, c(t)Y_8, e(t)Y_{10}] > 0, b' > 0$$  (3.12.15)

$$\frac{\partial Y_{12}}{\partial Y_8} = c(t)H_{Y_8} [a(t)Y_5, b(t)Y_7, c(t)Y_8, e(t)Y_{10}] > 0, c' > 0$$  (3.12.16)

and  $$\frac{\partial Y_{12}}{\partial Y_{10}} = e(t)H_{Y_{10}} [a(t)Y_5, b(t)Y_7, c(t)Y_8, e(t)Y_{10}] > 0, e' > 0$$  (3.12.17)

Corporate profits after taxes is the last leading indicator to be affected in the hypothesized sequence of events that constitutes an alter-
native monetary transmission mechanism. Corporate profits are usually assumed to exhibit a positive relationship with income and the level of some general price index and a negative relationship with labor compensation and employment. In our model, which is equation (3.12.13), corporate profits after taxes are determined by the value of contracts and orders for plant and equipment, by the average workweek, by the value of new orders for durable goods, and by the price of output to unit labor cost ratio. As explained earlier, industrial materials price changes have an influence on the corporate profits after taxes indicator. The effects of such changes, however, are captured through the influence of changes in the price to unit labor cost ratio.

An increase in the value of contracts and orders for plant and equipment results in higher profits for those firms that are involved in the construction of plants and the production of equipment. However, what constitutes profits for these firms are simply expenditures for other firms. Furthermore, as capital increases the return on it - the profit rate - declines; hence, a decline in corporate profits for all firms in the economy. In the case of new orders for durable goods, it is clear that an increase in this indicator results in higher corporate profits after taxes because consumer expenditures on durables make up most, if not all, of the expenditures on orders for new durable goods.

When average workweek in manufacturing increases, this means that manufacturing firms are faced with pressures on their production schedules due to an increased demand for their products. Higher demand for manufactured goods implies higher prices for these goods and higher profits.

\[^{19}\text{For a typical model using this approach see equation (12) in G. Chow and G. Moore (1972).}\]
When the price of output to unit labor cost ratio rises, this means that wage increases lag behind increases in the price of output. That implies that profit margins widen and corporate profits after taxes increase. And, insofar as net corporate profits are the driving force of business enterprise, when they increase, total investment spending rises and output, employment, and income increase.

13. Real Gross National Product: $Y_{13}$

GNP is the most comprehensive single measure of aggregate economic output. It represents the market value of the total output of goods and services produced by the nation's economy, before deduction of depreciation changes and other allowances for business and institutional consumption of durable capital goods. Output demand is measured by summing the expenditures involved in obtaining final goods and services by the ultimate investors or consumers. Thus, GNP demanded is the total of personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government purchases of goods and services. The constant dollar GNP series is derived by dividing components of the seasonably adjusted current-dollar series by appropriate price indexes and then summing them to the constant-dollar total. This eliminates the effects of price changes and results in a series which measures the physical volume of output.

To derive the equation which will be the final linkage in our transmission mechanism, we proceed as follows: The aggregate demand price level $P^d$, can be expressed as:

$$P^d = f(t)[Y_{13}, \bar{M}, Y_9, Y^p]$$  \hspace{1cm} (3.13.1)

where $Y^p$ is some concept of permanent income and where
Equation (3.13.1) is consolidated from the definition of real GNP,
\[ Y_{13} = C + I + G \]
where
\[ C = F[a(t)M, b(t)YP, c(t)P] \]
\[ I = G[a(t)YP, b(t)Yg, c(t)P] \]
\[ G = Go , \]  
(3.13.3)
where \( P \) is the general price level and government expenditures, \( G \), are assumed to be exogenous in our system, and where the partial derivatives of (3.13.3) are:
\[ \frac{\partial C}{\partial M} > 0, \quad \frac{\partial C}{\partial YP} > 0, \quad \frac{\partial C}{\partial P} < 0 \]
\[ \frac{\partial I}{\partial YP} > 0, \quad \frac{\partial I}{\partial Yg} > 0, \quad \frac{\partial I}{\partial P} < 0 . \]  
(3.13.4)

Changes in the growth rate of the money supply affect consumption in the same direction through direct and indirect wealth effects. That is, as the money supply growth rate increases the rate at which wealth is growing rises and so do expenditures on consumer durable and nondurable goods. By the same token, monetary changes affect consumption through interest rate changes which are equivalent to price changes of the various assets held in the portfolios of the public.

Friedman's version of permanent income is the expected future receipts from both human and non-human wealth. Although wealth series are available on an annual basis and would fit best in the wealth adjustment model, interpolated monthly estimates are considered unreliable and will not be used in this study. Regardless of what version of permanent income is used, this concept of income is the main determinant of consumer expenditures and one of the major factors underlying aggregate demand. As
permanent income rises consumer expenditures, especially on durable goods, increase and this leads to an increase in the aggregate demand which means that output and real GNP increase.

Changes in the general price level affect inversely both consumption and investment. On the other hand, the positive influence of stock price changes on investment is channeled via wealth, substitution, and expectational effects. The behavior of the stock price index is closely observed by the business community and increases in stock prices are more often than not interpreted as signals of improving economic conditions or the economic climate in the future. Thus, if stock prices are identified with a general mood of optimism, the stage for economic expansion has been set. Notice, however, that these expectational effects may affect either aggregate demand or supply, or both in the positive direction.

Increases in stock prices also affect investment via the channel of the wealth effect. As stock prices rise and capital gains are realized, business firms that hold common stocks in their portfolios may invest the proceeds in higher yielding assets. Capital gains realized by institutional investors are likely to result in higher dividends and/or investment in real assets whose rate of return is now high relative to what it was.

As mentioned in Section 9, the stock price index reflects the market valuation of the existing capital stock. An increase in the stock price index implies an increase in the price of existing real capital. Thus, since the yield on existing capital falls, the relative yield on newly created capital rises and the demand for new capital goods rises: i.e., investment rises.
Finally, the positive influence of permanent income on investment demand is realized through the accelerator effect. That is, permanent income changes result in positive consumption expenditure changes which, in turn, affect investment spending in the same direction.

The aggregate supply price level, $P^s$, can be expressed as:

$$P^s = g(t)[Y_{13}; \bar{X}, Y_{10}, Y_{11}]$$  \hspace{1cm} (3.13.5)

where,

$$\frac{2P^s}{3Y_{13}} > 0, \quad \frac{2P^s}{3\bar{X}} < 0, \quad \frac{2P^s}{3Y_{10}} < 0, \quad \frac{2P^s}{3Y_{11}} > 0$$  \hspace{1cm} (3.13.6)

Equation (3.13.5) is consolidated from the aggregate supply function where total output, $Q$, is represented as:

$$Q = H[a(t)P, b(t)\bar{X}, c(t)Y_{10}, e(t)Y_{11}]$$  \hspace{1cm} (3.13.7)

and where,

$$\frac{3Q}{3P} > 0, \quad \frac{3Q}{3\bar{X}} > 0, \quad \frac{3Q}{3Y_{10}} > 0, \quad \frac{3Q}{3Y_{11}} < 0,$$  \hspace{1cm} (3.13.8)

Changes in the growth rate of the money supply alter relative yield structures in individual portfolios and subsequent adjustments follow that increase stock prices or, what amounts to the same thing, depress the yield on existing capital goods. Once the yield on newly produced goods has risen, more of new capital goods are produced. But, increased demand for new capital goods has a dampening effect, due to higher prices, on the output of newly produced goods, whereas higher new capital goods prices stimulate the supply of them. Whether or not the output of newly produced real assets increases depends on the shifts of the demand for and the supply of real assets. In a monetarist framework, however, an increase in the money supply always leads to an increase in newly produced capital goods because the yield on real capital is determined by money market conditions. Thus, monetary increases are associated with higher output.
The idea that monetary changes influence income directly originated with Friedman who, more than twenty years ago, claimed that: "To the productive enterprise, money is a capital good, a source of productive services that are combined with other productive services to yield the products that the enterprise sells." (Friedman 1969, p. 52) Subsequent studies of the role of money in the aggregate production function have found evidence to the effect that real money balances influence significantly returns to scale and that they have a marginal product comparable to those of capital and labor. However, since real income — instead of the aggregate production function — is being studied here, nominal monetary changes are introduced as an explanatory variable for real GNP. That is, as the money supply increases, output increases because of increased utilization of resources in the production processes of the economy. As money and output increase, income increases up to the point where the monetary input factor reaches the point of diminishing returns.

Changes in the general price level affect the aggregate output supplied in a positive manner. The ratio of price of output to unit labor cost is an important factor underlying the aggregate supply schedule and its influence runs in the positive direction as well. That is, as output prices rise relative to unit labor costs, profits are increased which, in turn, stimulate business investment which means an outward shift in the aggregate supply schedule and an increase in output and income. Moreover, since per unit labor costs follow output prices increases, a shift in the aggregate demand follows that reinforces the increase in output from the supply shift.

For a study that justifies the use of changes in money rather than levels of money balances, see Z. Prais (1975).
The index of industrial materials prices reflects changes in manufacturing and trade inventories, contracts and orders for plant and equipment, housing construction, and new orders for durable goods. Even though changes in these indicators affect the demand for industrial materials, the index of industrial prices, itself, is one of the important factors underlying the aggregate supply function. That is, changes in industrial materials prices shift the aggregate supply function; namely, as the industrial materials prices index rises, the aggregate supply function shifts to the left and results in decreased output, or real GNP, and higher prices — assuming minor or no changes in aggregate demand.

The equilibrium condition for the aggregate demand and supply price levels is:

$$P_d = P_s$$  \hspace{1cm} (3.13.7)

Substituting (3.13.1) and (3.13.5) in (3.13.7) and solving implicitly for $Y_{13}$ we get that

$$Y_{13} = k(t)[Y^P, M, Y_9, Y_{10}, Y_{11}]$$  \hspace{1cm} (3.13.8)

or

$$Y_{13} = K[a(t)Y^P, b(t)M, c(t)Y_9, e(t)Y_{10}, f(t)Y_{11}]$$  \hspace{1cm} (3.13.9)

where

$$\frac{\partial Y_{13}}{\partial Y^P} = a(t)K_{Y^P}[a(t)Y^P, b(t)M, c(t)Y_9, e(t)Y_{10}, f(t)Y_{11}] > 0, a' > 0$$  \hspace{1cm} (3.13.10)

$$\frac{\partial Y_{13}}{\partial M} = b(t)K_M[a(t)Y^P, b(t)M, c(t)Y_9, e(t)Y_{10}, f(t)Y_{11}] > 0, b' > 0$$  \hspace{1cm} (3.13.11)

$$\frac{\partial Y_{13}}{\partial Y_9} = c(t)K_{Y_9}[a(t)Y^P, b(t)M, c(t)Y_9, e(t)Y_{10}, f(t)Y_{11}] > 0, c' > 0$$  \hspace{1cm} (3.13.12)

$$\frac{\partial Y_{13}}{\partial Y_{10}} = e(t)K_{Y_{10}}[a(t)Y^P, b(t)M, c(t)Y_9, e(t)Y_{10}, f(t)Y_{11}] > 0, e' > 0$$  \hspace{1cm} (3.13.13)

$$\frac{\partial Y_{13}}{\partial Y_{11}} = f(t)K_{Y_{11}}[a(t)Y^P, b(t)M, c(t)Y_9, e(t)Y_{10}, f(t)Y_{11}] < 0, f' < 0$$  \hspace{1cm} (3.13.14)

---

21 This reduced form equation for real GNP is similar to that derived by K. Brunner and A. Meltzer (1972).
Equation (3.13.9) is the reduced form equation for the determination of real GNP and constitutes the last linkage in our mechanism. Although changes in all of the leading indicators contribute in the determination of real GNP, the explanatory variables included in (3.13.9) are chosen as the most important ones since they are containing and reflecting the influences of the other indicators. It should be noted, however, that the indicator of corporate profits after taxes does not enter (3.13.9) because corporate profits are a component of real GNP. Also, note that treating the government expenditure variable as exogenous to our system and omitting it from the reduced form equation may result in an upward bias of the coefficients of the explanatory variables. That is, if $G$ is uncorrelated with $C$ and $I$ of (3.13.3), its omission may cause auto-correlation of the residuals in the regression equation of (3.13.9).

III. A Recapitulation of the Alternative Mechanism

The Brookings model limits the channels of monetary influence to the effects on capital investment and consumption through interest rate and wealth changes. The linkages of interest rates, wealth, and credit availability in the Wharton and FMP models are also Keynesian in nature and do not capture the influences sketched out in the portfolio balance and wealth adjustment models. The linkages of the St. Louis model constitute a typical, reduced form, monetarist model whereby monetary changes affect the price level and nominal GNP. And, whereas monetary impulses may be transmitted to the real sector through changes in interest rates, the price level, wealth, and credit availability, all these models show that their influence is realized with a long lag.\(^{22}\)

\(^{22}\)For a detailed account of the various large U.S. econometric models, see B. Hickman (1972) and the references to earlier works on these models contained therein.
In our transmission mechanism, the twelve leading economic indicators contained in the NBER 1967 short list are the linkages through which monetary impulses are channeled to income through wealth and relative price changes and expectational effects. In the system of thirteen equations that were developed earlier in this Chapter and restated below, monetary impulses are diffused to eight leading economic indicators which, in turn contribute in the determination of real GNP. Notice, however, that monetary changes affect real GNP directly through their influence on real money balances that enter as an input factor in the aggregate production function.

The set of equations that constitutes the more pragmatic monetary transmission mechanism is the following:

<table>
<thead>
<tr>
<th>Equation</th>
<th>Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_1$</td>
<td>$A[a_1(t)Y_13, b_1(t)Y_{13}]$</td>
</tr>
<tr>
<td>$Y_2$</td>
<td>$B[a_2(t)Y_1, b_2(t)Y_13, c_2(t)Y_{11}, e_2(t)Y_{13}]$</td>
</tr>
<tr>
<td>$Y_3$</td>
<td>$C[a_3(t)Y_3, b_3(t)Y_{13}]$</td>
</tr>
<tr>
<td>$Y_4$</td>
<td>$D[a_4(t)Y_2, b_4(t)Y_3, c_4(t)Y_5]$</td>
</tr>
<tr>
<td>$Y_5$</td>
<td>$E[a_5(t)Y_3, b_5(t)Y_3, c_5(t)Y_8]$</td>
</tr>
<tr>
<td>$Y_6$</td>
<td>$F[a_6(t)Y_3, b_6(t)Y_{13}]$</td>
</tr>
<tr>
<td>$Y_7$</td>
<td>$G[a_7(t)Y_2, b_7(t)Y_2, c_7(t)Y_3, e_7(t)Y_5, fY_7_{-1}]$</td>
</tr>
<tr>
<td>$Y_8$</td>
<td>$H[a_8(t)Y_1, b_8(t)Y_{11}, c_8(t)Y_{13}]$</td>
</tr>
<tr>
<td>$Y_9$</td>
<td>$I[a_9(t)Y_1, b_9(t)Y_{12}]$</td>
</tr>
<tr>
<td>$Y_{10}$</td>
<td>$J[a_{10}(t)Y_4, b_{10}(t)Y_{10}]$</td>
</tr>
<tr>
<td>$Y_{11}$</td>
<td>$K[a_{11}(t)Y_5, b_{11}(t)Y_6, c_{11}(t)Y_8]$</td>
</tr>
<tr>
<td>$Y_{12}$</td>
<td>$L[a_{12}(t)Y_5, b_{12}(t)Y_7, c_{12}(t)Y_8, e_{12}(t)Y_{10}]$</td>
</tr>
<tr>
<td>$Y_{13}$</td>
<td>$M[a_{13}(t)Y_5, b_{13}(t)Y^P, c_{13}(t)Y_9, e_{13}(t)Y_{10}, f_{13}(t)Y_{11}]$</td>
</tr>
</tbody>
</table>
The purpose of this study, broadly stated, is to incorporate and evaluate the role of the leading economic indicators into a transmission mechanism from changes in the money supply to real GNP. The hypothesis and/or theories that link the leading indicators together, like any hypothesis that attempts to embody certain important aspects of the behavior of economic units - while purposely omitting other less significant factors - is formulated as a model. The specification of our model consists of the formulation of the equations purporting to explain the process of the transmission of monetary impulses, of statements concerning the indicators that are used as explanatory variables, and of assumptions - to be stated in the following chapter - concerning the error terms of the equations to be estimated. Implicitly, our monetary transmission mechanism model is a representation of economic theory and explicitly is a supposition of the operative mechanism of the economic structure.  

The lag structures governing the influence of the explanatory variables were stated in general terms in this chapter but will become specific in the following chapter. Since the direction of influence between the indicators has been specified, the assumptions concerning the error terms along with the estimation techniques to be used will guide our choice of the less damaging econometric problems present in the estimation of a model using economic time series. Namely, the specification of the particular lag structures and the estimation techniques to be used will lead us to the acceptance of a trade-off between the common econometric problems

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23 This definition for a model was borrowed from J. Murphy (1973, p. 5)
of identification, simultaneity, autocorrelation, and multicollinearity.

The host of conceptual and estimation problems in our model are present because of our attempt to develop a more detailed and pragmatic transmission mechanism. That is, as feedback effects are allowed to influence endogenous variables, a causal chain or recursive system becomes inoperative. Following the monetarist tradition, however, we have sharply limited the number of explanatory variables we consider important and essential in the specification of the alternative monetary transmission process we developed. We have done so although utilization of additional indicators and other variables may have improved the theoretical basis of the model and the results to be obtained. Nonetheless, as Milton Friedman (1960, p.63) has pointed out, "...to expand the number of variables regarded as significant is to empty the hypothesis of its empirical content..."

In the following chapter, the structure that was derived above will be given forms that can be estimated statistically. More specifically, two subsets of hypotheses will be formulated: the first hypothesis subset deals with concurrently or isochronously realized effects from monetary changes to real GNP. The second hypothesis subset is concerned with monetary impulses being transmitted to real GNP with distributed lags whose length has been measured as the time difference between turning points in the series of the indicators involved.
CHAPTER FOUR

SPECIFICATION OF LAGS
AND MODELS TO BE ESTIMATED

The theoretical model of the alternative monetary transmission mechanism of the previous chapter was developed on the basis of a general portfolio balance framework. This descriptive construct simply states the relationships that link together the leading economic indicators with real GNP; these relationships being derived from generally accepted macroeconomic theory. However, the investigation of the explanatory power of the hypotheses advanced and the decision as to how well they explain the observed behavior of leading indicators cannot be established and accepted on purely theoretical grounds; empirical testing is needed.

Traditional statistical inference starts from prior knowledge of events or processes that are used as the basis of the model. The a priori information concerning this model, otherwise known as the maintained hypothesis, consists of accepting as correct the behavioral assumptions underlying the portfolio balance model from which we derived the system of the thirteen equations purporting to explain the transmission of monetary impulses through the linkages of the selected leading indicators. The maintained hypothesis is accepted as valid and goes unquestioned through the subsequent stages of hypothesis testing. Using a data set of 131 observations pertaining to the structure implied by the maintained hypothesis, a model consisting of thirteen equations designed to explain the implied structure,¹ and probability theory we can make inferences about

¹For a clear distinction between a model and a structure, see, for example, E. Malinvaud (1966, pp. 63-65) or T. J. Koopmans (1953, p. 29).
the causal ordering of the indicators and the lag structure suggested by the NBER timely ranking of turning points in the leading indicators series.

All traditional models recognize that monetary impulses affect output and income; the issue of the monetary lag, however, has remained unsettled. The Friedman lag doctrine dates back to 1959 when Friedman stated that: "...when the Federal Reserve System takes action today, the effect of that action may on some occasions be felt 5 months from now and on other occasions 10 months from now, on other occasions 2 years from now". (M. Friedman [1959, pp. 615-616]). The same theme was iterated and reiterated with the emphasis placed on the facts that the lag in the money-income relationships varies over time and that the variability in the monetary lag cannot be predicted. That is, no consistent or systematic factors explaining the lag variability have been found.²

The lag pattern of changes in the leading indicators provides us with a hypothesis to be tested about the lag in effect of monetary changes. There are reasons, however, to believe that in the case of some indicators such as the index of stock prices, for example, the adjustment of the dependent variable is accomplished within the period of a month. Such concurrent adjustment is entirely consistent with the efficient market hypothesis and the theory of rational expectations.

Although contemporaneous adjustment of most quantity indicators may be possible in annual data, the use of monthly observations may preclude the realization of such adjustment. Thus, we will first test the "concurrent hypothesis" where there are no lagged adjustments and then

the "distributed lag hypothesis" where lagged adjustments in the dependent variables are assumed to be present. The lag structure implied by the NBER ordering of turning points in the leading indicators series will be assumed to be the equivalent of the appropriate distributed lag structure and will be subjected to statistical testing.

The model pertaining to the concurrent hypothesis of adjustment in real GNP due to a monetary disturbance and changes in the leading indicators is the following:

\[
Y_1 = a_1 + b_1 M + c_1 Y_{1t} + U_{1t}
\]

where, \( a_1 < 0, b_1 > 0, c_1 > 0 \)

\[
Y_2 = a_2 + b_2 M + c_2 Y_1 + d_2 Y_{1t} + e_2 Y_{13} + U_{2t}
\]

where, \( a_2 < 0, b_2 > 0, c_2 > 0, d_2 > 0, e_2 > 0 \)

\[
Y_3 = a_3 + b_3 M + c_3 Y_{13} + U_{3t}
\]

where, \( a_3 < 0, b_3 > 0, c_3 > 0, d_3 > 0, e_3 > 0 \)

\[
Y_4 = a_4 + b_4 Y_2 + c_4 Y_3 + d_4 Y_{5} + U_{4t}
\]

where, \( a_4 < 0, b_4 > 0, c_4 > 0, d_4 > 0 \)

\[
Y_5 = a_5 + b_5 M + c_5 Y_3 + d_5 Y_{8} + U_{5t}
\]

where, \( a_5 < 0, b_5 > 0, c_5 > 0, d_5 > 0 \)

\[
Y_6 = a_6 + b_6 M + c_6 Y_{13} + U_{6t}
\]

where, \( a_6 < 0, b_6 > 0, c_6 > 0 \)

\[
Y_7 = a_7 + b_7 M + c_7 Y_2 + d_7 Y_3 + e_7 Y_{5} + f_7 Y_{t-1} + U_{7t}
\]

where, \( a_7 = 0, b_7 > 0, c_7 > 0, d_7 > 0, e_7 > 0, f_7 > 0 \)

\[
Y_8 = a_8 + b_8 M + c_8 Y_{11} + d_8 Y_{13} + U_{8t}
\]
where, \( a_{9} > 0, b_{9} > 0, c_{9} > 0, d_{9} > 0 \)

\[
y_{9} = a_{9} + b_{9}y_{11} + c_{9}y_{12} + u_{9t}
\]

where, \( a_{9} > 0, b_{9} > 0, c_{9} > 0 \)

\[
y_{10} = a_{10} + b_{10}y_{11} + c_{10}y_{4} + d_{10}y_{5} + u_{10t}
\]

where, \( a_{10} > 0, b_{10} > 0, c_{10} > 0, d_{10} > 0 \)

\[
y_{11} = a_{11} + b_{11}y_{5} + c_{11}y_{6} + d_{11}y_{8} + u_{11t}
\]

where, \( a_{11} > 0, b_{11} > 0, c_{11} > 0, d_{11} > 0 \)

\[
y_{12} = a_{12} + b_{12}y_{5} + c_{12}y_{7} + d_{12}y_{8} + e_{12}y_{10} + u_{12t}
\]

where, \( a_{12} > 0, b_{12} > 0, c_{12} > 0, d_{12} > 0, e_{12} > 0 \)

\[
y_{13} = a_{13} + b_{13}y_{p} + c_{13}y_{9} + d_{13}y_{9} + e_{13}y_{10} + f_{13}y_{11} + u_{13t}
\]

where, \( a_{13} > 0, b_{13} > 0, c_{13} > 0, d_{13} > 0, e_{13} > 0, f_{13} > 0 \)

The lags implied by the NBER ordering of the leading indicators are obtained by simply taking the difference between the leads of indicators with respect to the established benchmarks. For example, percent changes in the money supply lead the NBER benchmarks by fifteen months, while the lead of the contracts and orders for plant and equipment is six months. Thus, the lag between percent changes in the money supply and the contract and orders for plant and equipment indicator is nine months.

The time lags of feedback effects are calculated in the following manner: Assume that the round from changes in the money supply to the coincident indicators takes a fixed number of fifteen months to be completed. Let \( y_{i} \) be the indicator to be explained and \( y_{j} \) the indicator that transmits feedback effects to \( y_{i} \). Let \( t_{i} \) be the time lag from

\[ t_{i} = 3 \]

\(^3\)The constant term and the coefficient of \( y_{T-1} \) are restricted to zero and one, respectively, because of the specification of this equation.
monetary changes to \( Y_1 \) and let \( t_j \) be the time lead of \( Y_j \) over the turning point of some coincident indicators index. Then the time lag involved for the impact of \( Y_j \) to be realized on \( Y_1 \) is the sum \( (t_i + t_j) \). For instance, average workweek, \( Y_7 \), lags behind changes in the money supply eleven months and the price per unit labor cost index, \( Y_{10} \), leads the turning point of the coincident indicator index by two months. Thus, the time lag involved for the feedback effects from \( Y_{10} \) to be realized on \( Y_7 \) is thirteen months \((11 + 2 = 13)\).

Using the NBER implied lag structure, the model pertaining to the distributed lag hypothesis becomes:

\[
Y_1 = a_1 + \sum_{i=0}^{5} b_{1i} t_{i-1} + \sum_{j=0}^{7} c_{1j} Y_{13} t_{j} + U_{1t}
\]

\[
Y_2 = a_2 + \sum_{h=0}^{7} b_{2h} M_{t-h} + \sum_{i=0}^{2} c_{2i} Y_1 t_{i-1} + \sum_{j=0}^{9} d_{2j} Y_{11} t_{j} + \sum_{k=0}^{9} e_{2k} Y_{13} t_{k} + U_{2t}
\]

\[
Y_3 = a_3 + \sum_{i=0}^{8} b_{3i} t_{i-1} + \sum_{j=0}^{10} c_{3j} Y_{13} t_{j} + U_{3t}
\]

\[
Y_4 = a_4 + \sum_{h=0}^{2} b_{4h} Y_2 t_{h} + \sum_{i=0}^{1} c_{4i} Y_3 t_{i-1} + \sum_{j=0}^{15} d_{4j} Y_5 t_{j} + U_{4t}
\]

\[
Y_5 = a_5 + \sum_{h=0}^{9} b_{5h} M_{t-h} + \sum_{i=0}^{1} c_{5i} Y_3 t_{i-1} + \sum_{j=0}^{13} d_{5j} Y_8 t_{j} + U_{5t}
\]

\[
Y_6 = a_6 + \sum_{i=0}^{9} b_{6i} M_{t-h} + \sum_{j=0}^{11} c_{6j} Y_{13} t_{j} + U_{6t}
\]

\[
Y_7 = a_7 + \sum_{h=0}^{10} b_{7h} M_{t-h} + \sum_{i=0}^{3} c_{7i} Y_2 t_{i-1} + \sum_{j=0}^{2} d_{7j} Y_3 t_{j} + \sum_{k=0}^{1} e_{7k} Y_5 t_{k} + f_7 Y_7 t_{-1} + U_{7t}
\]

\[
Y_8 = a_8 + \sum_{h=0}^{11} b_{8h} M_{t-h} + \sum_{i=0}^{13} c_{8i} Y_{11} t_{i-1} + \sum_{j=0}^{13} d_{8j} Y_{13} t_{j} + U_{8t}
\]

\[
Y_9 = a_9 + \sum_{i=0}^{11} b_{9i} M_{t-i} + \sum_{j=0}^{13} c_{9j} Y_{12} t_{j} + U_{9t}
\]
where the expected signs of the sum of the lag coefficients are the same as in the concurrent hypothesis model and where the restrictions placed on the constant term and the coefficients of the \( Y_{7t-1} \) term in the equation for the average workweek are still valid.

Under ideal conditions, all the disturbance terms \( U_{gt} \) should satisfy the usual ordinary least squares (OLS) assumptions of zero mean, constant variance, zero covariance, and no contemporaneous correlation. More formally, the following assumptions are normally presumed to hold true in the application of the OLS technique in the estimation of our model.

1. \( U_{gt} \sim N(\mu, \sigma^2) \) indicates that the error terms are normally distributed.
2. \( E(U_{gt}) = 0 \) specifies zero expected value of the residuals for any value of \( Y_{gt} \).
3. \( E(U_i U_j) = \sigma^2 \) when \( i = j \). This is the property of homoscedasticity which requires that the variance of the residuals is constant and finite.
4. \( E(U_i U_j) = 0 \) when \( i \neq j \). This assumption requires that the error term associated with one observation is statistically independent of the error term associated with another observation.

That is, this property precludes the existence of serial correlation.
5. $E(Y_{gt} U_{gt}) = 0$, or its equivalent $\text{cov}(Y_{gt} U_{gt}) = 0$, means that all $Y_{gt}$ are statistically independent of $U_{gt}$. By this assumption we specify the direction of influence from the explanatory variables to the dependent variables and we exclude the possibility of contemporaneous feedback effects. This is a strong assumption and the condition of constant variance could not have been fulfilled without this assumption.

6. The rank condition $r(Y) = (k + 1) N$, where $k$ is the number of estimated parameters and $N$ is the number of observations, ensures that the columns and rows of the matrix of observations, $Y$, are linearly independent. If the rank condition is satisfied, the regressors are free of multicollinearity.

Violation of any of these assumptions concerning the error terms results in biased and inconsistent estimators. Unfortunately, the very purpose of this study leads to the specification of equations in which the disturbance terms may not satisfy all the assumptions above and which equations are underidentified. Generally, this is interpreted as resulting in unreliable estimates of the parameters of the model. To deal with this problem, additional indicators may have been introduced or a priori restrictions placed on particular parameters. T-C. Liu (1960), however, questions the specification of models in which restrictions are imposed on particular parameters or groups of them to secure identification. Liu's position is that econometric models are generally underidentified and that the most we can do is to estimate reduced form equations. The econometric problems involved in the estimation of our model are discussed in Appendix B.

The estimation of distributed lags by the Almon lag technique requires, in addition to the lag length, specification of the degree of the polynomial
used to approximate the configuration of the distribution of the weights and placement of endpoint restrictions. Since there is very little in the way of economic theory to constrain the number of the different combinations between the degree of the polynomials to be used and the endpoint restrictions, estimation of the model may become an exercise in "data mining".

In conditions where the logical analysis of an inference problem is very difficult, it can be of assistance to run a number of experiments for different numerical conditions. Thus, in preliminary tests it was found that short lags (up to four periods) can be approximated reasonably well with a first degree polynomial and that longer lags require the use of a second degree polynomial.4

In an effort to limit the extent of search through the degree and endpoint restriction spaces, the permissible degrees of polynomials to be used are one and two. This restriction seems reasonable because of two reasons:

1. Second degree polynomials are sufficiently flexible and can approximate fairly well lagged responses generated by theoretical processes similar to those resulting in a geometric lag or in an "inverted V" type of lad distribution.

2. None of the time path adjustments in the lagged responses of this model is believed to be of the configurations that a third or higher order polynomials trace out.

F-statistic tests designed to determine the consistency of endpoint

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4 This is in accordance with the findings of T. Amemiya and K. Morimune (1974).
restrictions are not conclusive. That is, in the preliminary tests, it was found that more than one restriction may be consistent. In such instances, other criteria must be used to select the optimum endpoint restrictions. These criteria consist of choosing consistent endpoint restrictions that yield appropriate signs, highest t-ratios, maximum $R^2$'s, Durbin-Watson statistics near two, and minimum percent errors.

Selecting the best regression equations on the basis of multiple criteria is a process with ample room for the introduction of ad hoc standards. To eliminate such possibility in the selection of endpoint restrictions, we adopt the following convention: For lag lengths of more than four months, in which second degree polynomials are used, we will impose zero restrictions on both ends of the lag distribution, otherwise far end restrictions will be placed on the weights of the distributions.\(^5\)

When imposing endpoint restrictions, however, the pattern of weights is shifted according to the restrictions placed on the lag distribution. This means that the lag effect of the time periods at the near, far, or both endpoints of the distribution is restricted to be zero. Because we are dealing with short lag lengths and because the NBER lag pattern implies that the endpoint lag effect is non-zero, imposing endpoint restrictions necessitates extending the length of the lag by one period.

Having adopted the above set of rules to avoid empirical ad hocery, the form of the distributed lag hypothesis model to be estimated becomes:

$$Y_1 = F(M < 2, 6, B >, Y_1 < 2, 8, B >)$$
$$Y_2 = F(M < 2, 8, B >, Y_1 < 1, 3, F >, Y_11 < 2, 10, B >, Y_{13} < 2, 10, B >)$$
$$Y_3 = F(M < 2, 9, B >, Y_{13} < 2, 11, B >)$$
$$Y_4 = F(Y_2 < 1, 3, F >, Y_3 < 1, 2, F >, Y_5 < 2, 14, B >)$$

\(^5\)For a discussion of the problems associated with placing improper endpoint restrictions on lag distributions, see Appendix A.
Y5 = F(M <2, 10, B >, Y3 <1, 2, F >, Y8 <2, 14, B >)
Y6 = F(M <2, 10, B >, Y13 <2, 12, B >)
Y7 = F(M <2, 11, B >, Y2 <1, 4, F >, Y3 <1, 3, F >, Y5 <1, 2, F >, Y7(-1))
Y8 = F(M <2, 12, B >, Y11 <2, 14, B >, Y13 <2, 14, B >)
Y9 = F(M <2, 12, B >, Y12 <2, 14, B >)
Y10= F(M <2, 13, B >, Y4 <2, 5, B >, Y5 <1, 4, F >)
Y11= F(Y5 <2, 5, B >, Y6 <2, 5, B >, Y8 <1, 3, F >)
Y12= F(Y5 <2, 5, B >, Y7 <1, 4, F >, Y8 <1, 3, F >, Y10 <1, 2, F >)
Y13= F(Y^P, M <2, 14, B >, Y9 <1, 3, F >, Y10 <1, 2, F >, Y11)

where the first number in the angular parentheses stands for the degree of the polynomial, the second number gives the lag length, and B and F signify "both" and "far" endpoint restrictions respectively.

In a final attempt to eliminate testing arbitrary functional forms, we restrict ourselves to testing only linear forms of the equations, although other functional forms may be consistent with the theory and very plausible. This restriction, along with the omission of variables from our model that may be significant, such as government spending, for instance, is suspected to lead to autocorrelation of the error terms of the regressions. However, in order to provide a remedy for this problem, the equations will be corrected for first or second degree autocorrelation by the method used in the Fed-MIT model. 6

Broadly stated, the intent of this study is to construct a model integrating the leading indicators into an alternative monetary transmission mechanism and test the hypothesis that monetary impulses can be traced through the linkages of the leading indicators via the lag structure implied by the NBER ordering of turning points in the series of the

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6 This technique of correcting for autocorrelation is discussed in Appendix B.
As it was stated earlier in this chapter, the maintained hypothesis consists of accepting as correct the behavioral assumptions underlying the portfolio balance model that leads to the derivation of our model. Notice, however, that the set of the thirteen equations are not a part of the maintained hypothesis; they are consequences to be tested. For each explanatory variable in the concurrent model, the null hypothesis is that the coefficient of that explanatory variable is not significantly different from zero. For each explanatory variable in the distributed lag hypothesis model, the null hypothesis is that the sum of the coefficients in the lag structure adopted from the NBER implied lag structure is not significantly different from zero. In both cases, the alternative hypothesis is that the coefficient (or sum of coefficients of the lag distribution) is significantly different from zero and of the expected sign. Thus, a one-tail t-test with a 5 percent probability of making a Type-I error is used throughout.

In Chapter Five, estimates of the two models are presented with a detailed explanation of the results. For the distributed lag model, only the sum of the distribution of the weights is presented in the text of the chapter. The complete weight distribution is tabulated in Appendix C.
CHAPTER FIVE

ESTIMATION AND INTERPRETATION OF THE RESULTS

I. Introduction

The time period covered by this research project is 1966 to 1976. The U.S. economy during these years was not stationary nor was it anywhere near the steady state growth path. In addition to the adjustments that occurred after the end of the Vietnam conflict, the U.S. economy experienced drastic structural changes in the second half of this period as a direct result of shortages of crude oil and derivative products.

Monetary developments during this period occurred amidst other significant economic developments. In the mid-seventies, the U.S. economy was still adjusting to shocks experienced in the early 1970's. These shocks included crop failures, price controls, and the implementation of environmental, safety, and consumer protection programs. Since 1970, the FOMC has focused on the growth rate of the money supply as the key intermediate target of monetary policy, and since 1972, it has placed additional emphasis on reserves available to support private non-bank deposits (RPDs) as the immediate target of monetary policy. However, the federal funds rate is still assigned a considerable amount of importance in the formulation of policy. For the purpose of this study, these events may also be considered as structural changes.

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1 For more details on the changes that took place in the U.S. economy during the mid-seventies, see N.H. Bowsher (1976).

2 A good account of targets and indicators of monetary policy can be found in D. Wrightsman (1976, Chapter 12) and in R.E. Lombra and R.G. Torto (1975).
Despite the several structural changes the U.S. economy experienced during these years, the choice of this time period was deliberate because it has become fashionable for the business community to watch closely every wiggle in the money supply data since the late 1960's. Thus, if reasonable links are established in our transmission mechanism during this period of drastic structural changes, the causality from monetary changes to real GNP, through the leading economic indicators and the interactions among them, should be even stronger and more stable during periods of relative structural stability in the U.S. economy.

For the purpose of this study, monthly data are used in testing the hypothesized relationships. The actual data used in the estimation of the parameters of our model are the NBER series of the leading indicators contained in the 1966 short list. Monthly data for all the indicators are available except for the real GNP and corporate profits after taxes indicators. These two series were derived by the simple interpolation method from quarterly data that were previously adjusted.¹

The advantages of using monthly data in the estimation of the hypothesized links in the alternative transmission mechanism are several:²

1. Economic policy decisions are usually influenced by the most recent changes in economic statistical series.

2. More accurate short-term forecasts are likely to be obtained from a monthly model than equally well specified quarterly or yearly models.

¹Monthly estimates for these series could have been obtained from the T-C. Liu recursive model (1969), but computational complexity makes their derivation impractical. Also, there is no reason to believe such estimates more reliable than the ones obtained through simple interpolation, although there may be serial correlation introduced in the estimates derived by the latter method.

²All these advantages of using a monthly model are due to T-C. Liu and E-C. Hwa (1974).
3. Much less simultaneity is involved in the system of economic relationships depicted by a model using monthly data.

4. Minimum specification error concerning the direction of causality may result from a monthly model when compared to quarterly or yearly models. Also, less serial correlation in the residuals may result from monthly models.

The costs of specification errors, under-identification, and simultaneity were weighted against structural simplicity, economic interpretation, and time and cost considerations because building a complete econometric model is well beyond the scope of this research project. That is, whereas a more complete model may have included additional exogenous variables and behavioral equations, they are omitted here since the only intent of the model is to trace through the influence of monetary changes through the leading indicators contained in the 1966 NBER short list and not to explain the business cycle.

The purpose of this chapter is to present the empirical results of the two versions of our model, interpret these results, and discuss in qualitative terms the performance of the concurrent and the distributed lag hypothesis models. Thus, in the following section we present the estimated equations for both versions of our model with explanations concerning the statistics in each equation, and in Section III, we conclude the chapter with a discussion of the functioning of the two versions of our model.

II. Discussion of the Results

The sets of the equations constituting a) the concurrent hypothesis

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5 The equations of our model were estimated by PLANETS, the computer program used by the Brookings Institution. The references to the techniques used by this econometric program are: P. J. Dhrymes (1970), A. S. Goldberger (1964), J. Johnston (1972), and H. Theil (1971).
model and b) the distributed lag hypothesis model are presented below. The numbers in parentheses are the estimated t-ratios, and the numbers in square brackets are the beta coefficients for the explanatory variables. \( \overline{R}^2 \) is the adjusted coefficient of determination and D-W stands for the Durbin-Watson statistic. Terms followed by an asterisk have coefficients that are statistically insignificant at the 5 percent level when a one-tail t-test is made.

\( U_{gt-1} \) are the residuals of the original regressions; the residuals were saved, lagged one period, and then used as regressors in order to correct for first order autocorrelation in the equations of the second iteration.\(^6\) The coefficients of the lagged residual terms are equivalent to the coefficients of autocorrelation obtained by the Cochrane-Orcutt technique, and when they are statistically significant, they suggest the possibility of incomplete specification in the original equations.\(^7\) Incomplete specification for a particular equation of our model includes the following possibilities: (i) inappropriate functional form; (ii) missing variables; (iii) redundant variables; and (iv) a lag structure other than the one specified in the equation.

1. Net Changes in Consumer Installment Debt: \( Y_1 \)
   a) \( Y_1 = -40.1852 + .1392x + .0437Y_1 + .8042u_{t-1} \)
      \([-11.661] \quad [2.131] \quad [14.557] \quad [15.138] \)
      \([.0879] \quad [.6161] \)
      \( \overline{R}^2 = .779, \ D-W = 2.023 \)

\(^6\) For further discussion on the use of lagged residuals to correct for autocorrelation, see Appendix B.

\(^7\) Original equations are the equations that were estimated without using the lagged values of the residuals to correct for autocorrelation.
b) \( Y_t = -45.5249 + .6376M + .0465Y_{13} + .8219U_{2t-1} \)

\((-11.796) (6.532) (14.090) (15.834)\)

\([.4113] [.6556] \)

\( R^2 = .793, \ D-W = 2.087 \)

These are the two versions of the first equation in the model of the alternative monetary transmission mechanism. In this equation, net changes in consumer installment debt are explained by percentage changes in the money supply narrowly defined, \( M \), and real GNP, \( Y_{13} \).

The influence of monetary changes and the impact of real GNP on net changes in consumer installment debt are shown clearly in the two equations and manifested in adjusted \( R^2 \) statistics of .779 for the concurrent hypothesis version, equation (a), and .793 for the distributed lag hypothesis version, equation (b). The coefficients for \( M \) and \( Y_{13} \) in equation (a) are explained in the following manner: As the growth rate in the money supply increases by one percentage point, \( Y_t \) increases by .1392 billion dollars and as real GNP rises by one billion dollars, the dependent variable rises by .0437 billion dollars. The meaning of the coefficients of the explanatory variables in equation (b) is the following: A one percentage point increase in the money supply during the time period \( (t-i) \) cumulates to a .6376 increase in the dependent variable, \( Y_t \), over \( i \) time periods (months in this case). Also, as real GNP grows by one billion dollars at time \( (t-j) \), the dependent variable, \( Y_t \), increases by .0465 billion dollars by time period \( t \). The interpretation of the coefficients for the rest of the equations are explained in a similar fashion.

The relative impacts of the monetary variable and real GNP on the dependent variable are given by the beta coefficients which are used as
a rank ordering concerning the statistical importance of each explanatory variable.\(^8\) The beta coefficients of real GNP are substantially higher than those of the monetary variable in these equations. This signifies that the relative impact of real GNP on net changes in consumer installment debt is higher than the influence of percentage changes in the money supply \(\bar{M}\).

Since there is not a robust statistic by which to test the two versions of the equations in our model for superior performance, no definite statements can be made concerning relative performance on the basis of the standard statistics shown. In other words, we can only make judgmental qualitative statements about the effect of each of the variables in the two versions of the equations based on t-statistics.

The t-ratio of the monetary variable in the lag hypothesis equation is about three times higher than the t-ratio of this variable in the concurrent hypothesis equation. This may be interpreted as an indication that a distributed lag on \(\bar{M}\) is a "better" explanatory variable than the contemporaneous value of \(\bar{M}\). On the other hand, the t-ratios for real GNP are approximately equal in the two equations and this presents us with a situation where the concurrent and the distributed lag version of the variable are of "equal importance" in the determination of the dependent variable.

The coefficients of both explanatory variables are statistically significant and the Durbin-Watson statistic in both equations indicates that there is no autocorrelation present in the residuals of the two estimated equations. However, as it was mentioned earlier in this

\(^8\)The beta coefficient is defined as the product of the regression coefficient of an explanatory variable times the ratio of the standard error of that explanatory variable to the standard error of the dependent variable.
chapter, the t-ratio for the $U_{1t-1}$ terms suggests the possibility of incomplete specification in the original equations.

2. Change in Book Value of Manufacturing and Trade Inventories: $Y_2$

   a) $Y_2 = 75.0455 + .5173M + .6951Y_1 + .3615Y_{11} - .1057Y_{13} + .5654U_{2t-1}$

   \[
   \begin{align*}
   (3.758) & \quad (2.227) & \quad (3.789) & \quad (8.649) & \quad (-4.615) & \quad (7.396) \\
   [.1390] & \quad [.2895] & \quad [1.019] & \quad [-.6207] \\
   \end{align*}
   \]

   $R^2 = .590, D-W = 2.046$

   b) $Y_2 = 126.0400 + 2.2395M + 1.5521Y_1 + .5226Y_{11} - .1856Y_{13} + .6047U_{2t-1}$

   \[
   \begin{align*}
   (4.218) & \quad (5.770) & \quad (6.699) & \quad (8.464) & \quad (-5.269) & \quad (7.916) \\
   [.6018] & \quad [.6465] & \quad [1.4744] & \quad [-1.0900] \\
   \end{align*}
   \]

   $R^2 = .651, D-W = 2.035$

This linkage in our transmission mechanism estimates changes in the value of manufacturing and trade inventories in terms of percentage changes in the money supply, $M$, net changes in consumer installment debt, $Y_1$, industrial materials prices, $Y_{11}$, and real GNP, $Y_{13}$.

In both equations, the coefficients of the first three explanatory variables have the expected signs and are statistically significant, while the real GNP coefficient is opposite to what was expected which renders it statistically insignificant according to the criterion mentioned in Chapter Four. In the concurrent hypothesis equation, the index of industrial materials prices has the highest relative impact on the dependent variable, followed by the impact of net changes in consumer installment debt and of monetary changes. The same pattern of relative impacts is observed in the distributed lag hypothesis equation, as shown by the beta coefficients.

The t-ratios of the monetary variable's coefficient and the coefficient for $Y_1$ in the equation for the distributed lag hypothesis are twice
as much as the respective t-ratios in the concurrent hypothesis equation, while the t-ratios for the coefficient of Yll are practically the same in the two equations. The difference in the magnitude of the t-ratios of \( t \) and Yl between the two equations suggest that the lag form of these variable may be preferable to the contemporaneous form, while the t-ratios for Yll indicate that the concurrent form of this variable may be at least as "good" as the distributed lag form.

On the basis of the adjusted coefficients of determination, one may say that the second equation explains a higher percentage of variation in the dependent variable and, therefore, it is better than the first equation. Such comparison, however, is not valid because the higher \( R^2 \) of the second equation may be derived from the lagged residual of the concurrent hypothesis equation. Lastly, the Durbin-Watson statistics show no autocorrelation among the residuals of these two equations.

Index of Net Business Formation: Y3

a) \[
Y3 = 43.9257 + 0.1745t + 0.0587Y13 + 0.9136U_{3t-1}^9 \\
(17.952) (3.746) (27.532) (24.081) \\
[0.0983] [0.7227]
\]

\( R^2 = 0.914, \text{ D-W} = 1.838 \)

b) \[
Y3 + 46.3456 + 0.9679t + 0.0540Y13 + 0.9233U_{3t-1} + 0.1975V_{3t-1}^9 \\
[0.5452] [0.6648]
\]

\( R^2 + 0.938, \text{ D-W} = 2.031 \)

The function of the lagged residual \( V_{3t-1}^9 \) in the third iteration of this and several other equations is similar to that of \( U_{3t-1} \), the difference being that its use, along with that of \( U_{gt-1} \), corrects for second order autocorrelation in the residuals of the equations.
In the third linkage of our mechanism, the index of net business formation is explained by percentage changes in the money supply, $M_t$, and real GNP, $Y_{13}$. The explanatory power of these equations is manifested in relatively high coefficients of determination accompanied by significant coefficients for the independent variables. The Durbin-Watson statistics indicate the absence of autocorrelation in the residuals of the equations, but significant coefficients for the lagged residual terms suggest incomplete specification of the original equations.

As we can see from the beta coefficients, the relative impact of real GNP is greater than that of the monetary variable in both equations, while the t-ratio of the real GNP coefficient is not much different in the two equations. The t-ratio for the coefficient of $M_t$ in the distributed lag equation is approximately five times higher than that of the concurrent hypothesis equation. Thus, it appears that while either form of the real GNP variable performs equally well, the distributed lag form of the monetary variable is more appropriate than the contemporaneous form.

It is worth noting that the distributed lag form of the explanatory variables raises only slightly the coefficient of determination and at the same time increases the extent to which the residuals are autocorrelated. That is, the residuals of the equation for the distributed lag hypothesis are corrected for second order autocorrelation.

4. Layoff Rate in Manufacturing Industries: $Y_4$
   
   a) $Y_4 = 5.0682 - .0081Y_{2t} - .0404Y_{3t} + .0907Y_{5t} + .8610U_{4t-1}$
   
   \[ (19.809) (-6.932) (-15.460) (12.907) (16.568) \]
   
   \[ [.3006] [.7153] [.6725] \]
   
   $R^2 = .833$, D-W = 2.135
b) \[ Y_4 = 6.3329 - .0045y_{2t}^2 - .0517Y_3 + .0936Y_5 + .8356U_{\text{4t-1}} \]

\[ (23.809) (-4.250) (-20.926) (16.141) (15.655) \]

\[ [- .1670] [-.9154] [.6940] \]

\[ R^2 = .884, \quad D-W = 1.974 \]

The fourth set of equations in our model explains the layoff rate in manufacturing industries in terms of changes in manufacturing and trade inventories, \( Y_2 \), the index of net business formation, \( Y_3 \), and the contracts and orders for plant and equipment indicator, \( Y_5 \).

The coefficients of changes in manufacturing and trade inventories are statistically insignificant in both equations by virtue of the fact that they have a negative sign, whereas a positive sign was expected. The coefficients for the other explanatory variables are significant in the two equations and their interpretation is similar to that in the equations for net changes in consumer installment debt.

The relative impact of the index of net business formation, \( Y_3 \), is higher than the relative impact of contracts and orders for plant and equipment in both equations. Notice, however, that the t-ratios of the coefficients for the two statistically significant explanatory variables are substantially higher in the distributed lag equation than in the concurrent equation. Again, this suggests the possibility that the distributed lag form of these two variables may be better than their contemporaneous form in the determination of the layoff rate.

The adjusted coefficient of determination in the distributed lag equation shows that this equation explains about five percent more of the variation in the dependent variable than the concurrent equation does. Finally, the Durbin-Watson statistics indicate that the residuals of both equations have been purged of the autocorrelation problems.
5. Value of Contracts and Orders for Plant and Equipment: Y5

a) \( Y_5 = -5.4688 + 0.0023f_t + 0.0415Y_3 + 0.3187Y_8 + 0.5052U_{5t-1} \)

\[ \begin{align*} 
& (-5.447) \quad (1.444) \quad (3.911) \quad (34.181) \quad (6.355) \\
& [.0031] \quad [.0991] \quad [.8984] \\
R^2 &= .947, \quad D-W = 2.201
\]

b) \( Y_5 = -11.8933 + 0.0535\hat{M} + 0.0946Y_3 + 0.3401Y_8 + 0.2708U_{5t-1} \)

\[ \begin{align*} 
& (10.315) \quad (1.729) \quad (8.192) \quad (32.417) \quad (2.859) \\
& [.0719] \quad [.2259] \quad [.9587] \\
R^2 &= .948, \quad D-W = 2.009
\]

In these two equations, the dependent variable is explained by percentage changes in the money supply, \( \hat{M} \), the index of net business formation, \( Y_3 \), and the value of new orders for durable goods, \( Y_8 \).

All the regression coefficients have the expected signs in both equations with the exception of the coefficient for the monetary variable which is insignificant at the five percent level. The ordering of the statistical significance of the explanatory variables, in terms of the beta coefficients, is the same in the two equations. Namely, the value of new orders for durable goods has the highest relative impact on the dependent variable, followed by the relative impacts of the index of business formation and the percentage changes in the money supply.

The t-ratios for the coefficients of \( \hat{M} \) and \( Y_3 \) are higher in the distributed lag equation than the corresponding t-ratios in the concurrent equation. This may be an indication that the distributed lag forms of these variables are preferable to the contemporaneous forms. However, the opposite is true for the t-ratio for the coefficient of \( Y_8 \); the t-ratio is higher in the concurrent equation which suggests that the contemporaneous form of this variable may be a "better specification" than the distributed lag form.
6. Index of Permits for New Private Housing Units: $Y_6$

a) $Y_6 = 12.3147^* + 2.2085\hat{M} + 0.0886Y_{13} + 0.8801U_{6t-1}$

$$R^2 = 0.775, \text{D-W} = 2.051$$

$$\begin{array}{c}
\text{t-ratio} \\
(5.456) \\
(4.945) \\
(17.545)
\end{array}$$

b) $Y_6 = 17.8049^* + 8.8366\hat{M} + 0.0574Y_{13} + 0.9724U_{6t-1}$

$$R^2 = 0.952, \text{D-W} = 2.158$$

The sixth linkage in the model of the alternative monetary transmission mechanism is the index of permits for new private housing units which serves as a proxy for new housing demand. This index is explained by percentage changes in the money supply, $\hat{M}$, and real GNP, $Y_{13}$.

The coefficients of both explanatory variables are statistically significant in the two equations but the relative impact of monetary changes outweighs the influence of real GNP in the determination of the dependent variable in both versions. On the basis of the t-ratios for the coefficients we may infer that the distributed lag form of the variables performs better than their contemporaneous form.

The constant terms of both equations are statistically insignificant from zero which says that when monetary growth is restricted to zero and real GNP is zero, there will be no permits for new private housing units issued. As in all other equations, the Durbin-Watson statistics show no autocorrelation in the residuals of the two equations, but significant coefficients for the lagged error terms suggest the possibility of incomplete specification in the original equations. Finally, notice that the adjusted coefficient of determination for the second equation shows the
distributed lag version explaining about twenty percent more of the varia-
tion in the dependent variable than the concurrent model.

7. Average Workweek, Manufacturing Industries: Y7

a) \[ Y7 = 2.9606* - .0075M + .003Y2 + .0087Y3 - .0220Y5 + .9086Y7_{t-1} - .3637U_{7t-1} \]
\[
\begin{array}{cccccc}
(1.198) & (-1.249) & (.163) & (1.997) & (-1.405) & (14.519) & (-3.466) \\
(.0526) & (.0078) & (.1089) & (.1153) & (.9195)
\end{array}
\]
\[R^2 = .804, D-W = 2.080\]

\[ Y7 = 2.5271* + .0038M - .0029Y2 + .0071Y3 - .0039Y5 + .9190Y7_{t-1} - .4168U_{7t-1} \]
\[
\begin{array}{cccccc}
(.812) & (.306) & (-1.107) & (1.072) & (-.192) & (10.873) & (-3.467) \\
(.0267) & (.0761) & (.0888) & (.0204) & (.9300)
\end{array}
\]
\[R^2 = .753, D-W = 2.102\]

In these autoregressive equations of our model, the constant term was
restricted to be zero and the coefficient of \( Y7_{t-1} \) to be one. Indeed, the
constant terms are not statistically different from zero and the coeffi-
cients of the lagged dependent variable in the two equations are not statisti-
cally different from one.¹⁰ Here, the indicator of the average workweek
is explained by percentage changes in the money supply, \( \dot{M} \), changes in manu-
facturing and trade inventories, \( Y2 \), the index of net business formation,
\( Y3 \), contracts and orders for plant and equipment, \( Y5 \), and the average
workweek of the previous time period, \( Y7_{t-1} \).

In the first equation, the constant term and the regression coeffi-
cients of \( \dot{M}, Y2, \) and \( Y5 \) are not statistically different from zero. The
coefficients for the variables \( Y3 \) and \( Y7_{t-1} \) are statistically significant,
but as we can see from the value of the beta coefficients, most of the

¹⁰The t-ratios under the null hypothesis that the coefficients of the
the \( Y7_{t-1} \) terms are equal to one are -1.462 for the first and -.958 for the
second equation, which lead us to accept this null hypothesis.
impact on the dependent variable comes from its lagged value that serves as an explanatory variable. In the case of the second equation, all the regression coefficients are not significantly different from zero, with the exception of the coefficient for $Y_{t-1}$.

There are several points about these equations that are worthy of our attention: First, the adjusted coefficients of determination are relatively high, while most of the regression coefficients are statistically insignificant. Second, the ranking of the importance of the explanatory variables changes from one equation to the other. Third, the t-ratio of the coefficient for $Y_{t-1}$ in the second equation, where it is the only significant explanatory variable, is less than in the first equation.

The peculiarities of the results of these equations clearly point out the problem of multicollinearity among the regressors. Because of the severity of the multicollinearity problem here, there is very little we can say about the two equations because the estimated regression coefficients are highly biased and, therefore, unreliable.

8. Value of New Orders for Durable Goods: $Y_8$

a) $Y_8 = -33.9509 - 0.0526M^* + 0.1020Y_{11} + 0.0485Y_{13} + 0.789U_{8t-1}$

\[ (-17.256) \quad (-1.892) \quad (21.217) \quad (21.653) \quad (13.360) \]
\[ [- 0.0251] \quad [0.5110] \quad [0.5058] \]

$R^2 = 0.981$, $D-W = 2.065$

b) $Y_8 = -66.3367 - 0.3267M^* + 0.0208Y_{11} + 0.0896Y_{13} + 0.8905U_{8t-1}$

\[ (-25.350) \quad (-5.777) \quad (3.254) \quad (29.552) \quad (20.224) \]
\[ [- 0.1559] \quad [0.1042] \quad [0.9345] \]

$R^2 = 0.981$, $D-W = 2.125$
These two equations are the eighth linkage which estimates the value of new orders for durable goods in terms of percentage changes in the money supply, $\bar{m}$, the index of industrial materials prices, $Y_{11}$, and real GNP, $Y_{13}$.

The coefficients of the monetary variable are statistically insignificant in both equations in the sense that they possess a sign opposite to what was expected. But, the coefficients of the other two explanatory variables are significantly different from zero and their meaning is the following: As the index of industrial material prices rises by one point, the value of new orders for durable goods rises by $0.1020$ billion dollars, and when real GNP increases by one billion, the dependent variable rises by $0.0485$ billion dollars in the concurrent hypothesis equation. In the distributed lag equation, a one point increase in $Y_{11}$ leads to a $0.0208$ billion dollar increase in $Y_{8}$ and a one billion dollar rise in $Y_{13}$ causes a $0.896$ billion dollar increase in the dependent variable over the specified lag lengths.

In the first equation, the relative impact of the industrial materials prices index is higher than that of real GNP on the dependent variable, while the opposite is true in the second equation. The t-ratio for the coefficient of $Y_{11}$ in the first equation is approximately six times higher than the t-ratio of $Y_{11}$ in the second equation, thus making the concurrent version of this variable the potentially better form. In the case of real GNP, however, the t-ratio in the distributed lag equation is higher than the corresponding statistic in the contemporaneous equation and this suggests that the distributed lag form of the real GNP variable may be of higher importance in the determination of the dependent variable.

The adjusted coefficients of determination are identical in the two equations and the Durbin-Watson statistics suggest no autocorrelation in
their residuals. The significant coefficients of the lagged residual terms indicate positive serial correlation in the original equations which, in turn, suggests the possibility of incomplete specification for these equations.

9. Index of 500 Common Stock Prices: \( Y_9 \)

a) \[
Y_9 = 86.8196 + .4971M + .1013Y_{12} + .9196U_{gt-1}
\]
\((50.096)\) \((4.889)\) \((3.786)\) \((22.353)\)
\[.1919\] \[.1450\]
\(\bar{R}^2 = .827, \ D-W = 1.793\)

b) \[
Y_9 = 90.1717 + 1.4055M - .0224Y_{12} + .9113U_{gt-1} + .2863V_{gt-1}
\]
\((48.491)\) \((9.694)\) \((- .886)\) \((26.849)\) \((2.932)\)
\[.5428\] \[-.0320\]
\(\bar{R}^2 = .900, \ D-W = 1.973\)

This linkage in our model of the monetary transmission mechanism captures the effects of percentage changes in \( M_1, M, \) and corporate profits after taxes, \( Y_{12}, \) on the most volatile leading economic indicator: the index of stock prices for 500 common stocks.

In the concurrent hypothesis equation, the coefficients of the explanatory variables show statistically significant impacts on the index of stock prices. However, the influence of the monetary variable is greater than that of corporate profits after taxes, as indicated by the beta coefficients in this equation. In the distributed lag hypothesis equation, the sum of the coefficients for \( Y_{12} \) is statistically insignificant, while the t-ratio of the monetary variable is twice as much as in the first equation which suggests that the distributed lag form of the variable \( M \) may contribute more in the determination of the dependent variable.
J.E. Tanner and J. M. Trapani (1977) have found evidence which confirms that contemporaneous monetary changes exert a direct influence on stock prices while, at the same time, securities markets are efficient. In their words, "our reexamination confirms that both are true—that markets are efficient and that monetary growth tends to affect stock prices" (p. 261). However, the idea that lagged values of the monetary variable may be the better form, instead of the contemporaneous form, is not consistent with the efficient market hypothesis. That is, significant coefficients for lagged values of $\dot{M}$ imply that market participants consistently failed to predict the indirect effects of monetary changes on stock prices or that monetary changes were entirely unanticipated.

The Durbin-Watson statistics show that there is no autocorrelation in the residuals of the two equations. Notice, however, that the first equation is corrected for first order autocorrelation, while the second equation required correction for second order autocorrelation in its residuals. Without further investigation of the conceptual and econometric problems involved in the estimation of this linkage in our mechanism, we cannot offer plausible explanations for the behavior of the residuals in the second equation.

10. Price per Unit Labor Cost Index: $Y_{10}$

\[ Y_{10} = 80.3876 - 0.2346f_t^* + 0.6641Y_4^* + 2.6470Y_5 + 0.7760U_{10t-1} \]

\[
\begin{array}{rrrrr}
(66.328) & (-3.975) & (1.201) & (34.572) & (13.613) \\
\end{array}
\]

\[ R^2 = .927, \ D-W = 2.353 \]
The price to unit labor cost ratio index constitutes the tenth linkage of our model and the explanatory variables are: percentage changes in the money supply, $\bar{M}$, the layoff rate in manufacturing industries, $Y4$, and the value of contracts and orders for plant and equipment, $Y5$.

In these equations, the coefficients for the monetary variable and the layoff rate are statistically insignificant. The coefficients of the contracts and orders for plant and equipment indicator are significant and the t-ratio of the coefficient in the second equation is more than double the value of the t-ratio in the first. This suggests that the lagged form of this variable may be preferable to the contemporaneous form in the determination of the price per unit labor cost index.

The Durbin-Watson statistics show the absence of autocorrelation from the residuals of these regressions and the adjusted coefficients of determination indicate that, on the average, more than ninety-five percent of the variation in the dependent variable is explained by fitting these regressions. High $R^2$'s coupled with insignificant coefficients for the explanatory variables point to the problem of multicollinearity. That is, because of strong relationships among the explanatory variables, the coefficient of each variable is arbitrarily assigned a value which is extremely sensitive to specification changes.
11. Index of Industrial Materials Prices: $Y_{11}$

a) $Y_{11} = 8.9484 + 2.0300Y_5 - .2074Y_6^* + 3.9190Y_8 + .8667U_{11t-1} - .1804$  
   $\begin{pmatrix} 2.916 \\ -14.672 \\ 20.173 \\ -14.37 \\ -1804 \\ 7821 \end{pmatrix}$  
   $R^2 = .981$, D-W = 2.064

b) $Y_{11} = -4.9873 + 2.9677Y_5 - .1455Y_6^* + 3.8305Y_8 + .9034U_{11t-1} + .3325V_{11t}$  
   $\begin{pmatrix} -2.448 \\ 6.071 \\ -15.081 \\ 22.857 \\ 28.360 \\ 3.589 \end{pmatrix}$  
   $\begin{pmatrix} .2101 \\ -1265 \\ .7644 \end{pmatrix}$  
   $R^2 = .992$, D-W = 2.016

The index of industrial materials prices is another linkage through which monetary impulses are transmitted to real GNP in our model. In the equation above, this index is explained by the value of contracts and orders for plant and equipment, $Y_5$, the index of permits for new private housing units, $Y_6$, and the value of new orders for durable goods, $Y_8$.

The coefficients of $Y_5$ are statistically different from zero and the $t$-ratio in the second equation may be an indication that the lag form of this variable is more appropriate than the contemporaneous form. Similarly, the coefficients of $Y_8$ are statistically significant and the higher $t$-ratio of the coefficient in the second equation suggests that the distributed lag may be more appropriate than the contemporaneous form for this variable.

From the magnitude of the beta coefficients, we can see that the relative impact of the value of new orders for durable goods is higher than that of contracts and orders for plant and equipment.

The coefficient for the housing permits index is statistically insignificant by virtue of the fact that it possesses a sign contrary to what was expected. The negative sign for the coefficient of $Y_6$ is sus-
pected to be caused by the fourth possibility of incomplete specification, i.e., an inappropriate lag structure, because actual construction starts affect the prices of industrial materials and not the intent to build housing units. As was explained in Chapter Three, actual construction lags behind the issuance of permits six to twelve months.

12. Corporate Profits After Taxes: \( Y_{12} \)

a) \[ Y_{12} = -259.0579 - 0.3407Y_5^* + 5.044Y_7 + 1.2256Y_8 + 0.6776Y_{10} + 0.4722U_{12t-1} \]

\[ (-14.003) \quad (-1.251) \quad (12.267) \quad (9.434) \quad (9.911) \quad (5.868) \]

\[ [-0.0683] \quad [0.1929] \quad [0.6928] \quad [0.4210] \]

\[ R^2 = 0.978, \quad D-W = 2.194 \]

b) \[ Y_{12} = -232.8787 - 1.8717Y_5 + 4.5948Y_7 + 1.9032Y_8 + 0.5292Y_{10} + 0.6760U_{12t-1} \]

\[ (-13.890) \quad (-7.665) \quad (12.305) \quad (17.475) \quad (9.737) \quad (10.046) \]

\[ [-0.3753] \quad [0.1757] \quad [1.0758] \quad [0.3288] \]

\[ R^2 = 0.989, \quad D-W = 2.174 \]

The indicator of corporate profits after taxes is the twelfth linkage in our transmission mechanism. In these equations, it is explained by the value of contracts and orders for plant and equipment, \( Y_5 \), the average workweek, \( Y_7 \), the value of new orders for durable goods, \( Y_8 \), and the price per unit labor cost index, \( Y_{10} \).

In the concurrent hypothesis equation, only the coefficient of \( Y_5 \) is statistically insignificant. The ranking of the importance of the explanatory variables by the beta coefficients is the following: \( Y_8, Y_{10}, Y_7 \). In the equation for the distributed lag hypothesis, all regression coefficients are statistically significant and the ranking of the importance of the explanatory variables is: \( Y_8, Y_5, Y_{10}, Y_7 \).

The t-ratios for the sum of the coefficients of \( Y_5 \) and \( Y_8 \) in the
second equation are considerably higher than the corresponding statistics in the first equation. This suggests that the distributed lag form of these variables may be superior to the contemporaneous form in capturing the effects of changes in Y5 and Y8 on the dependent variable. The t-ratios for the coefficients of Y7 and Y10 are approximately equal in the two equations which means that either form of these variables may perform equally well in the determination of corporate profits after taxes.

13. Real Gross National Product: Y13

a) \[ Y_{13} = -25.4496 + 0.9846Y_P - 0.2343M^* + 0.2269Y_9 + 0.3009Y_{10} - 0.0543Y_{11} + (-2.826) (92.853) (-2.577) (5.520) (3.239) (-2.327) \]
\[ + 0.2894U_{13t-1} + 0.8596V_{13t-1} \]
\[ (3.807) (8.080) \]
\[ R^2 = 0.998, D-W = 2.166 \]

b) \[ Y_{13} = -22.0328 + 0.9841Y_P - 0.5561M^* + 0.2593Y_9 + 0.2522Y_{10} - 0.0471Y_{11} + (-2.008) (74.721) (-2.949) (5.784) (2.422) (-1.889) \]
\[ + 0.2141U_{13t-1} + 0.9042V_{13t-1} \]
\[ (2.630) (8.128) \]
\[ R^2 = 0.998, D-W = 2.125 \]

Real GNP, instead of nominal GNP, was chosen to be the income variable explained by monetary changes through the leading economic indicators because in the 1966 NBER ordering of the indicators, real GNP is a coincident indicator, while nominal GNP is explained by permanent income, \( Y_P \), percentage changes in the money supply, \( M \), the index of stock prices, \( Y_9 \), the price to unit labor cost index, \( Y_{10} \), and the index of industrial
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materials prices, Yll.

All the coefficients of the explanatory variables have the expected signs and are statistically significant in both equations, with the exception of the coefficients for the monetary variable, which are insignificant by virtue of the fact that they have a sign contrary to what was expected. The Durbin-Watson statistics show no autocorrelation present in the residuals of the two equations and the adjusted coefficients of determination, which are identical, are the highest obtained in this model. Notice, however, that the technique of correcting for autocorrelation is employed twice to free the residuals of the two equations of this problem.

Most of the impact on real GNP comes from the permanent income variable in the two equations. In the concurrent version of this equation, the relative impact of the permanent income variable on real GNP is followed by the relative impacts of Y10, Y9, and Yll. In the distributed lag hypothesis equation, the ranking of the influence of the explanatory variables in terms of beta coefficients is the following: Y^P, Y9, Y10, and Yll. The t-ratios for the coefficients of Y10 and Yll are higher in the first equation, and the t-ratio for the coefficient of Y9 is higher in the second equation. The differences in the t-ratios of the coefficients in the two equations are not great enough to warrant statements as to which form of the explanatory variables is more appropriate in the determination of real GNP.

III. Concluding Remarks

From the results obtained for the concurrent and distributed lag

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11 The series for permanent income is constructed by taking a three month moving average of the real GNP series.
hypotheses of our model we are led to reject the null hypothesis that the alternative monetary transmission mechanism cannot capture the impacts of monetary impulses to real GNP through the linkages of the leading economic indicators. This, however, presents us with two alternatives for further consideration. First, we may say that the two versions of our model contain enough explanatory power to be considered sufficient constructs of the structure explained by the model. The second alternative is to consider a hybrid model of the type explained below.

Generally speaking—on the basis of the number of statistically significant regression coefficients, t-ratios, and adjusted coefficients of determination—we cannot ascertain that one version of the model is superior to the other. The failure of the concurrent and the distributed lag versions of our model to yield expected signs of statistically significant coefficients for the monetary variable and some of the other indicators suggests that a partly concurrent, partly distributed lag equation model, with lag structures other than the ones implied by the NBER ordering of turning points in the leading indicators series, may approximate the transmission of monetary impulses to real GNP better than either version of the model.

The possibility of using some variables in their contemporaneous form and others in their distributed lag form may also be considered. It is conceivable that while past values of one variable may affect the present value of the dependent variable, past values of some other variable may have no effect on the regressand. The possibility that a partly distributed lead, partly concurrent and partly distributed lag between and within the equations of our model may perform better should also be investigated prior to judging one model to be superior to others.
The investigation of the performance of models, other than the entirely concurrent or distributed lag models, is well beyond the scope of this study. However, the possibility that lag structures other than the ones specified here may be superior was examined and it was found that when the lag lengths of the monetary variable were increased, its coefficients became statistically significant in equations where they were not significant. These possibilities are some of the options that a complete investigation of our model for an alternative monetary transmission mechanism warrants. In the following chapter, we shall consider some additional paths of research that would improve the explanatory power of our model.
CHAPTER SIX

SUMMARY AND CONCLUSIONS

The purpose of this research project is twofold: First, it constructs an alternative transmission mechanism of monetary impulses to real GNP, based on twelve leading indicators, within a general portfolio balance framework. Second, it evaluates the role of the indicators in this mechanism by a concurrent and a distributed lag version of the model developed to describe the alternative transmission apparatus.

Changes in the leading indicators are transfused to the coincident indicators and, since monetary changes consistently precede changes in the leading indicators and a strong relationship is shown to exist between them, this study sets out to test the hypothesis that the leading indicators constitute important linkages in the process through which monetary impulses are channeled to income via wealth, substitution, and expectational effects. The NBER lag structures implied by the ordering of turning points in the series of the leading indicators are also tested indirectly.

The approach of this study uses twelve leading indicators as the linkages through which monetary impulses are transmitted to real GNP, while more traditional works have used GNP components as the linkages in the transmission process. The construction of the alternative monetary transmission mechanism presented in this study hinges on a general portfolio adjustment model. Using such a framework to evaluate the role of the leading indicators in the monetary process is possible because, in addition to reflecting the state of the economy, the

1See, for example, the study of P.S. Rose (1974-75).
behavior of most of the indicators conforms to what the portfolio adjustment framework predicts. Furthermore, leading indicators not only reflect changes in wealth and relative prices, but adjustment to such changes as well, and they influence income through such changes and expectational effects.

The maintained hypothesis upon which our model is based consists of accepting as correct the behavioral assumptions underlying the general portfolio balance model. Notice, however, that most of the equations of our model are of the reduced form in the sense that they are derived from a set of structural equations. Using a data set of 131 monthly observations for the 1966 to 1976 period pertaining to the structure implied by the maintained hypothesis, the model purporting to explain the monetary transmission mechanism which consists of thirteen equations, is estimated by OLS methods.

After a careful examination of the advantages and disadvantages of several types of distributed lag structures and cross spectral techniques, estimation of the distributed lag hypothesis form of our model by using Almon polynomial distributed lags appears to be the most appropriate method. Despite claims that specification errors concerning the length of the lag, the degree of the polynomial, and the endpoint restrictions can be detected, there is no single test that can test for optimum lag length, degree of polynomial, and endpoint restrictions simultaneously. Thus, specification errors introduced by inappropriate lag lengths, incorrect degree polynomials, and wrong endpoint restrictions may very well be reflected in the results.

Having investigated several econometric problems involved in the estimation of our model, we believe that the set of the thirteen equations estimated represents a close approximation to an internally consistent

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2 The latest such claim is found in P.C. Harper and C.L. Fry (1978).
model. And, having adopted the view that econometric models are generally under-identified and that the most we can do is to estimate reduced form equations without a priori restrictions, estimation of the model proceeds along the single equation method. That is, each equation is estimated separately from the rest of the model. Although feedback effects are allowed to be realized in some of the indicators, simultaneity bias does not appear to be damaging in the case of the distributed lag version of our model. This is because the iterative method we have used in the estimation of each equation frees the residual in the present period from strong correlation with the explanatory variables.

Most of the postulated relationships and hypothesized linkages in our model are found to be statistically significant at the five percent level of significance. Failure of some expected relationships to materialize is attributed to incomplete specification of the original equations and to the econometric problems introduced by such specification. From the results of the two versions of our model, it appears that inappropriate lag structures cause the failure to obtain the expected associations.

The variability of the monetary lag is widely accepted in the economic literature and is reflected in the notion of average NBER lags.\(^3\) Whereas average NBER lags for the 1873 to 1965 period were taken as approximately correct, the corresponding lags for the 1966 to 1976 period may have been quite different and more appropriate for our study.\(^4\) However, while providing theoretical and empirical support for pursuing the alternative

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\(^3\) For an account of the variability of the monetary lag investigated by non-parametric methods, see G.C. Uselton (1974).

\(^4\) The ordering of the leading indicators in the 1975 NBER short list is different than that of the 1966 list. This strengthens our position that lag structures other than the ones used here are more appropriate in the estimation of the distributed lag hypothesis version of our model.
approach of explaining the transmission of monetary impulses to the real sector of the economy, the obtained relationships in the hypothesized linkages open a wide area of investigation.

From the results obtained for the two versions of our model and on the basis of existing statistics, we cannot ascertain that one version is superior to the other. It appears, however, appropriate to say that a model consisting of concurrent and distributed lag equations and/or containing some contemporaneous and some lagged forms of the explanatory variables would outperform either version of the model that were tested.

During the course of this research project, there were several questions brought to light, but they were bypassed in order to keep this undertaking within reasonable limits. Some of the issues that were raised can be examined within the model we have constructed, while other questions can be answered by more extensive and elaborate econometric models. First, let us turn to the investigations that can be carried out with the existing model.

Financial assets are only claims against the expected earnings of real assets. That is, real assets and financial assets are just opposite sides of a balance sheet, so they would adjust simultaneously to the monetary and various other shocks originating with changes in the leading indicators. Thus, the hypothesized sequence of adjustments in our model may be at odds with the theory of rational expectations and the efficient markets hypothesis. This suggests that the integration of our model with those two bodies of thought can bridge the dichotomy between traditional macroeconomic theory and the theory of finance.

The fact that the contemporaneous hypothesis version of our model does not perform better than the distributed lag hypothesis version raises some new questions. For instance, it may be that only unexpected changes
in the growth rate of the money supply, or any other indicator, have
significant impacts on the endogenous variables while expected changes
cause adjustments in the dependent variable prior to the actual changes
in the explanatory variables. The investigation of the impacts of
unexpected changes is important because significant lagged coefficients
for the explanatory variables in the determination of indicators such as
the stock price index imply that market participants cannot predict the
effects of changes or that such changes are totally unexpected.

A second reason that the contemporaneous version of our model does
not outperform the distributed lag version could be found in the defini­
tion of the variables themselves. For example, percentage changes in the
money supply narrowly defined may be weakly related to the value of con­
tracts and orders for plant and equipment, but may be strongly associated
with percentage changes in this indicator. One of the advantages of
using percentage changes for all the indicators, instead of levels, is the
possibility of greatly reducing the multicolinearity problems among the
explanatory variables.

Nominal GNP lags behind real GNP according to the 1966 NBER ordering
of the indicators. However, since nominal values are used for the indi­
cators that measure quantity variables, it seems reasonable to expect that
explaining nominal GNP, instead of real GNP, would be a better choice.
A model explaining nominal GNP would be more consistent with the mone­
tarist position which predicts that monetary changes will always affect
this endogenous variable in the same direction.

One major shortcoming of all monetary theory frameworks is their
weakness in dealing with and explaining the variability in the monetary
lag over business cycles. If a monetary lag does indeed exist and varies
from cycle to cycle, this variability may be explained by different
responses in the variables affected. The technique of varying parameters, due to E.C. Prescott and T.F. Cooley (1973) and (1976), can estimate changing responses in the dependent variables of our model and can shed light on the causes underlying the variability in the monetary lag. It appears that, in addition to the reasons suggested by other investigators, the variability in the response of each of the leading indicators to monetary changes may contain plausible explanations for the variability, asymmetry, and unpredictability of the monetary lag.

G. G. Kaufman (1969) has found that the broader the definition of money, the later are the income periods that yield the highest correlations. Thus, the use of percentage changes in the money supply narrowly defined is in accordance with the monetarist practice to use monetary variables whose definition varies with the time interval of the data. This, however, does not imply that changes in a broader definition of money may not have more significant impacts on the hypothesized linkages of our mechanisms.

Another important issue that can be investigated through the leading ---and for that matter, all indicators---is the relative effectiveness of monetary and fiscal policies. However, this and the following suggestions for future research involve the creation of a more extensive model. The responsiveness of the leading economic indicators to monetary or fiscal policy changes is the result of wealth and relative price changes, which result is transmitted to income and prices. Thus, by following monetary and fiscal impulses through the linkages of the indicators, we can judge not only the potency of each policy to affect income, but also, how such changes affect the various sectors and the different economic

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5 For a detailed discussion of the various money supply concepts and the substitutions allowed by each concept, see D. I. Fand (1967).
agents in our system.

In a study of turning points in business fluctuations, Clark Warburton (1959) ascertains that monetary changes precede turning points in economic activity which, in turn, lead changes in the velocity of money. Changes in the growth rate of the money supply affect the leading indicators directly or indirectly through wealth, substitution, and expectational effects. However, Warburton (1971) also points out that changes in the money's rate of use (or velocity of circulation) should be taken into account. For example, even if there is zero growth in the money supply but velocity has risen substantially, this may have a significant impact on the behavior of some of the indicators. Despite questions concerning the exogeneity of velocity, the incorporation of this variable in our model should be considered. Examining the role of the velocity of money in our model amounts to an indirect examination of the impacts of financial innovations in our transmission mechanism.

Feedback effects from the coincident indicators, other than real GNP, and from the lagging indicators to the leading indicators were omitted. The inclusion of such feedback effects will further strengthen the hypothesized linkages in the monetary transmission process and improve the explanatory power of our model. Undoubtedly, indicators such as the unemployment rate, industrial production, and manufacturing, trade, and retail sales have repercussions on the leading indicators and the income variable explained.

Further disaggregation and use of all the NBER economic indicators to construct an econometric model describing in detail an even more pragmatic transmission of monetary impulses to income is another area of fruitful investigation. In such a detailed model, some indicators may be used as instrumental variables and the under-identification problem can be solved.
so that estimation by simultaneous equation techniques becomes feasible. A more extensive econometric model can approximate more accurately the monetary transmission process as described by monetarists and yield more reliable estimates of the parameters. That is, such a model can provide more connecting linkages with the desirable properties and show how monetary impulses are diffused through these additional linkages to income.

Lack of a statistical measure to test the relative performance of the concurrent versus the distributed lag versions of our model necessitated our making qualitative statements about the contemporaneous and lagged forms of the explanatory variables. Also, since there is no unique statistical test that can determine the optimum lag length, the degree of the polynomial, and the endpoint restrictions, we adopted some rules in order to avoid searching for "best" results. Therefore, research in developing such statistical tests is a promising area of future investigation.

The relevance of this study is that it affords evidence bearing upon the monetarist position, in general, and upon the alternative transmission mechanism developed, in particular. In other words, the empirical results support the hypothesis that monetary impulses are transmitted to income through the leading indicators. As mentioned in Chapter Five, the U.S. economy experienced several structural changes during the period under study. Yet, despite these changes, variations in the growth rate of the money supply appear to have dominated other forces at work. Therefore, since there are several reasonably good relationships in the assumed linkages of our transmission mechanism during the 1966 to 1976 period, these relationships will display stronger connections during periods of relative structural stability.
This study elaborates on the Friedman hypothesis concerning the relationship between indicators by showing how changes in the growth rate of the money supply affect—via wealth, substitution, and expectational effects—real GNP through the leading indicators. By the same token, the statistical evaluation of the leading indicators in the alternative transmission process confirms the unpredictability of the lag in the effect of monetary policy. This means that large variations in the growth rate of the money supply often render monetary policy actions procyclical and make the transition to the optimum steady state virtually impossible to accomplish. In view of the unpredictability of the monetary lag, the policy implication of this investigation is that Friedman's idea of a steady growth in the money supply appears to have much merit.
APPENDIX A. METHODOLOGICAL CONSIDERATIONS

IN DISTRIBUTED LAG MODELS: A SURVEY
I. INTRODUCTION

The purpose of this appendix is to survey various distributed lag model formulations, discuss the problems associated with their estimation, examine cross spectral analysis techniques, and present the basis of tests concerning polynomial distributed lag structures as well as their limitations.

In section II the implications of methodological issues involved in the formulation and estimation of distributed lags will be considered briefly, as the rationale for using polynomial distributed lags is developed.

Section III deals with techniques of spectral and cross spectral analysis as relating to lagged adjustments. Also, their application to econometric models will be investigated in the light of the limitations inherent in the nature of these techniques.

Finally, a review of tests concerning the length of the lag, the degree of the polynomial, and the endpoint restrictions will be presented in Section IV in conjunction with their limitations. The appendix ends with a conclusion concerning the value of these tests.
II. The Rationale of Polynomial Distributed Lags

The single equation, multivariate, static linear econometric model of the form:

\[ Y_t = a + \beta X_t + \gamma V_t + \ldots + \eta Z_t + U_t; \quad t = 1, 2, \ldots, n \quad (A.2.1) \]

is a special case of a multivariate dynamic economic model and is a poor analogue of real economic behavior for empirical purposes. Having specified the regression equation in this manner, we assume that, in fact, the current values of the dependent variable depend on current values of the explanatory variables \( X, V, \ldots, Z \), but not on any past values of these variables. This implies that the model is an operative depiction of economic behavior whereby perfect knowledge is freely available, markets are functioning perfectly, and all adjustments are made instantaneously.

However, if we allow for the existence of frictions such as uncertainty, expectations, search costs, adjustment costs, transaction costs, inertia in decision making, gestation lags, hedged reactions, and institutional restrictions, lags in economic behavior are certain to result.\(^1\) In fact, Christopher Sims (1973, p. 1) maintains that: "A time series regression model arising in econometric research ought in nearly every case to be regarded as a distributed lag model until proven otherwise." Although most economic behavior may be characterized by delayed adjustment processes, lagged reactions are more prominent in some kinds of economic behavior than in others. For example, consumer patterns, investment behavior, portfolio balance, labor market adjustments and production processes are subject to different search and adjustment

\(^1\) See A. Sinai (1974, pp. 7-8).
costs, varying transaction delays and gestation periods, and subject to
different inertia and market imperfections. As a result of these
frictional restrictions, different adjustment patterns occur.

A formulation of the model that would allow for the current as well
as past values of the independent variables to affect $Y_t$ would be of the
form:

$$Y_t = a + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_i X_{t-i} + \ldots$$
$$+ \gamma_0 Y_t + b_1 Y_{t-1} + \ldots + \gamma_j Y_{t-j} + \ldots$$
$$+ \ldots + \eta_0 Z_t + \eta_1 Z_{t-1} + \ldots + \eta_m Z_{t-m} + \ldots + U_t$$

(A.2.2)

or, in summation notation,

$$Y_t = a + \sum_{i=0}^{\infty} \beta_i X_{t-i} + \sum_{j=0}^{\infty} \gamma_j Y_{t-j} + \sum_{m=0}^{\infty} \eta_m Z_{t-m} + U_t$$

(A.2.3)

This general form for a linear, stochastic, multivariate dynamic economic
model is called a distributed lag model because the influence of the
explanatory variables on the dependent variable is distributed over a
number of lagged values of the explanatory variables. If we let $\beta_i =
\beta_i, \gamma_i = \gamma_i, \ldots, \eta_m = \eta_m$, equation (A.2.2) becomes:

$$Y_t = a + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_i X_{t-i} + \ldots$$
$$+ \gamma_0 Y_t + \gamma_1 Y_{t-1} + \ldots + \gamma_j Y_{t-j} + \ldots$$
$$+ \ldots + \eta_0 Z_t + \eta_1 Z_{t-1} + \ldots + \eta_m Z_{t-m} + U_t$$

or simply $Y_t = a + \sum_{i=0}^{\infty} \beta_i X_{t-i} + \sum_{j=0}^{\infty} \gamma_j Y_{t-j} + \sum_{m=0}^{\infty} \eta_m Z_{t-m} + U_t$

(A.2.5)

Equations (A.2.3) or (A.2.5) constitute an infinite distributed lag
model for the determination of $Y_t$ in which a sustained unit change in an
explanatory variable affects the dependent variable over all future periods,
with some portion of the independent variable's overall effect being
realized in each time period. The coefficients $\beta_i, \gamma_j, \ldots, \eta_m$ of

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This formation of the model will become clear later in this section.
equation (A.2.5) are called the distributed lag coefficients, while the \( a_i \)'s, \( b_j \)'s \( g_m \)'s of equation (A.2.3) are the weights of the distributed lag model. The individual distributed lag coefficients \( \beta_i, \gamma_j, \ldots, \eta_m \) are interpreted as measures of the marginal response of \( Y_t \) to a unit change in the respective explanatory variables \( t-1, t-j, \ldots, t-m \) periods ago.

Each of the distributed lag coefficients \( \beta_i = \beta a_i, \gamma_j = \gamma b_j, \ldots, \eta_m = \eta g_m \) is the product of two components:

1) The lag effect which is the proportion of the total effect that occurs in the given period for a particular explanatory variable (the \( a_i \)'s, \( b_j \)'s, \ldots, \( g_m \)'s) and

2) The economic effect of a sustained change in an explanatory variable which is the economic reaction of \( Y_t \) per unit change in the explanatory variable.

The weights of the distributed lag show the time path of response or adjustment of \( Y_t \) to changes in the explanatory variables. However, since the distributed lag coefficients and weights differ only by the multiplicative constants \( \beta, \gamma, \ldots, \eta \), they are usually discussed interchangeably.

As a theoretical model, equation (A.2.5) only states that the influences of the explanatory variables are distributed over time.

However, there is an infinitely large number of parameters to be estimated in the present form of equation (A.2.5). We simply cannot estimate an infinite series of parameters from finite samples. For this problem to be overcome, it requires truncating the explanatory variables and this can be done by applying zero restrictions to the subset of the distributed lag coefficients at the far end of the distribution or by introducing
simplifying schemes. However, prior to reviewing the finite distributed lag techniques, let us turn our attention to some assumptions about the distributed lag coefficients and disturbance terms that have to be satisfied before the statistical methods of estimation and hypothesis testing can be applied.

It is customarily assumed that the total effect of each explanatory variable is finite, that is:

\[
\sum_{i=0}^{\infty} \beta_i = A, \quad \sum_{j=0}^{\infty} \gamma_j = B, \ldots, \quad \sum_{m=0}^{\infty} \eta_m = C < \infty
\]

so that the model will not be explosive. The assumptions about the disturbance terms, \( U \), are:

1. \( E(U_t) = 0 \)
2. \( E(U_tU_t) = \sigma^2 \)
3. \( E(U_tU_s) = 0 \)
4. \( X_t, V_t, \ldots, Z_t \) are fixed in repeated sampling so that

\[
E(X_tU_t) = 0, \quad E(V_tU_t) = 0, \ldots, \quad E(Z_tU_t), \quad \text{and}
\]

\[
\begin{bmatrix}
1 & X_1 & X_0 & \ldots & V_1 & V_0 & \ldots & Z_1 & Z_0 & \ldots \\
1 & X_2 & X_1 & \ldots & V_2 & V_1 & \ldots & Z_2 & Z_1 & \ldots \\
\vdots & & & & \vdots & & & \vdots & & \vdots \\
1 & X_N & X_{N-1} & \ldots & V_N & V_{N-1} & \ldots & Z_N & Z_{N-1} & \ldots
\end{bmatrix}
\]

has rank \( i + j + m < n \). The last assumption requires that the number of observations, \( n \), exceeds the number of parameters to be estimated and that no linear relations are present between the explanatory variables.

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3Often, the weights of a distributed lag model \( Y_t = \sum_{i=0}^{\infty} \sum_{j=0}^{k} W_{ij} X_{j+t-1} + U_t \) are normalized by imposing the condition \( \sum_{i=0}^{\infty} \sum_{j=0}^{k} W_{ij} = 1, \ 0 < W_{ij} \leq 1, \) for \( i=0, 1, 2, \ldots \) and for \( j=1, 2, \ldots, k. \) In such instances, the distribution of weights can be looked upon and treated as probability density functions.
The history of distributed lag models originated in the work of Irving Fisher and Tinbergen and dates back to the 1930's.\(^4\) In the business cycle literature, under the guise of "dynamic multipliers," "flexible accelerator," and "habit persistence," similar topics were also discussed. However, the recent popularity of distributed lags as an operative econometric technique is attributed to the work of L.M. Koyck (1954), P. Cagan (1956), M. Nerlove (1956) and (1958) and S. Almon (1965).

One of the most popular distributed lag models in applied econometrics is Koyck's geometric lag scheme. As the name indicates, the distributed lag coefficients are assumed to be declining continuously according to the pattern of some geometric series. Let the original model be of the form

\[ Y_t = a + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + U_t \quad (A.2.6) \]

where the usual assumptions about the error term are satisfied.\(^5\) Koyck's lag scheme assumes that recent values of X exert a higher influence on \(Y_t\) than values of X in more distant periods. The particular pattern that the weights follow is described by the geometric series \(\beta_1 = \lambda^1 \beta_0, \quad 0<\lambda<1.\)

Substituting in the original model we obtain:

\[ Y_t = a + \beta_0 X_t + (\lambda \beta_0) X_{t-1} + (\lambda^2 \beta_0) X_{t-2} + \ldots + U_t \quad (A.2.7) \]

Lagging equation (A.2.7) by one period and multiplying by \(\lambda\) we get:

\[ Y_{t-1} = a\lambda + \lambda \beta_0 X_{t-1} + (\lambda^2 \beta_0) X_{t-2} + (\lambda^3 \beta_0) X_{t-3} + \ldots + \lambda U_{t-1} \quad (A.2.8) \]

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\(^4\)For an account of the early history of this topic, see M. Nerlove (1958).

\(^5\)Hereafter, the presentation of distributed lag models will be based on the use of a simple distributed lag model. However, all results can be generalized when more than one explanatory variable is included.
Subtracting (A.2.8) from (A.2.7) we obtain:

\[ Y_t - \lambda Y_{t-1} = a - a\lambda + \beta_0 X_t + U_t - \lambda U_{t-1} \quad (A.2.9) \]

or,

\[ Y_t = a(1-\lambda) + \beta_0 X_t + \lambda Y_{t-1} + V_t \quad (A.2.10) \]

where, \( V_t = U_t - \lambda U_{t-1} \).

Equation (A.2.10) is an autoregressive lag scheme known as Koyck's transformation.⁶

The Koyck transformation avoids the two basic defects of distributed lag models because it achieves the maximum economy of degrees of freedom and it avoids multicollinearity to a certain degree, since \( Y_{t-1} \) is usually less correlated with \( X_t \) than successive lagged values of the latter. However, this type of autoregressive model contains other undesirable consequences:

1. Despite the fact that \( U_t \) is serially independent in the original model, the error term \( V_t = U_t - \lambda U_{t-1} \) is autocorrelated in the transformed equation (A.2.10).

2. The lagged variable \( Y_{t-1} \) is not independent of the error term \( V_t \) because \( E(V_t Y_t) \neq 0 \) and so \( E(V_t Y_{t+s}) \neq 0 \) for \( s>0 \) and all \( t \).

3. The autocorrelation of \( V_t \) superimposed on values of \( Y_{t-1} \), which are contemporaneously correlated with the error term, yields not only biased OLS estimates but estimates that are inconsistent.⁷

⁶A modified Koyck transformation allows one or more of the lag coefficients to be determined directly from the original equation and the remaining lags are allowed to decline geometrically. For instance, if one believes that the first two lags should be determined independently from the geometrically declining lag, the original model would be \( Y_t = a+\beta_0 X_t+\beta_1 X_{t-1}+(\beta_2 \lambda^2)X_{t-2}+(\beta_2 \lambda^3)X_{t-3}+(\beta_2 \lambda^4)X_{t-4}+\ldots+U_t \) and the modified Koyck transformation would become \( Y_t = a(1-\lambda) + \beta_0 X_t + (\beta_1-\beta_0)X_{t-1}+ (\beta_2-\beta_1\lambda)X_{t-2} + \lambda Y_{t-1} + (U_t - \lambda U_{t-1}) \).

⁷The OLS estimates are asymptotically biased; that is, the bias in
4. The power of the Durbin-Watson statistic in detecting autocorrelation is severely impaired by the combined violation of two assumptions concerning the OLS error term.

Phillip Cagan (1956) suggested the adoptive expectations model whereby expectations are revised in proportion to the error connected with the previous level of expectations. This model is based on the hypothesis that the value of $Y_t$ depends not on the actual value of the explanatory variable $X_t$ but, rather, on the expected or permanent level of $X_t$, denoted by $X_t^*$. The original form of this model is:

$$Y_t = a + X_t^* + U_t \quad (A.2.11)$$

But $X_t^*$ cannot be observed directly, so, we postulate that expectations concerning its value are formed by the rule

$$X_t^* - X_{t-1}^* = \rho (X_t - X_{t-1}^*) \quad 0 < \rho \leq 1 \quad (A.2.12)$$

Expectations are revised each period on the basis of the most recent experience and $X_t^* - X_{t-1}^*$ is the change in current expectations. However, expectations are rarely realized in full and there is usually a difference between realized and expected values. Thus, $X_t^*$ is partly determined by past expectations and partly by the desire of economic units to eliminate the above difference, by adjusting their expectations in view of the immediate experience; in other words:

small samples due to $E(Y_{t-1}V_t) \neq 0$, does not vanish as $n \to \infty$, hence the estimates are inconsistent.

The adoptive expectations model is often formulated as: $(X_t^* - X_{t-1}^*) = (X_{t-1} - \rho X_{t-1}^*)$. When $X_t$ is not yet known, expectations need to be adapted by comparing $X_{t-1}^*$ with $X_{t-1}$, the immediate past experience.
\[ X_t^* = X_{t-1}^* + \rho (X_t - X_{t-1}^*) \]  
(A.2.13)

Solving the original model for \( X_t^* \) we have:

\[ X_t^* = -\frac{\alpha}{\beta} + \frac{1}{\beta}Y_t - \frac{1}{\beta}U_t \]  
(A.2.14)

and

\[ X_{t-1}^* = -\frac{\alpha}{\beta} + \frac{1}{\beta}Y_{t-1} - \frac{1}{\beta}U_{t-1} \]  
(A.2.15)

Substituting (A.2.14) and (A.2.15) in the rule of adaptive expectations, equation (A.2.12) we obtain:

\[
\left[ -\frac{\alpha}{\beta} + \frac{1}{\beta}Y_t - \frac{1}{\beta}U_t \right] - \left[ -\frac{\alpha}{\beta} + \frac{1}{\beta}Y_{t-1} - \frac{1}{\beta}U_{t-1} \right] = \rho \left[ X_t - \frac{\alpha}{\beta} + \frac{1}{\beta}Y_{t-1} - \frac{1}{\beta}U_{t-1} \right]
\]  
(A.2.16)

collecting terms gives

\[ Y_t = \alpha + (\beta \rho)X_t + (1 - \rho)Y_{t-1} + [U_t (\rho - 1)U_{t-1}] \]  
(A.2.17)

Equation (A.2.17) is similar to the Koyck transformation model, equation (A.2.18). This similarity between the two models is a direct result of the geometrically declining weight scheme. The adaptive expectations models is appealing to applied econometric work (despite the rigidity of the distribution of the lag weights) because of its ability to account for expectations about future factors. Unfortunately, the similarity of the advantages of this model to those of the Koyck transformation extends to the undesirable consequences as well. Thus, the adaptive expectation model is plagued by the same difficulties as the Koyck transformation model.

---

9 By successive substitutions in equation (A.2.13), of \( X_{t-1}^* \), \( X_{t-2}^* \), ...
we see that Cagan's model implies a geometrically declining distributed lag form for \( X_t^* \) as a function of all past \( X \).

10 Cagan used expected variables in the more general equation of the form \( X_t = \alpha X_t^* + U_t \), trying out different \( \rho \)'s, constructing the associated \( X_t^* \) series, and choosing that which yielded the maximum \( R^2 \) in this equation. If the search procedure finds that \( \rho \) which maximizes \( R^2 \) and if the model is correct, then the resulting estimates are maximum likelihood estimates (Z. Griliches, [1967, pp. 16-17]).
While the adaptive expectations model attributes the lags to uncertainty of the future and delay in the process of adjustment between anticipation and realization, another model is developed from the partial adjustment hypothesis. Nerlove (1956) combined the Cagan adaptive expectations model with the Koyck's transformation procedure to provide a rationale and a simple estimation technique applicable to a wide range of problems. Nerlove's partial adjustment model uses a lag structure to explain technological, institutional, and/or psychological barriers to making adjustment to a change instantaneously. The same model can also be used to express the desire to phase out the increasing costs of rapid changes (M. Dutta [1975, p. 192]).

In Nerlove's model, current values of the independent variables determine the desired or "target" value of the dependent variable. Hence, the initial model:

$$Y_t^* = aX_t + U_t.$$  \hspace{1cm} \text{(A.2.18)}

However, since only some fixed fraction of the desired adjustment is completed within any one particular time period, we obtain:

$$Y_t - Y_{t-1} = \delta(Y_t^* - Y_{t-1}^*).$$  \hspace{1cm} \text{(A.2.19)}

Combining equations (A.2.18) and (A.2.19) we obtain:

$$Y_t = a\delta X_t + (1-\delta)Y_{t-1} + \delta U_t.$$  \hspace{1cm} \text{(A.2.20)}

Even though Nerlove's partial adjustment model belongs to the class of autoregressive models, there is no reason to assume the presence of autocorrelation in the error terms of equation (A.2.20) if there was none to begin with. This is an improvement over the previous models, but an obvious difficulty with the partial adjustment model is that, usually, it is unreasonable to assume that the desired value of Y depends
only on the contemporaneous value of X. As Johnston (1972, p. 301) points out, it may not be rational to base economic decisions concerning \( Y_t \) solely on the current value of \( X_t \), especially when \( X \) is changing from period to period.

In several instances, distributed lag models, where the weights of the lag distribution follow a geometrically declining scheme from the present time period into the past, may not be appropriate. The weights of the distribution may be increasing initially and then decline, instead of falling in all successive time periods. This form of lag pattern is specified to be of the "inverted V" type and was suggested by Robert Solow (1960). The values of the weights of the inverted V lag distribution are not arbitrarily specified but are defined by the Pascal function - or Pascal probability function when its variable is regarded as random.

The original finite general distributed lag model

\[
Y_t = a + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_s X_{t-s} + U_t, \quad (A.2.21)
\]

can be written as

\[
Y_t = a + \beta (w_0 X_t + w_1 X_{t-1} + \ldots + w_s X_{t-s}) + U_t \quad (A.2.22)
\]

where the disturbance term satisfies the usual OLS assumption and the weights are defined by the Pascal lag scheme:

\[
w_i = \binom{i+r-1}{i} (1-\lambda)^r \frac{\lambda^i}{i!} (1-\lambda)^{i-1} \lambda^i \quad i=0,1,\ldots \quad r>0 \text{ and } 0<\lambda<1 \quad (A.2.23)
\]

In applications of the Pascal function to distribute lags, \( i \) is the period of the lag, \( r \) is an integer chosen arbitrarily, and \( \lambda \) is a parameter to be estimated. Substituting values of \( w_i \) from (A.2.23) for \( i=0,1,2,\ldots \) in equation (A.2.22) we obtain:

\[
Y_t = a + \beta (1-\lambda)^r \left[ X_t + r\lambda X_{t-1} + \frac{r(r+1)}{2!} \lambda^2 X_{t-2} + \ldots \right] + U_t. \quad (A.2.24)
\]
For values of $r > 1$ we obtain "inverted V" lag distributions, but when $r = 1$ the Pascal distribution reduces to a geometric lag distribution $w_l = (1-\lambda) \lambda^l$. While the "inverted V" lag distribution may approximate closely the theory of expectations, Jan Kmenta (1971, pp. 488-489) shows in an illustrative example how the Pascal lag model involves error terms that are autocorrelated. As a result of serial correlation in the error terms, estimation of this model by OLS methods leads to inconsistent estimates. Moreover, computational complexity increases with increasing values of $r$. Finally, all members of the Pascal family of distributions can be approximated reasonably well by other polynomial distributed lag models.

A powerful and flexible technique for estimating unimodal, smooth lag distributions that was developed by lag functions can approximate an arbitrary distributed lag to any degree of accuracy. The lag operator, $L$, is defined as $L(X_t) = X_{t-1}$, and has the following properties:

1. $L \left[ L(X_t) \right] = L^2X_t = X_{t-2}$
2. $L^mX_t = X_{t-m}$ and
3. $(aL^m + bL^n)X_t = aL^mX_t + bL^nX_{t-m} = aX_{t-m} + bX_{t-n}$

The lag operator is used to estimate the general form of autoregressive models known as generalized rational distributed lag functions.

Let our original distributed lag model be of the form:

$$Y_t = \beta_0X_t + \beta_1X_{t-1} + \beta_2X_{t-2} + \ldots \quad (A.2.25)$$

When applying the lag operator to the right hand side of equation (A.2.25) we obtain:

$$Y_t = \beta_0X_t + \beta_1LX_t + \beta_2L^2X_t + \beta_3L^3X_t + \ldots \quad (A.2.26)$$

or, $$Y_t = (\beta_0 + \beta_1L + \beta_2L^2 + \beta_3L^3 + \ldots) X_t \quad (A.2.27)$$

11 Inconsistent estimates are those estimates whose sampling distributions do not tend to converge, as the sample size increases, on the population parameters.
or, \[ Y_t = \beta(L)X_t, \]  
(A.2.28)

where \( \beta(L) \) is the polynomial in \( L \) in equation (A.2.27). If the sequence \( \beta_i \) has a rational generating function, then we can write (A.2.28) as:

\[ Y_t = \beta(L)X_t = \frac{A(L)}{B(L)} X_t \]  
(A.2.29)

where \( A(L) \) and \( B(L) \) are polynomials in the lag operator, such that:

\[ A(L) = A_0 + A_1 L + A_2 L^2 + \ldots + A_i L^i \]  
(A.2.30)

and

\[ B(L) = B_0 + B_1 L + B_2 L^2 + \ldots + B_j L^j \]  
(A.2.31)

where \( i \) and \( j \) are finite integers. Multiplying (A.2.28) by \( B(L) \) we obtain:

\[ B(L)Y_t = A(L)X_t \]  
(A.2.32)

Using (A.2.30) and (A.2.31) and normalizing \( B_0 \) to unity, we can write (A.2.32) as:

\[ (1 + B_1 L + B_2 L^2 + \ldots + B_j L^j)Y_t = (A_0 + A_1 L + A_2 L^2 + A_i L^i)X_t \]  
(A.2.33)

The rational lag scheme is more general than the finite lag function and the Koyck distributed lag function because it contains both schemes as special cases. Indeed, when \( B(L) = 1 \) and \( A(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + \ldots + \beta_i L^i \), we have the finite distributed lag function:

\[ Y_t = A_0 X_t + A_1 X_{t-1} + \ldots + A_i X_{t-i} - B_1 Y_{t-1} - B_2 Y_{t-2} \ldots - B_j Y_{t-j} \]  
(A.2.34)

or

\[ Y_t = \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + \beta_i X_{t-i} \]  
(A.2.35)

However, when \( B(L) = 1 - \lambda L \) and \( A(L) = 1 - \lambda \), we obtain the Koyck transformation:

\[ (1-\lambda L)Y_t = (1-\lambda)X_t \]  
(A.2.36)

or

\[ Y_t - \lambda Y_{t-1} = (1 - \lambda)X_t \]  
(A.2.37)
or \[ Y_t = (1-\lambda)X_t + \lambda Y_{t-1} \]  

(A.2.38)

The use of OLS is inadequate and the estimation of a rational distributed lag function of the form of equation (A.2.34) continues to be a problem. However, the major disadvantage in actual use lies in the violation of the important OLS assumption of nonautocorrelation. Thus, serial correlation in the error terms of the rational distributed lag structure results in inconsistent and inefficient OLS estimates. Although several iterative methods have been developed to estimate non-linear parameters in the face of autocorrelation, the use of rational distributed lags is burdened by the absence of standardized statistical runs to estimate the lag coefficients and, at the same time, to deal with the autocorrelated error terms. Specification errors are another problem that can be caused by approximating the tail of the distribution incorrectly, or by imposing a smooth pattern of weights when in fact this is false, or by restricting the lag distribution to be unimodal with each and every weight between zero and one.

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12When more than one independent variable is present on the right hand side (rhs) of a regression equation, the Koyck lag is imposed on every rhs variable by the presence of \( Y_{t-1} \). In other words, any regression that contains \( Y_{t-1} \) on the rhs involves the specification of a geometric lag for the dynamic effects of each rhs variable.

13For a formulation of the rational distributed lag structure where serial correlation of the error terms is obvious, see A. Sinai (1974, pp. 85-88).

14See for example, P.J. Dhrymes (1971, Chapters 6, 7, and 9), J. Johnston (1972, pp. 303-320), and Zellner and Geisel (1970).

Whereas all autoregressive models assume a scheme of geometrically declining weights, the Almon lag technique - due to Shirley Almon (1965) - does not assume such a rigid relationship between the distributed lag coefficients. Instead, this technique assumes that whatever the pattern of successive weights may be, it can be approximated by a polynomial. Thus, the Almon lag technique is a flexible and powerful finite lag specification developed to deal with a wide spectrum of lag forms.

One of the major advantages of the Almon lag technique is its flexibility in the case where the best-fitting lag structure is sought. Also, this is the only model that allows bimodal forms in the distribution of weights. And, in those cases where lag distributions follow such a pattern, it is the only technique that can detect and pick it up. More importantly, however, the serial correlation that plagues the lagged endogenous variable models, the Pascal distribution model and the rational distributed lag model is less likely to present a problem in the Almon lag technique. Finally, the multicollinearity problem - which is almost always present in models dealing with time series - is of a lower degree here than in the general distributed lag model of the form: \[ Y_t = a + \beta_0X_t + \beta_1X_{t-1} + \ldots + \beta_nX_{t-n} + U_t. \]

To demonstrate the use of the Almon lag technique in estimating a lagged relationship, let our starting model be the finite general formulation of distributed lags:

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16According to the approximation theorem of Weirstrass, a continuous function on a closed interval can be approximated to any degree of closeness by an appropriate polynomial. The degree of the polynomial should be at least one more than the number of turning points in the curve assumed to describe the shape of the distribution of the weights.
\[ Y_t = a + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_k X_{t-k} + U_t \]  
(A.2.39)

If economic theory suggests that a second degree polynomial is appropriate in approximating the lag structure, we would take:

\[ \beta_i = \alpha_o + \alpha_1 + \alpha_2 i^2 \]  
(A.2.40)

Substituting the \( \beta_i \)'s of equation (A.2.40) for those in (A.2.39), we obtain:

\[ Y_t = a + \alpha_0 X_t + (\alpha_0 + \alpha_1 + \alpha_2) X_{t-1} + \ldots + (\alpha_0 + k\alpha_1 + k^2\alpha_2) X_{t-k} + U_t \]  
(A.2.41)

Rearranging terms in equation (A.2.41), we have:

\[ Y_t = a + \alpha_0 \left( \sum_{i=0}^{k} X_{t-i} \right) + \alpha_1 \left( \sum_{i=1}^{k} i X_{t-i} \right) + \alpha_2 \left( \sum_{i=1}^{k} i^2 X_{t-i} \right) + U_t \]  
(A.2.42)

If we let

\[ z_{1t} = \sum_{i=0}^{k} X_{t-i}, \quad z_{2t} = \sum_{i=1}^{k} i X_{t-i}, \quad \text{and} \quad z_{3t} = \sum_{i=1}^{k} i^2 X_{t-i}, \]  
(A.2.43)

equation (A.2.42) can be written as:

\[ Y_t = a + \alpha_0 z_{1t} + \alpha_1 z_{2t} + \alpha_2 z_{3t} + U_t \]  
(A.2.44)

Estimators of \( \alpha, \alpha_0, \alpha_1, \) and \( \alpha_2 \) of this regression model can easily be obtained by applying OLS to equation (A.2.44). Let these estimators be \( \hat{\alpha}, \hat{\alpha}_0, \hat{\alpha}_1, \) and \( \hat{\alpha}_2. \) Then, from equation (A.2.40) we get that:

\[ \hat{\beta}_0 = \hat{\alpha}_0, \]
\[ \hat{\beta}_1 = \hat{\alpha}_0 + \hat{\alpha}_1 + \hat{\alpha}_2, \]
\[ \hat{\beta}_2 = \hat{\alpha}_0 + 2\hat{\alpha}_1 + 3\hat{\alpha}_2, \]
\[ \vdots \]
\[ \hat{\beta}_k = \hat{\alpha}_0 + k\hat{\alpha}_1 + k^2\hat{\alpha}_2. \]

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17 This exposition is based on the presentation of H.H. Kelejian and W.E. Oates (1974, pp. 154-155).
Thus, with the Almon lag technique we were able to obtain estimates of the k parameters $\beta_k$ by simply obtaining estimates of the three parameters $\alpha_0$, $\alpha_1$, and $\alpha_2$.\textsuperscript{18}

Often, to obtain better estimates, we might wish to impose end-point restrictions on the configuration of the distribution of the lag coefficients. Hence, if we believe that the value of the independent variable has no contemporaneous effect on the dependent variable, because of delays in obtaining information for example, then $\beta_0$ is specified to be zero. On the other hand, if we postulate that the effect of a change in the independent variable diminishes to zero after k periods, then $\beta_k$ is specified to be zero.\textsuperscript{19} Imposing end-point restrictions on the distributed lag coefficients increases the efficiency of estimation if the restrictions are true, but results in biased and inconsistent estimates if the restrictions are unjustifiable and not true.\textsuperscript{20}

When the change in the independent variable is expressed as a discrete change, then the individual coefficients $\beta_i = \Delta Y_t / \Delta X_{t-1}$ - or simply weights - of a polynomial distributed lag scheme show the marginal effect of a sustained unit change in the explanatory variable on $Y_t$ during a given time period.\textsuperscript{21} And, the sum of weights gives the combined overall economic and lag effects of a unit change in the independent variable on Y over the entire length of the lag.

\textsuperscript{18}When the degree of the polynomial equals the number of lagged periods and no end-point restrictions are imposed, then the Almon lag technique reduces to ordinary multiple regression.

\textsuperscript{19}For an example of the algebra involved when end-point restrictions are imposed, see J. Kmenta (1971, pp. 472-493).

\textsuperscript{20}On this point, see P.K. Trivedi (1970).

\textsuperscript{21}The distributed lag effect described by the $\beta_i$'s, may also be expressed graphically by the time profile, which plots $\beta_i$ against the value of i.
To aid in comparing different PDL schemes, the summary statistic average lag is defined as:

$$\theta = \frac{\sum \beta_i}{\sum \beta_i}$$  \hspace{1cm} (A.2.46)

Thus, the average lag $\theta$ is a weighted average of the $i$'s, the weights being proportional to $\beta_i$, and, in a sense, it measures how the various values of the $\beta$'s are distributed on the time profile. If all the weights are positive, the average lag gives the center of gravity of the lag distribution. When the $\beta$'s corresponding to earlier lags are relatively larger than subsequent weights, the average lag will be small. However, when the average lag is large, most of the distributed effect is realized at larger values of $i$. According to the interpretation by R.F. Engle and T.-C. Liu (1972, p. 681), "The average lag is closely related to the point in time at which half the adjustment from initial to final value of the dependent variable has occurred and if the weight-diagram is symmetric and unimodal, it will be exactly that point."

Despite the several advantages over the other distributed lag schemes, the Almon lag technique has some limitations. The lag length, the degree of the polynomial, and end-point restrictions must be specified. Unfortunately, there is little in the form of economic theory to suggest these parameters. And, as a result, specification errors may occur. Since a reliable test of specification error does not exist, and since $R^2$ and SSE are not very sensitive to specification changes, it is often hard to discriminate between alternative lag forms.

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22The average lag implied by an autoregressive model of the form $Y_t = \alpha X_t + \beta Y_{t-1} + U_t$ is $\theta = \beta/(1-\beta)$.
III. Spectral and Cross Spectral Analysis Versus Distributed Lags

Spectral and cross spectral techniques have recently become some of the most important and widely used statistical tools in the physical sciences. And, searching for techniques to deal with the difficulties encountered in the estimation of distributed lag models, economists have asserted that spectral, cross spectral, and partial cross spectral analysis can avoid these problems and provide direct and relevant information about leads and lags between economic time series.23

The basic idea behind spectral and cross spectral analysis is that a time series generated by a stochastic process can be decomposed into an infinite number of sine and cosine waves with infinitesimal random amplitude (M. Nerlove [1964, p. 241]). A sine wave $X(t)$ with period $p$, or frequency $F (=1/p)$, and amplitude $A^{24}$ can be expressed as:

$$X(t) = A\sin (2\pi ft) \quad (A.3.1)$$

A time series $Y(t)$ can be viewed as an infinite series, where $t$ assumes values from $-\infty$ to $+\infty$. And, the time series element $Y_t$ can be expressed as the sum:

$$Y_t = \sum_{i=1}^{A_i\sin(2\pi ft)} \quad (A.3.2)$$

where $A_i$ is the amplitude of the sine wave with frequency $f_i$. The graph of the relationship between amplitude and frequency is called the frequency power spectrum.

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23See, for example, V. Bonomo and C. Schotta (1969) or T.J. Sargent (1968).

24Amplitude is the maximum height of a wave above or below zero.
While spectral analysis is concerned with examining a series $X(t)$ from the viewpoint of its frequency content, cross spectral analysis, between two series $X(t)$ and $Y(t)$ is concerned with the relation or interaction between such sets of variables in terms of their relative frequencies. Partial cross spectral analysis is used to measure the interrelation between two series when the effects of other series have been isolated. Thus, the concepts involved in distributed lags are "similar" only to those in cross and partial cross-spectral analysis. More explicitly, the two major objectives of these techniques are to:

1. Measure the degree to which two stochastic series are interrelated, and
2. Determine the type of the lag relationship involved.

If $X(t)$ and $Y(t)$ are two stationary time series with zero mean such that $Y(t)$ has the spectrum $f_y(w)$ and Cramer representation:

$$Y_t = \int_{-\infty}^{\infty} e^{it\omega} \, dZ_y(\omega),$$

(A.3.3)

then the power cross spectrum $Cr(\omega)$ between $X(t)$ and $Y(t)$ is a complex function of $\omega$ and arises both from:

$$E[dZ_x(\omega)d\overline{Z_y(\omega)}] = 0, \quad \omega \neq \lambda$$

$$= CR(\omega) \, d\omega \quad \omega = \lambda$$

(A.3.4)

and

$$\mu^{XY}_t = E[X_t \overline{Y}_{t-1}] = \int_{-\pi}^{\pi} e^{it\omega} Cr(\omega) \, d\omega.$$  

(A.3.5)

$Z(\omega)$ is a complex random process with uncorrelated increments such that (A.3.4) hold true and $\mu^{XY}_t$ is the cross spectral representation of the covariance sequence. (C.W. Granger [1969, pp. 424-425]).

The two fundamental and important diagrams in cross spectral analysis are the coherence and the phase diagrams. The coherence diagram provides an approximation of the square of the correlation co-
efficient between corresponding frequency components. The phase diagram, on the other hand, provides evidence of time lags between components if and when such time lags do indeed exist. The coherence and phase functions are both derived from the cross spectrum and are defined as:

\[
C(\omega) = \text{Cr} \left| \frac{\omega}{f_x(\omega) f_y(\omega)} \right|^2 \tag{A.3.6}
\]

and

\[
\phi(\omega) = \tan^{-1} \frac{\text{Imaginary part of Cr}(\omega)}{\text{Real part of Cr}(\omega)}
\]

respectively.

Essentially, the coherence is the square of the correlation coefficient between corresponding frequency components \(X_t\) and \(Y_t\). The phase measures the phase difference between corresponding frequency components, and when one series leads the other, the ratio \(\phi(\omega)/\omega\) measures the extent of the time lag involved. However, as C.W. Granger and H.J. Rees (1968) point out, the phase diagram is usually more difficult to interpret than the coherence diagram because the significance of the phase diagram varies, primarily with the corresponding values of the coherence diagram. There is indeed little to be gained from studying a lag structure among two series if the correlation between them is weak.

As it was mentioned earlier, the partial cross spectrum is used to measure the interrelation between two series when the effects of other series have been isolated. Partial cross spectral techniques provide an effective way of describing the association among two or more variables when one is in fact causing responses in the others. But, since in most economic behavior, feedback effects are occurring, "...the coherence and phase diagrams become difficult or impossible to interpret, particularly the phase diagram," according to C.W. Granger (1969, p. 428).
Cross spectral techniques have not gained as wide popularity as polynomial distributed lags in applied econometrics. One of the reasons for the unwillingness of econometricians to apply these techniques to models involving time series relationships is based on the grounds that whatever results can be obtained from the cross spectrum in the frequency domain can equally well be derived from the autocorrelations in the time domain (G.H. Jenkins [1961, p. 141]). From the relation between the power spectrum \( f(\omega) \) and the autocovariances \( (k) \):

\[
f(\omega) = \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{\gamma(k)}{\sigma^2} \cos(\omega k) dk ,
\]

where \( \rho(k) = \gamma(k)/\sigma^2 \) are the autocorrelations satisfying the condition \( \rho(k) = \rho(-K) \) and \( \rho(0) = 1 \), since \( \gamma(0) = \sigma^2 \), it follows that knowledge of the population (or the generating process of) autocovariances \( \rho_k \) is equivalent to knowledge of the population spectrum. As a matter of fact, the only fundamental advantage of frequency domain estimation methods, according to C. Sims (1973) is in the introduction of a computationally useful technique used for inverting certain types of large matrices.

Furthermore, the interpretation of phase statistics has been misunderstood by econometricians primarily because of confusion over the orismology of cross spectral analysis. Most of the terminology of cross spectral analysis—including the concepts of leads and lags—was developed in the context of deterministic engineering systems analysis. The confusion evolves around the engineering term "pure delay" in the frequency domain which is a close equivalent that corresponds to the econometrician's notion of a lag in the time domain.

Thus, a linear dynamic input-output relationship can be expressed as a distributed lag in the form:
\[ Y(t) = \int_{0}^{\infty} w(i)X(t-i)di^{25}, \quad (A.3.9) \]

where \( w(i) \) is a distributed lag function. For the system to display stability, the major condition of this class of models is that if the input variable is a sinusoid of a given frequency \( f \), such as \( X(t) = \cos(2\pi ft) \), the output will be a sinusoid as well. The output sinusoid will be of identical frequency and of the form:

\[ Y_t = G(f)\cos[2\pi ft+\alpha(f)]^{26} \quad (A.3.10) \]

once the disturbances decay to zero (J.C. Hause [1969, p. 2143]). Leads and lags in a system of the form of equation (A.3.10) are conventional definitions of measuring the sign and the magnitude of the phase shift. Thus, at a specified frequency \( f \), output \( Y(t) \), leads input, \( X(t) \), if the phase shift \( X(f) \) is positive. If \( X(f) \) is negative, output lags input. Therefore, the engineering definitions of lead and lag in investigations of linear dynamic input-output models were merely a method of describing the phase shift of the output sinusoid on the frequency domain, but not the time domain.

The concept of delay in deterministic systems corresponds closely to the notion of time lags we envision when examining the response behavior of economic units. When dealing with a linear delay between an input and output, the system can be represented by:

\[ Y_t = \lambda X(t-k) \quad (A.3.11) \]

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\(^{25}\)For discrete time models, expression (A.3.9) is written in the form:

\[ Y_t = \sum_{i=0}^{\infty} w_i X_{t-i}, \text{ where at least one } w_i \neq 0. \]

\(^{26}\)G(f) and \( \alpha(f) \) are real functions of \( f \). G(f) is a non-negative function, known as the gain of the system, that measures the amplitude of the output sinusoid when the input sinusoid's height is one. X(f) is the phase shift that, by convention, takes on values between \(-\pi\) and \(+\pi\) radians.
where $\lambda$ is a constant and $k$ is the length of the time delay. If the system is a pure delay operator and the input consists of

$$X(t) = \cos(2\pi ft)$$

then the output will be of the form:

$$Y(t) = \lambda \cos(2\pi f(t-k))$$

with the phase $\alpha(f) = -2\pi fk$. To obtain the length of the delay, we divide $\lambda$ by the frequency of the input expressed in radians, since $\lambda/2\pi f = -k$. However, equation (A.3.11) represents "...the only deterministic linear system for which there is a simple correspondence between the phase lead or lag and delay in real time... For all other linear input-output systems, it is incorrect to interpret $\lambda/2\pi f$ as if there is a pure delay between input and output" (J.C. Hause [1969, p. 214-215]).

If the pure delay model is adopted when in fact a distributed lag model is more appropriate, then the variable $i = \alpha(f)/2\pi f$ as a measure of pure delay is misleading.27 On the other hand, E. Malinvand (1966, p. 473) has given particular emphasis to the significance of distributed lags in models purporting to investigate economic behavior and has suggested why they are more plausible than pure delays. Furthermore, when dealing with dynamic linear systems that are more than simple input-output models, a meaningful economic interpretation of the phase (and $i = \alpha(f)/2\pi f$) is almost impossible. And, in many instances, sets of variables used in the computation of cross spectral statistics may very well be distributed lag models of one or more other variables. This, however, brings us to the familiar problem of identification which cross spectral analysis seems ineffective in dealing with.

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27 For a demonstration of this point, see the appendix in J.C. Hause (1969).
In the context of the present study, where all the explanatory variables used are the leading economic indicators contained in the short NBER list, there are two additional limitations on the use of cross spectral analysis, namely, the length of the record and non-stationarity of the series involved. The data sample consists of 131 observations and an implicit part of the maintained hypothesis is that it takes approximately 15 months for the completion of one round of changes in money to real GNP. Thus, we are dealing with less than 9 complete rounds; a very low number upon which to base inferences concerning the structure of the process or the time stability of the assumed structure. However, the limitation of stationarity that is required in the application of cross spectral analysis is more severe. Some of the leading economic indicators and real GNP contain two forms of non-stationarity:

1. Variance that changes with time, and
2. Mean that changes with time, or trend.

Application of cross spectral analysis techniques to the model postulated in this study would yield erroneous results as a consequence of biases in cross spectral statistics. And as M. Nerlove (1966, pp. 254–55) points out,

In any finite realization process, trends will be indistinguishable from very low frequency components... Thus, since most economic time series do show trends of one sort or another, the power spectrum of a typical time series will show very high power concentrated at frequencies near zero, and gradually diminishing power at higher frequencies.

Stationarity means that the expected value of any element of a series of time t is independent of time and the expected value of the covariance of that element at t and t+i is a function of the time difference i only. Stationarity can also be taken to mean that after removing the trend of the mean, the process generating the residual does not change over time.
To bypass the difficulty of non-stationarity due to trends, the series are first detrended by simple regressions on time in order to obtain the estimated mean functions.\(^\text{29}\) Then, the residuals of these regressions are obtained by subtracting the estimated from the actual values. These residuals, in turn, are treated as the observations of new processes and subjected to cross spectral analysis. Having obtained the power spectra of the series, along with their corresponding coherences, phase angles, and gains, questions such as the following may be answered:

1. Do the series contain cyclical elements, and if so, what are their periods?

2. Do the series display similar cycles?

3. Are there any significant lead-lag relations present?\(^\text{30}\)

The existence of lead-lag relations between indicators is explicitly assumed in the hypothesis that the NBER timely ordering of the indicators is correct. Moreover, questions that cross spectral analysis can answer are of restricted benefit in understanding a monetary transmission mechanism, albeit they may enhance one's understanding of the business cycle. In view of this and the limitations surrounding the application of cross spectral methods to models that are of the distributed lag nature, cross spectral techniques are deemed as a sub-optimum choice. The formulation of the model dictates, more or less, the use of polynomial distributed lags.

\(^{29}\) Non-stationarity due to changes in variance is bypassed by using moving averages or other arithmetical operations on the series. These operations are called filters and the use of such operations to filter out power at low frequencies is called pre-whitening. However, since the number of terms in a moving average reflects a judgment on the speed of adjustment, pre-whitening often involves errors.

\(^{30}\) For an actual example, see P.J. Dhrymes (1970, p. 481).
IV. Tests of PDL's: Their Rationale and Implications

The existence of lagged relationships, or absence thereof, is not an empirically testable proposition within the Almon lag technique. Traditionally, this has necessitated reliance on ad hoc methods of selecting the parameters of the lag structure since there is practically nothing in the form of economic theory to suggest the length of the lag, the degree of the polynomial, and the imposition of end point restrictions.

In a simple distributed lag model as:

\[ Y_t = \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_n X_{t-n} + U_t, \quad (A.4.1) \]

we can estimate the regression coefficients (or weights) by the use of OLS, provided that the length of the lag is less than the number of observations. When the disturbance terms fulfill the usual OLS assumptions, the estimates of the weights will be unbiased, consistent, and efficient. However, in models that involve economic time series the problem of multicollinearity plagues the results, and, as a consequence, most—if not all—of the estimated coefficients will be statistically insignificant. This is the case because a high degree of multicollinearity causes the determinant \( |X'X| \) to approach zero while at the same time the variances \( \sigma_\beta^2 \) tend to "explode."

To bypass this problem, econometricians have imposed restrictions on the lag coefficients, based on ex ante information concerning the distribution of the true weights. Thus, the essence of the Almon lag technique is to estimate the model of equation (A.4.1) subject to the explicit restriction that the weights lie on a polynomial of pre-determined degree. One of the advantages of the Almon lag technique is that it reduces the number of parameters to be estimated from \((n+1)\) to \((p+1)\), where \(n\) and \(p\) are the length of the lag and the degree of the polynomial
respectively, and simultaneously decreases the degree of the multicollinearity involved. R.J. Shiller's method (1973) lessens the degree of multicollinearity by imposing a smooth pattern of weights and is superior to the Almon lag technique when percentage changes or first log differences are used.\(^31\)

If such restrictions are true, then the estimates will turn out to be unbiased, consistent, and more efficient than the simple multiple regression estimates. However, placing erroneous restrictions on the true weights has the effect of producing inconsistent estimates and leads to invalid results, although in some instances it may yield estimators of smaller mean square error than estimators obtained by ordinary multiple regression. And as P. Schmidt and R.N. Waud (1973, p. 11) assert, even in this case, the usual tests of hypothesis will not be valid and it is difficult to detect those cases in which an illegitimate constraint decreases the mean square error.

Shirley Almon (1965) suggested that in order to determine the appropriate lag length alternative ranges of n should be tried. The determination of an approximately correct lag length should be based on the following criterion: Compute the simple correlation coefficient between the dependent variable and successive values of the lagged variable both for levels and first differences. When the correlation coefficient \(r_{XX_{t-n-1}}\) turns out to be less than \(r_{XX_{t-1}}\), or when the weights of the distribution begin alternating signs at \((t-n-1)\), truncate the distribution at \((t-n)\).\(^32\)

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\(^31\)The essence of Shiller's method is that the lag coefficients are weighted not only by the time lag, but by other factors as well. Shiller's method, however, suffers from the limitation that units of measurement affect the results.

\(^32\)The effect of the endpoint restriction \(\beta_{-1}=0\) is to force the con-
Almon also suggested that $\beta_{-1}=0$ and $\beta_n=0$ (this is equivalent to $\beta_{t+1}=0$ and $\beta_{t-n}=0$). The first constraint implies that past values of the independent variable have no influence on future values of the dependent variable. The second constraint simply means that the influence of the independent variable at time $(t+n)$ and beyond decays to zero. However, when the length of the lag is overstated or understated, a specification error is committed that leads to biased and inconsistent estimates and void tests (P. Schmid and R.N. Waud [1973, p. 13]). Thus $t$-tests cannot show that an incorrect lag length has been chosen.

The mean lag, the sum of weights in the lag distribution, and the expected forecast error display a strong dependence on the behavior of the lag distribution at the tails. Hence, the econometrician's effort to estimate the best fitting lag structure is by the search method. The search procedure, however, yields poor results in estimating the length of the lag, the degree of the polynomial, and the correct specification of the endpoint constraints. Also, P. Frost (1975, p. 608) has shown that $E(\beta_1)$ and $\text{var}(\beta_1)$ depend on the degree of the polynomial and the length of the lag and that the search method through the entire temporaneous influence of the explanatory variable backwards to previous periods, while the one of $\beta_n=0$ is to push the influence of the explanatory variable at time $(t+n)$ forward. Practical experience shows that when both restrictions are imposed, the direction of the shift in influence is unpredictable.

Note that this method is applicable only in the case where a second degree polynomial is used to approximate the pattern of the weights. Also, truncation of the distribution of weights on the basis of alternating signs can be erroneous: There is no justification for not allowing alternating signs if such pattern is theoretically correct or possible.
lag space for the best lag structure results in biased estimates of the weights that are not normally distributed and that the estimated $\text{var}(\beta_i)$ is biased downwards.$^{34}$

As the lag length, $n$, increases, most of the var $(\beta_i)$ decrease because the constraint that the lag coefficients lie on a polynomial of degree $p$ becomes more restrictive. The statistical cost of using too high a degree is that there is a loss in efficiency, but the Almon lag estimates will still be consistent and unbiased. On the other hand, when the chosen degree of the polynomial is less than the optimum, the polynomial used is not flexible enough to trace out the lag structure and will lead to biased and inconsistent estimators and invalid tests (L.C. Godfrey and D.S. Poskitt [1975, pp. 107-108]).

In applications of the Almon lag technique, the choice of alternative lag lengths is based on Theil's criterion of maximizing $R^2$ or minimizing the residual variance. However, $R^2$'s (and $t$-ratios) are unreliable indicators of mispecified lag structures. As J.D. Merriwether (1973, p. 573) indicates, "it is quite possible to have very severe mis-specification and virtually identical $R^2$ as from a much better specified estimator." But, since a reliable test of specification error has not been developed, practicing econometricians continue using $R^2$ as a criterion for choosing among alternative distributed lag models.

T. Amemiya and K. Morimune (1974) have shown that:

1. For a given degree of autocorrelation, $\rho$, the optimal degree of the polynomial, $p$, increases as $T^*(T^* = T[\lambda/(1-\lambda)],$ where $T$ is the number

$^{34}$A significantly large downwards bias usually results from the choice of successive regressions that minimize the residual variance (H. Theil [1971, p. 544]).
of observations, $\lambda = \frac{\sigma_X^2 \beta \lambda}{(\sigma + \sigma_X^2 \beta \lambda)}$,  
and $\lambda$ as defined in footnote (35) increases,

2. For a given $T^*$, the optimal $p$ decreases as $\rho$ increases,

3. The optimal $p$ increases discontinuously with $T^*$, and

4. The optimal $p$ will be lower as:
   a. The lag distribution is smoother,
   b. The degree of multicollinearity is greater,
   c. The sample size is smaller,
   d. The ratio of the variance of the error term to that of
   the dependent variable is larger.

They have also developed a method for selecting the optimum degree of
the polynomial used in the Almon lag technique. Their method of testing
for the optimum degree, however, is restrictive and is applicable only
to special cases because they assume stationarity in a first order
autoregressive process, such that $E(X_t) = 0$ and $E(X_t X_{t+g}) = \sigma_X^2 \frac{|g|}{(1-\rho^2)}$.

The procedure of testing the validity of the endpoint restrictions
imposed on the Almon lag distribution is based on fitting the distributed
lag equation with no restrictions and then fitting it with restrictions.
The consistency of the imposed endpoint restrictions is investigated by
applying an F-ration test, the F statistic defined as:

$$F_{n-k, T-2n-1} = \frac{Q_1 T - 2n - 1}{Q_2 n - k}$$  \hspace{1cm} \text{(A.4.2)}

---

35 The Amemiya and Morimune method is based on selecting the value
of $p$ that minimizes the "loss or efficiency function:

$L = \text{tr}(M^{-1} X X)$, where

$$M = E(\beta \epsilon - \beta) (\beta \epsilon - \beta)'$$

and $\Lambda = \frac{1}{1-\rho^2} \begin{bmatrix} 1 & \rho & \cdots & \rho^n \\ \rho & 1 & \cdots & \rho^{n-1} \\ \vdots & \vdots & \ddots & \vdots \\ \rho^n & \rho^{n-1} & \cdots & 1 \end{bmatrix}$

36 The F-statistic actually used in this study is the one suggested
by R. Hall (1975, p. 12). It is defined as $F = \frac{1}{q (Q_2 - Q_1)}/(Q_1/(T-k)1}$
where \( n \) is the number of observations, \( k \) is the number of parameters estimated, \( T \) is the number of observations, \( Q_1 \) is the unconstrained, and \( Q_2 \) is the constrained sum of residuals (P.T. Dhrymes [1971, pp. 228-229]). If \( F>F_\alpha \), where \( F_\alpha \) is defined by \( \Pr(F>F_\alpha) = \alpha \), then we reject the hypothesis that the restrictions are consistent. That is, significantly high \( F \)-values imply that the endpoint restrictions are not consistent with the given data sample and that they should not have been imposed. However, L.G. Godfrey has suggested that tests concerning the Almon lag restrictions may be inaccurate if the lag length is large and/or the independent variable is trending.\(^{37}\)

For the geometric estimator of the lag structure, Zvi Griliches (1967) has shown that the bias in the average lag is extremely sensitive to underspecification of the lag structure. And, in the absence of a dependable test of specification error, users of distributed lags have been cautioned to have a strong a priori argument to support the application of a geometrically declining weight distribution (J.D. Merriwether [1975, p. 573]). In the case of the Almon lag scheme, when the lag coefficients are assumed to reflect an expectational mechanism, the shapes of the weight distributions should be smooth. This requirement means that high degree polynomials should be excluded, whereas a particular data set may, in fact, require a high degree polynomial to approximate reasonably well the weight distribution. If expectations are of the extrapolative or of an extrapolative-regressive nature, the estimation

\[
F = \frac{Q_2}{Q_1 - Q_2} = \frac{\sum (y_t - \hat{y}_t)^2}{\sum (y_t - \bar{y})^2}
\]

where \( q \) is the number of constraints imposed and the other variables as defined above. The degrees of freedom for this \( F \)-statistic are \( q \) and \( (T-k) \) for the numerator and the denominator respectively.

\(^{37}\)This point was brought to this investigator's attention in private correspondence with L.G. Godfrey of the University of York, England.
of the coefficient $\beta_0$ should be freed from the rest of the lag structure, since it may not bear any relation to the rest of the lag coefficients (F. DeLeeuw [1965, p. 37]).

C.P. Harper (1977) has suggested specification error tests that allow one to detect empirically an incorrect lag length and/or degree of polynomial used in the Almon lag technique. Assuming a correct specification of the model but with erroneous lag length, the test requires that the error term vector be null. If $U \neq \emptyset$, then an incorrect lag length has been employed. Then assuming a proper lag length and an incorrect polynomial, if $U \neq \emptyset$, this implies a too small degree polynomial was used. However, these methods appear ineffective in detecting a too high degree polynomial. In addition to the loss of the efficiency property of the estimators, misspecification in the model's form is likely to lead to non-exogeneity (C. Sims [1973, p. 52]). The two other major limitations of Harper's suggested tests are the following:

1. While this method deals with simultaneous determination of the optimum lag length and degree of the polynomial, it ignores the determination of endpoint restrictions.

2. As M.D. Godfrey (1967) and T. Amemiya and K. Morimune (1974) admit, tests concerning the degree of the polynomial will not be valid if the independent variables are trending or if the lag length is large.

Regression methods are suitable for hypothesis testing and estimation, not for a search for the best-fitting lag. Unfortunately, there

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Harper's tests are based on the RASET and RESET tests developed by J.B. Ramsey (1960) and J.B. Ramsey and R.F. Gilbert (1969) to test for non-zero means of the residuals.
is little and incomplete knowledge about systematic hypothesis testing of alternative forms of distributed lags except for some crude tests.\textsuperscript{39} Econometricians usually try a few polynomial distributed lag forms and then quit when reasonably good results are obtained.

\textsuperscript{39}For symptoms of incorrect lag lengths or order of polynomials used in the Almon lag technique, see R. Hall (1975).
APPENDIX B. ECONOMETRIC PROBLEMS INVOLVED
IN THE ESTIMATION OF OUR MODEL
The purpose of this study, broadly stated, is to incorporate the role of the leading economic indicators into a transmission mechanism from changes in the money supply to real GNP. The hypotheses and/or theories that link the leading indicators together, like any hypothesis that attempts to embody certain important aspects of the behavior of economic units, while purposely omitting other less significant factors, can be formulated as a model. That is, any specification relating economic variables may constitute a model. The specification of a model consists of the formulation of the equations purporting to explain certain regularities or processes, statements concerning the explanatory variables, and assumptions pertaining to the error terms. Implicitly, our monetary transmission mechanism model is a representation of economic theory and explicitly is a supposition of the operative mechanism of an economic structure.

The hypotheses advanced to describe how monetary impulses are transmitted to real GNP were developed in the context of the general portfolio balance model. This descriptive construct simply states the postulated relationships which link together the various leading economic indicators as they have been observed to behave. That is, in order to advance the usefulness of the series for the leading indicators, causal relationships were specified. Since the direction of influence between the indicators has been specified, this construct constitutes an economic model, once the assumptions governing the behavior of the error terms have been stated.

The assumptions concerning the error terms of the equations of our model were stated in Chapter Four. Upon specification of the contemporaneous and distributed lag hypothesis models, our primary aim is to verify the linkages that constitute the transmission mechanism. This
amounts to testing statistically the strength of the postulated relationships and the lag structures implied by the NBER timely ordering of turning points in the series of the leading indicators.

Initially, a model based solely on the ordering of the leading indicators was constructed in which only one-way causal relationships were specified and feedback effects were excluded from influencing the other endogenous variables, leading indicators in this instance. That model satisfied all the conditions of a causal chain, or recursive system, and OLS could have been used successfully to estimate the structural parameters involved. However, since the intent of this study is to develop an alternative and more detailed transmission mechanism, feedback effects could not have been excluded from the model. As a result of this attempt towards more realism, a host of conceptual and estimation problems are introduced into the model.

As the models stand now in Chapter Four, there are several conceptual and practical difficulties involved in their estimation. The presence of these problems is due to violation of certain OLS assumptions. However, prior to investigating the nature of these problems and the alternatives available for obtaining internal conceptual consistency of our models, let us examine the role of the lagged residuals used in all of the equations as independent variables.

The assumption that the error term associated with one observation is statistically independent of the error term associated with another observation precludes the existence of serial correlation in the residuals of a regression equation. Autocorrelation results from incorrect specification of functional forms and/or the omission of variables which are important in the determination of the dependent variable. Although there are several techniques making the estimation in the
presence of autocorrelation possible, the procedure of using lagged residuals as regressors is considered superior to the other methods for the following reasons:

1. It possesses computational simplicity,
2. Interpretation of the results is more precise,
3. It reduces the severity of the heteroscedasticity problems,
4. The question of convergence does not arise here, and
5. The existence of multiple solutions is precluded.

Different techniques of estimation in the presence of autocorrelation give different results, but the Cochrane-Orcutt method yields estimated parameters which approximate those of the generalized least squares method. Operationally, the Cochrane-Orcutt technique uses an iterative technique which adds the product of the serial correlation coefficient with the lagged residual to the rhs of the equation and it searches for the value of the serial correlation coefficient that minimizes the standard error of the estimate. Thus, the procedure of correcting for autocorrelation by using lagged residuals as regressors is equivalent to the Cochrane-Orcutt method, the difference being that our method ends on the second iteration equation, unless correction for second order autocorrelation is desired, in which case our method terminates in the third iteration equation. The regression coefficients of the lagged residual terms are an estimate of the serial correlation coefficients and in all equations are approximately equal.

\( U_{gt} \) are the disturbance terms in the present time period and \( U_{gt-1} \) are the error terms of the previous time period. That is, an iterative estimation method is to be employed here. First, the regressions are to be estimated and the residuals saved and lagged by one period. Then, the lagged residuals are to be used as independent variables in each of
the equations. The use of lagged residuals as regressors has been justified by the builders of the Fed - MIT model as appropriate in those instances whereby the adjustment of the variables under consideration is slow.¹

While the use of lagged residuals does not affect significantly the values of the lag coefficients and leaves the average lag intact, it has the property of raising the estimated t-statistics and, in most cases, the $R^2$ values. One of the major advantages of the use of lagged residuals as regressors is that they have the tendency to free the residuals of the equation in the second iteration of correlation with the dependent variable which plagues the residuals of the first iteration equation. Fears that the use of lagged residuals as regressors might introduce an additional degree of multicollinearity among the regressors are unfounded:

$U_{gt-1}$ is less likely to be correlated with the other regressors $Y_{gt}$ than $U_{gt}$ is.²

In the formulation of our dynamic model, in addition to the functional relations, we have had to deal with causality.³ In H.A. Simon's words, causality is an asymmetrical relation among certain variables, or subsets of variables, in a self-contained structure (H.A. Simon [1953, p. 73]). In a dynamic model as ours, lagged relations can usually be interpreted as causal relations, although there is no necessary connection between the asymmetry of this relation and asymmetry in time. One

¹See F. DeLeeuw (1965) and E. Gramlich (1968). This technique is also used by B. Klein (1977) who maintains that the residuals of the equation using $U_{gt-1}$ as regressors measure unanticipated changes in the dependent variable.

²Another reason that the use of $U_{gt-1}$ is not believed to add to the multicollinearity that might exist among the regressors is the fact that the coefficients in the two iterations remain practically unchanged.

³The definition of causality given by R.H. Strotz and H.O.A. Wald (1960) is the following: X is the cause of Y if it is possible by controlling X indirectly to control Y; however, it may not be possible by regulating Y to peripherally regulate X.
of the OLS assumptions is that the error term of each equation must be uncorrelated with all the explanatory variables in that equation; i.e., \( \text{Cov}(Y_{gt}, U_{gt}) = 0 \). This assumption implies that causality, or the direction of influence, runs from the explanatory variables to the dependent variables.

When the assumption \( \text{Cov}(Y_{gt}, U_{gt}) = 0 \) is violated, the exogeneity of the variable \( Y_{gt} \) and the causal ordering is no longer preserved. This is the essence of the simultaneity problem. It usually occurs when an explanatory variable in one equation is a dependent variable in another equation that involves some of the same variables as the ones in the first equation. The simultaneous equation bias is a result of the correlation between the disturbance terms and the independent variables and it is caused by the simultaneous satisfaction of some of the equations in the model. However, as P. Rao and R. Miller (1971) indicate, when there is no correlation between the error terms and the explanatory variables, then there is no simultaneous equations model. The upshot of this is that the estimation of a single equation taken from a simultaneous equations model does by no means imply that the estimates contain elements of simultaneity bias.\(^4\) Thus, while simultaneity may appear to be obvious in the equation for \( Y_8 \) and \( Y_{11} \), for example, the implied simultaneity bias may not exist and single equation estimation may be valid, especially for the distributed lag version of our model.

In order for the model to provide us with useful and reliable information about the monetary transmission mechanism, it has to be restrictive enough so that only one set of parameter values is consistent with the data set and the model. If there are not sufficient restrictions imposed

\(^4\)For a discussion of this point, see P. Rao and R. Miller (1971).
in the model, there may be several sets of parameter values consistent with the data set and the model. On the other extreme, if we were to make the model too restrictive, no set of structural parameter values may be consistent with both the data and the model. We say that the structure is just identified when the model is only sufficiently restrictive so that one and only one set of structural parameter values is consistent with the data and the model. Thus, identification is a problem dealing with the formulation of certain relations that associate a specified model with a structure. However, as we have seen, the equations of this model are underidentified and this may necessitate use of estimation techniques other than OLS.

The identification problem does not arise in recursive models, and in a single-equation model, this problem is assumed away. However, interaction among the leading indicators in our model may necessitate the estimation of simultaneous equations, and thus, the identification problem may become a difficult exercise in logic. That problem requires that in a complete model each of the equations has a unique statistical form. In other words, the model is identified if its structural form parameters can be derived from the reduced form parameters. Strangely enough, identification of each of the simultaneous equations in a model depends on the number of variables excluded from it, while at the same time being operative in the other equations of the model.\(^5\)

The necessary condition for identification, otherwise known as the order condition, states that the total number of variables in the model,

---

\(^5\)This is what A. Koutsoyiannis (1973, p. 339) has called the paradox of identification.
A, less the number of variables in the particular equation, B, should be equal to the number of the endogenous variables in the model, C, minus one. That is, if \( A - B = C - 1 \), then the equation is exactly identified and the parameters of the equation are uniquely determined. When \( A - B \leq C - 1 \), the equation is un- or under-identified and there is no method of obtaining reliable estimates of the parameters, other than using instrumental variables. Finally, when \( A - B > C - 1 \), the parameters of the equation are over-identified; this simply means that there exists more than one set of consistent estimates of the parameters.

M. Dutta (1975, p. 267) asserts that if the necessary condition of identification is satisfied, then the sufficient condition, known as the rank condition, is also satisfied. It has been pointed out that for statistical estimation to have merit, the mathematical identification of the equations in the model is necessary. Identification by itself, however, does not imply that the specified equation or model is true.\(^6\) And, identification is usually secured through \textit{a priori} zero restrictions; i.e., it can be fabricated via exclusion or inclusion of variables from the model. Here, though, there is an implicit assumption made concerning the parameters of the variables included in the particular equation. It is assumed that these parameters are non-zero, but in practice they may very well turn out to be statistically insignificant from zero.\(^7\)

Whenever an equation is conceptually a part of a larger model representing a system of economic relations, then the problem of the simultaneity

\(^6\)This point is explained in J. L. Murphy (1973, p. 428).
\(^7\)For an elaboration of this and related problems, see F. L. Basmann (1965).
bias is very likely to occur. Also, whenever an explanatory variable is not independent of the residual in that equation, i.e., when Cov(Y\_g,\_t U\_g,\_t) \neq 0, simultaneity occurs. The method of using OLS on each equation separately is proper in causal chains, or recursive systems, but it results in biased and inconsistent estimates if applied in a system of simultaneous equations. This bias happens because the OLS technique does not permit parameters of one equation to influence the estimation of parameters in another equation. Furthermore, OLS fails to take into account the influence of the covariances, Cov(U\_h,\_t U\_g,\_t), in estimation of the parameters, and the estimates of the variances, var(U\_g,\_t), are computed separately one at a time without involving the influence of the other disturbances. Consequently, OLS estimates are deficient in a simultaneous equations model and are no longer the same as maximum likelihood estimators.

Although interdependence is a fact of economic life, one may argue that economic interdependence is recursive and not simultaneous. J. Johnston's evaluation is that when institutional realities and other frictions are taken into account, Wald's argument that economic systems are recursive rather than simultaneous contains much merit. Johnston also points out that it is difficult to find examples of markets where equilibrium values are determined simultaneously and that some adjustment mechanism must be specified in order to make the model more realistic.

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8 Simultaneity does by no means imply interdependence when interpreted as the situation in which certain events take place at the same point in time (see R. Bentzel and B. Hansen [1954, p. 159]).
9 For a discussion of the bias of these estimates, see J. Johnston (1972, pp. 242-244).
10 These points are discussed in J. L. Murphy (1973, p. 412).
11 See, for example, R. H. Strotz and H. O. A. Wald (1960).
12 See J. Johnston (1972, p. 379).
However, to avoid interdependence, and the associated identification problems and obtain recursiveness, a model constructed on the principle of the disequilibrium method of the Stockholm School must deal with sufficiently short time intervals. Marshallians on the other hand, have argued that we may not be justified in deviating from the general position that everything depends on everything else in an interrelated general equilibrium economy. T. C. Liu (1960), for example, questions the specifications of models in which restrictions are imposed on particular parameters or groups of them. His position is that econometric models are generally underidentified and that the most we can do is to estimate reduced form equations without a priori restrictions.

The estimation of parameters in simultaneous equations models is based on the additional assumptions that the residuals are non-autocorrelated and uncorrelated with the predetermined variables. And, since these assumptions always become very specific, it seems reasonable, from an applied econometrics point of view, to be skeptical about the usual zero correlations assumptions. R. Bentzel and B. Hansen's position (1954) is that the various zero correlation assumptions are introduced ad hoc only because they allow a certain method of estimation to be applied. Furthermore, they insist that econometricians must confess that they know very little about the residuals other than that, in all probability, they are interrelated in a complicated manner.

13 In the disequilibrium model of the Stockholm School, static equilibrium conditions are the main cause of interdependence in econometric models. In that model, the definition of short time periods excludes the possibility that successive adjustments towards equilibrium take place within the period. Thus, all interdependence caused by equilibrium conditions and aggregation of variables within and over time periods is ruled out (see R. Bentzel and B. Hansen [1954, pp. 153-163]).
We noted earlier that the identification problem does not arise in recursive systems because recursive models are estimated in the original form, whereas in interdependent systems the estimation method is applied to the reduced form equations. However, even in recursive models, the assumptions of zero correlation concerning the residuals of the equations may be hard to justify for, as K. Wallis (1969) points out, the error terms represent the influence of omitted variables, some of which may be common to several of the equations in the model. In the model of the alternative monetary transmission mechanism, the omission of some government expenditure variable leads to violation of assumptions about the error terms and renders a recursive model's estimates as unreliable as the estimates obtained by using the OLS uniequation method.

Usually, in attempting to bypass the difficulties involved in the estimation of a model that is under-identified, additional exogenous variables are introduced in the model, often on an ad hoc basis. The intent of such practices is to obtain "more reliable" estimates of the structural parameters of the model. Strictly speaking, our model is partly simultaneous and partly recursive; that is, it is block recursive. The main problem involved in estimating monthly relationships in such a model is to determine or verify the lag structures or the time path of delayed responses of the dependent variables due to changes in the explanatory variables.\footnote{T.C. Liu (1960) maintains that part of the central problem in monthly models is the determination of lag structures in the serial correlations of the error terms as well.}

Exogenous variables are given for the model and their values are not determined by the structure. While exogenous variables are known and determining the endogenous variables, they are assumed to be unaffected.
by the endogenous variables. More explicitly, the direction of influence runs from the exogenous to the endogenous variables, but not in the other direction. However, non-exogeneity can result from any kind of mispecification in the model's form. And, as K. Wallis (1969, p. 784) has indicated,

Unless at some stage one is prepared to neglect the errors induced by regarding as exogenous, for the purpose of the study, which may really be endogenous in some more extensive system, one is inexorably led toward construction of a complete economic model.

Some of the leading indicators are subject to a common set of economic influences and they move together over time; thus, they are collinear as evidenced by the correlation matrix of Table 1. This type of behavior on the part of some leading indicators introduces the problem of multicollinearity in the estimation of the equations of our model. Multicollinearity arises from the presence of interdependence in the regressors of a multivariate regression and a high degree of it results in obtaining estimates of the regression coefficients that are very imprecise. The coefficients are unreliable because of the large variances of the OLS estimators.

The problem of multicollinearity is clearly exhibited in the results of the equation for the average work week indicators, where the t-statistic values show insignificant coefficients and yet, the F-ratio statistic shows that they are significant. In the case of this equation, the fact that an autoregressive model is used does not explain alternating signs for the regression coefficients when a different data set is used.

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15 See C. A. Sims (1973).
In order to free the regression estimates from the multicollinearity problem, researchers usually increase the time period of the data set and the accuracy of the data or transform the data into first differences. While the former approach is often fruitful, the latter approach introduces autocorrelation in the residuals of the equation where there was no autocorrelation to begin with. Eliminating regressors from the set of the explanatory variables in order to correct for multicollinearity results in specifications errors. Thus, if economic theory or a priori reasoning dictates the inclusion of certain regressors in the set of explanatory variables, specification considerations supercede concerns over the multicollinearity problem.

One may also challenge the reliability of the results obtained by this model of a monetary transmission mechanism on the basis of stability considerations, since several structural changes occurred in the U.S. economy during the period of 1966 to 1976. In econometric parlance, a structural change occurs when the parameters of a model change in response to factors within or outside the model.

The polynomial distributed lags estimated by our model are only approximations to continuous adjustment processes. However, most economic theory is formulated in terms of continuous variables and processes, and economic paradigms assume the same characteristics in econometric models. And, if continuity is assumed, it should hold throughout the time interval that generated the data set. As D. J. Poirier (1976, p. 2) points out, when the variable causing the parameter change is of qualitative nature, discontinuous models of structural change are appropriate. That is, the Chow test can be used to detect structural changes and dummy variables can then be used to
account for these changes.  

When the forces that caused the structural change are continuous and can be quantified, the dummy variables should be interacted with the regressors so that continuity may be tested. As an alternative to using dummy variables, D. J. Poirier advocates the use of spline functions in models where several structural changes have occurred.

Due to the immense computational complexity involved in the estimation of spline functions, they were viewed as impractical, although more reliable results may have been obtained by their use. Dummy variables were used only in preliminary estimations in order to establish the occurrence of structural changes since the end of 1973. Binary variables were not included in the final estimation of the model for several reasons:

1. The estimation technique becomes very narrowly tailored to the particular data set,

2. Some of the changes were short-lived, such as the oil embargo of 1973, while others were easily absorbed by the economy,

3. Some of the factors that may have caused changes were continuous while others were not, and

4. The intent of this study is to evaluate the performance of the leading economic indicators in the proposed transmission mechanism in the midst of all factors that contributed to the functioning behavior of our economy in the 1966 to 1976 period and investigate how monetary impulses are transmitted to real GNP via the indicator's linkages.

16 The Chow test can detect whether the coefficients obtained by partitioning the time interval belong to the same structure (see G. C. Chow, 1960).

17 The idea behind the spline function is the use of piecewise functions in which the pieces are connected in a smooth fashion. For a good exposition of spline functions, their use, and a computer program to estimate them, see D. J. Poirier, (1976). For technique of fitting spline functions by standard regression methods, see D. B. Suits, A. Mason, and L. Chan (1978).
Were we to isolate fiscal policy influences, international trade and monetary developments, structural changes, and other assorted villains, the hypothesized transmission mechanism would be operating in a vacuum.
APPENDIX C. WEIGHT DISTRIBUTIONS OF

THE DISTRIBUTED LAG MODEL
### DEPENDENT VARIABLE: Y1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>T-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-45.5249</td>
<td>-11.796</td>
</tr>
<tr>
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### Model Statistics
- \( R^2 \): 0.799 (Uncorrected) 
- \( R^2 \): 0.793 (Corrected)
- DW: 2.084
- \( F(3,119): 157.252 \)
- RSS: 1038.1
- SE: 2.953
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R-Squared: 0.651 (Corrected)

F(5,115): 45.719

RSS: 10130

SE: 9.385

DW: 2.035
DEPENDENT VARIABLE: Y3

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R-Squared: 0.940
R-Squared: 0.938
DW: 2.031

F(4,114): 443.827
RSS: 286.85
SE: 1.586
**DEPENDENT VARIABLE: Y4**

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**R-Squared:** 0.884 (Corrected)  
**DW:** 1.974

**F(4,112):** 222.322  
**RSS:** 2.467  
**SE:** 0.148
**DEPENDENT VARIABLE: Y5**

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R-Squared: 0.954
(Uncorrected)

R-Squared: 0.952
(Corrected)

DW: 2.158

F(3,115): 788.534
RSS: 7598.4
SE: 8.128
## DEPENDENT VARIABLE: \( Y_7 \)

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### ALMON LAGS

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### R-Squared
- Uncorrected: 0.766
- Corrected: 0.753

### Other Statistics
- DW: 2.102
- F(6,113): 61.566
- RSS: 7.382
- SE: 0.255
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**ALMON LAGS**

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**R-Squared:** 0.981

(Uncorrected)

**DW:** 2.125

**F( 4,112):** 1460.652

**RSS:** 157.56

**SE:** 1.578
DEPENDENT VARIABLE: Y9

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ALMON LAGS

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R-Squared: 0.904 R-Squared: 0.900
(Uncorrected) (Corrected)

F(4,111): 261.056 RSS: 1242.8

DW: 1.973 SE: 3.346
## DEPENDENT VARIABLE: Y10

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| Y4       | -0.0442     | - 1.047     |
| Y4(-1)   | -0.0707     | - 1.047     |
| Y4(-2)   | -0.0795     | - 1.047     |
| Y4(-3)   | -0.0707     | - 1.047     |
| Y4(-4)   | -0.0442     | - 1.047     |

| Y5       | 1.1562      | 71.933      |
| Y5(-1)   | 0.8671      | 71.933      |
| Y5(-2)   | 0.5788      | 71.933      |
| Y5(-3)   | 0.2890      | 71.933      |

### ALMON LAGS

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R-Squared: 0.992
(Uncorrected)

R-Squared: 0.992
(Corrected)

F( 5,119): 2948.974
RSS: 1915.4
SE: 4.012

DW: 2.016
DEPENDENT VARIABLE: Y12

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DW: 2.174  SE: 1.646

F(5,120): 2172.282  RSS: 324.22
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**R-Squared:** 0.998

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| DW: 2.125 | SE: 3.626 |

**F(7, 108): 7815.206 | RSS: 1420.6**
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Source: Business Conditions Digest, March 1976, p. 107 and subsequent issues of this publication
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Source: **Business Conditions Digest**, September 1976, P. 106, and subsequent issues of this publication
Table 6. Change in Book Value of Manufacturing and Trade Inventories.

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Source: Business Conditions Digest, December, 1976, p.113, and subsequent issues of the publication
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Source: Business Conditions Digest, December 1976, p. 97, and subsequent issues of this publication
Table 8. Layoff Rate, Manufacturing. Per 100 Employees

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Source: Business Conditions Digest, February 1977, and subsequent issues of this publication
Table 9. Value of Contracts and Orders for Plant and Equipment.

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Source: Business Conditions Digest, April 1975, p. 108, and subsequent issues of this publication.
Table 10. Index of Permits for New Private Housing Units; 1967=0.

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Source: *Business Conditions Digest*, December 1976, p. 98, and subsequent issues of this publication.
Table 11. Average Workweek of Production Workers in Manufacturing.

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Source: Business Conditions Digest, December 1976, p. 106, and subsequent issues of this publication.
Table 12. Value of New Orders for Durable Goods.

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Source: *Business Conditions Digest*, December, 1976, p. 106, and subsequent issues of this publication.
Table 13. Index of Stock Prices, 500 Common Stocks; 1941-43=100.

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Source: Business Conditions Digest, December 1976, p. 97, and subsequent issues of this publication.
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Source: *Business Conditions Digest*, January 1976, p. 96, and subsequent issues of this publication.
Table 16. Corporate Profits After Taxes.

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Source: Business Conditions Digest, April 1976, P. 111, and subsequent issues of this publication.

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Source: Business Conditions Digest, August, 1976, p. 108, and subsequent issues of this publication.
REFERENCES


Hall, R. E., "The Theory and Application of Polynomial Distributed Lags", Lecture Notes for the Data Resources Educational Program, April, 1975.


