AN ANALYSIS OF SECTORAL COMPONENTS OF AGGREGATE ECONOMIC ACTIVITY

by

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CHAPTER I

INTRODUCTION

This chapter first states the two main objectives of this thesis. The section provides an outline of the analytical scheme utilized to pursue these objectives and concludes with a brief summary of the results of the investigation.

I.A. Thesis Problem and Objectives

Much of the research on business cycles has been within the context of the movements of and the interrelationships between series of national aggregates. To an even greater extent, most of the literature concerning cyclical stabilization has been concerned with the responses of such national aggregates to federal monetary and fiscal policy actions.

This treatment of cyclical variations in the level of economic activity is not really consistent with the true nature of the phenomenon known as the business cycle. As stated by Arthur F. Burns:

> With everything rising and falling in unison, there would be little need to fuss with specific factors in business, and one might center attention exclusively on aggregate activity. But business cycles . . . are of very different character. They are marked by expansions and contractions that are only partially diffused through the economy, and it is therefore of the utmost importance to obtain as clear a notion as we can of how specific cycles of different activities are tied together.[1]

[1]Arthur F. Burns, "New Facts on Business Cycles," in Business Cycle Indicators, ed. by Geoffrey Moore, Vol. I (Princeton, N.J.: Princeton University Press, 1961), p. 17.

The cyclical variations which occur in the overall level of economic activity are really a weighted summation of the pattern of cyclical fluctuations of the individual sectors of the economy. Each of these component sectors have different patterns of cyclical fluctuation and of secular growth. The sectors do not all move together. Every month some activities reach cyclical peaks while others decline. But the peaks tend to occur in bunches and likewise the troughs. The business cycle as measured by aggregate measures is the alternating succession of majorities of individual expansions, next of contractions, and so on.[1]

Further, even with that group of activities whose expansions and contractions are relatively coincident, each of the individual series probably has its own particular magnitude of cyclical amplitude and also a particular lag structure when compared with the general cycle.

The first objective of this study, therefore, is an examination of the specific patterns of growth and of cyclical fluctuations of the individual sectors which together comprise the complex entity known as, "the economy." The results of such analysis should provide a systematic analysis of the relative contribution of each sector to aggregate growth and to the cycles within the overall level

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[1]Wesley C. Mitchell, What Happens During Business Cycles (New York: National Bureau of Economic Research, 1951), p. xv.

of economic activity. Such research should help to pinpoint the primary sources of instability causing the fluctuations of aggregate production.

In employing aggregate analysis in the study of cyclical stabilization, economists assume, either explicitly or implicitly, that responses to either shocks or policy actions are uniform among the individual sectors[1] or that specific difference in sectoral response are not of concern to the authorities administering stabilization policy. Just as sectors differ with respect to cyclical timing and amplitude, however, it would seem unrealistic to ascribe to each of the sectors an identical response pattern to monetary and fiscal policy actions. As stated by Maurice Mann, referring particularly to monetary policy:

> Sectoral effects were recognized at the time of the revitalization of monetary policy in the 1950's but were treated more as an academic curiosity than as a significant policy consideration . . . Recently, however, there has been heightened concern regarding the distribution of the burden of adjustment to changes in monetary policy among the various sectors of the economy . . . As a result, monetary policy-makers are obligated to consider questions of sectoral incidence and equity, as well as stabilization. *The need for more precise knowledge in this area is clearly imperative*. (Italics mine.)
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> Monetary restraint in 1966 clearly suggested the potential importance of sectoral effects. Although severe sectoral effects may be desirable from the standpoint of the objectives of general stabilization policy,

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[1]See, for instance, Bert G. Hickman, "Diffusion, Acceleration, and Business Cycles," *American Economic Review*, IL (September, 1959), 535-65, for just such an explicit assumption.

> the costs may be unacceptable from the standpoint of sectoral goals. In addition adverse sectoral effects may contribute to over-all economic imbalances that policy may be trying to minimize . . . Policy-makers are aware of the differential effects of various tools or combinations of various tools. *The development of of econometric models should contribute to this knowledge.*[1] (Italics mine.)

The voluminous works of many authors, such as Mitchell, Burns, Moore, etc., under the auspices of the National Bureau of Economic Research,[2] have previously examined the business cycle process in terms of investigating the movements of a large number[3] of interrelated disaggregated data series. In one such work, which is representative of the general type of methodology employed by the N.B.E.R. in the study of the business cycle, Mitchell,[4] on the basis of empirical investigation of a diverse set of time series, attempted to develop a model of business cycles based upon empirical regularities in order to demonstrate how the cyclical movements of all the various economic series fit together into the general business cycle processes of expansion, recession, contraction, and revival.

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[1]Maurice Mann, "How Does Monetary Policy Affect the Economy?" *Federal Reserve Bulletin*, IX (October, 1968), 807-808.

[2]See G.H. Moore, ed., *Business Cycle Indicators*, pp. 736-744, for a complete list (up to 1961) of N.B.E.R. publications on business cycles.

[3]It is quoted in John J. Clark and Morris Cohen, *Business Fluctuations, Growth, and Economic Stabilization* (New York: Random House, 1968), p. 6, that Mitchell examined over 800 data series.

[4]Mitchell, *What Happens During Business Cycles*.

Within these analyses, the relationship between the movements of the variable associated with stabilization policies (that is interest rates, the money supply, government expenditures, government deficits, etc.) and all of the other economic variables were implicitly investigated in the process of analyzing the total pattern of movement during business cycles. However, the research was primarily interested in classifying the variables into groups of leading, coincident, and lagging series, rather than the explicit investigation of the specific responses of the individual sectors to movements of the policy variables.

On the other hand, the response of individual sectors to stabilization policy has been the subject of considerable research, but most work has concentrated analysis upon the effects of countercyclical policies upon only a few specific sectors, particularly residential construction and state and local government investment.[1]

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[1]For example, see Sherman L. Maisel, "The Effects of Monetary Policy on Expenditures in Specific Sectors of the Economy," Journal of Political Economy, LXXXVI (July-August, 1968), Part II, 796-814; Eugene Brady, "A Sectoral Econometric Study of the Postwar Residential Housing Market," Journal of Political Economy, LXXV (April, 1967)1967), 147-58; Jack Guttentag, "The Short Cycle in Residential Construction," American Economic Review, LI (June, 1961), 275-298; Frank Morris, "Impact of Monetary Policy on State and Local Governments: An Empirical Study," Journal of Finance, XV (May, 1960), 232-249; Charlotte Phelps, "The Impact of Monetary Policy on State and Local Government Expenditures in the United States," in Impacts of Monetary Policy, ed. by Commission on Money and Credit (Englewood Cliffs, N.J.: Prentice Hall, Inc.), pp. 255-268; William Shropshire, "Interest Rates and Local Government Spending: The North Carolina Experience, 1955-58," Southern Economic Journal, XXXII (April, 1966), 440-50.

The second objective of this study, therefore, is an investigation of the effects of monetary and fiscal policy actions upon a set of individual sectors, with concentration upon the responses of output of the individual industry groups to movements in those variables associated with countercyclical stabilization policies. As Mann has pointed out, economists and policy-makers have recognized that monetary and fiscal policy actions affect the composition of demand and production in addition to influencing their volume. The results of this analysis provide evidence of the effects which monetary and fiscal policy have upon the structure of output.

I.B. Outline of Analysis

Prior to the actual analyses, Chapter Two discusses the sources and characteristics of the data series which are employed in the analyses of Chapters Three, Four, and Six.

As stated in section I.A., the first objective of this study is an examination of the specific patterns of growth and of cyclical fluctuations of the individual sectors. To study the sectoral patterns, two different analytical techniques are employed. First, in Chapter Three, the patterns of cyclical variation are studied in terms of conventional, descriptive statistical procedures. The individual sectoral patterns are compared with the reference cycle of the National Bureau of Economic Research. Secondly, in Chapter Four, the more powerful analytical techniques of time series analysis are utilized. The relationship between the variance patterns of the individual sectoral outputs are compared statistically with the pattern of fluctuation of overall economic activity through the use of spectral and cross-spectral analysis.

The second objective is an investigation of the effects of monetary and fiscal policy actions upon the outputs of individual sectors. To achieve this objective, a simple model of the relation between sectoral outputs and the aggregate variables normally specified as determinants of aggregate demand in macroeconomic general equilibrium models is developed in Chapter Five; and, in Chapter Six, this model is utilized to empirically test for the existence of differential sectoral responses to changes in these aggregate variables.

In a previous study, Leonall Anderson estimated the differential effects of monetary and fiscal policy actions upon the output of ten selected sectors by calculating their average income elasticities and then indirectly estimating the sectoral effects by assuming certain levels of response to policy actions on the part of aggregate income.[1] This thesis adds to economic knowledge in that, unlike the "simulation" study of Anderson, it tests directly, on the basis of the 1947-69 experience, for the influence of monetary and fiscal policy actions upon sectoral outputs. Further, this analysis involves the systematic study of the responses of a complete

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[1]Leonall C. Anderson, "The Incidence of Monetary and Fiscal Measures on the Structure of Output," Review of Economics and Statistics, IVL (August, 1964), 260-268.

set of sectors, rather than studying the effects upon either one particular sector or a few selected sectors as have previous investigations.

As opposed to either simulation analysis or the "reduced-form" approach, both of which analyse the total effects of monetary and fiscal policy actions, the model developed in Chapter Five includes aggregate income and monetary and fiscal policy-related variables in order to estimate separately the direct and the indirect effects of policy actions, as measured by movements in the policy-related aggregate variables.

In Chapter Six, regression analysis, based upon this model, is employed to estimate the partial elasticity of each sector's output with respect to each policy-related variable in order to provide evidence concerning the existence of differential sectoral effects of monetary and fiscal policy actions. In addition, series of regressions, in which lags of varying lengths are specified between the aggregate variables and the sectoral outputs, are performed in order to study the lag between movements in the policy-related variables and the resultant sectoral responses.

In Chapter Seven, the results of the empirical analyses are discussed, interpreted, and related to the findings of previous studies.

Chapter Eight contains a summary of what has been done and concludes with a brief discussion of the implications of the results concerning the choice between monetary and fiscal policies as the more appropriate stabilization tool.

I.C. Brief Summary of the Results

The analyses contained in both Chapters Three and Four produced relatively similar results. The separate sectors were indicated to have very different patterns of variation, particularly with respect to cyclical amplitude. A comparison of the quality of evidence in these two chapters also demonstrates the superiority of the spectral and cross-spectral approach to the use of conventional descriptive statistics.

The regression results presented in Chapter Six did indicate that monetary and fiscal policy actions have direct effects upon sectoral outputs. The findings supported the generally held views that monetary policy primarily affects the durable-goods and related sectors and that a significant "outside" lag exists between monetary policy actions and the consequent sectoral responses. The evidence also suggested that fiscal policy actions have small but more widespread direct effects upon sectoral outputs. Generally, the findings seemed to demonstrate a short lag between fiscal policy actions and their effects upon the outputs of the individual sectors.

CHAPTER II

DESCRIPTION OF THE DATA

This chapter discusses the sources and characteristics of the data series which are employed in the empirical analyses.

II.A. Output Series

The focus of this study is upon the real cycles experienced through time by individual sectors of the economy. The investigations of the individual patterns of variation and of the differential responses of the sectoral outputs to variations in policy-related variables are in real terms--not in terms of nominal income or money value of output. The analysis utilizes output series from two basic sources. A set of disaggregated indexes of industrial production is utilized as one measure of real sectoral outputs. Indexes of gross product in constant dollars, disaggregated by major industry division, are the other data series employed as measures of real sectoral output.[1] These two distinct data sources are utilized because each type of data has one advantageous characteristic which the other lacks: the indexes of industrial production are available monthly, but are only available for the manufacturing industries; on the other hand, the indexes of gross

[1]While such index data would not be applicable if the objective of the research concerned the levels of sectoral outputs, since the primary concern is with the patterns of variation, the use of index data is appropriate.

product provide a thirteen sector division of the entire gross national product, but are only available in annual form.

The Indexes of Industrial Production

The total industrial output of the economy is disaggregated in terms of the two-digit S.I.C. industry groups. The available indexes include all of the two-digit industries, except Ordinance (S.I.C. 19), so that the set of disaggregated indexes utilized may be thought of as a partition of all manufacturing activities into twenty-four sectors.[1] A listing of the industry groups utilized is presented in Table I. The total index of industrial production including utilities, which is approximately equivalent to the aggregation of the twenty-four sectoral indexes, is also utilized in the analyses of Chapters Three and Four.

These indexes of industrial output have been compiled by the Division of Research and Statistics of the Board of Governors of the Federal Reserve System. The disaggregated series are available for the period 1947 to the present; the total index is available for the period 1947 to the present; the total index is available from 1919.

The sectoral series utilized in this study are themselves aggregations of more detailed series. These very detailed output

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[1]In actuality, the data set does not include all two-digit groups. The data series for Coal includes both Anthracite (S.I.C. 11) and Bituminous Coal (S.I.C. 12). The degree of aggregation is due to the availability of the data in this form.

TABLE I

MONTHLY DISAGGREGATED INDEXES OF INDUSTRIAL PRODUCTION

Sectors	S.I.C. Code
Primary metals	33
Fabricated metal products	34
Non-electrical machinery	35
Electrical machinery	36
Transportation equipment	37
Instruments and related products	38
Clay, glass, and stone products	32
Lumber and products	24
Furniture and fixtures	25
Miscellaneous manufactures	39
Textile mill products	22
Apparel products	23
Leather and products	31
Paper and products	26
Printing and publishing	27
Chemicals and products	28
Petroleum products	36
Rubber and plastic products	30
Foods and beverages	20
Tobacco products	21
Coal	
Crude oil and natural gas	13
Metal mining	10
Stone and earth minerals	14

series have been compiled by the Division of Research and Statistics of the Federal Reserve from a great variety of different sources.[1] A large proportion of the individual series are based upon man hour statistics supplied by the Bureau of Labor Statistics. The remainder are based upon data collected from Census data or from a number of other sources, such as the relevant manufacturer's association, etc.[2] The method utilized to combine the individual detailed series into the sectoral and total indexes is the weighted average of relatives. The weights used are based upon value-added in individual industries in 1957 collected by the Census Survey of Manufacturers. The value-added data for mining industries are based upon the 1954 Census of Mineral Industries.[3]

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[1]These series for the period 1947-61 have been compiled from the Board of Governors of the Federal Reserve System, Industrial Production, 1957-59 Base (Washington, D.C.: Government Printing Office, 1965); they have been continued through 1966 from Board of Governors of the Federal Reserve System, Industrial Production Indexes, 1961-66 (Washington, D.C.: Government Printing Office, 1967), for 1967 from Board of Governors of the Federal Reserve System, Industrial Production Indexes, 1967 (Washington, D.C.: Government Printing Office, 1968), and up through 1969 by utilization of several recent issues of the Board of Governors of the Federal Reserve System, Federal Reserve Bulletin.

[2]For a detailed description of the sources and description of the products included, see Board of Governors of the Federal Reserve System, Industrial Production, 1957-59 Base, pp. S4-S19.

[3]For a more detailed description of the compilation of these indexes, see Board of Governors of the Federal Reserve System, Industrial Production Measurement in the United States: Concepts, Uses, and Compilation (Washington, D.C.: Government Printing Office, 1954).

The Indexes of Gross Product

This data set is composed of annual indexes of gross product, in constant dollars, for the fourteen mutually exclusive major industries and for the total economy (which is an index of Gross National Product).[1] These annual indexes are calculated from data compiled by the National Income Division of the Office of Business Economics. The series are available for the period 1947-68.[2] A listing of the twelve major industry divisions which have been employed as separate sectors in the empirical analysis are presented in Table II. Hereafter, this group of sectors is referred to as the "broadly-defined" sectors.

II.B. Other Data Series

In order to study the sectoral responses to monetary and fiscal policy actions, other data series corresponding to each of the aggregate variables specified in the sectoral model (presented

[1]For the empirical analysis, the "Government and Government enterprises" and the "Rest of World" sectors will not be included in the study.

[2]The observations for the period 1947-65 have been collected from the U.S. Department of Commerce, Survey of Current Business (April, 1967), pp. 18-24; were continued through 1968 utilizing the U.S. Department of Commerce, Survey of Current Business (July, 1969), pp. 13-24. As stated by George Jaszi, the Director, Office of Business Economics, "construction (of these data series) consists of assemblying statistics from a wide range of primary sources and using complex estimating techniques to fit these data into the concepts of economic accounting." For details as to these methods, see U.S. Department of Commerce, National Income (Washington, D.C.: Government Printing Office, 1955).

TABLE II

SECTORS OF DISAGGREGATED INDEXES OF GROSS NATIONAL PRODUCT

Agriculture, forestry, and fisheries
Mining
Contract construction
Nondurable goods manufacturing
Durable goods manufacturing
Transportation
Communication
Electric, gas, and sanitary services
Wholesale trade
Retail trade
Finance, insurance, and real estate
Services

in Chapter Five) are necessary. As the measure of aggregate real income or demand, the gross national product in constant (1958) prices is utilized.[1] As the interest rate series to be utilized, the yield on long term government bonds has been collected.[2] While this particular rate, just as any single rate, cannot be a perfect proxy for the set of numberous interest rates which actually exist in the economy, since all interest rates are highly correlated, it is hoped that the pattern of fluctuation of the long term bond yield is an acceptable available substitute for the relevant variance pattern. Both money stock series were collected from the Federal Reserve Bulletin.[3]

In order to study the influence of fiscal policy actions, the measure known as the high employment budget surplus or deficit has been chosen. The high employment budget is, in effect, an estimate

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[1]This series, together with the interest rate series has been collected, for the 1947-66 period, from U.S. Department of Commerce, Business Statistics (Washington, D.C.: Government Printing Office, 1968). The series has been brought up to date by use of various issues of the U.S. Department of Commerce, Survey of Current Business.

[2]This is a series of monthly averages of daily figures. From April 1953, the bonds included in the sample are fully taxable and due or callable after ten or more years, and prior to April 1953, fifteen or more years, U.S. Department of Commerce, Business Statistics, p. 105. Initially, alternate interest rates were also employed, but yielded very similar results.

[3]Board of Governors of the Federal Reserve System, Federal Reserve Bulletin, X (October, 1969), 787-805. In order to produce the broadly-defined money stock series, the figures for time deposits and the money stock (M_1) in each period were added together.

of the national income accounts budget at some arbitrarily defined "full employment" level of economic activity. Since the high employment budget does not reflect cyclical variations in receipts or expenditures, movements in this measure, other than that of a constant rate of growth, should be due to discretionary fiscal actions.[1] Since the sectoral model is specified in real terms, the deficit and money stock series have been deflated through use of the GNP implicit price deflator series.[2]

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[1]This data series is produced by the research staff of the Federal Reserve Bank of St. Louis. Quarterly estimates of the high employment budget figures are available in Keith M. Carlson, "Estimates of the High-Employment Budget, 1947-68," Federal Reserve Bank of St. Louis Review, IL (June, 1967), 6-14, which also provides a general discussion of the estimation and significance of these series. The series has been brought up through 1969 using Federal Reserve Bank of St. Louis, "Technical Notes for Estimates of the High Employment Budget," (unpublished paper, 1970). This second paper provides details on procedures utilized to estimate high employment GNP and budget measures.

[2]This series has been obtained from the U.S. Department of Commerce, National Income and Product Accounts of the United States, 1929-65, for the 1947-65 period. The remainder of the data series was obtained from the Federal Reserve Bank of St. Louis, "Technical Notes for Estimates of the High Employment Budget."

CHAPTER III

THE INVESTIGATION OF EMPIRICAL REGULARITIES: CONVENTIONAL ANALYSIS

In both this and the next chapter, the sectoral patterns of growth and fluctuation are examined, in order to emphasize differences in these patterns among the individual sectors. In this chapter, the growth rates over the entire period are first examined. In the rest of the chapter the magnitudes of cyclical amplitude and the lag structure of the sectoral outputs are compared with the general business cycles, as measured by the N.B.E.R. reference cycle.

III.A. Rates of Growth

During the period, 1947-68, the level of the United States GNP has grown approximately 128 percent. Of course, the process has not been one of "balanced" growth; some sectors have experienced dynamic growth during the post World War II period, while the level of output for one particular sector under study has actually declined.

For the disaggregated indexes of industrial production, the specific growth rates experienced during the 1947-68 period range from an increase in real output of 434 percent by the Chemicals and products sector to a decrease in physical output of 29 percent by the Coal production sector. A complete listing of the percent increase in output for each sector during the period is presented in Table III. The percent increases in output of each of the twelve broadly-defined sectors and of total GNP over the 1947-68 period are listed in Table IV.

TABLE III

GROWTH OF INDUSTRIAL PRODUCTION BY SECTOR AND FOR TOTAL INDUSTRIAL PRODUCTION, 1947-68

Sector	Percent Increase
Chemicals	434
Transportation equipment	320
Rubber and plastics	291
Electrical machinery	269
Instruments	243
Furniture	164
Paper	163
Stone and earth minerals	155
Total Industial Production	152
Nonelectrical machinery	130
Petroleum	122
Fabricated metal products	121
Clay, glass, stone products	118
Printing	115
Miscellaneous	103
Apparel products	102
Crude oil	93
Textile mill products	78
Food and beverages	70
Primary metals	51
Metal mining	49
Tobacco products	48
Lumber	39
Leather	20
Coal	-29

TABLE IV

GROWTH OF GROSS PRODUCT IN CONSTANT DOLLARS FOR THE BROADLY-DEFINED SECTORS AND FOR THE TOTAL ECONOMY, 1947-68

Sector	Percent Increase
Communications	355
Electric, gas, and sanitary services	348
Finance, insurance, real estate	169
Wholesale trade	166
Durable manufacturing	155
Total Gross National Product	128
Nondurable manufacturing	121
Services	115
Retail trade	105
Contract construction	85
Mining	60
Transportation	56
Agriculture, forestry, and fisheries	38

While the pattern of secular growth of the individual sectors is not directly related to either of the two primary objectives of this study, some measures of growth of the sectoral outputs is included for two reasons. First, to demonstrate a wide divergence of experience among the sectors in growth as well as with respect to the patterns of cyclical variation. More specifically, these measures of secular growth have been included in order to help in the interpretation of the analysis of cyclical amplitudes. The data indicates that some of the sectors have not experienced true cyclical behavior, in that their historical pattern has been one of changing rates of growth, with no periods in which the level of production declined. By looking at both the statistics concerning the growth trends and the cyclical data, it is possible to obtain a more realistic assessment as to whether such sectors have actually been relatively unaffected by variation or whether these are cases of cyclical fluctuation around a trend of rapid growth.

III.B. The Patterns of Cyclical Fluctuation

In order to study the relative magnitudes of cyclical variation within the individual sector outputs, the annual percentage change in each sector's output during the four expansionary phases and four recessionary phases during the 1947-69 period have been computed. Based upon these measures, the average annual percent increase during expansions and the average annual percent decrease during recessions are presented in Table V for the set of disaggregated production indexes and in Table VII for the set of sectoral gross products.[1]

The Monthly Indexes

The historical performance of the twenty-five industrial sectors, as summarized in Table V, is difficult to discuss concisely. The relative cyclical amplitudes of individual sector's outputs, as compared with the cyclical pattern of the total index of industrial production, vary widely from one expansionary phase

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[1]For each of the monthly series of disaggregated production indexes, the percentage changes have been calculated on the basis of the change from either peak to trough or trough to peak. The data points designated as peaks are the maximum levels of output which most nearly correspond with the upper turning point of the N.B.E.R. reference cycle. Similarly, the troughs are the minimum level of output in each individual series corresponding to the lower turning points of the N.B.E.R. reference cycle. Of course, the month in which a particular sectoral output series reached either a peak or trough do not exactly correspond to the reference cycle dates, and this lead-lag relationship will be discussed subsequently. On the basis of the construction, known as the reference cycle, the dates designated by the National Bureau of Economic Research to have been either peaks or troughs for general "business cycle" activity during the period studies are presented in Table VI.

For the individual series of sector gross product in constant prices, since these series are available only in annual form, less precise measures of the amplitude of expansions and recessions have been calculated on the basis of the change taking place from the year designated as including a turning point of the N.B.E.R. reference cycle to the year containing the next reference cycle turning point.

It should be noted that the use of percentage increases and decreases as measures of comparison causes, in general, the percentage change in output to be higher during expansions than in contractions phases. This results from the fact that the denominator for the percentage declines is the peak output while the demonimator for the percentage increases is the level of output at the lower turning point.

TABLE V

AVERAGE ANNUAL PERCENTAGE CHANGES IN INDEXES OF INDUSTRIAL PRODUCTION DURING EXPANSIONS AND CONTRACTIONS, 1948-69

Sector	Average Annual Increase During Expansion	Average Annual Decrease During Contraction
Primary metals	29.1	-49.3
Metal mining	22.7	-38.9
Transportation equipment	19.4	-21.9
Rubber and plastics	18.8	-21.5
Coal	18.5	-44.9
Electrical machinery	17.5	-18.2
Chemicals	15.2	- 6.0
Nonelectrical machinery	14.7	-23.2
Instruments	13.8	-11.2
Fabricated metal products	12.1	-19.1
Furniture	12.0	-17.5
Paper	10.9	-11.3
Total Industrial Production	10.4	-12.0
Textile mill products	10.3	-20.6
Clay, glass, stone products	10.3	-14.1
Stone and earth minerals	10.1	- 8.8
Miscellaneous	9.3	-15.6
Lumber	9.0	-24.7
Apparel products	8.6	-11.4
Petroleum	7.8	- 7.6
Crude oil	7.6	-11.1
Leather	6.6	-18.1
Printing	5.7	- 2.3
Tobacco	4.7	- 8.4
Food and beverages	3.9	- 5.4

TABLE VI

UPPER AND LOWER TURNING POINTS OF THE GENERAL BUSINESS CYCLE (THE REFERENCE CYCLE OF THE NATIONAL BUREAU OF ECONOMIC RESEARCH), 1948-68

Upper Turning Point Dates	Lower Turning Point Dates
November 1948	
	October 1949
July 1953	
	August 1954
July 1957	
	April 1958
May 1960	
	February 1961

Source: Gottfried Haberler, Prosperity and Depression (Cambridge, Mass.: Harvard University Press, 1964), pp. vii-viii.

to another. To attempt a very brief summary of these statistics, it seems obvious (from examination of the average annual percentage changes) that the three most volatile sectors during the 1947-69 period have been the Primary metals, Metal mining, and Coal production sectors. In order to pinpoint those sectors which have been the primary sources of fluctuation in the economy, the proportion of industrial output produced by the sectors must also be considered. Adjusting for sector size,[1] the major sources of fluctuation in the aggregate level of production would seem to have been the following five sectors: (1) Primary metals (7 percent); (2) Transportation equipment (10 percent); (3) Nonelectrical machinery (8 percent); (4) Electrical equipment (6 percent); (5) Fabricated metal products (6 percent).

In addition, three other sectors (Metal mining (1 percent), Coal production (1 percent), and Rubber and plastics products (2 percent)) seem also to have been primary sources of instability, but these sectors contributed relatively small proportions of total output.[2]

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[1]The figures in parentheses after each sector indicates the proportion of total industrial output produced by that sector during the 1957-59 period. These proportions have been formed in Board of Governors of the Federal Reserve System, Industrial Production, 1957-59 Base, pp. S4-S19.

[2]These eight sectors have been chosen because both the average percentage increases and decreases of each were substantially larger (in absolute terms) than the average percentage increase and decrease calculated for the total Index of Industrial Production.

It also seems possible to identify a group of six industrial sectors which have been relatively stable:[1] (1) Printing and publishing (5 percent); (2) Foods and beverages (10 percent); (3) Petroleum products (2 percent); (4) Stone and earth minerals (1 percent); (5) Tobacco products (1 percent); (6) Crude oil and natural gas (6 percent). Another sector, Chemicals and products, seems to have been stable with respect to declines in output. However, due to the rapid growth of production by this sector during the postwar period (Table III), the percentage increases during expansionary phases were much greater than industrial output in general.[2]

The Annual Indexes

The data series relating to the indexes of gross product in constant dollars have been included in this study, because they

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[1]These particular sectors have been chosen because both the average percentage increase and decrease of each were less than the increase and decrease calculated for the total Index of Industrial Production. Again, the figures in parentheses are the proportion of total industrial production during 1957-59 contributed by that sector.

[2]The overall significance, with respect to the interpretations of the statistics in Tables V and VII, of the growth pattern of the Chemicals and products sector should be discussed. This measurement of the amplitude of cyclical variation achieved by utilizing percentage changes probably underestimates the size of the "business cycle component" in those output series which have experienced substantial growth over the period. For such series, measurement of the amplitude of cyclical fluctuations around their long-run upward trend might provide a more accurate measure. However, since the cyclical amplitude is also investigated utilizing cross-spectral techniques somewhat later in this chapter, such a third method has not been attempted. The statistics relating to the percentage changes do provide a simple, yet effective, descriptive measure of the relative amplitudes, and the use of cross-spectral analysis allows precise statistical estimation and testing of the relative amplitudes of each individual sector.

provide disaggregated measures of the level of real output of almost the entire economy. However, the use of such annual series causes the measurement of the relative amplitudes of the sectoral outputs to be somewhat crude. In particular, the measurement of the percentage change during periods designated as recessions have been biased, since most of the contractions lasted twelve months or less so that the use of annual observations would be expected to indicate a level of production somewhat higher than the true minimum. Further, to the extent that the cycles of the individual sectors have not been coincident with the overall business cycle, as measured by the N.B.E.R., additional biases in the measures of relative amplitudes have been introduced by the necessity of employing annual series. Even though the percentage change statistics may not accurately reflect the true cyclical pattern of sectoral outputs, at least a brief discussion of the available evidence, as presented in Table VII, may be worthwhile.

Examining the average annual percentage changes in level of output during recessions and also comparing the individual changes of sectoral output during each recession with those of total gross national product, it appears that only two sectors, Durable manufactures and Mining, exhibited true cyclical behavior. First, those two sectors experienced the two largest declines in average annual percentage change in output during recessions. Second, in all four recessionary periods, output levels in both sectors suffered a larger

TABLE VII

ANNUAL PERCENTAGE CHANGES IN INDEXES OF GROSS PRODUCT IN CONSTANT DOLLARS DURING EXPANSIONS AND RECESSIONS BY SECTORS, 1948-68

Sector	R 48-49	E 49-53	R 53-54	E 54-57	R 57-58	E 58-60	R 60-61	E 61-68	Average E	Average R
Total Gross National Product	--	7	- 1	4	- 1	4	2	6	5	-1
Agriculture, forestry, and fisheries	- 3	2	2	--	3	2	1	1	1	1
Mining	-11	6	- 3	5	- 9	3	1	3	5	-6
Contract construction	4	7	2	3	- 2	2	-2	2	4	1
Nondurable manufacturing	- 2	5	- 2	5	- 2	6	1	6	6	-1
Durable manufacturing	- 8	14	-10	4	-12	8	2	10	9	-8
Transportation	-12	4	- 1	2	- 7	4	-	7	4	-5
Communication	5	9	2	9	3	8	4	10	9	4
Electricity, gas, sanitary service	10	10	10	7	4	8	4	7	8	7
Wholesale trade	- 1	5	1	7	1	6	5	7	6	2
Retail trade	3	4	1	4	- 1	4	-	6	4	1
Finance, insurance, real estate	3	6	7	5	4	4	5	6	5	5
Services	--	2	--	6	3	4	4	5	5	2

relative decline than did Gross National Product. In addition, Durable manufactures experienced a significantly greater average annual percentage increase in output during expansions. While the Mining sector's average percentage increase was absolutely smaller than that of GNP, this sector's long-run growth has been one of the slowest; therefore, it seems reasonable to conclude that the relative cyclical amplitudes of at least these two sectors have been greater than that of the overall economy.

Except for the fact that the percentage decline of output for the Transportation sector during the 1953-54 recession was fractionally less than that of Gross National Product, this sector satisfies the same criteria as were applied to the Mining sector, so that the evidence also seems to indicate that the Transportation sector has experienced cyclical variation of greater relative amplitude than aggregate production.

On the other hand, both on the basis of comparison of the experience during each period and by considering the average percentage changes, the output series of four of the sectors have no apparent cyclical pattern at all: (1) Communications; (2) Electricity, gas, and sanitary services; (3) Finance, insurance, and real estate; (4) Services. The output of these sectors did not decline in any of the recessionary periods, and the average percentage change for each sector's output during recessions was positive. On the basis of the average percentage changes in output, at least two of these sectors, Finance, insurance, and real estate, and Services might be categorized as relatively more stable than the overall level of economic activity.

However, on the basis of the evidence in Table VII, it is very difficult to make a judgement as to the relative amplitudes of variation of the sectors other than the five classified above (and Agriculture, forestry, and fisheries, to be mentioned in the next paragraph). It is difficult to judge even the Communications or Electricity, gas, and sanitary services sectors, which were mentioned in a preceding paragraph, because of the large absolute difference between the average rate of growth during expansions as compared with recessions. In terms of cyclical variation around a trend, these two sectors are subject to considerable fluctuations.

The Agriculture, forestry, and fisheries sector seems to have experienced a unique pattern of variation. Over the entire period, this sector experienced the least amount of growth. In addition, on the basis of the average percentage changes, this sector was the most stable of the twelve, with the smallest absolute difference between the average percent change during expansions and the average change during recessions. Most important, however, is the observation that the pattern of fluctuation simply does not seem to conform to the general business cycle. In particular, this was the only sector to experience a decrease in output during a general expansionary period.

III.C. The Lead-Lag Relationships

For the calculation of the percentage changes in output utilized in (III.A.), the peaks and the troughs, which most nearly corresponded to the general business cycle turning points as designated by the N.B.E.R. reference cycle, were identified for each of the individual sectoral output series. In this section, the lead-lag relationship between the cycles in overall economic activity and the cycles in each of the sectoral production series is investigated by comparing the data of each individual turning point with those of the reference cycle. This analysis is presented for the data set of monthly disaggregated indexes of industrial production only. No analysis of the lead-lag relationships with respect to the second set of sectoral real outputs has been included, since those series were composed of annual data.

As might have been expected, a considerable degree of variation in the length of lead or lag has been found to exist within each series. For example, examining the relationship between each upper turning point of the total Index of Industrial Production and the N.B.E.R. reference cycle, the peak of the total index is found, in one case, to have a one month lag and, at the other extreme, another peak leads the reference cycle turning point by four months. If the difference between the extreme estimates is designated as the "range," an indication of the extent of variation in the lengths of the individual leads and lags is indicated by noting that the median "range" for the upper turning points of the twenty-four sectors was approximately ten months and the median "range" for the lower turning points was six months. Although this analysis does not, therefore, provide precise measures of the lead or lag associated with each sector, Table VIII does present the median lead or lag for peaks and troughs separately and, in addition, the "range" of the estimates for peaks and for troughs. These median measures are expressed in terms of months, with a positive value indicating a lead and a negative figure a lag.

In general, the cyclical patterns of most of the sectoral output series seem to have led the N.B.E.R. reference cycle. Seventy-five percent of the sectors were found to lead the general cycle at the upper turning point and eighty-eight percent led at the lower turning point. Only one sector, Metal mining, was found which generally lagged behind the overall business cycle at both peaks and troughs. The most common pattern seemed to be relatively short leads at both turning points.

However, there were several cases, particularly with respect to the relationship at the peaks, where the sectoral output series anticipated the general economic decline by a relatively large number of months. The Lumber and products, Textile mill products, Leather and products, Paper and products, and Furniture and fixtures sectors all were found to have median leads of greater than six months at the upper turning point. These five sectors seem to have

TABLE VIII

TIMING RELATIONSHIPS OF SECTORAL CYCLES COMPARED WITH THE REFERENCE CYCLES OF THE NATIONAL BUREAU OF ECONOMIC RESEARCH, 1948-69

Sector	Length of Median Lead or Lag (in Months)[a]		Range (in Months)	
	Peaks	Troughs	Peaks	Troughs
Primary metals	0.0	1.0	6	5
Fabricated metal products	2.0	0.0	10	6
Nonelectrical machinery	0.5	-1.5	8	1
Electrical equipment	3.0	4.0	5	5
Transportation equipment	2.5	-1.0	5	2
Instruments	0.0	0.5	5	5
Clay, glass, stone products	0.5	2.0	6	7
Lumber	9.0	2.0	27	8
Furniture	6.5	0.0	18	9
Miscellaneous	2.5	3.0	19	5
Textile mill products	8.0	4.0	15	6
Apparel products	0.5	5.0	7	8
Leather	12.0	1.0	9	10
Paper	6.5	3.5	27	26
Printing	- 3.0	1.0	5	6
Chemicals	- 0.5	3.0	4	3
Petroleum	2.5	2.5	11	7
Rubber and plastics	0.5	0.0	11	4
Foods and beverages	- 0.5	3.5	16	10
Tobacco products	4.0	2.5	12	16
Crude oil	- 0.5	2.5	10	8
Metal mining	- 1.5	-1.5	8	3
Stone and earth minerals	- 2.0	3.0	4	6
Coal	5.0	0.0	7	5
Total Index	2.0	0.5	5	4

[a]A positive number indicates a lead; a negative indicates a lag.

several common characteristics which might account for their presence in this group, for example: (1) they all tend to be consumer rather than investment-oriented; (2) they are all relatively closely related to raw materials--leather, fibers, and wood.

III.D. The Seasonal Components

Although the relative amplitudes and the time patterns of the yearly cycle of the monthly output series is not directly related to an analysis of the individual patterns of business cycle variations, a brief description of the seasonal components is included, because in most economic time series, including these related to levels of real output, the seasonal component is found to contribute a major proportion of the total variance within the series. Since this is the case, the analysis of the particular patterns of seasonal variation provides a more complete description of the total pattern of fluctuation of the individual sectoral output series.

The Federal Reserve publication, Industrial Production, 1957-59 Base in addition to containing the output series also contains data described as "seasonal factors" for each series for each year of the period 1947-61.[1] These "factors" are monthly indexes of the relative level of production as compared with the average level of production during the entire year. The average "seasonal factor" for each month over the period has been calculated for each series and for the total index. Utilizing these average "seasonal factors," the average

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[1]Board of Governors of the Federal Reserve System, Industrial Production, 1957-59 Base, pp. S133-S147.

percentage changes from the trough to the peak of the annual cycle has been computed for each series. These percentage changes (ranked by size) are presented in Table IX; in addition, the month in which the peak and the trough were found to occur in the annual cycle (as represented by the seasonal factor averages) are also presented.

Looking at Table IX, the heterogenous nature of the individual sectoral patterns is again evident. In fact, the differences among sectors seems even greater with respect to their seasonal variations than the other characteristics.

While the average percentage change in output between trough and peak for the total Index (for the annual cycle) is found to have been nine percent, the Metal mining sector was subject to a much larger annual cycle--an average difference between trough and peak of 66 percent. Those sectors found at the top of the scale would seem to be affected, in one way or another, by weather-related factors. The most volatile, Metal mining, would seem to be due directly to weather conditions, since the peak output is found in June and the minimum in January. It would seem that the Tobacco products and Foods and beverages sectors are primarily affected by the time pattern of the growing of crops. Similarly weather-related explanations would seem reasonable for most of those sectors with relatively large seasonal cycles.

Turning to consideration of the time pattern, there seem to be at least three possible factors affecting the pattern of output of

TABLE IX

AVERAGE PERCENTAGE CHANGES IN OUTPUT DURING THE YEAR FOR SECTORS AND MONTHS IN WHICH PEAKS AND TROUGHS OCCUR, 1947-61

Sectors	Average Percent Change	Peak	Trough
Metal mining	66	June	January
Tobacco	34	August	December
Coal	29	October	July
Electrical machinery	25	October	July
Leather	22	February	July
Rubber and plastics	22	October	July
Apparel products	22	February	July
Textile mill products	22	October	July
Lumber	22	September	January
Primary metals	21	March	July
Foods and beverages	20	September	February
Paper	20	October	July
Stone and earth minerals	19	August	February
Miscellaneous	16	October	July
Clay, glass, stone products	12	May	January
Transportation equipment	12	January	August
Printing	10	October	July
Furniture	10	October	July
Total Industrial Production	9	October	July
Chemicals	9	March	July
Nonelectrical machinery	8	March	August
Fabricated metal products	7	October	July
Petroleum	6	August	April
Instruments	6	December	July
Crude oil	4	February	July

the annual cycles. To provide a specific example of a series affected by two of these factors, consider the time pattern of the total index: peak in October and trough in July. It would seem obvious that there is a tendency for the level of production to be low in July due to the institution of the "summer vacation." A second Western institution, "Christmas," may be a factor in causing October to be the month during which the most sectoral peaks occurred. Weather-related reasons are the third general factor which may have a major effect in shaping annual output cycles.

This chapter has presented evidence, utilizing descriptive statistics, of the differences among the sectors with respect to patterns of growth and of variation. The investigation of these variance patterns is continued in the next chapter; however, very different methods of analysis are employed. At the end of the next chapter the results of both this chapter and Chapter Four are compared and summarized.

CHAPTER IV

INVESTIGATION OF THE EMPIRICAL REGULARITIES: ANALYSIS WITH SPECTRAL TECHNIQUES

This chapter continues the analysis of the patterns of fluctuation of the individual sectors. The initial section offers a brief description of spectral techniques. After the sections discussing the procedures and the results, the last section summarizes and compares the evidence which both this chapter and Chapter Three have provided concerning the differences in variance patterns of the sectoral outputs.

IV.A. Brief Discussion of the Analytical Tools

The application of spectral techniques to the analysis of economic time series involves the treatment of a time series as a "signal" which has been produced by a physical stochastic process. This "signal" contains frequency components which correspond to cycles per unit of time, and the purpose of the analysis is, therefore, to examine the frequency components in order to make inferences about the overall variance pattern of the time series.

This statistical techniques decomposes the variance of the signal into a specified number of different frequency components, and then estimates, for each frequency component, the proportion of the total variance of the time series which is contained in each of the frequency components. The distribution of these estimates is known as the "power spectral density function" or "spectrum."[1] In the study of the pattern of fluctuation of a time series, these spectra indicate those frequencies which contribute a relatively large proportion of the total variation in the series. Peaks in the spectra show those cycle components which contain a great deal of information concerning the pattern of fluctuation in the series through time.

It is possible to compare the processes underlying two separate time series samples through the use of cross-spectral analysis. The cross-spectrum provides a covariance decomposition in the frequency domain for two series, and the cross-spectral methods relate the frequency components of one series to the corresponding frequencies of another series and yield a set of summary statistics for each frequency band which are roughly analogous to those obtained from regression analysis.

The cross-spectral statistic, coherence, is calculated for each frequency and is the analogue of the coefficient of determination,

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[1]This summary presentation of spectral techniques is based upon discussion in C.W.J. Granger and M. Hatanaka, Spectral Analysis of Economic Time Series (Princeton, N.J.: Princeton University Press, 1964). The exact computing formulae for the estimates of the power spectrum and also the cross-spectral statistics are presented in Vittorio Bonomo and Charles Schotta, Jr., "A Spectral Analysis of Post-Accord Federal Open Market Operations," American Economic Review, LIX (March, 1969), 50-61. The computer program employed to estimate both the spectral and cross-spectral statistics was adapted from the programs in the Princeton Econometric Research Program Research Memorandum No. 59 by Charles Schotta and James Crook for use upon the IBM System 360.

with a range, $0 < C^2(i) < 1$. In the calculation of coherence, one series is shifted along the time axis relative to the other series by an amount that maximizes coherence for that frequency. Two series which are totally dissimilar would have a value for $C^2(i) = 0$. A coherence of 1.0, on the other hand, implies that two series are exactly alike, aside for timing differences.

A second statistic yielded by cross-spectral analysis is gain, which is an analogue of the regression coefficient. It measures the relative amplitude of variations of one series as compared with those of a base series.

Phase, a third summary statistic, is an angular measure of the shift required along the time axis in order to maximize the coherence between the two series. It may, therefore, provide information about the lead-lag relationship between the two series in the frequency domain. In the cross-spectral estimation program utilized for this study, a transformation of the phase is calculated. This statistic, tau, expresses the time shift directly in terms of the digital units of the data (in this case, months).

These cross-spectral summary statistics are employed to study the relationships between the variance patterns of the specific sectors and the variance pattern found in the aggregate level of economic activity. Specifically, each of the sectoral output series will be "crossed" with the total index of industrial production (a measure of aggregate economic activity). The coherence statistics will provide a measure of the general similarity of the variance pattern of each of the sectoral series to that of the reference series. Through examination of the gain statistics, the relative amplitude (with respect to each frequency component) of the fluctuations in each series will be compared with the reference series in order to identify those series which are the primary sources of instability--causing fluctuations in aggregate production. Finally, the tau statistics will be employed to see whether significant lead-lag relationships exist between individual sectors and the general level of economic activity.

IV.B. Discussion of the Data Series Utilized and the Analysis Procedures

The spectral techniques are employed only upon the monthly sectoral output series,[1] since a relatively large number of data points are necessary with these statistical methods in order to obtain worthwhile tests of significance for the cross-spectral summary statistics, while at the same time specifying a reasonable number of frequency bands (so that a detailed estimate of the power spectrum may be obtained). Including the total index of industrial production, there are twenty-five output series, each with 271 observations, involved in this analysis.

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[1]As previously explained, all of the series are in non-seasonally adjusted form. For spectral analysis, it is generally advisable to use such non-adjusted data, since the current methods of seasonal adjustment are imperfect and may themselves introduce cyclical variation or bias the data in other ways. (Granger and Hatanaka, Spectral Analysis of Economic Time Series, p. 219.)

In theory, spectral analysis is applicable only to stationary series.[1] It is obvious, however, that these output series contain a definite trend component. Therefore, transformation of the data is necessary in order to act as a "filter" for the dominant energy found at the very low frequencies. In many cases, first-differencing is used as such a filter.[2] In this study, the data series are transformed into percentage change form.[3] This procedure also acts as a high pass filter for the frequency elements corresponding to a trend in mean and further transforms all the data of all the series into equivalent units so that the gain statistic is meaningful.

IV.C. The Patterns of Fluctuation

The statistical techniques of cross-spectral analysis is utilized in this subsection in order to study the relationships existing between the variance pattern of each of the sectoral output series and the pattern of variation of overall economic activity. Ideally, a measure such as gross national product would have been utilized as the time series relating to the level of aggregate

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[1]A stationary series is one in which no trend exists with respect to either mean or variance.

[2]See, for example, Bonomo and Schotta, "A Spectral Analysis of Post-Accord Federal Open Market Operations." For a discussion of first-differencing acting as a high-pass filter, see Gwilym M. Jenkins and Donald G. Watts, Spectral Analysis and its Applications (San Francisco: Holden-Day, Inc., 1968).

[3]Tests have been performed alternately utilizing first differencing and transformation to percentage changes as a filter with very similar results.

economic activity. Unfortunately, no national product or income measures are available monthly, so that the total Index of Industrial Production, including Mining and the utility sectors, has been chosen as the best available measure of the level of aggregate economic activity.[1] This reference series has been "crossed" with each of the individual output series, and the resulting cross-spectral summary statistics yield evidence with respect to the relative degree of conformity of each sector to variations in general economic activity, the relative volatility of each sector, and the timing relationship of movements in each sectoral output compared with fluctuations in aggregate economic activity.

The Degree of Similarity in Patterns of Variation

The first set of the three summary statistics to be analysed are estimates of "coherence." As explained briefly in (IV.A.), the measure, coherence, is somewhat analogous to the coefficient of determination, and indicates the degree of similarity between the variance pattern of the two time series at that frequency. Generally,

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[1]In a cross-spectral study of business cycle indicators, Hatanaka (Granger and Hatanaka, Spectral Analysis of Economic Time Series, Chapter 12) states that, after consultation with Geoffrey H. Moore, he decided to utilize this Index as the reference series for the monthly data. It should be noted that the evidence of Chapter Three indicated that the total Index seemed to lead the N.B.E.R. reference cycle at the business cycle turning points; this fact should be recalled when integrating the cross-spectral lead-lag findings. Further, the cyclical amplitude of industrial production is generally somewhat larger than that of overall economic activity; again, this fact should be remembered during the discussion of the gain statistics.

all three of the cross-spectral statistics are of interest only in those frequency bands where substantial spectral energy is discovered. In this light, the estimated values of the coherence for the frequency bands corresponding to the business cycle frequencies, the seasonal component and its harmonics (five frequencies), and the highest frequency band[1] are presented in Table X. In all cases where a numerical value is found, the coherence has been found to be significantly different from zero at the .95 probability level;[2] in those cases where no value is presented, the statistic was not indicated to be significantly greater than zero.

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[1]These seven particular frequency components have, of course, been chosen because these bands were shown (by the existence of peaks in most of the series' spectra) to be those which contained the dominant spectral energy. The range of cycle lengths corresponding to the conventional concept of the business cycle would include the second, third, and possibly the fourth frequency intervals (the fifty, thirty-three, and twenty-five month cycles, respectively--or in frequency terms, the band between .02 and .04 cycles per month). Since the shape of the annual cycle generally does not resemble a simple sine wave, the power spectrum of economic time series normally exhibit peaks at the harmonics of the annual cycle in addition to a peak at the annual cycle itself. The frequencies corresponding to the annual cycle and its harmonics are the following:

.08 cycles/month = 12 month cycle
.17 cycles/month = 6 month cycle
.25 cycles/month = 4 month cycle
.33 cycles/month = 3 month cycle
.42 cycles/month = 2.4 month cycle

[2]Tables for significant values and confidence intervals for all three cross-spectral statistics may be found in Vittorio Bonomo and Charles Schotta, Jr., "Statistical Tables for Time Series Analysis," Technical Paper No. 69-1 (Blacksburg, Va.: Department of Economics, V.P.I., 1969).

TABLE X

COHERENCE STATISTICS FOR SELECTED FREQUENCIES BETWEEN EACH SECTOR AND TOTAL INDUSTRIAL PRODUCTION

Sector	Frequencies (cycles/month)						
	.03	.08	.17	.25	.33	.42	.50
Primary metals	.677	---	.786	.852	.661	.825	.790
Fabricated metal products	.935	.464	.814	.896	.831	.761	.965
Nonelectrical machinery	.810	.379	.671	.910	.825	---	.882
Electrical machinery	.844	.557	.904	.925	.861	.856	.927
Transportation equipment	.818	---	.383	.375	---	---	---
Instruments	.788	.533	.778	.309	.824	.550	.863
Clay, glass, stone products	.856	---	.899	---	.469	.892	.920
Lumber	.813	---	.832	.807	.782	.884	.536
Furniture	.804	.431	.771	.887	.801	.801	.900
Miscellaneous	.840	.462	.906	.787	.879	.787	.922
Textile mill products	.828	.648	.938	.945	.854	.931	.979
Leather	.651	.617	.895	.849	.843	.867	.925
Apparel products	.762	.381	.867	.832	.704	.912	.889
Paper	.699	.537	.882	.937	.729	.917	.946
Printing	.464	.546	.922	.505	.825	---	.689
Chemicals	.874	.625	.938	.917	.756	.886	.815
Petroleum	.686	---	.730	---	---	---	.521
Rubber and plastics	.857	.420	.822	.876	.666	.854	.803
Foods and beverages	---	.357	.873	.797	.782	.715	.669
Tobacco products	---	.312	.904	.883	.842	.908	.516
Coal	.470	.411	.373	.824	.795	.724	.575
Crude oil	.645	---	---	---	---	.344	.585
Metal mining	.404	.478	.558	.711	.539	---	.573
Stone and earth minerals	---	---	.836	.529	---	---	.742

Considering the coherence statistics corresponding to the business cycle frequencies (.03 cycles/month), in only three cases out of twenty-five is there no statistically significant degree of similarity in the pattern of variation: Foods and beverages; Tobacco products; and Stone and earth minerals. For the other twenty-one sectors, the evidence indicates that the hypothesis that the output levels of these sectors conform to the general business cycle cannot be rejected. However, these coherence statistics show that the pattern of cyclical fluctuation of the output of some sectors, such as Fabricated metal products, are very similar to the general business cycle, while others, such as Metal mining or Coal, do not conform as closely to the general business cycle.

Detailed interpretation of the coherence statistics for the other frequencies is not presented. In brief, these coherences, with respect to those frequencies corresponding to seasonal variation, seem to demonstrate the fact that most of the sectors are subject to a considerable seasonal cycle. The variation in values both between the different harmonics within the same sector and among the different sectors would seem to point out that each individual seasonal cycle has a somewhat different "shape."

Differential Cyclical Amplitudes

The second cross-spectral statistic to be discussed is the "gain." As explained in section (IV.A.), the gain measures the amplitude of the variation in one time series as compared with the amplitude of the variation in the reference cycle. Just as for the other statistics, it is possible to calculate confidence intervals for the gain estimates, so that it is possible to test the hypothesis that a given sectoral output series has an amplitude significantly greater or smaller than that of the reference cycle. In other words, if the gain statistic were found to be significantly greater than 1.0, the hypothesis that the cyclical amplitude of that sector's output was not different from that of the general cycle could be rejected. Therefore, the gain statistic of the crosses of the total Index upon each sectoral output series, for the business cycle frequencies, provides a meaningful statistical test of the relative volatility of each output sector with respect to the general business cycle.

In the process of estimating the set of cross-spectra, a gain statistic for each of the fifty frequencies has been estimated. However, this analysis is only concerned with the gain statistics corresponding to the business cycle frequencies, and in particular the .03 cycles/month frequency component. Table XI presents the set of twenty-five sectors classified into three groups on the basis of the estimated gain statistics corresponding to the .03 cycle/month frequency:[1]

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[1]The first number in parenthesis following the sector is the estimated gain; the second number is the estimated confidence band.

TABLE XI

GAIN STATISTICS FOR THE .03 CYCLES/MONTH FREQUENCIES BETWEEN EACH SECTOR AND TOTAL INDUSTRIAL PRODUCTION

Sector	Gain	Confidence Interval
Group I: (Gain significantly greater than one)		
Primary metals	2.91	±1.40
Fabricated metal products	1.36	± .23
Nonelectrical machinery	1.76	± .52
Electrical machinery	1.69	± .46
Transportation equipment	1.59	± .52
Rubber and plastics	1.53	± .46
Group II: (Gain not statistically different from one)		
Instruments	.94	± .32
Clay, glass, stone products	1.08	± .28
Lumber	1.34	± .40
Furniture	1.13	± .35
Miscellaneous	1.28	± .35
Textile mill products	1.20	± .34
Apparel products	.75	± .26
Leather	.89	± .41
Paper	.86	± .35
Metal mining	1.63	±1.37
Coal	1.44	± .96
Group III: (Gain significantly less than one)		
Printing	.26	± .17
Chemicals	.76	± .20
Petroleum	.57	± .24
Food and beverages	.15	± .16
Tobacco products	.17	± .20
Crude oil	.55	± .20
Stone and earth minerals	.37	± .47

(1) those sectors for which the gain statistic was discovered to be significantly greater than 1.0; that is those sectors which are identified as more volatile than the general level of economic activity;

(2) those sectors for which the gain was not found to be significantly different from zero;

(3) those sectors for which the gain was estimated to be significantly less than 1.0; these sectors are indicated to be relatively stable and insulated from general fluctuations in economic activity.

As may be observed from the findings set forth in Table XI, those sectors identified as the most volatile are the sectors which produce capital goods: Primary metals, machinery, Transportation equipment, etc. Those sectors identified as the most stable are producers of non-durable consumer-oriented goods: Foods and beverages, Tobacco products, Petroleum products, etc.

<u>The Lead-Lag Relationship</u>

As the introductory section (IV.A.) explained, the summary statistic, "tau," provides a measure, in months, of the lead-lag relationship between two time series for each frequency component. By examination of the set of these statistics for the reference series crossed on all of the sectoral output series, the lead-lag relationship between each of the sectoral outputs and the general cycle can be determined. Table XII lists those sectors which the

TABLE XII

SECTORS WITH SIGNIFICANT LEADING OR LAGGING RELATIONSHIPS WITH RESPECT TC TOTAL INDUSTRIAL PRODUCTION FOR THE .03 CYCLES/MONTH FREQUENCY

Sector	Gain	Confidence Interval
Leading Sectors		
Lumber and products	3.03	± .31
Furniture and fixtures	2.50	± .32
Textile mill products	2.27	± .29
Apparel products	1.90	± .36
Leather and products	3.68	± .48
Rubber and plastics	1.99	± .31
Lagging Sector		
Nonelectrical machinery	-2.21	± .31

tau statistic indicated that the estimated lead or lag was significantly greater than zero at the .95 confidence level for the business cycle frequencies.[1] Of the twenty-four sectors, the cross-spectral evidence indicated that eighteen of the series were coincident, six of the sectors seemed to lead the general cycle, and only one sector was identified as lagging the general cycle at the business cycle frequencies.

IV.D. Summary of the Patterns of Variation of Sectoral Outputs

To begin a summary of the findings relating to the monthly series, consider the evidence with respect to differential cyclical amplitudes among the sectors. Both types of analysis demonstrated that definite differences did, in fact, exist among the sectors, and further both analyses were very similar in their classification of those sectors which have been the most volatile and those which have been relatively stable (Tables V and XI). The volatile group seems to be composed primarily of durable goods industries, which might be expected to produce a relatively high proportion of investment goods; on the other hand, the stable group of sectors is made up of non-durable goods sectors, many of which produce a high proportion of consumer-oriented goods.

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[1]For interpretation of the table, the first number following the sector name is the length (in months) of the lead or lag; the second number is the confidence interval. These statistics relate to the .03 cycles/month frequency component.

Turning to the subject of the timing relationships between cycles in the individual sectors and the overall business cycle, the evidence of both analyses is not as similar, but is compatible. Study based on the N.B.E.R. reference cycle turning points tended to indicate a great deal of variability within each sector between the different cyclical periods. However, the evidence pointed to the level of output of most sectors generally leading the reference cycle turning points. The cross-spectral evidence was based upon a comparison with the total Index (which itself was found generally to lead the N.B.E.R. cycle) so that the discovery that most of the sectors were coincident was generally compatible with the reference cycle data. Those sectors indicated as having a significant lead by the cross-spectral results were, in general, non-durable goods, consumer-oriented sectors. Four of those leading sectors (Furniture and fixtures, Textile mill products, Apparel products, and Leather products) produce a significant proportion of goods for which periodic changes in styles or fashions dictated by the industries are common.

While the evidence produced by the analysis in Chapter Three is relatively similar to the findings of the cross-spectral analysis, comparison demonstrates the analytical advantages of the more sophisicated statistical techniques. The analysis in Chapter Three have produced only descriptive measures of the differences. The cross-spectral summary statistics provide statistically testable measures of the relationship between the variance pattern of each sectoral output series and the pattern of fluctuation in overall economic activity. In particular, use of the cross-spectral gain statistics have identified those sectors which have been either significantly more volatile or more stable than the general business cycle.

Evidence from the analysis also allows several generalizations to be made concerning the patterns of seasonal variation. There seems to be a great range in the amplitudes of such variations, but all sectors do seem to have a seasonal cycle. Although a high proportion of the seasonal cycles seem to have peaks in October and troughs in July, there is also considerable diversity with respect to this characteristic.

Finally, a brief summary of the evidence presented in Chapter Three relating to the set of sectors for which only annual data was available, should be included. No attempt at study of the timing relationships between the sectors and the general business cycle was attempted. Further, analysis could not proceed with respect to observations relating directly to sectoral turning points, so that the measures of cyclical amplitudes are probably mostly biased. However, three sectors (Durable manufactures, Transportation, and Mining) were identified as more volatile than the overall economy. These results are again not unexpected and are similar to the results relating to the monthly series. Further, the Finance, insurance, and real estate and Service sectors were identified as relatively more stable than the overall economy.

In general, these results would seem to indicate that the individual sectors do, in fact, have different patterns of variation. That such diversity does exist should serve as a further justification for the second objective of the study: to investigate the differential response of sectoral outputs to movements in variables closely related to federal policy actions.

CHAPTER V

THEORETICAL BASIS FOR EMPIRICAL ANALYSIS

The findings of Chapters Three and Four reveal that the assumption, implicit in aggregate models utilized for the study of the effects of monetary and fiscal policy actions, that national product is composed of homogenous units of output is unrealistic. Stabilization policies which stimulate aggregate economic activity cause much greater expansion of output in some sectors than in other sectors.

The second objective of this thesis is the investigation of such differential sectoral responses to monetary and fiscal policy actions. In order to study these effects, this chapter presents a simple demand model, which serves as a formal structure for the empirical analysis. The model specifies sectoral output to be a function of aggregate income, the rate of interest, and the excess of real government expenditures over revenues.

Prior to description of this sectoral model two introductory sections are included which offer a few remarks about both aggregate general equilibrium models, upon which this sectoral relation is based, and certain theoretical multi-sector models, to which this sector model is related. The actual sectoral model is then discussed; and an analysis, in terms of this model, of differential sectoral responses to changes in the levels of the aggregate variables is presented. Finally, an alternate formulation of the model, in which changes in the money stock are specified as the monetary variable, is included.

V.A. Aggregate National Income Models and Multi-Sector Multiplier Models

National income theory came into real being during the 1930's, with the statement, in simplified form, of what is now known as "Keynesian theory," by J.M. Keynes, in his General Theory of Employment, Interest and Prices.[1] Although Keynes also discussed the demand for money and its relation with the rate of interest and indirectly with the level of investment, the early focus of Keynesian analysis was on the importance of the effects of fiscal policy upon the level of national income.

A simple model of national income determination based upon the Keynesian concept of the consumption function does provide a model for the study of the effects of countercyclical fiscal policy. In fact, the values usually computed for the appropriate government expenditure and tax multipliers offer evidence that fiscal policy should be a strong stabilization tool. The fact that a relatively small change in government expenditure of taxes could have a large effect on the level of national income most probably contributed to the preoccupation with the non-monetary aspects of Keynesian theory.

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[1] John M. Keynes, General Theory of Employment, Interest, and Money (New York: Harcourt, Brace and Co., 1936).

Based upon Keynes' analysis, an aggregate model was developed not long after the General Theory was published, which explicitly included the effects of the monetary sector upon the determination of national income. This type of model has come to be known as an "IS-LM' model, and its development has been attributed to both Hicks[1] and Hanson.[2] As in other areas of economics, the development of more realistic and more complicated model of national income determination has taken place in the three decades since their beginnings in the General Theory. Of course, many different formulations exist of such aggregate general equilibrium models, but two of the widely-known specifications are the macro-equilibrium models of Bailey[3] and of Patinkin.[4]

Aggregate models of much greater complexity have since been developed, in order to describe, in a more realistic manner, the true workings of the economy. However, since the application of the sector model to be developed in this chapter is primarily to provide a formal structure for analysis of the response of the individual production sectors to stabilization actions, it is felt that a

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[1] John R. Hicks, "Mr. Keynes and the 'Classics': A Suggested Interpretation," Econometrica, V (April, 1937), 147-59.

[2] Alvin H. Hansen, A Guide to Keynes (New York: McGraw-Hill Book Co., Inc., 1953).

[3] Martin J. Bailey, National Income and the Price Level (New York: McGraw-Hill Book Co., 1962).

[4] Don Patinkin, Money, Interest, and Prices (2nd ed.; New York: Harper and Row, 1965).

model based upon refined "IS-LM" model such as that of Bailey can provide a satisfactory structure for explanation of such effects.

V.B. Multi-sector Multiplier Models

The other class of economic models, to which this study's explanatory model is related, is the set of multi-sector multiplier models developed by Goodwin,[1] Metzler,[2] and Chipman.[3] While the Metzler model explicitly discusses the case of a multi-country or multi-regional model, the other two models are of a more general nature and could apply to a multi-part economic system which consists of a number of interrelated regions, income groups, or (as in the case of this study) industrial sectors. The Goodwin model, in particular, has been constructed along the lines of a multiple sector economy, as in an input-output model.

All three models are based upon a very simple Keynesian national income model of the type: $Y = C + I$. Linear expenditure equations are constructed for each of the n sectors (or regions or countries), and the set of equations describing the equilibrium conditions is specified in matrix form. By inversion of the

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[1]Richard M. Goodwin, "The Multiplier as a Matrix," Economic Journal, LIX (December, 1949), 537-55.

[2]Lloyd A. Metzler, "A Multi-regional Theory of Income and Trade," Econometrica, XVIII (October, 1950), 32--54.

[3]John S. Chipman, "The Multi-Sector Multiplier," Econometrica, XVIII (October, 1950), 355-74.

coefficient matrix, a matrix multiplier for the economic system can be derived.[1]

While the general concept of a disaggregated national income model originates with multi-sector multipliers, as described above, the analysis contained in these three papers is not really of use in the investigation undertaken in this study. The purpose of developing the sector model is the analysis of the effects of economy-wide shocks, caused by monetary and fiscal policy actions, upon the individual sectors, so that these multi-sector multiplier models are not really appropriate for two basic reasons. First, since these models have been based on a simple one equation Keynesian model, any interaction between the monetary sector and the real sector is beyond their analytical scope. Further, such models[2] were primarily developed with the purpose of examining the effects upon the system or upon the other sectors of a change in one individual sector, which in a sense is the reverse of the main interest of this study.

V.C. The Sectoral Output Model

In this study, the market for goods and services is assumed to be composed of "n" separate sectors, rather than relying upon the

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[1]See Chipman, "The Multi-sector Multiplier," pp. 359-60, for a presentation of such a matrix model and for the derivation of the matrix multiplier.

[2]Particularly that presented in Metzler, "A Multi-regional Theory of Income and Trade." See the explicit analysis of the effect of an autonomous shift in the level of investment in one country in p. 343.

simplifying assumption of a single homogenous product. This section develops a sectoral function for use in the empirical analysis. One important use to which aggregate national income models have been put is the study of the effects of monetary and fiscal policy upon aggregate income or production. Therefore, it is natural that the sectoral model presented in this section is based directly upon the aggregate expenditure functions normally specified in aggregate general equilibrium models, such as that of Bailey.

As is the case for aggregate output, it seems very likely that the demand for output of each individual sector would be directly related to the level of aggregate income. Consumption expenditures for the output of any given sector, so long as the output were not an inferior good, would be positively related to the income level. Similarly investment expenditures for the output of any given sector would most probably be related positively to aggregate income, since expectations for increases in demand should be stimulated.

Further, just as is normally assumed in aggregate expenditure functions, the demand for the ith sector's output would generally be negatively related to the rate of interest. If the choice between consumption and saving is assumed to be affected by the rate of interest, it would seem likely that an increase in the interest rate would decrease the demand for the output of any given sector. The effect of an increase in the rate of interest upon investment expenditures and therefore upon the output of any sector would also be expected to be negative.

In Keynesian-based models, increases in autonomous government expenditures are assumed to have a direct positive effect upon production, since they are one of the components of aggregate demand. Similarly, increases in government revenues are taken to have a negative effect upon the level of aggregate expenditures, as they are withdrawals from either disposable income (a major determinant of consumer spending) or profits of businesses (a major factor in investment expenditures). In many instances, budget deficits (or surpluses) are employed as a measure of the net direct expansionary (deflationary) influence of fiscal activities upon aggregate production.[1] It seems likely that an excess of government expenditures over revenues would, in general, have an expansionary effect upon the sectoral outputs.

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[1]Use of the deficit as a measure of the influence of fiscal impact ignores the effects of the "balanced budget multiplier." However, the actual size of the "balanced budget multiplier" certainly seems to be open to question. Based upon the works of William J. Baumol and Maurice H. Preston, "More on the Multiplier Effects of a Balanced Budget," American Economic Review, VL (March, 1955), 140-48, Alvin H. Hansen, "More on the Multiplier Effects of a Balanced Budget: Comment," American Economic Review, IVL (March, 1956), 157-60, and Robert E. Park, "Distributional Aspects of the Balanced Budget Multiplier," Review of Economics and Statistics, IL (February, 1967), 119-22, it would seem that this multiplier is certainly less than one, and may in fact be negative.

Since it seems reasonable to assume the values of the aggregate variables to be determined exogenously to the individual sector, the sectoral model may be specified in a simple form consisting of a single equation. The function is specified in real terms, and the output of the ith sector (X_i) is assumed to be positively related to real aggregate income (Y) and the excess of real government expenditures over revenues (D),[1] and negatively related to the rate of interest (R):

$$X_i = f_i(Y,R,D) \qquad \text{for } i = 1, 2, \ldots, n \tag{V-1}$$

$$\text{where } \delta X_i/\delta Y > 0;\ \delta X_i/\delta R < 0;\ \delta X_i/\delta D > 0$$

[1]In this model, it is assumed that governmental authorities specify the real level of government expenditures, with the nominal value determined exogenously and depending upon the price level. This assumption corresponds to the idea that the government authorities decide upon a "shopping list" of goods and services to be purchased, which is based upon needs and is not affected by changes in the level of national income or the price level. Similarly, Y, aggregate income and government revenues are (theoretically at least) specified such that variations in national income do not affect the size of the government deficit or surplus. The excess (or surplus) of government expenditures over revenues is, therefore, specified such that it is determined by fiscal policy authorities. If the model were specified such that real government revenues and expenditures were included as separate variables, it would seem that the analysis might provide "richer" results since the separate sectoral effects of changes in either expenditures or revenues could be investigated. Unfortunately, such an alternate specification of the sectoral relations was briefly tested and did not produce meaningful results.

The purpose of developing this sectoral equation is the analysis of the responses of individual sectoral outputs to movements in policy-related aggregate variables. To facilitate such analysis, it would be convenient if the explicit sectoral equations were specified such that changes in sectoral output were an additive function of the changes in real aggregate income, in the rate of interest, and in the real deficit. One particular form in which a relationship might be specified is in terms of percentage changes, as in (V-2):

$$\text{(V-2)} \qquad X_i^* = b_i Y^* - r_i R^* + g_i D^* \qquad \text{for } i = 1, 2, \ldots, n$$

$$\text{where } X^* = (\Delta X/X)/\Delta t$$

This particular formulation, in percentage change terms, is analogous to the specification of (V-1) as a multiplicative function, as in (V-3):

$$\text{(V-3)} \qquad X_i = (Y^{b_i} \cdot R^{-r_i} \cdot D^{g_i}) \qquad \text{for } i = 1, 2, \ldots, n$$

This construction is common in economic models and is desirable (as demonstrated by (V-2)) in that the exponents of the aggregate variables correspond to constant elasticities of output.[1]

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[1]If an exponential function is transformed to logarithmic form and then differentiated with respect to time, the resulting equations are approximations of the relationship between percentage rates of change of the variables. The coefficients of these percentage changes are equal to the exponents of the original variables, and so these exponents correspond to constant partial elasticities.

$$\text{(i)} \qquad D = A^a B^b$$

$$\text{(ii)} \qquad \log D = a \log A + b \log B$$

Although the sectoral model contains only one equation, it is based upon "IS-LM" analysis and includes aggregate income as one of th- variables affecting the demand for sectoral output, rather than being a reduced form equation including only the two monetary and fiscal policy-related variables. In many studies, empirical analysis of the effects of policy actions has utilized a basic reduced-form approach,[1] and the empirical relationship which is found between the policy-related variable and aggregate income or product measures the total response to changes in the measure of the stabilization action. The inclusion of aggregate income as one variable is very advantageous for the study of the effects of

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(iii) $$\frac{d}{dt}(\log D) = \frac{d}{dt}(a \log A) + \frac{d}{dt}(b \log B)$$

(iv) $$\frac{1}{D} \cdot \frac{dD}{dt} = a(\frac{1}{A} \cdot \frac{dA}{dt}) + b(\frac{1}{B} \cdot \frac{dB}{dt})$$

(v) $$\frac{dD/D}{dt} = a(\frac{dA/A}{dt}) + b(\frac{dB/B}{dt})$$

(vi) $$\frac{dD/D}{dt} \simeq \frac{\Delta D/D}{\Delta t}$$

With the model specified in this form a certain degree of abstraction from reality must be accepted, since, in the case where the deficit were zero, the value of the right side of the function would also be zero. However, in terms of the percentage change formulation (V-2), the actual effect of a zero deficit upon output would have no effect upon output.

[1]Milton Friedman and David Meiselman, "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958," in Stabilization Policies, ed. by the Commission on Money and Credit (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963), pp. 165-268, is a widely known example of analysis in terms of reduced form equations.

monetary and fiscal policies upon sectoral outputs, because it allows the separate estimation of the direct and the indirect effects of the stabilization policies. Monetary and fiscal policy actions affect the level of aggregate income and production; therefore, such policy actions have indirect effects upon the individual sectoral outputs through the income-output relationship. The strength of these indirect effects upon the output of any given sector is measured by the partial elasticity of that sector's output with respect to changes in aggregate income. The sectoral model is also based upon the assumption that monetary and fiscal policy actions have direct effects upon sectoral outputs; the magnitude of these effects are measured by the partial elasticities of sectoral output with respect to each of the policy-related variables.

V.D. Differential Sectoral Responses to Monetary and Fiscal Policy Actions

One way of describing the assumption of homogenous product utilized in aggregate macro models, in terms of the sectoral model specified in this chapter, would be to say that the partial elasticities of output for all "n" goods with respect to each of the aggregate variables were identical: i.e., the level of output for each sector was changed by exactly the same degree by a given change in any of the arguments in the demand functions.

$$b_1 = b_2 = b_3 = . . . = b_{n-1} = b_n$$

etc.

The evidence of Chapters Three and Four indicate, however that the patterns of fluctuation among the individual sectoral outputs have not been identical but, in fact, quite diverse. In particular, the experience of the individual sector outputs have been very dissimilar with respect to the amplitude of their fluctuations. This analysis suggests that the sectoral responses to economy-wide shocks, such as countercyclical monetary or fiscal policy actions, have not been uniform.

It does seem logical that some sectors would be affected more than certain others by changes in each of the aggregate variables, which have been included in the sectoral model. For example, it seems likely that the output of a sector, which sells a relatively high proportion of its production to the government, would have a larger response to an increase in government expenditures, as compared with the Tobacco products sector. Similarly, those sectors whose outputs are primarily durable goods or investment goods would most probably be affected to a larger degree by a change in the rate of interest than would sectors producing nondurable consumption goods.

The sectoral model presented in (V.C.) provides a very useful framework for the analysis of such differential effects. The existence of differential responses among the sectoral outputs to changes in one of the aggregate variables can be easily explained in terms of a set of sectoral equations (of the general form (V-3)) in which the partial elasticities among the sector with respect to each of the aggregate variables are different:

$b_i \neq b_j$ for i = 1, 2, . . .,n and j = 1, 2, . . .,n

$r_i \neq r_j$ for i = 1, 2, . . .,n and j = 1, 2, . . .,n

etc.

The direct effects upon the individual sectors of changes in the levels of real government expenditures and revenues, which would lead to a change in the size of the deficit, should be reflected in the relative sizes of their respective partial elasticities. Since this sectoral model is based upon macroeconomic models of the "IS-LM" type, monetary policy actions would affect expenditures through effects upon the rate of interest, which is assumed to be determined (exogenously with respect to any given commodity sector) in the monetary sector (of such "IS-LM" models). Therefore, the existence of differences in the individual sectoral partial elasticities with respect to the rate of interest would indicate that monetary policy actions would have differential effects upon sectoral outputs. On the basis of the evidence presented in Chapters Three and Four, it would be expected that the partial elasticities with respect to any given aggregate variable among the sectors would vary over a considerable range. For example, *a priori* reasoning would suggest that investment goods sectors, such as the Primary metals sector or the machinery sectors, would be discovered to have much larger partial elasticities of output with respect to the rate of interest than would consumer-oriented sectors, such as Apparel products or Foods and beverages sectors.

V.E. Alternative Specification of the Model

The sectoral model developed in the previous section is based upon the Keynesian or "IS-LM" approach, with the effects of monetary policy acting upon the real sectors through the monetary sector by variations in the rate of interest. Many monetary economists believe that it is more appropriate to analyse the direct relationship between changes in the money stock and income. Proponents of the modern quantity theory approach argue that most monetary policy actions actually involve manipulation of these monetary aggregates and further that market interest rates do not reflect monetary policy actions accurately due to the influence of expectations and many other factors.[1]

Therefore, in order to avoid biases in the analysis of the influence of monetary policy actions upon the sectoral outputs if the interest rate is, in fact, a poor choice as an indicator of monetary effects, the sectoral model may also be specified in terms of the direct relationship between the money stock and the output of the ith sector:

$$\text{(V-4)} \quad X_i = (Y^{b_i} \cdot M^{m_i} \cdot D^{g_i}) \qquad \text{for } i = 1, 2, \ldots, n$$

[1]For excellent discussion of market interest rates as indicators of monetary influences, see Thomas Mayer's comments in Monetary Process and Policy, ed. by George Horwich (Homewood, Ill.: Richard D. Irwin, 1967), pp. 317-18.

Just as in the case of the sectoral function including the rate of interest, differential sectoral responses would be reflected by differences in the magnitudes of the individual sectoral elasticities with respect to the monetary variable.

Now that two alternate specifications of an explanatory model relating sectoral outputs to aggregate policy-related variables have been developed, the next chapter first discusses transformation of the model into a stochastic form to be utilized in the empirical testing. Following these introductory sections, the main body of the chapter reports the results of the empirical estimation of the partial elasticities of each sector's output with respect to each of the aggregate variables.

CHAPTER VI

THE EMPIRICAL ANALYSIS

In the first section, the explanatory relation set forth in the last chapter is translated into empirically testable form. The second section contains a brief discussion of the effects upon the estimation of the partial elasticities which might be caused by the exclusion of significant variables from the sectoral relation. The third section refers to the data actually used in the empirical tests, beginning with an explanation as to why the direct effects of monetary policy actions are estimated in terms of the two alternate definitions of the money stock. Also included in the third section is an explanation of the manipulations of the data which were necessary for the logarithmic regressions.

The fourth section is the main body of the chapter and presents the results of the regression analyses. It is divided into two subsections--the first pertains to the regressions relating to the set of twenty-four manufacturing sectors, and the second relates to the set of the twelve major sectors. The same analytic procedures are applied to both data sets.

In the subsection concerned with study of the responses of the twenty-four manufacturing sectors, the partial elasticities of each sector output with respect to each of the aggregate variables are estimated by direct least squares regression. The results are presented in Tables XIII, XIV, and XV. These initial regressions are estimates of the coincident relationships between the aggregate variables and each sectoral output. Since there is considerable previous evidence to indicate the existence of lags between both monetary or fiscal policy actions and the resulting effects upon the levels of sectoral outputs, regressions are also calculated in which lags are specified between each of the aggregate variables and the sectoral outputs. By choosing that particular combination of lags which yields the "best" regression results for each sector, the lag between a change in each aggregate variable and its maximum effect upon the output level is estimated. These results are presented in Tables XX, XXI, and XXII. This subsection also includes a cross-spectral analysis of the lag structure between variations in each of the aggregate variables and each of the sectoral output series.

The second subsection of the fourth part of this chapter estimates the effects of changes in each of the aggregate variables upon the outputs of the twelve broadly-defined sectors. Lagged regressions are also performed in order to investigate whether there are significant lags in the effects of either monetary or fiscal policies upon each sectoral production level. These results are presented in Tables XXIII through XVII.

Immediately following the presentation of each set of regression results, a very brief discussion of them is included. However, detailed analysis and interpretation of the results is delayed until Chapter Seven.

VI.A. Transformation of the Theoretical Relationship into an Empirical Statement

The output of the ith sector has been specified to be a function of (1) the level of aggregate income or production, (2) the excess of government expenditures over revenues, and (3) either the rate of interest (as in (V-3)) or the real money stock (as in (V-4)):

$$\text{(V-3)} \qquad X_i = (Y^{b_i} \cdot R^{-r_i} \cdot D^{g_i}) \qquad \text{for } i = 1, 2, \ldots, n$$

$$\text{(V-4)} \qquad X_i = (Y^{b_i} \cdot M^{m_i} \cdot D^{g_i}) \qquad \text{for } i = 1, 2, \ldots, n$$

For the purposes of empirical testing, the partial elasticities of sectoral output with respect to the aggregate variables are more easily estimated when the equation is transformed into logarithmic formulation. Further, for testing purposes, the relations must be rewritten in the form of stochastic equations by the inclusion of a stochastic error term, u_i:[1]

$$\text{(VI-1)} \qquad \log X_i = a_i + b_i \log Y + r_i \log R + g_i \log D + u_i$$

$$\text{(VI-2)} \qquad \log X_i = a_i + b_i \log Y + m_i \log M + g_i \log D + u_i$$

The partial elasticities of the aggregate variables for each sector have been estimated, utilizing direct least squares regression

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[1]See J. Johnston, Econometric Methods (New York: McGraw-Hill Book Co., 1963), pp. 3-7, for a discussion of the purposes of the inclusion of such an error term and of exact and inexact equations.

techniques, by the estimation of the coefficients of the above stochastic equations. These calculated values will be the best linear unbiased estimators of the theoretical partial elasticities only if the relationships estimated and the sets of data employed satisfy the assumptions associated with the general linear model.[1] In particular, the possible existence of simultaneous equation bias should be considered with all economic models. In this case, the relationships specified attempt to explain output of an individual sector in terms of variables relating to the aggregate economy, and it therefore seems reasonable to assume that the values of the aggregate measures are, in fact, exogenously determined with respect to any given sectoral output.

VI.B. The Effect of Unspecified Variables upon the Regression

Since the purpose of the empirical testing is the analysis of the relationships between variations in sectoral outputs and monetary and fiscal policy actions, the sectoral equations have been specified only in terms of three aggregate, policy-related variables. To the extent that sectoral outputs are, in fact, affected by changes in other factors such as prices, technology, etc., the estimated partial elasticities, with respect to those variables which are included, may be biased. As long as the other factors affecting sectoral outputs have counteracting effects, it would seem possible

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[1]See chapters four and eight of Johnston, Econometric Methods, for a rigorous specification of these assumptions.

to specify the stochastic equation in terms of the three aggregate variables with the idea that the other variables are specified by "u." If for some or all of the sectors, however, certain unspecified variables exist which have a systematic and substantial influence upon the sectoral output, then the estimated partial elasticities may be biased.

Consider the sectoral model of (V-1) expressed in vector notation (for convenience in the following discussion):[1]

(VI-3) $$X_i = \underline{b}_i \underline{Y}' + u_i$$

where $\underline{b}_i = (b_i \; r_i \; g_i)$ and $\underline{Y} = (Y \; R \; D)$[2]

The least squares estimator of $\underline{b}_i$ is $\hat{\underline{b}}_i$ and is equal to

(VI-4) $$\hat{\underline{b}}_i' = \underline{M}_{yy}^{-1} \underline{m}_{yy}'$$

where $\underline{M}_{yy}$ represents the moment matrix

$$\underline{M}_{yy} = \begin{matrix} m_{yy} & m_{yr} & m_{yd} \\ m_{ry} & m_{rr} & m_{rd} \\ m_{dy} & m_{dr} & m_{dd} \end{matrix}$$

and m_{xy}' the moment vector

$$\underline{m}_{xy} = (m_{xy} m_{xr} m_{xd})$$

Calculating the moments with $\underline{Y}$ for the equation (VI-2) produces

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[1]This discussion of the effect of excluding variables from the regression equation is based upon Carl F. Christ, Econometric Models and Methods (New York: John Wiley and Sons, 1966), pp. 453-64.

[2]Notation such as $\underline{x}$ or $\underline{X}$ indicate a vector or matrix, respectively.

(VI-5) $\quad \underline{m}'_{xy} = \underline{M}_{yy} \underline{b}'_i + \underline{m}'_{uy}$

and utilizing (VI-4), the following relationship may be obtained:

(VI-6) $\quad \underline{\hat{b}}_i = b'_i + \underline{M}_{yy}\underline{m}'_{uy}$

It is not possible to calculate either $\underline{b}'_i$, the vector of true coefficients, or $\underline{m}'_{uy}$, the moment vector of Y with the unobservable distances, u, but this algebraic analysis demonstrates that if $\underline{m}_u Y \neq \underline{0}$, then $\hat{b}_i \neq b_i$. Further, equation (VI-6) implies that a direct and positive relationship exists between the degree of intercorrelation of exluded and included variables and the amount by which th estimated coefficients are biased.

The possible effects of the excluded variables upon the estimated coefficients are not easily determined. It would seem likely that a complex pattern of interrelated influences would exist, since the factors most probably would tend to have counteracting effects. Evidence relating to the degree of intercorrelation between each of the potentially important, but unspecified variables and each of the variables which have been included would involve theoretical and empirical analyses which should appropriately be the concern of other studies. Therefore, for the purposes of this thesis, it will be assumed that the biases are small and may be safely ignored.

VI.C. Data for the Regression Analysis

In order to estimate the partial elasticities of the aggregate variables in equation (V-3), regression analysis has been performed upon the transformed logarithmic-linear stochastic relation specified earlier as equation (VI-1).

$$\text{(VI-1)} \qquad \log X_i = a_i + b_i \log Y + r_i \log R + g_i \log D + u_i$$

In Chapter Five, the sectoral relation was specified both in terms of monetary policy acting through interest rate variations and in terms of the direct effects of changes in the money stock upon sectoral outputs (equations (V-3) and (V-4) respectively.) Section VI.A. has translated these relationships into empirically testable statements in equations (VI-1) and (VI-2).

However, within the field of monetary economics, discussion has continued concerning the proper definition of the money stock, with disagreement upon whether time deposits should or should not be included. Friedman and others feel that "M_2" (including time deposits) is the proper money stock concept and have presented considerable empirical evidence in support of this view.[1] A second group of monetary economists regard the narrow definition, as used by the Federal Reserve and other government agencies, as more

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[1]For two studies of an empirical definition of money which support "M_2" as the best choice, see George G. Kaufman, "More on an Empirical Definition of Money," American Economic Review, LIX (March, 1969), 78-87, and Milton Friedman and David Meiselman, "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958."

appropriate, and empirical support also exists for this position.[1] Therefore, the logarithmic stochastic relation specified earlier as equation (VI-2) has, for the actual empirical analysis, been subdivided into two alternate specifications: one in terms of "M_1," the narrowly defined money stock (equation VI-3); and the second in terms of "M_2," the money stock defined to include time deposits (equation VI-4):

$$\text{(VI-3)} \qquad X_i = c_i + b_i Y + m_i M_1 + g_i D + v_i$$

$$\text{(VI-4)} \qquad X_i = d_i + b_i Y + t_i M_2 + g_i D + w_i$$

The sectoral equations have been defined explicitly in terms of both alternative definitions of the money stock in order to investigate whether the use of "M_2" rather than "M_1" causes any significant differences in the results. If such differences do, in fact, appear, it may provide some further empirical evidence as to which of the two definitions is preferable for analytical purposes.

The data series, which are employed in the regression analyses, were collected in either monthly, quarterly, or annual form. Since only quarterly series were available for both gross national product and the "high employment" deficit, the monthly industrial

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[1] In addition to many demand for money studies which have argued that little is gained by including time deposits, refer to Richard H. Timberlake, Jr., and John Forston, "Time Deposits in the Definition of Money," American Economic Review, LVII (March, 1967), 190-193, which tests the significance of time deposits using the same methods as Friedman and Meiselman, "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958," over a different period and presents conflicting results.

output series were converted into quarterly series by a simple averaging process. The regression analysis of the manufacturing sectors are therefore performed in terms of quarterly data. Annual data series of the aggregate variables were calculated by averaging the monthly and quarterly data series, for use in the regression analysis of the annual output series.

The regressions have been performed in terms of logarithms. Non-positive values are not defined in logarithmic form, so that certain manipulations of the "high employment" deficit series were necessary. In order to produce a series containing all positive values for the fiscally-related measure, the largest negative value was first determined. The absolute value of this figure plus 1.00 was then added to all the quarterly deficit figures producing an "index" of the "high employment" deficit which had values greater than or equal to 1.00.[1]

VI.D. Least Squares Estimates of the Sectoral Relations

This section applies regression analysis to both data sets. The first subsection presents the analysis of the manufacturing sectors and includes detailed discussion of the analytical procedures. The second subsection deals with the twelve broadly-defined sectors and contains only the empirical results.

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[1]The possible effects of this transformation upon the estimated partial elasticities with respect to the deficit is discussed in the interpretation of the empirical results in Chapter Seven.

The Manufacturing Sectors

Direct least squares regression, utilizing quarterly data, was performed upon equations (VI-1), (VI-3), and (VI-4) for each of the twenty-four industrial sectors. Table XIII presents the estimates of the partial elasticities specified in equation (VI-1). Table XIV contains the results of the regressions performed upon equation (VI-3), and Table XV sets forth the estimates of the partial elasticities specified in equation (VI-4).

The first three columns of figures are the estimated partial elasticities (for each sector) of the following variables:

$Y \equiv$ real GNP

$R \equiv$ rate of interest (yield on long term government bonds)

$M_1 \equiv$ the real money stock defined as the sum of currency and demand deposits

$M_2 \equiv$ the real money stock defined as the sum of currency, demand and time deposits

$D \equiv$ the real "high employment" deficit

The fourth column in the tables reports the R^2, the coefficient of determination, related to each sectoral regression.

Quickly surveying the three sets of estimated elasticities, a highly significant positive relationship has been discovered between real GNP and the output of almost every sector. Only in the case of the Coal sector is a statistically positive relationship not found.

An examination of the results presented in Table XIII, with respect to the direct effects of interest rate changes upon sectoral outputs, shows that these estimates of the coincident relationship in five sectors to have partial elasticities which are both statistically significant and which have the theoretically correct (negative) sign. Of the remaining sectors, fourteen have estimated interest elasticities which were not indicated to be significantly different from zero. The estimated interest elasticities of five sectors were discovered to be significant and positive. In Tables XIV and XV, the regressions indicate that changes in the money stock have a significant positive effect upon the outputs of four sectors using M_1 and seven sectors employing M_2.

The estimated partial elasticities with respect to changes in the deficit are found to be positive and statistically significant for ten sectors in the case of the equations containing the interest rate (Table XIII) and for eleven sectors in the specification including the money stock (both Tables XIV and XV).

These results presented in Tables XIII through XV have been regressions of equations (VI-1, 3, 4) which were, in turn, direct transformations of the relationships (V-3) and (V-4). These original theoretical relationships were specified without regard for the possible existence of lags in the effect of changes in the

TABLE XIII

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, RATE OF INTEREST, OR HIGH EMPLOYMENT DEFICIT, COINCIDENT RELATIONS, (1948-69 II QUARTERLY)[a]

Sector	Y	R	D	R^2
Primary metals	1.2294#	- .5655#	- .0206	.51
Fabricated metal products	1.2945#	- .1960*	.0178	.96
Nonelectrical machinery	1.5098#	- .2871*	.0572#	.93
Electrical machinery	1.6294#	- .0014	.0080	.96
Transportation equipment	1.5016#	.0594	- .0060	.92
Instruments	1.3380#	.2807*	- .0066	.97
Clay, glass, stone products	.9769#	- .0067	.0224*	.93
Lumber	.6730#	- .2399*	.0026	.62
Furniture	1.4620#	- .0494	.0440#	.97
Miscellaneous	1.1628#	- .1493	.0012	.94
Textile mill products	.8931#	- .1153	- .0073	.89
Apparel products	.9746#	.0439	.0212	.94
Leather	.2733*	.0631	.0127	.69
Paper	1.2340#	.0459	.0379	.98
Printing	.8485#	.1230*	.0168#	.97
Chemicals	1.7565#	.2146*	.0422#	.99
Petroleum products	.7709#	.1245*	.0163*	.96
Rubber and plastics	1.8223#	- .0180	.0242*	.98
Foods and beverages	.6780#	.0703	.0182	.90
Tobacco products	.3626#	.2130	.0162	.87
Coal	.6156*	- .5299#	- .0316	.16
Crude oil	.5815#	.0827	.0020	.90
Metal mining	.8284#	- .1642	.0283	.41
Stone and earth minerals	.8460#	.2536	.0421*	.87

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by *, at the .01 level by # (based upon t-ratios).

TABLE XIV

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, THE MONEY STOCK, OR HIGH EMPLOYMENT DEFICIT, COINCIDENT RELATIONS, (1948-69 II QUARTERLY)[a]

Sector	Y	M_1	D	R^2
Primary metals	.3679#	1.2011*	- .0284	.49
Fabricated metal products	1.0725#	- .0053	.0244*	.96
Nonelectrical machinery	1.0208#	- .1330	.0680	.93
Electrical machinery	1.6420#	- .0784	.0073	.96
Transportation equipment	1.5576#	.0634	- .0034	.92
Instruments	1.8053#	- .8144#	- .0046	.97
Clay, glass, stone products	1.0463*	- .4230	.0183	.93
Lumber	.3686#	.1739	- .0039	.59
Furniture	1.4067#	- .0040	.0423#	.97
Miscellaneous	.9375#	.3057	- .0010	.94
Textile mill products	.6660#	.5273*	- .0063	.90
Apparel products	1.0724#	- .2632	.0203*	.94
Leather	.2443#	.5533#	.0199*	.72
Paper	1.3353#	- .2697	.0370#	.98
Printing	.9818#	.0192	.0211#	.97
Chemicals	2.3500#	-1.2956#	.0408#	.99
Petroleum products	1.0052#	- .5095*	.0157*	.96
Rubber and plastics	1.7797#	.1218	.0247*	.98
Foods and beverages	.8281*	- .3853	.0171	.91
Tobacco products	.7817#	-1.0271#	.0138	.90
Coal	- .2740	1.5786#	- .0348	.19
Crude oil	.6495#	.1435	.0061	.90
Metal mining	.9126#	-1.4881*	.0092	.44
Stone and earth minerals	1.3064#	- .9455*	.0419#	.87

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by *, at the .01 level by # (based upon t-ratios).

TABLE XV

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, THE MONEY STOCK INCLUDING TIME DEPOSITS, OR HIGH EMPLOYMENT DEFICIT, COINCIDENT RELATIONS, (1948-69 II QUARTERLY)[a]

Sector	Y	M_2	D	R^2
Primary metals	.6395*	- .0664	- .0408	.46
Fabricated metal products	.9776#	.1174	.0220*	.96
Nonelectrical machinery	1.3804#	- .2460	.0717#	.93
Electrical machinery	2.0596#	- .5391#	- .0028	.97
Transportation equipment	2.4123#	-1.0526#	- .0251	.94
Instruments	2.3310#	- .8413#	- .0140	.98
Clay, glass, stone products	1.2352#	- .3320*	.0156	.93
Lumber	.6538#	- .3166	- .0118	.61
Furniture	1.0783#	.4090#	.0506#	.97
Miscellaneous	.6700#	.4034#	.0043	.94
Textile mill products	.3055#	.5698#	.0002	.91
Apparel products	.7286#	.3692#	.0301#	.95
Leather	.4289#	- .1047	.0127	.69
Paper	1.3075#	- .0266	.0389#	.98
Printing	.7609#	.2801#	.0265#	.98
Chemicals	2.3742#	- .3247*	.0462#	.99
Petroleum products	1.3738#	- .5760#	.0089	.98
Rubber and plastics	1.4978#	.3796#	.0312#	.98
Foods and beverages	.6925#	.0817	.0222*	.90
Tobacco products	.7027#	- .1347	.0206*	.86
Coal	- .5280*	.6756*	- .0358	.13
Crude oil	1.2375#	- .7015#	- .0093	.95
Metal mining	1.3596#	- .8962*	.0049	.44
Stone and earth minerals	1.8886#	- .9417#	.0317*	.89

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by *, at the .01 level by # (based upon t-ratios).

aggregate variables upon the sectoral outputs. The relationships were, in common with most national income models, comparative static formulations implicitly assuming adjustment from one equilibrium to another within the period studied. There is considerable reason to suppose, however, that a lagged relationship exists between changes in the policy-related aggregate variables and the resulting variations in sectoral outputs. A large body of empirical research has investigated the lag in the effect of monetary policy and has generally discovered a lag of two quarters or more between a change in the money stock and its consequent effects upon economic activity.[1] According to Mayer, the predominant view of economists investigating the lag in the effect of fiscal policy is that the effects of discretionary fiscal policy actions are slower than monetary policy.[2] However, most general discussion of this lagged relationship assumes a total lag which includes the time needed for legislative action. The length of the actual lag between a change in tax, or other revenue rates, and its effect upon aggregate economic activity is generally considered to be much

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[1]For an excellent summary and discussion of the empirical literature relating to the lag in monetary policy, see Thomas Mayer, Monetary Policy in the United States (New York: Random House, 1968), pp. 181-189.

[2]Mayer, Monetary Policy in the United States, pp. 193-94.

shorter, perhaps less than one quarter.[1] Similarly, the actual lag between expenditures (or what is more important, government orders) and its impact upon aggregate economic activity is probably much less than one year.[2]

While some divergence appears in discussion of the actual length of the lag, substantial evidence does exist that both monetary and fiscal policy actions have a lagged effect upon aggregate economic activity. This study includes an empirical investigation of the existence of such lags in the effects of policy actions upon individual sectoral outputs, rather than restricting the analysis to empirical results based only upon the estimated elasticities of the coincident relationships.

Therefore, initially cross-spectral techniques are utilized in order to provide a measures of the probable lag structure in the relationship between the sectoral outputs and each of the aggregate variables. Also a series of regressions are calculated, in which various lags between the aggregate variables and the sectoral outputs have been specified. In this way, inferences can be made about the length of the lag between variations in the aggregate measures and in outputs of the various sectors.

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[1]In the Commission on Money and Credit, ed., Money and Credit (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961), pp. 244-245, the statement is made that a decrease in personal income tax rates would have a substantial effect within three months and a maximum effect in about six months.

[2]Commission on Money and Credit, ed., Money and Credit, p. 245.

Cross-Spectral Evidence

Since cross-spectral analysis enables us to investigate the statistical significance of the estimated lags, this statistical tool is a convenient instrument to study the length of lags between changes in each of the aggregate variables (specified in equations VI-1, VI-3, and VI-4) and the consequent sectoral responses.

Neither GNP nor the deficit series are available in monthly form, so that the estimates of the spectra of all the data series and all the cross-spectra are based upon the quarterly time series.[1] The estimated spectra of GNP, the interest rate, and both money stock series exhibited a definite peak in the business cycle frequencies (the 24, 30, and 40 month cycles) reaffirming the cyclical (in the traditional sense) nature of these series. On the other hand, the "high employment" deficit spectrum did not exhibit any definite peaks, which would tend to indicate a more random nature to that series' variance pattern.

The relevant summary statistics of the "crosses," (at the business cycle frequency (30 month cycle)) between each of the sector outputs and the alternate aggregate series are presented in the following tables: (1) GNP in Table XVI; (2) the interest rate in Table XVII; M_1 in Table XVIII; and M_2 in Table XIX. The results of

[1]Just as in Chapter Four, the data series were transformed to percentage change form for use in the cross-spectral analysis. The series contained ninety observations each, and spectra with twenty frequency bands were estimated.

TABLE XVI

CROSS-SPECTRAL STATISTICS FOR REAL GROSS NATIONAL PRODUCT AND THE SECTORAL OUTPUT SERIES FOR THE BUSINESS CYCLE FREQUENCY

Sector	Coherence	Tau	Significant Lag (mo.)
Primary metals	.788		
Fabricated metal products	.849		
Nonelectrical machinery	.823	.63	1.89
Electrical machinery	.690		
Transportation equipment	.812		
Instruments	.712		
Clay, glass, stone products	.861		
Lumber	.884		
Furniture	.715		
Miscellaneous	.760		
Textile mill products	.837		
Apparel	.707		
Leather	.737		
Paper	.729		
Printing	.500		
Chemicals	.860		
Petroleum	.625		
Rubber and plastics	.886		
Foods and beverages	.459		
Tobacco	---		
Coal	.664		
Crude oil	.585		
Metal mining	---		
Stone and earth minerals	.345		

TABLE XVII

CROSS-SPECTRAL STATISTICS FOR INTEREST RATE
AND THE SECTORAL OUTPUT SERIES FOR
THE BUSINESS CYCLE FREQUENCY

Sector	Coherence	Tau	Significant Lag (mo.)
Primary metals	.617		
Fabricated metal products	.581		
Nonelectrical machinery	.621		
Electrical machinery	.414		
Transportation equipment	.633		
Instruments	.561		
Clay, glass, stone products	.594		
Lumber	.596	2.05	6.15
Furniture	.357		
Miscellaneous	.450		
Textile mill products	.551	1.59	4.77
Apparel	.432		
Leather	.453	2.24	6.72
Paper	.461		
Printing	.401		
Chemicals	.561		
Petroleum	.560		
Rubber and plastics	.525		
Foods and beverages	.395		
Tobacco	---		
Coal	.388		
Crude oil	.565		
Metal mining	---		
Stone and earth minerals	---		

TABLE XVIII

CROSS-SPECTRAL STATISTICS FOR NARROWLY DEFINED MONEY STOCK AND THE SECTORAL OUTPUT SERIES FOR THE BUSINESS CYCLE FREQUENCY

Sector	Coherence	Tau	Significant Lag (mo.)
Primary metals	.465	3.08	9.24
Fabricated metal products	.584	2.93	8.79
Nonelectrical machinery	.395	----	----
Electrical machinery	.658	2.29	6.87
Transportation equipment	.359	----	----
Instruments	.485	3.26	9.78
Clay, glass, stone products	.418	2.82	8.46
Lumber	.496	1.77	5.31
Furniture	.650	1.95	5.85
Miscellaneous	.448	2.38	7.14
Textile mill products	.439	1.56	4.68
Apparel	.416	1.66	4.98
Leather	.565	.99	2.97
Paper	.456	2.34	7.02
Printing	.531	----	----
Chemicals	.523	2.88	8.64
Petroleum	---	----	----
Rubber and plastics	.470	1.68	5.04
Foods and beverages	.344	2.25	6.75
Tobacco	---	----	----
Coal	.383	----	----
Crude oil	---	----	----
Metal mining	.525	----	----
Stone and earth minerals	.326	----	----

TABLE XIX

CROSS-SPECTRAL STATISTICS FOR MONEY STOCK, INCLUDING TIME DEPOSITS, AND THE SECTORAL OUTPUT SERIES FOR THE BUSINESS CYCLE FREQUENCY

Sector	Coherence	Tau	Significant Lag (mo.)
Primary metals	.494	2.68	8.04
Fabricated metal products	.609	3.22	9.66
Nonelectrical machinery	.553	2.21	6.63
Electrical Machinery	.681	2.88	8.64
Transportation equipment	.349	----	----
Instruments	.610	2.61	7.83
Clay, glass, stone products	.593	3.14	9.42
Lumber	.617	2.34	7.02
Furniture	.717	2.56	7.68
Miscellaneous	.503	2.97	8.91
Textile mill products	.479	2.27	6.81
Apparel	.449	2.52	7.56
Leather	.515	1.50	4.50
Paper	.583	2.90	8.70
Printing	.660	2.24	6.72
Chemicals	.651	3.17	9.51
Petroleum	.418	2.57	7.71
Rubber and plastics	.524	2.39	7.17
Foods and beverages	.422	2.68	8.04
Tobacco	---	----	----
Coal	.463	2.39	6.87
Crude oil	.439	1.89	5.67
Metal mining	.477	1.84	5.52
Stone and earth minerals	.496	2.40	7.20

the "crosses" between the deficit series and the output series did not yield any meaningful results and are therefore not reported.

By way of interpretation, the reader may recall that co-herence is a measure of the similarity of the variance patterns of the two time series and is roughly analogous to the coefficient of determination. In cases where coherence figures are omitted, the estimate was not statistically significant (at the .05 level). Tau is an estimate (in quarters) of the length of the lag. Here again figures which were not statistically significant are omitted. The last column in each table simply translates the tau statistics into a measure of the lag in terms of months.

The coherence statistics reported in Table XVI indicate that there is a highly significant relationship between the pattern of cyclical fluctuation in GNP and the pattern of each sectoral output series. Only in the cases of the Tobacco and the Metal mining sectors was the coherence not significant. Only in the single case of the Nonelectrical machinery sector was the tau found to differ significantly from zero, so that the general relationship between changes in GNP and in sector output seem to be coincident.

The cross-spectral results with respect to the "crosses" between the interest rate and the sectoral output series are quite similar to the GNP results. As indicated in Table XVII, the co-herence statistics indicate a significant degree of similarity between the variance pattern, in the business cycle frequencies, of the interest rate and all of the sectoral outputs except Tobacco, Metal mining, and Stone and earth minerals. The tau statistics generally do not indicate the existence of significant lags between changes in the rate of interest and the resultant sectoral responses. However, the tau statistics with respect to the Lumber, Textile mill products, and Paper sectors suggest a lag in the effect upon these sectors' outputs of 6.2, 4.8, and 6.7 months respectively.

Table XVIII and XIX present the cross-spectral results for the "crosses" of each of the two alternate money stock series upon the sectoral output series. The coherence statistics in Table XVIII indicate a statistically significant degree of similarity between the variance patterns, in the business cycle frequency, of "M_1" for all sectors except Petroleum products, Tobacco products, and Crude oil and natural gas. In the "crosses" between "M_2" and the output series, the coherence statistics are all significant except for that of the Tobacco sector. Note that in all but three cases (the Transportation equipment, Leather products, and Metal mining sectors), the coherence statistics were higher for the crosses between "M_2" and the output series. The tau statistics indicate that a significant lag exists between changes in the stock of money and the consequent sectoral responses, irrespective of the money stock definition used. Significant lags between the series exist in most sectors and are somewhat longer when the broadly-defined money stock is employed.

As mentioned previously, the cross-spectral results which relate to the relationship between the "high employment" deficit and the sectoral outputs did not indicate any appreciable degree of similarity of variance patterns, either at the business cycle or any other frequencies. Therefore, no indication as to the nature of the lag structure could be inferred.

In summary, the cross-spectral results suggest that very little lag probably existed between changes in aggregate income and the resultant sectoral responses. Since come significant lags were discovered, the evidence suggests the possibility of a coincident relationship between interest rate changes and effects upon sectoral outputs. The analysis indicates, however, a significant lag of generally two or three quarters between changes in the money stock and the consequent sectoral output responses. Finally, no inference can be made about the lags of fiscal policy actions based upon the cross-spectral evidence.

Regression Analysis

In order to study the lag in the effects of monetary and fiscal policy actions upon the output levels of the individual sectors, direct least squares regression was performed upon equations (VI-1), (VI-3), and (VI-4), with various lags being specified between the aggregate variables and each of the sectoral output series. In other words, the partial elasticities were calculated by regression analysis in which, for example, the interest rate series included data relating to the period 1947I-1968II while the output series included data from 1948I-1969II, so that a lagged relationship of one year was specified in that particular regression.

A set of such regressions were performed for each of the individual sectors with respect to each of the three alternate specifications of the sectoral equation. The first included the rate of interest. The second contained the narrowly defined money stock. The third employed the broadly-defined money stock. Initially, in each such set, regressions were computed in which GNP was alternately lagged zero, one, and two quarters, the rate of interest was lagged one through six quarters, the two alternative money stock series one through eight quarters, and the high employment deficit, one through six quarters.

The nature of the particular lags specified in one regression in each set should produce estimated partial elasticities which have a value for the coefficient of determination which will allow a choice of the "best" regression equation. In general, this was defined as that equation which had the highest coefficient of determination.

In some of the regressions, the estimated partial elasticities had signs opposite to the expected theoretical signs and changes in the specification of lags did not alter this result. In these cases, the particular combination of a four quarter lag for either the rate of interest, or the money stock, and a coincident relation for both GNP and the high employment deficit have been chosen. This combination was selected because (a) a coincident relationship between the deficit and the sector output almost always produced the "best fit" in those regressions where the estimated elasticity was statistically significant, and (b) a four quarter lag between the monetary policy-related variable and output was found to be the most common in those regressions where either the interest rate or the money stock has a statistically significant partial elasticity.[1] This choice of the "4-0" lag pattern, can therefore, be considered as representative of the results of the regressions for each such sector, rather than the "best" regression, since the choice of the regression with the highest coefficient of determination would not be meaningful for the purposes of this study.

The process of choosing the "best" combination of assumed lags for each set of regressions has been undertaken, because the particular lag which yields the "best" results represents the length of the lag between a change in the policy variable and its maximum effect upon the output level of that sector. If the regression results indicate that the highest coefficient of determination is obtained in the case of a given sector when GNP is coincident, the interest rate lagged three quarters, and the high employment deficit

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[1]The choice of a coincident relationship between GNP and the output series resulted from the fact that such a specification resulted in the highest "t-value" for the estimated income elasticity in all cases.

one quarter, these findings are interpreted as showing that the effective lag between a change in the rate of interest and its sectoral response is three quarters, that the lag between variations in the deficit and their effects upon sectoral output is one quarter, and that changes in aggregate demand (measured by GNP), exert their maximum effects upon the sector's output within one quarter.

On the basis of these sets of lagged regressions, therefore, the particular set of lags which yielded the "best estimates" of the partial elasticities were chosen for each sector for each of the three alternate specifications of the sector equation.

Table XX reports the results for the sectoral model containing the rate of interest as the monetary policy related variable. The results for the model using "M_1" are set forth in Table XXIX. The results relating to the model specified in terms of "M_2" are presented in Table XXII. Both the lag which had been specified for that sectoral regression and its estimated partial elasticity are listed for each of the twenty-four sectors. In the seventh column the coefficients of determination for each sectoral regression are reported. In the instances where the regression results for a lag of four quarters for the monetary policy variable or for a zero quarter lag for the deficit have been reported as the representative equation, i.e., no "best" regression was found, a subscript "r" appears on that particular lag figure (as in the case of the Electrical machinery sector in Table XXII).

TABLE XX

ESTIMATED PARTIAL ELASTICITIES OF SECTOR OUTPUTS WITH RESPECT TO REAL GNP, RATE OF INTEREST, OR HIGH EMPLOYMENT DEFICIT, WITH ASSUMED LAGS, (1948-69 QUARTERLY)[a]

Sector	Y	lag (qtrs.)	R	lag (qtrs.)	D	lag (qtrs.)	R^2
Primary Metals	1.7333#	0	-1.0803#	4	-.0114	0	.70
Fabricated Metal Products	1.3903#	0	- .3040#	3	.0189*	2	.97
Nonelectrical Machinery	1.6606#	0	- .4495#	4	.0456#	0	.95
Electrical Machinery	1.7649#	0	- .1292	4	.0141	0	.96
Transportation Equipment	1.8132#	0	- .2292	4	.0068	0	.93
Instruments	1.4652#	0	.1807	4	-.0057	0	.97
Clay, Glass, Stone Products	1.1533#	0	- .1718*	2^r	.0294#	0^r	.93
Lumber	.8087#	0	- .3813#	3	.0104	0	.68
Furniture	1.4608#	0	- .0505	2	.0441#	0	.97
Miscellaneous	1.1686#	0	- .1616*	2	.0018	0	.94
Textile Mill Products	.9985#	0	- .2208#	3	-.0020	0	.90
Apparel Products	.9682#	0	.0601	4	.0287#	1	.95
Leather	.4394#	0	- .0863	4	.0210*	1	.70
Paper	1.2882#	0	- .0018	3	.0395#	0	.98
Printing	.7934#	0	.1809*	3	.0148*	1	.98
Chemicals	1.8070#	0	.2292*	3	.0451#	1	.99
Petroleum Products	.8290#	0	.0779	3	.0172*	0	.96
Rubber and Plastic	2.0035#	0	- .1883*	3	.0314#	0	.98
Foods and Beverages	.6516#	0	.0979	2	.0172	0	.90
Tobacco Products	.3827#	0	.2274#	4	.0431*	4	.92
Coal	.9800#	0	- .9106#	4	.0152	0	.47
Crude Oil	.7882#	0	- .1069	4	.0102	0	.91
Metal Mining	1.0928#	0	- .4007*	4	.0646*	3	.45
Stone and Earth Mining	.9210#	0	.1991	3	.0423	0	.87

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by *, at the .01 level by # (based upon t-ratios).

TABLE XXI

ESTIMATED PARTIAL ELASTICITIES OF SECTOR OUTPUTS WITH RESPECT TO REAL GNP, THE MONEY STOCK, OR HIGH EMPLOYMENT DEFICIT, WITH ASSUMED LAGS, (1948-69 II QUARTERLY)[a]

Sector	Y	Lag (qtrs.)	M_1	Lag (qtrs.)	D	Lag (qtrs.)	R^2
Primary metals	.3679#	0	1.2011*	0	-.0284	0	.49
Fabricated metal products	1.0456#	0	.1228	3	.0267#	2	.96
Nonelectrical machinery	1.1749#	0	.0528	4	.0666#	0	.93
Electrical machinery	1.6662#	0	-.2386	4	.0074	0	.96
Transportation equipment	1.5823#	0	-.0819	4_r	-.0042	0_r	.92
Instruments	1.7530#	0	-.5952*	4_r	.0014	0_r	.97
Clay, glass, stone products	.8878#	0	.5074*	2	.0295*	0	.93
Lumber	.2259#	0	.9892#	2	-.0002	0	.65
Furniture	1.4315#	0	-.1497	3	.0419#	0	.97
Miscellaneous	.9421#	0	.2987	3	-.0029	0	.94
Textile mill products	.6660#	0	.5273*	0	-.0063	0	.90
Apparel products	1.0927#	0	-.3795	4	.0297#	1	.95
Leather	.2443#	0	.5533#	0	.0199*	0	.72
Paper	1.3201#	0	-.2104	4	.0389#	0	.98
Printing	.9529#	0	.2010	4	.0214#	0	.97
Chemicals	2.2847#	0	-1.0584*	4	.0501#	0	.99
Petroleum products	.9370#	0	-.1436	3	.0200*	0	.96
Rubber and plastics	1.8507#	0	-.3036	4	.0228*	0	.98
Food and beverages	.7096#	0	.2834	3	.0215*	0	.90
Tobacco products	.7402#	0	-.7733*	4	.0399#	4	.92
Coal	-.2594	0	1.6922#	4	.0151	0	.22
Crude oil	.6256#	0	.3102	4	.0055	0	.91
Metal mining	.3351*	0	1.9947#	2	.0821#	3	.49
Stone and earth minerals	1.0854#	0	.3618	3	.0515#	0	.87

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by *, at the .01 level by # (based upon t-ratios).

TABLE XXII

ESTIMATED PARTIAL ELASTICITIES OF SECTOR OUTPUTS WITH RESPECT TO REAL GNP, THE MONEY STOCK INCLUDING TIME DEPOSITS, OR HIGH EMPLOYMENT DEFICIT, WITH ASSUMED LAGS (1948-69 II QUARTERLY)[a]

Sector	Y	Lag (qtrs.)	M_2	Lag (qtrs.)	D	Lag (qtrs.)	R^2
Primary metals	.4846#	0	.1448	5	- .0370	0	.46
Fabricated metal products	.8707#	0	.2617*	3	.0218*	2	.96
Nonelectrical machinery	1.1825#	0	.0012	4	.0667#	0	.93
Electrical machinery	2.0056#	0	- .5182*	4_r	.0009	0_r	.97
Transportation equipment	2.3367#	0	-1.0526*	4_r	- .0220	0_r	.94
Instruments	2.2358#	0	- .7934*	4_r	- .0107	0_r	.98
Clay, glass, stone products	1.0266#	0	- .0741	2	.0209*	0	.93
Lumber	.5656#	0	- .2447	4_r	- .0289	0_r	.62
Furniture	1.0968#	0	.4107#	3	.0494	0	.97
Miscellaneous	.6405#	0	.4684#	3	.0042	0	.94
Textile mill products	.2692#	0	.6417#	2	.0048	1	.92
Apparel products	.8177#	0	.2950*	4	.0370#	1	.95
Leather	.4363#	0	- .1219	4	.0151	1	.70
Paper	1.2821#	0	.0056	4	.0395#	0	.98
Printing	.7397#	0	.3369#	4	.0266#	0	.98
Chemicals	2.3794#	0	- .3637*	4	.0465#	0	.99
Petroleum products	1.2239#	0	- .4612*	4	.0121*	0	.97
Rubber and plastics	1.5606#	0	.3308#	4	.0292#	0	.98
Food and beverages	.6127#	0	.1930	3	.0239*	0	.90
Tobacco products	.6180#	0	.0050	2	.0486#	4	.89
Coal	- .7900	0	1.1015#	4	.0107	0	.23
Crude oil	1.0977#	0	- .5789*	4_r	- .0051	0_r	.94
Metal mining	.9986#	0	- .4550	4	.0428	3	.44
Stone and earth minerals	1.6536#	0	- .6900*	4	.0388*	0	.89

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by *, at the .01 level by # (based upon t-ratios).

In each of the three tables of lagged regression results, the estimated partial elasticities with respect to changes in GNP were found to be positive and highly significant for practically every sector. Only in the case of the Coal sector was the estimated elasticity not statistically significant (Tables XXI and XXII). In addition, a coincident relationship between output and GNP was discovered to yield the best results in every case.

The specification of a lagged relationship (Table XX) led to a doubling (five to ten) of the number of sectors for which the interest elasticity has the correct theoretical sign and was statistically significant (at the .05 level). The lengths of lags producing the "best" regression results ranged from two to four quarters.

The results presented in Table XXI show that the specification of a lagged relationship between the "M_1" and the sectoral outputs led the number of sectors in which the estimated partial elasticity with respect to variations in "M_1" was both positive and significant to increase to seven, as compared with four for coincident relationships. Using "M_2," the lagged regressions resulted in positive and significant partial elasticities in eight sectors, one more than was the case for the coincident regressions.

The assumption of a lagged relationship between the deficit and the output series resulted in an increase in the number of sectors with significant partial elasticities. This number varied in each of the three alternative specifications of the sectoral equations. For example, in the case of the equation containing the interest rate as the monetary policy-related variable (Table XX), the "best" equations in four sectors resulted from the specification of a one quarter lag, and in one sector each from the specification of lags of two, three and four quarters. In the two other tables, the lagged results were very similar, despite the fact that there were fewer sectors in which a specified lag of one quarter produced improved results.

The Broadly-defined Sectors of the Economy

Direct least squares regression was also performed upon equations (VI-1), (VI-3), and (VI-4), utilizing the annual series of indexes of gross product for each of the twelve broadly-defined sectors of the economy. Table XXIII presents the estimates of the partial elasticities of each sectoral output with respect to variations in GNP, the interest rate, and the "high employment" deficit (equation VI-1). The results of the regressions upon equation (VI-3), employing "M_1" are set forth in Table XXIV. Those equations which contain the estimated partial elasticities of each sectoral output with respect to changes in GNP, "M_2," and the deficit are presented in Table XXV.

The estimated partial elasticities with respect to changes in real GNP were found to be positive for every sector; and, with the exception of the contract construction sector in Table XXIII, all

TABLE XXIII

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, RATE OF INTEREST, OR HIGH EMPLOYMENT DEFICIT, COINCIDENT RELATIONS, (1948-68 ANNUALLY)[a]

Sector	Y	R	D	R^2
Agriculture, forestry, and fisheries	.2312*	.1069	.0067	.90
Mining	.4872*	.0726	- .0008	.95
Contract construction	.0200	.5404*	.0067	.91
Nondurable manufacturing	1.0810*	- .0798*	.0107*	.99
Durable manufacturing	1.3127*	- .1987	.0316*	.98
Transportation	1.1514*	- .4621*	- .0112	.93
Communications	1.5937*	.2094	.0222	.99
Electricity, gas, and sanitary services	1.0950*	.5980*	.0375*	.99
Wholesale trade	1.4074*	- .0928	.0315*	.99
Retail trade	.9483*	- .0433	.0086*	.99
Finance, insurance, real estate	1.1740*	.1044	.0289*	.99
Services	1.1004*	- .0577	.0272*	.98

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by * (based upon t-ratios).

TABLE XXIV

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, THE MONEY STOCK, OR HIGH EMPLOYMENT DEFICIT, COINCIDENT RELATIONS, (1948-68 ANNUALLY)[a]

Sector	Y	M_1	D	R^2
Agriculture, forestry, and fisheries	.4067*	- .3303	.0068	.90
Mining	.5530*	.1910	.0018	.95
Contract construction	.8501*	-1.2277*	.0096	.86
Nondurable manufacturing	.9572*	.1907	.0103*	.99
Durable manufacturing	.9945*	.5523	.0321*	.97
Transportation	.3865*	1.4780*	- .0111	.92
Communications	1.9220*	- .5271	.0230	.99
Electricity, gas, and sanitary services	2.0355*	-1.5293*	.0397*	.99
Wholesale trade	1.2590*	.2566	.0313	.99
Retail trade	.8648*	.2312	.0091*	.99
Finance, insurance, real estate	1.3216*	- .1379	.0300*	.99
Services	1.0093*	.1500	.0270*	.98

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by * (based upon t-ratios).

TABLE XXV

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, MONEY STOCK INCLUDING TIME DEPOSITS, OR HIGH EMPLOYMENT DEFICIT, COINCIDENT RELATIONS, (1948-68 ANNUALLY)[a]

Sector	Y	M_2	D	R^2
Agriculture, forestry, and fisheries	.4630*	- .1441	.0075	.90
Mining	.6894*	- .1634	- .0009	.95
Contract construction	1.3863*	-1.0126*	.0079	.97
Nondurable manufacturing	.8636*	.1724*	.0108*	.99
Durable manufacturing	1.0575*	.1652	.0353*	.94
Transportation	.1941*	.7038*	- .0137	.94
Communications	1.8522*	.0031	.0263*	.99
Electricity, gas, and sanitary services	2.3416*	- .7333*	.0423*	.99
Wholesale trade	1.0649*	.3314*	.0328*	.99
Retail trade	.8038*	.1324*	.0089*	.99
Finance, insurance, real estate	1.2921*	.0173	.0310*	.99
Services	.7887*	.3500*	.0293*	.98

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by * (based upon t-ratios).

the estimated elasticities were statistically significant (at the .05 level). The estimated interest elasticities presented in Table XXIII show only the partial elasticities of the Nondurable manufacturing and Transportation sectors to be both negative and statistically significant. The interest elasticities of four other sectors also had the expected theoretical sign but do not appear to be statistically different from zero. The results presented in Table XXIV show the partial elasticities of output with respect to changes in "M_1" of the transportation sector to be positive and statistically significant. In Table XXV, the estimated sectoral elasticities with respect to variations in "M_2" were positive and significant for five of the twelve sectors. Finally, the regression results of the three alternate sectoral equations (Tables XXIII, XXIV, and XXV) show that the estimated partial elasticity of output with respect to changes in the deficit measure to be positive and statistically significant in seven, six, and eight of the sectors, respectively. In no case was the estimated partial elasticity with respect to the deficit found to be negative and statistically significant.

For the same reasons that a series of lagged regressions were calculated in the case of the quarterly manufacturing sector data series, sets of regressions have been computed in which a lag of one year was specified in real GNP and lags of one and two years were specified for the interest rate, the money stock and for the "high employment" deficit.

The two tables of regression results contain the same results presented earlier in Tables XXIII and XXIV in those cases where the coincident regression equation provided the "best" results for that particular sector. In the case of any sector for which a lagged specification improved the results, that particular combination of lags, its corresponding estimated partial elasticities, and the coefficient of determination for the regression equation have been presented. Table XXVI contains the estimated partial elasticities of output with respect to changes in GNP, the interest rate, and the "high employment" deficit. Table XXVII presents the set of "best" regression results for the equation (VI-3). The specification of lags between "M_2" and sector outputs did not improve any estimated equations.

The results of the lagged regressions did not improve the estimated equations for any of the sectors for either GNP or the high employment deficit. It would seem that the maximum effects of variations in both GNP and the fiscal measure occur within one year. The specification of a lagged relationship between the interest rate and the sectoral outputs did improve the regression results for two sectors. The interest elasticities for the outputs of both the Mining and the Durable manufacturing sectors were

TABLE XXVI

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, RATE OF INTEREST, OR HIGH EMPLOYMENT DEFICIT, WITH SPECIFIED LAGS, (1948-68 ANNUALLY)[a]

Sector	Y	Lag (yrs.)	R	Lag (yrs.)	D	Lag (yrs.)	R^2
Agriculture, forestry, and fisheries	.2312*	0	.1069	0	.0067	0	.90
Mining	.6199*	0	- .0333*	1	.0017	0	.95
Contract construction	.0200	0	.5404*	0	.0067	0	.91
Nondurable manufacturing	1.0810*	0	- .0798*	0	.0107*	0	.99
Durable manufacturing	1.4129	0	- .2743*	1	.0275*	0	.98
Transportation	1.1514*	0	- .4621*	0	- .0112	0	.93
Communications	1.5937*	0	.2094	0	.0222	0	.99
Electricity, gas, and sanitary services	1.0950*	0	.5980*	0	.0375*	0	.99
Wholesale trade	1.4074*	0	- .0928	0	.0315*	0	.99
Retail trade	.9483*	0	- .0433	0	.0086*	0	.99
Finance, insurance, real estate	1.1740*	0	.1044	0	.0289*	0	.99
Services	1.1004*	0	- .0577	0	.0272*	0	.98

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by * (based upon t-ratios).

TABLE XXVII

ESTIMATED PARTIAL ELASTICITIES OF SECTORAL OUTPUTS WITH RESPECT TO REAL GNP, MONEY STOCK, OR HIGH EMPLOYMENT DEFICIT, WITH SPECIFIED LAGS, (1948-68 ANNUALLY)[a]

Sector	Y	Lag (yrs.)	M_1	Lag (yrs.)	D	Lag (yrs.)	R^2
Agriculture, forestry, and fisheries	.4067*	0	- .3303	0	.0068	0	.90
Mining	.5112*	0	.6000*	1	.0025	0	.95
Contract construction	.8501*	0	-1.2277*	0	.0096	0	.86
Nondurable manufacturing	.9572*	0	.1907	0	.0103*	0	.99
Durable manufacturing	.9945*	0	.5523	0	.0321*	0	.99
Transportation	.3865*	0	1.4780*	0	- .0111	0	.97
Communications	1.7815*	0	.7526*	2	.0298*	0	.99
Electricity, gas, and sanitary services	1.7298*	0	.1591	2	.0581*	0	.99
Wholesale trade	1.2889	0	.4836*	2	.0279*	0	.99
Retail trade	.8673*	0	.3131*	2	.0086*	0	.99
Finance, insurance, real estate	1.3216*	0	- .1379	0	.0300*	0	.99
Services	1.0095*	0	.6862*	0	.0249*	0	.99

[a]Constant terms were computed but are not shown. Significance at the .05 level is indicated by * (based upon t-ratios).

estimated to have the correct theoretical sign and to be statistically significant when a one year lag was specified.

Turning to the regression results presented in Table XXVII, the specification of a lagged relationship between "M_1" and the sectoral outputs led to improved equations in five of the twelve sectors. For the Mining sector a one year lag between "M_1" and output gave the "best" equation. In the four other sectors, the "best" equations resulted from the specification of a two year lag between the money stock and the output series.

This chapter has presented the results of regression analysis which estimated the partial elasticities with respect to real GNP, the interest rate, "M_1," "M_2," and the "high employment" deficit for each of the twenty-four manufacturing sectors and for the twelve major sectors of the economy. In addition, both the cross-spectral and regression analysis have yielded empirical evidence concerning the length of lag between policy actions and the consequent effects upon sectoral outputs. In the next chapter, these results are discussed, interpreted, and compared to the findings of past empirical studies.

CHAPTER VII

INTERPRETATION OF THE EMPIRICAL ANALYSIS

Chapter Six presented the results of the regression equation, which estimated the partial elasticities of the aggregate variables with respect to each of the sectoral outputs. In this chapter, these findings are interpreted and related to the results of previous empirical studies.

The chapter is divided into five main parts. The first discusses how well the sectoral equations, postulated in Chapter Five, were able to explain the patterns of fluctuation in sectoral outputs. The next three sections discuss the estimates of the partial elasticities with respect to changes in GNP, the monetary variable, and the deficit measure. In each of the sections, the existence of differential sectoral effects is noted, the sectors most affected are identified, and the evidence relating to the lag between changes in each of the aggregate variables and the resultant sectoral responses is interpreted. The fifth section integrates the findings of the empirical analysis and compares these results with those of Anderson's study of the effects of monetary and fiscal policy actions upon the structure of output.

VII.A. The Significance of the Overall Relationships

The regression results for all three specifications of the sectoral equation indicate that the variance patterns of the aggregate variables specified in the simple sectoral equations postulated for this analysis explain a large proportion of the variance in the outputs. If the coefficient of determination is interpreted as a measure of the proportion of the total variance in sectoral output explained by the variables in the regression,[1] only in the case of a few sectors do the equations explain less than 90 percent of the variance, and in many instances, the coefficient of determination was found to be in the .98-.99 range.

While for most sectors the regression results show generally that this study's sectoral equations explain a very high proportion of the variance in output level, there were several sectors among the manufacturing group and one in the set of major sectors for which the coefficients of determination indicate that the model does not provide a particularly good explanation of variations in output level. Six of the twenty-four manufacturing sectors are found (in Table XX) to have coefficients of determination of less than .90: Primary metals (.70); Lumber (.68); Leather (.70); Coal (.47); Metal mining (.45); Stone and earth minerals (.87).[2] The fact that the model does not provide a good explanation of the variance in outputs for these

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[1]For an explanation of the statistical theory underlying this interpretation, see Edward J. Kane, Economic Statistics and Econometrics (New York: Harper and Row, 1968), p. 242.

[2]The numbers in parentheses are that sector's coefficient of determination in Table XX.

sectors may be due, at least partially, to the existence of particularly strong seasonal cycles in their output patterns. Recalling Table IX, one discovers that these six sectors are all found in the most volatile half of the set when ranked by size of seasonal cycles. In fact, the two sectors with the lowest coefficients of determination, Metal mining and Coal, rank one and two in the size of annual cycles. However, such seasonal variation can only be a partial explanation, since, for example, the sectors with the fourth largest annual cycle, Electrical machinery, can be found to have a coefficient of determination of .96 in Table XX.

In the set of broadly-defined sectors, only the regression equations of the Contract construction sector are found to have a coefficient of determination of less than .90. Since these regressions were computed employing annual data, the existence of annual cycles cannot explain poor performance.

It seems that the output levels of these few sectors are not as dependent upon aggregate demand factors as are the other sectors. In the case of these seven sectors, there are probably other variables or conditions which exert important influences upon the levels of production but have been excluded from this analysis. However, the purpose of this study is to determine whether or not a simple demand model, incorporating the direct effects of monetary and fiscal policy actions, provides a good explanation of variations in real production in individual sectors. While this model is apparently inadequate in the case of some of the sectors, a detailed analysis of the reasons behind such inadequacies is not within the scope of this study.[1]

In general, the regression results do suggest that it is possible to trace most of the variations in the real production of individual sectors either to changes in aggregate expenditures or to monetary and fiscal policy actions which directly affect demand. Haberler has stated that "changes in effective demand, rather than changes in supply, are the proximate cause of the cyclical movement in real output."[2] Haberler was speaking of variations in aggregate real output; the regression results obtained in this study support this position.

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[1]It does seem worthwhile to note that three of the manufacturing sectors in this group are closely related: Primary metals, Coal, and Metal mining. It may be the interrelationships between these three sectors accentuate the extent of variation in output not explained by aggregate demand factors. For example, steel strikes would cause output drops in the other two sectors much greater than would occur in the other sectors through the strikes' effects upon GNP.

[2]Gottfried Haberler, Prosperity and Depression (Northhampton, England: John Dickens and Co., Ltd., 1964), p. viii.

VII.B. The Estimates of the Partial Elasticities With Respect to Changes in Real Gross National Product

With the exception of Coal production among the manufacturing sectors and the Contract construction among the broadly-defined sectors, the estimates of the partial elasticities of every sectoral output with respect to changes in real GNP were all found to be positive and highly significant. The regression results obtained for sectors such as Electrical machinery, Transportation equipment, Mining, or Communications, suggest that changes in GNP were the dominant factor explaining the pattern of variation in sectoral production. The estimated elasticities of these sectors with respect to GNP are statistically significant (while those of the policy-related variables are not) and the coefficients of determination are .96, .93 (Table XX), .95, and .99 (Table XXVI) respectively. The predominance of the aggregate expenditure measure as the most important factor explaining changes in sectoral output levels was, of course, expected and is consistent with the findings of Chapters Three and Four.

The lagged regression results and the cross-spectral analysis provide empirical evidence that changes in aggregate income had their maximum effect upon output levels in the manufacturing sectors within one quarter. In no case were the regression equations improved by the specification of a lagged relationship between real

GNP and sectoral outputs. Neither lagged regression nor the cross-spectral analyses[1] supplied empirical support for the hypothesis that a significant lag exists between changes in aggregate income and consequent changes in sectoral production levels.

The relative sizes of the estimated partial elasticities with respect to changes in real GNP are, in essence, another empirical measure of the relative volatility of the individual sectors. If all sectors had equal amplitudes of variation and growth rates, than all of the sectoral elasticities would be equal to the aggregate value. However, as demonstrated in Chapters Three and Four, not all sectors move together. Some sectors are much more dynamic and volatile than are others. The estimated sectoral partial elasticities again show that this is indeed the case.[2]

Considering first the set of manufacturing sectors, one finds that the highest estimated partial elasticities with respect

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[1]In the cross-spectral analyses, one sector, Electrical machinery was found to have a significant lag, but the lagged results did not yield similar results.

[2]Throughout this analysis, differences in the size of the estimated elasticities is used as evidence that there have been differential effects among sectors. To be more rigorous, further study should statistically test these differences among the regression coefficients. See Gregory C. Chow, "Tests of Equality between Sets of Coefficients in Two Linear Regressions," Econometrica, XXVIII (July, 1960), 591-605, for a description of a simple test of whether the coefficients of two regression equations are different. See also E. Malinvaud, Statistical Methods of Econometrics (Chicago: Rand McNally and Company, 1966), for a discussion of such a test.

to real GNP are the following: (1) Rubber and plastics (2.0035); (2) Transportation equipment (1.8132); (3) Chemicals (1.8070); (4) Electrical machinery (1.7649); (5) Primary metals (1.7335); and (6) Nonelectrical machinery (1.6606).[1]

Comparing these results with the rankings in Table V of relative cyclical volatility (as measured by average percentage change during expansions and contractions) one discovers that the lowest ranking in Table V for any of these sectors was eighth. Further, the cross-spectral results presented in Table XI, analysis in terms of the size of the gain statistics showed that five of these six sectors belonged in the group of sectors significantly more volatile than the aggregate level of production.

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[1]The figure in parentheses after the sector name is the estimated partial elasticity with respect to real GNP reported in Table XX. Since three alternate sectoral models have been specified, the regressions produced three estimates of the partial elasticities of each sector output with respect to changes in GNP. This analysis will utilize the estimates produced by the regression estimates of equation (VI-1)--that including the interest rate as the monetary variable. The results of these regression equations rather than those relating to either of the equations including the money stock have been chosen partly because the coefficients of determination for this specification were the highest for almost every sector. In addition, there is much less covariance between the interest rate series and the GNP than in the case of either money stock series and GNP, so that the estimates of the partial elasticities include smaller biases in the regression equations including the rate of interest. It should be remembered, however, that the partial elasticities with respect to GNP probably do include a certain degree of upward bias for at least some of the sectors.

Turning to those sectors which were found to have relatively low estimated partial elasticities with respect to GNP, the results in Table XX indicate that the six sectors with the smallest estimated elasticities are the following: (1) Tobacco products (.3827); (2) Leather (.4393); (3) Foods and beverages (.6516); (4) Crude oil (.7882); (5) Lumber (.8087); and (6) Petroleum products (.8290).

Referring again to Table V, one finds that these six sectors are all in the group of the eight least volatile sectors, as measured by percentage change over the business cycle. Comparing the regression results with the cross-spectral evidence (Table XI) one finds that four of these six sectors were classified as significantly less volatile than aggregate output, while the other two were not found to be significantly less volatile than aggregate output.

Considerable variation also was shown in the sizes of the estimated partial elasticities with respect to real GNP in the case of the twelve broadly-defined sectors. The regression results in Table XXVI show the three sectors with the highest elasticities to be Communications (1.5937), Durable manufacturing (1.4129), and Wholesale trade (1.4074). Comparing these results with the findings in Chapter Three is not as productive, since the analysis of cyclical fluctuations in annual series could not be as precise.[1]

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[1]Refer to section III.B. for a discussion of the weaknesses of this analysis in the case of the annual series.

The evidence in Table VII reveals that of these three, only the Durable manufacturing sector exhibited more cyclical volatility than aggregate production. In the case of the other two sectors, both experienced more rapid growth during expansions, but did not suffer greater contractions during recessionary periods.

The three major sectors having the smallest estimated partial elasticities wer (in Table XXVI): Contract construction (.000);[1] Agriculture, forestry, and fisheries (.2312); and Mining (.6199). Referring to Table VII, two of these sectors are shown to have been less volatile than aggregate production. However, the Mining sector exhibited major cyclical variations, so that the regression results are contradictory for this sector. It may be recalled that two components of this sector (the Metal mining and Coal sectors) were found to be in that group of manufacturing sectors whose output variations were not adeuqately described by the model employed in this study. The contradiction found at this point is probably another manifestation of this same phenonemon.

To briefly summarize the preceding paragraphs, the size of the estimated partial elasticities is, in general, directly related to the relative amount of cyclical variation which occurs in the sectoral output levels. Therefore, the relative sizes of

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[1]The estimated partial elasticity with respect to real GNP was not indicated to be significantly different from zero (at the .05 level).

partial elasticities with respect to changes in real GNP indicate the differential size of indirect effects of either monetary or fiscal policy actions. So these estimates of the partial elasticities with respect to changes in real GNP are important to the study of the differential effects of monetary and fiscal policy actions, because the relative sizes of the estimated elasticities indicate which sectors are affected most and which least by variations in aggregate economic activity resulting from the policy actions.

In a previous study of the differential sectoral responses to monetary and fiscal policy actions, Leonall Anderson[1] estimated the effect upon the income level which would occur due to changes in the money stock, in government expenditures, and in revenues. So, by examining the relative size of the sectors' income elasticities, Anderson discovered which of the ten sectors would be affected most by both monetary and fiscal policy actions. Anderson's group of sectors are not the same as the sectors included in this study, but his estimates of the income elasticity of output are presented in Table XXVIII[2] for comparative purposes.

Matching, to the extent possible, Anderson's estimated income elasticities with those estimated in Chapter Six (for example

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[1]Leonall C. Anderson, "The Incidence of Monetary and Fiscal Measures on the Structure of Output."

[2]Anderson, "The Incidence of Monetary and Fiscal Measures on the Structure of Output," p. 264.

TABLE XXVIII

ANDERSON'S ESTIMATES OF INCOME ELASTICITIES OF SECTORAL OUTPUTS (ANNUAL DATA 1929-41 AND 46-59)

Sector	Income Elasticity
Construction	
State and local governments	.86
Public utilities	1.03
Commercial	1.21
Industrial	1.34
Residential	1.72
Capital Goods	
Producer durables	1.30
Farm equipment	1.14
Consumer Goods	
Autos	1.66
Furniture	1.28
Food	.51

Source: Leonall C. Anderson, "The Incidence of Monetary and Fiscal Measures on the Structure of Output," Review of Economics and Statistics, IVL (August, 1964), 264.

in Table XX), one finds, for instance, that his estimated elasticity of the Food sector is relatively similar to the elasticity estimated by this study for the Food and beverage sector (.51 versus .6156). His estimate of the income elasticity for the output of the Furniture sector is also fairly similar to that of this study (1.28 versus 1.4608). While the rest of the sectors in the Anderson study are not as directly comparable as in these two cases, it would seem that his estimated income elasticities for Producer's durables, Farm equipment, and Autos are somewhat smaller than the estimates for similar durable goods sectors in this study. Finally, it is difficult to compare Anderson's estimates of the income elasticities of the Construction sectors with the estimated elasticity of the Contract construction sector, found in this study, since the results relating to this particular sector in this study are suspect.

Since Anderson employed different data series for a different time period, it is not surprising that the results are not identical even for those sectors which are directly comparable. The relative similarity of the estimates, however, does support the validity of the regression results presented in Chapter Six.

VII.C. The Estimated Elasticities With Respect to Changes in the Monetary Variables

The regression results provide not just one, but three tests of the existence of direct effects of monetary policy actions upon sectoral outputs. The original "IS-LM" type, in which monetary policy actions were assumed to affect the real sectors through the rate of interest, seemed to produce the best results.[1]

The first subsection discusses the regressions estimating the partial elasticities in equation (VI-1)--the relation including the rate of interest. The second subsection interprets the regressions estimating equation (VI-3)--that including "M_1;" and the third analyzes the results of the regressions estimating the partial elasticity of each sectoral output with respect to "M_2" (equation VI-4). The final subsection discusses the relatively poor results produced by analyses in terms of the money stock and summarizes the evidence of the first three subsections concerning the sectoral effects of monetary policy actions.

The Estimated Interest Elasticities

The lagged regression results for the manufacturing sectors (presented in Table XX), show that the estimated interest elasticities of output for ten sectors were both negative in sign and statistically significant (at the .05 level). The t-ratios indicated that the estimates of the interest elasticities for eleven other sectors were not significantly different from zero, so the null hypothesis that interest rate changes had no direct effects on sectoral

[1]The criteria by which the specification containing the interest rate was selected as the "best" of the three alternatives are explained later in this section.

production could not be rejected for these sectors. The estimated interest elasticities of the other three sectors indicated that a significant positive relationship existed between the interest rate and the output levels of these sectors. Such estimated positive interest elasticities are most probably spurious regression results. While it would be possible that interest rate movements might have positive output effects upon certain industries, such results do not seem meaningful for these sectors (Printing and publishing, Chemicals, and Tobacco). For the purposes of this study, therefore, the estimates obtained from the regression equations are assumed to be biased and interest rate movements are assumed to have no direct effects upon output of these three sectors. In all future cases where the regression results for some of the sectors indicate a statistically significant, but theoretically perverse relation between variations in the aggregate variable and sector output, the estimates are treated similarly and the findings are interpreted as showing that no direct influence exists.

Even ignoring the relative sizes of the negative interest elasticities, the regression results support the hypothesis that interest rate variations have differential sectoral effects, since ten sectoral outputs are affected adversely by interest rate movements, while there is no evidence that the other fourteen are so influenced.

The group of ten sectors, indicated by the regression results to be significantly affected by interest rate movements are listed in Table XXIX.[1] Of the ten, five sectors would be classified as durable goods sectors and two are closely related to primary metals production (Coal and Metal mining) so that seven of the ten could be considered as durable goods or investment-oriented sectors.

Examining the relative sizes of the estimated interest elasticities, a very wide range exists, so that there would seem to be a further degree of differential impact among the sectors. In Table XXIX, one finds that the sectors indicated to be most interest-sensitive are either primarily investment-durable goods sectors (Primary metals and Nonelectrical machinery) or closely related to them (the Coal sector).

The results of the regressions in which a lagged relationship was specified between the interest rate and the output series provide support for the hypothesis that there is a lag between interest rate changes and their maximum effect upon sectoral outputs. For every sector in which the interest elasticity was indicated to be significant, the regression equation yielding the best relationship involved a specified lag of two to four quarters between the interest rate and the output series. It is very interesting to notice the almost perfect relationship between the relative size of the estimated interest elasticity and the length of lag.

TABLE XXIX

SECTORS WITH SIGNIFICANT INTEREST ELASTICITIES, ELASTICITIES OF OUTPUT, AND SPECIFIED LAGS (FROM REGRESSION RESULTS IN TABLE XX)

Sector	Interest Elasticity	Lags (qtrs.)
Primary metals	-1.0803	4
Coal	- .9106	4
Nonelectrical machinery	- .4495	4
Metal mining	- .4007	4
Lumber	- .3813	3
Fabricated metal products	- .3040	3
Textile mill products	- .2208	3
Rubber and plastics	- .1883	3
Clay, glass, stone products	- .1718	2
Miscellaneous	- .1616	2

The evidence of the regression results relating to the twelve broadly-defined sectors is very similar to the findings just presented for the manufacturing sectors. In the set of sectoral regression equations which yielded the highest coefficient of determination (Table XXVI), the estimated interest elasticities of four sectors' outputs were indicated to be both negative and significant (at the .05 level). The estimated interest elasticities of six other sectors were not found to be significantly different from zero, although for four sectors, the estimates did have the correct theoretical (negative) sign. The interest elasticities of the remaining two sectors were indicated to be both positive and statistically significant. Again, it must be assumed that the estimated elasticities for these two sectors are spurious.[1]

These findings relating to the twelve broadly-defined sectors, also support the hypothesis that monetary policy actions, working through the monetary sector to affect the rate of interest, have differential sectoral impacts. In the case of eight sectors, the evidence does not indicate the existence of any direct effects

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[1]These positive estimated elasticities are not interpreted as meaningful empirical evidence that interest rate movements have positive effects on output in either the Construction or the Electricity, gas, and sanitary service sectors. As previously stated in VII.B., with regard to the Construction sector, the sectoral relationships specified for the empirical analysis seem to be inadequate to explain changes in output for some of the sectors under analysis. In the case of these two sectors, variations in output are caused by factors other than the five aggregate variables employed in this analysis, and the exclusion of these variables from the regression equation led to biased estimates of the regression coefficients.

upon sectoral outputs of interest rate movements. For the four interest-sensitive sectors, monetary policy has been indicated, by the relative sizes of the estimated interest elasticities, to have slight effects upon the outputs of the Nondurables manufacturing and the Mining sectors, and substantial effects upon the outputs of both the Durable goods and Transportation sectors.

The specification of a lagged relationship improved the regression equations of only two of the twelve sectors, but these two were sectors in which the interest elasticity was found to be statistically significant. The maximum response of most sectors to interest rate movements seemed to occur within one year. At the same time, there was evidence that a significant lag exists between variations in the rate of interest and the maximum effects of the changes upon the output of two sectors--Durable manufacturing and Mining.

It is possible to make comparisons between the findings of the quarterly and annual analyses concerning the length of the lag between interest rate changes and output responses for these two sectors. The specified lag which yielded the best regression equation for such Durable goods sectors as Primary metals, Non-electrical machinery, Electrical machinery, and Transportation equipment was four quarters and for no sector was a coincident relationship between the interest rate series and the sectoral outputs found to produce results superior to a lagged relationship. Similarly, assumed lags of four quarters were indicated to produce the best regression equations for both the Coal and Metal mining sectors in the quarterly regression analysis (Table XXIX).

There have been previous analyses of the interest elasticities of investment and of expenditures on consumer durables, but these estimated elasticities are not strictly comparable with the estimated interest elasticities of sectoral outputs presented in Table XXIX. First, these findings relate to the interest elasticity of expenditures in nominal terms, rather than the elasticity of a measure of real physical product. Secondly, the evidence usually relates to aggregate expenditures, rather than to specific sector products. Finally, the interest elasticity of expenditures upon certain consumer durable products have been estimated in past studies, but these product groups are not precisely comparable with the sector classifications in this study. It is still possible, however, to make rough comparisons of the estimates of interest elasticity of sectoral outputs with some of the previous evidence.

Many recent empirical studies have estimated the interest elasticity of investment expenditures and found the elasticity to be both substantial and statistically significant. For example, Yehuda Grunfeld, in his study of the data of eight large firms, estimated the average interest elasticity of investment in plant and equipment to have been -0.5.[1] In a widely quoted paper, Jorgenson obtained an estimated interest elasticity of -.379.[2] Hammer obtained an estimate of -0.5 for the long run interest elasticity of investment;[3] a study by Goldfeld also estimated the interest elasticity of investment to be -0.5 or -0.6;[4] and Griliches and Wallace, in an analysis based upon the Grunfeld paper, obtained an estimated interest elasticity of -.37.[5] In Table XXIX, several of the sectors found to have significant interest elasticities oc output would seem to be precisely those sectors which would produce the bulk of those goods purchased by investment expenditures--the Primary metals, Nonelectrical machinery, Lumber, and Fabricated metal products sectors. In fact, the estimated interest elasticities of output for the Nonelectrical machinery and Fabricated metal products sectors were -.4495 and

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[1]Yehuda Grunfeld, "The Determinants of Corporate Investment," in The Demand for Durable Goods, ed. by Arnold C. Harburger (Chicago: University of Illinois Press, 1960), p. 240.

[2]Dale W. Jorgenson, "Capital Theory and Investment Behavior," American Economic Review, LIII (May, 1963), 258.

[3]Frederick Hammer, The Demand for Physical Capital (Englewood Cliffs, New Jersey: Prentice-Hall, 1964), p. 112.

[4]Stephen Goldfeld, Commercial Bank Behavior and Economic Activity (Amsterdam: North-Holland, 1966), p. 166.

[5]Zvi Griliches and Neil Wallace, "The Determinants of Investment Revisited," International Economic Review, VI (September, 1965), 324.

-.3040, which are reasonably close to the estimates of the interest elasticity of investment. Similarly, the regression results based upon annual data estimated the interest elasticity of Durable manufacturing production to be -.2743. Now, while these results are not directly comparable, since the investment studies utilized aggregate data for different time periods and also relate to expenditures rather than real output, the similarities do lend support to the validity of the estimates of sectoral interest elasticities obtained in Chapter Six.

In a study of expenditures upon consumer durables, Hamburger estimated the interest elasticities of expenditures on new autos and of expenditures for other durables.[1] He found the interest elasticities to be -.85 for auto purchases and -.17 on expenditures for other durables. Once again, these previous findings are not directly comparable with the results in Chapter Six, but it is interesting to note that the estimated interest elasticity of durable manufacturing output, (Table XXVI), -.2743, is between Hamburger's two measures of interest elasticity of expenditures for two components of this production.

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[1]Michael J. Hamburger, "Interest Rates and the Demand for Durable Goods," American Economic Review, LVII (December, 1967), 1131-1153. He indicates that the major components of other durables are furniture and household equipment. As the interest rate, Hamburger utilizes the yield on Aaa corporate bonds.

The Estimated Elasticities with Respect to Changes in the Narrowly Defined Money Stock

Of the twenty-four manufacturing sectors, seven are found to have estimated elasticities of output with respect to changes in "M_1" which were both positive and statistically significant (Table XXI). Among these seven, the regression equation yielding the best results for the Primary metals, Leather, and Textile mill products sectors, was the estimation of the coincident relationship in which no lag was assumed between the money stock and the output series. Since changes in the money stock are generally assumed to affect production only with a significant lag, the estimates of the elasticities of output with respect to "M_1" for these three sectors may be suspect.

Of the remaining seventeen manufacturing sectors, the estimated elasticities with respect to "M_1" for fourteen were not shown to be significantly different from zero; and it must be assumed, on the basis of this evidence, that monetary policy actions resulting in variations in "M_1" cause no direct output responses by these sectors.

For three sectors, Table XXI contains estimated elasticities with respect to "M_1" indicating the existence of a significant negative relationship between changes in "M_1" and output. Since it does not seem reasonable that the production of the Instruments, Chemicals, or Tobacco sector should be negatively related to changes in the narrowly-defined money stock, these estimates of the sectoral elasticities must be assumed to be spurious. It therefore seems most appropriate to include these three sectors in the group for which the evidence has indicated that variation in the money stock has no direct influence upon the sector output.

Examining those sectors for which the empirical evidence supports the hypothesis that monetary policy actions, as measured by changes in "M_1," directly affect output, one finds the Primary metals sector, which is closely related to the production of investment and other durable goods. Also included are the Clay, glass, and stone products and the Lumber sectors, both of which provide materials for construction activities. Both the Coal and Metal mining sectors, which are closely related to the Primary metals sectors, are also included in the group.

The evidence from the lagged regressions provides an indication of the length of lag between monetary policy actions, as measured by changes in the narrowly-defined money stock, and the maximum resulting response in real production by the various sectors. The lags yielding the best regression equations were in the range of two to four quarters.[1]

Turning to the results for the set of twelve broadly-defined sectors (Table XXVII), for five of the sectors the partial

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[1]This ignores the three sectors discussed earlier for which the coincident relationship yielded the best regression equations.

elasticities with respect to "M_1" have been estimated to be both positive and statistically significant (at the .05 level). The results in Table XXVII show that the estimated partial elasticities for another five sectors are not significantly different from zero. Finally, in the case of two sectors, Contract construction and Electricity, gas, and sanitary services, the regression results indicate that there is a significant negative relationship between changes in "M_1" and variations in output for these sectors.

Those sectors, which have been indicated to be influenced by variations in "M_1" are not the same sectors shown by the estimated interest elasticities to be affected by monetary policy actions. Only the Transportation sector was found to have both a significant positive partial elasticity with respect to "M_1" and a significant negative interest elasticity. In particular, these results are peculiar in that the Durable manufacturing sector, which is closely related to investment, was not indicated to have a positive partial elasticity with respect to "M_1."

As shown in Table XXVII, the specification of lags between the money stock and output series resulted in the improvement in the regression equations of six sectors. The evidence provided by the lag specification suggests that the maximum effects of money stock changes upon sectoral outputs occurred within one year for the Transportation sector, while it implies that a significant lag exists with respect to the other sectors which have significant positive partial elasticities.

The Estimated Elasticities With Respect to Changes in the Money Stock Defined to Include Time Deposits

The regression results relating to the relationship between variations in the broadly-defined money stock, "M_2," and sectoral outputs were found to be substantially different from the estimates of the sectoral elasticities with respect to "M_1." As portrayed in Table XXV, the number of manufacturing sectors with estimated partial elasticities with respect to "M_2" which are both positive and statistically significant is eight. For nine sectors, the partial elasticities of sectoral product with respect to changes in "M_2" were not estimated to be statistically different from zero; and for seven sectors, the partial elasticities with respect to "M_2" were estimated to be both negative and statistically different from zero. Therefore, the regression results indicate direct sectoral responses (with a lag) to variations in "M_2" by eight sectors; and conversely there is no evidence that output rates of the other manufacturing sectors are influenced by changes in the real money stock (defined to include time deposits), except as such changes affect the level of aggregate spending.

The estimated values of the elasticities with respect to changes in the real money stock were very different between the two alternate definitions of the money stock. Eight sectors were found to have positive significant elasticities in the regressions including "M_2," while the number was seven for "M_1"--but only the Coal and Textile mill products sectors were common to both sets. Further, in the case of some sectors, the sign of the elasticity was different between the two regression equations. Such results are obviously traced to the different variance patterns between the two money stock series, with the regression results for each sector favoring the alternate money stock which has the pattern of fluctuation conforming more closely to that of the output series. Comparing the groups of sectors for which positive and significant estimated elasticities were obtained with respect to "M_1" and "M_2," no sharp distinction can be made between the types of sectors found in the two groups, since both groups include mining, durable and nondurable manufacturing sectors.

Thespecification of lags between "M_2" and each output series produced measures of the lag in sectoral responses very similar to that provided by the equations including the interest rate as the monetary variable. The specified lags producing the best results were in the two to four quarter range, with four quarters being the most common.

In the regression results for the set of twelve broadly-defined sectors (Table XXV), the partial elasticities of five sector outputs with respect to "M_2" were estimated to be positive and statistically significant (at the .05 level). Of the remaining seven sectors, the estimated partial elasticities of five were not found to be significantly different from zero; while for the other two sectors, the estimated elasticities indicated a negative relationship between variations in "M_2" and their output.

On the basis of these results, the hypothesis that monetary policy actions have direct positive effects on output is supported in the case of five sectors. By comparison of the relative sizes of the estimated elasticities, it would seem that the Transportation sector would be affected to the greatest extent by changes in "M_2," with the Wholesale trade and Service sectors also affected considerably, and the output levels of the Nondurable manufacturing and Retail trade sectors influenced to a lesser degree.

Unlike the evidence with respect to interest rate movements and changes in "M_1," the specification of a lagged relationship between the expanded money stock series and the output series did not improve the regression equations for any of the twelve broadly-defined sectors. Such lack of improvement would support the hypothesis that the maximum effect, if any, of changes in the broadly-defined money stock upon sectoral outputs occurs within one year.

Interpretation of the Evidence Concerning the Effects of Monetary Policy Actions

The regression results discussed in all three previous subsections support the hypothesis that monetary policy actions do exert direct influence upon the real level of output of the various sectors of the economy. The three sets of results also provide evidence of differential response patterns by the sectors to changes in monetary policy-related variables. Finally, findings from all three subsections suggest the existence of a significant lag between monetary policy actions and their resulting direct effects upon sectoral outputs.

However, the three alternate analyses of the effects of monetary policy actions have produced somewhat dissimilar results. Since the results are somewhat different, it seems necessary to discuss the differences and to make a decision as to which of the results seem most accurate. Unfortunately, no easy unequivocal decision is possible; but, on balance, the estimation of the sectoral effects of monetary policy actions in terms of interest rate movements seem to have produced the best results.

This decision has been based upon a two-step process. First, consider the regression results for each of the three alternate specifications. In particular, examine the "box score" presented in Table XXX, which presents the number of sectors estimated to have partial elasticities which (1) are significant and have the correct theoretical sign, (2) are not significant, (3) are significant and have the theoretically inverse sign, for both sector classifications. These statistics indicate the superiority of the results relating to the rate of interest and to "M_1" over those relating to "M_2," in that the estimated partial elasticities with

TABLE XXX

CLASSIFICATION OF SECTORS BY THE SIGN AND SIGNIFICANCE OF THEIR ESTIMATED PARTIAL ELASTICITIES WITH RESPECT TO THE MONETARY VARIABLE FOR BOTH DATA SETS

	Number of Sectors		
Monetary Variable	Correct Sign & Significant	Not Significant	Incorrect Sign & Significant
Manufacturing Sectors			
R	10	11	3
M_1	7	14	3
M_2	8	9	7
Broadly-defined Sectors			
R	4	6	2
M_1	6	5	1
M_2	5	5	2

respect to "M_2" showed a negative significant relationship between changes in the money stock and manufacturing sector outputs almost as many times as they did a significant positive relationship--in about one-third of the manufacturing sectors. For the other broadly-defined sectors, the regression results relating to "M_1" seem slightly better than either of those relating to the interest rate or to "M_2," in that only one of twelve sectors was found to have an estimated partial elasticity indicating the existence of a negative significant relationship between "M_1" and the sector output.

Turning to the second criterion, the results relating to the interest rate seem superior to those relating to "M_1." the estimates of the partial elasticities of output with respect to changes in "M_1" for either the Nondurable manufacturing or the Durable manufacturing sectors were not found to be significantly different from zero (Table XXVII), while the interest elasticities for both of these sectors were estimated to be significant. Since the manufacturing sector of the economy is generally viewed as one of the most volatile components of aggregate activity and particularly since the Durable manufacturing sector is primarily involved with investment goods, these results make the validity of the estimated partial elasticities with respect to "M_1" somewhat suspect as compared with the interest rate results. Further, in the group of manufacturing sectors, the interest elasticities of the Fabricated metal products and Nonelectrical machinery sectors were indicated to be negative and statistically significant, while the estimated partial elasticities of these sectors with respect to "M_1" were not found to be significantly different from zero (Tables XX and XXI). Since these two sectors are primarily involved in the production of consumer durables and investment goods, it seems reasonable that monetary policy actions should be found to have direct effects upon these sectors.

Therefore, based upon these somewhat arbitrary criteria, the results obtained from interest rate variations seem, on balance, to provide the most valid measure of the differential sectoral effects of monetary policy actions upon the levels of real output.

Although many previous aggregate studies have found that changes in the money stock exert a very important influence upon the level of aggregate economic activity, there are several reasons why the empirical results in this analysis did not show the same strong relationship (particularly with respect to "M_2"). First, the aggregate studies such as those of Friedman and Meiselman,[1]

[1]Milton Friedman and David Meiselman, "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958," in Stabilization Policies, ed. by Commission on Money and Credit (Englewood Cliffs, N.J.: Prentice-Hall, 1963), pp. 165-268.

Anderson and Jordan,[1] and Keran,[2] have investigated the empirical relationship between changes in the nominal money stock and a measure of aggregate economic activity in current dollar terms, and the correlation between the two series has, therefore, been improved by price level variations in both series. This study examines the direct relation between the real money stock and real output, and this relationship may be much weaker. Secondly, the empirical analysis in Chapter Six included both a measure of real aggregate expenditures (GNP) and the real money stock, so that only the direct effect of monetary policy actions, in addition to those influences working through the money-aggregate expenditures relation, has been measured by the partial elasticities with respect to the money stock. In previous analyses, only the money stock was included in the regression equation, so that findings of a stronger positive relationship between money stock changes and economic activity would be expected.

In addition to studying the evidence of significant direct relations between money stock variations and the product levels of individual sectors, this analysis expressed the relation in two

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[1]Leonall C. Anderson and Jerry L. Jordan, "Monetary and Fiscal Actions: A Test of their Relative Importance," Review of the Federal Reserve Bank of St. Louis, L (November, 1968), 11-24.

[2]Michael W. Keran, "Monetary and Fiscal Influences on Economic Activity--The Historical Evidence," Review of the Federal Reserve Bank of St. Louis, LI (November, 1969), 5-24.

alternate forms, in order to investigate the differences which would result from utilizing the broader definition of the money stock (including time deposits) in place of the more conventional money stock definition. As would be expected, the estimated partial elasticities with respect to "M_1" were considerably different than the estimated elasticities with respect to "M_2" even for sectors for which both estimated elasticities were indicated to have the correct theoretical sign and to be statistically significant. However, in addition, changing the definition of the money stock caused more drastic dissimilarities. As explained in VII.C., the results with respect to "M_1" show that monetary policy actions seem to have direct effects on a group of seven manufacturing sectors, while the results relating to "M_2" show the direct influence to affect an almost entirely different group of eight sectors.

The empirical analysis of the lag in the effects of monetary policy actions, in terms of the two alternate money stock definitions, has also produced conflicting results. While the cross-spectral findings and the regression results for the manufacturing sectors indicated that the lag in the effect for changes in both "M_1" and "M_2" were relatively similar, the findings relating to the set of twelve broadly-defined sectors produced quite different indications. The findings relating to "M_1" (Table XXVII) suggested the existence of a significant lag in sectoral effects for five of six sectors where the partial elasticity was estimated to be positive and significant. However, the findings relating to the lag between changes in "M_2" and the resultant sectoral effects (Table XXV), on the other hand, indicated that the maximum effects occurred within one year.

While the coherence statistics of the cross-spectral analysis (Tables XVIII and XIX) suggested that there was a closer relationship between variations in the "M_2" and the output series than between "M_1" and the output series, the results of the regression equations including "M_2" as the monetary variable were much inferior to those with "M_1." Therefore, on balance, the empirical evidence included in this study suggests that the narrowly-defined money stock is the better series for empirical analysis of monetary policy actions.

Now that the results of the three alternate specifications of the monetary variable have been compared, this section will conclude with a short general interpretation of the evidence regarding the influence of monetary policy actions upon sectoral outputs. The regression results suggest the existence of differential sectoral effects of such policy actions, with those sectors most affected being durable goods, investment-oriented sectors, and mining sectors. At the same time, the results imply that the output levels of at least a majority of the sectors are not directly affected by monetary policy actions.

These results, therefore, agree with the past statements in economic literature which designate the durable and investment goods sectors as those most affected by monetary policy actions. For example, the Commission on Money and Credit states the the "general monetary measures have their direct major impact upon capital formation with smaller effects upon consumer durables."[1]

The regression results of the lagged regressions suggest the existence of a significant lag in the direct effects of monetary policy actions upon sectoral outputs. For the manufacturing sectors, for which analysis in terms of quarterly data was possible, the findings indicate a lag of two to four quarters between change in the monetary variable and its maximum resultant effect upon output. The median of the estimated lags would seem to be between three and four quarters, and there seemed to be a direct relationship between the size of the estimated partial elasticity and the length of lag indicated by the regression equations.

The analysis of the monetary policy lags with respect to the output of the twelve broadly-defined sectors would not be precise due to the availability of the data series only in annual form. The results are not unequivocal, but the findings for many of the sectors do suggest the existence of substantial lags in the effects of monetary policy actions upon sectoral outputs.

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[1]Commission on Money and Credit, ed., Money and Credit, p. 246.

Although prior studies have not examined the lag between monetary policy actions and their maximum impact upon the real output of individual sectors, many previous analyses have investigated the lag between monetary actions and their effects upon aggregate economic activity measured in nominal terms. The estimates of the outside lag produced by these studies vary over a considerable range,[1] but as stated by Mayer, "there is strong evidence that the lag is actually at least two quarters."[2]

In particular, these results relate to evidence on the length of the lag presented by Karaken and Solow.[3] They state that the lag between monetary policy actions and their effects upon production of investment goods is long, since the actions primarily affect new orders whereas output responds very sluggishly to changes in new orders, and estimate the lag to be at least one year, which compares to an estimate of approximately one year as found by this study.

Chapter Six also included cross-spectral analysis of the outside lag, and this investigation is closely related to the

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[1]For an excellent summary of the empirical studies of the outside lag, see Mayer, Monetary Policy in the United States, p. 189.

[2]Mayer, Monetary Policy in the United States, p. 183.

[3]Albert Ando, E. Cary Brown, Robert Solow, and John Kareken, "Lags in Monetary and Fiscal Policy," in Stabilization Policies, ed. by the Commission on Money and Credit (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1963).

previous analysis of the outside lag by Bonomo and Schotta.[1] They employed "M_1" and "M_2" in nominal terms as their monetary variables and the total index of industrial production as the output measure in their cross-spectral analysis, and estimated the outside lag to be slightly more than two months. While the Bonomo-Schotta results indicate a shorter lag than that estimated by cross-spectral techniques in this study, the discrepancy may be due to differences in analytical procedures, rather than for substantive reasons. In addition to utilizing nominal money stock figures, the Bonomo-Schotta analysis was different in that they used monthly data (rather than quarterly) for a different time period and a first-difference transformation (rather than percentage changes) as a "high-pass" data filter.

To conclude the discussion of the length of the outside lag in monetary policy, the findings of this study seem in reasonable agreement with the estimates produced by the previous studies and have produced further evidence of a somewhat different nature, since the analysis investigated the relationships in real terms and on a disaggregated basis.

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[1]Vittorio Bonomo and Charles Schotta, "Some Aspects of the Outside Lag in the Effect of Monetary Policy: A Preliminary Report," Proceedings of the American Statistical Association, (August, 1968), pp. 482-90.

VII.D. The Estimated Elasticities with Respect to Changes in the "High Employment" Deficit

The partial elasticity of each sectoral output with respect to changes in the "high employment" deficit has been estimated in each of the three alternate specifications of the sectoral relationship; and, for each sector, the estimates of its partial elasticity were similar in each of the regression equations. To a large degree, the sectors, in each of the three specifications, for which the partial elasticities of output with respect to the deficit were found positive and significant were the same in all three cases. In the set of regression equations estimating equation (VI-1), fourteen of the manufacturing sectors were indicated to have positive and significant estimated partial elasticities (Table XX). In the set of regression equations estimating equation (VI-3), partial elasticities for fifteen sector outputs which were positive and significant were obtained (Table XXI), and for the regression equations estimating equation (VI-4), the partial elasticities of thirteen sectors were found to have the correct theoretical sign and to be statistically significant (Table XXII). For comparative purposes, the estimates of the partial elasticities with respect to changes in the "high employment" deficit, for all of the manufacturing sectors in which positive and statistically significant values were obtained, have been listed in Table XXXI. The headings above each column of estimated sectoral elasticities refers to the set of

TABLE XXXI

THE ESTIMATED ELASTICITIES WITH RESPECT TO CHANGES IN THE HIGH EMPLOYMENT DEFICIT IN EACH OF THE ALTERNATE SPECIFICATIONS FOR THOSE MANUFACTURING SECTORS IN WHICH A SIGNIFICANT RELATIONSHIP WAS FOUND

Sector	Eq. VI-1	Lag (qtrs.)	Eq. VI-3	Lag (qtrs.)	Eq. VI-4	Lag (qtrs.)
Fabricated metal products	.0189	2	.0267	2	.0218	2
Nonelectrical machinery	.0456	0	.0666	0	.0667	0
Clay, glass, stone products	.0294	0	.0295	0	.0209	0
Furniture	.0441	0	.0419	0	.0494	0
Apparel products	.0287	1	.0297	1	.0370	1
Leather	.0210	1	.0199	0	.0151*	1
Paper	.0395	0	.0389	0	.0395	0
Printing	.0148	1	.0214	0	.0266	0
Chemicals	.0451	1	.0501	0	.0465	0
Petroleum	.0172	0	.0200	0	.0121	0
Rubber and plastics	.0314	0	.0228	0	.0292	0
Food and beverages	.0172*	0	.0215	0	.0239	0
Tobacco products	.0431	4	.0399	4	.0486	4
Metal mining	.0646	3	.0821	3	.0428*	3
Stone and earth minerals	.0423	0	.0515	0	.0338	0

*This estimated elasticity was not indicated to be significantly different from zero (at the .05 level).

regression equations from which they come. For later reference, the lag specified in the regression equation is printed following the elasticity value.

The regression evidence relating to the set of twelve broadly-defined sectors is very similar to those discovered for the set of manufacturing sectors. The estimated values of the partial elasticities for each sector were very similar among the three sets of regressions, and the estimated elasticities show that fiscal policy actions have small but significant direct effects upon the production levels of a high proportion of the sectors. In the regression equations estimating equation (VI-1), the estimated partial elasticities of seven of the twelve sectors were indicated to be both positive and significant (Table XXVI); and in those regressions estimating the relationships in equations (VI-3) and (VI-4), the partial elasticities were estimated to be positive and significant for the same eight sectors (Tables XXVII and XXV respectively). For comparison, the estimated sectoral elasticities which were indicated to be positive and significant have been listed in Table XXXII.

In all the sets of regression equations, the partial elasticities with respect to changes in the "high employment" deficit for all of the remaining sectors' outputs were not indicated to be significantly different from zero (at the .05 level). In no case was an estimated partial elasticity found both to be significant and have the incorrect theoretical sign.

TABLE XXXII

THE ESTIMATED ELASTICITIES WITH RESPECT TO CHANGES IN THE HIGH EMPLOYMENT DEFICIT IN EACH OF THE ALTERNATE SPECIFICATIONS FOR THOSE BROADLY-DEFINED SECTORS IN WHICH A SIGNIFICANT RELATIONSHIP WAS FOUND

Sector	Eq. VI-1	Lag (yrs.)	Eq. VI-3	Lag (yrs.)	Eq. VI-4	Lag (yrs.)
Nondurable manufacturing	.0107	0	.0103	0	.0108	0
Durable manufacturing	.0275	0	.0321	0	.0353	0
Communications	.0222*	0	.0298	0	.0263	0
Electricity, gas, and sanitary services	.0375	0	.0581	0	.0423	0
Wholesale trade	.0315	0	.0279	0	.0328	0
Retail trade	.0086	0	.0086	0	.0089	0
Finance, insurance, real estate	.0289	0	.0300	0	.0310	0
Services	.0272	0	.0249	0	.0293	0

*This estimated elasticity was not indicated to be significantly different from zero (at the .05 level).

On the basis of this empirical evidence, it seems that fiscal policy actions, as measured by changes in the "high employment" deficit, elicit much smaller direct responses in sectoral outputs, but these output effects seem more evenly spread throughout the sectors--for section VII.C. indicates that, at most, monetary policy actions have direct effects upon ten sectors. As shown in Table XXXI, some of the sectors for which positive and statistically significant estimated elasticities were obtained are primarily durable goods or investment-oriented sectors (Fabricated metal products, Nonelectrical machinery, and Clay, glass, and stone products), and two are mining sectors (Metal mining and Stone and earth minerals), but most are nondurable manufacturing and/or "consumer-product-oriented" sectors.

There are a number of reasons why the estimated elasticities of sectoral output with respect to changes in the deficit measure were discovered to be relatively small. First, this analysis has measured the direct effect of the changes in the net demand by government for goods and services. This source of demand is spread over a large number of sectors, so that the sectoral partial elasticities would be expected to be relatively small. Further, the importance of variations in the "high employment" deficit may be underestimated by the regression analysis, due to the data transformation necessary to utilize the "high employment" deficit series in the "log" regressions. As explained in VI.C., the deficits were converted to a series containing all positive numbers by the addition of a constant term to each deficit value. By this action, the relative volatility of the fiscal variable was reduced.[1]

These regression results support the hypothesis that fiscal policy actions have a direct effect upon a majority of the sectors in both classifications. Further, the differential relative sizes of the estimated partial elasticities and the fact that some of the sectors were not found to be directly affected support the hypothesis that fiscal policy actions have differential effects upon individual sectoral outputs. However, the partial elasticities were estimated to be between .0200 and .0800; and, because of such small values together with the probable degree of error in the estimation procedure, it does not seem worthwhile to attach a high degree of significance to the ranking of sectors by size of these estimates.

Looking at the evidence produced by the specification of lags between the deficit and output series, it is obvious that the length of the lag in the sectoral effects for almost all of the manufacturing sectors seems to be one quarter or less. For the set of twelve broadly-defined sectors, the findings are less precise, due to the

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[1]For example, consider the case when the deficit in period 1 was 1.00 and increased in period 2 to 2.00. The percentage increase in the deficit was one hundred percent. However, since approximately fourteen was added to each deficit figure, the change in the index utilized in the regression analysis between these two periods would be from fifteen to sixteen--a much smaller percentage increase.

annual data, but the evidence does not suggest the existence of a significant lag as a coincident relationship provided the best regression equation for every sector.

Since this analysis has measured the direct demand effect of changes in the deficit upon sectoral outputs, the discovery of a short lag would be expected and is in agreement with past findings. The lag between fiscal policy actions and the indirect effect upon individual sectors through aggregate demand would be expected to be considerably longer, but such indirect effects would be measured by the partial elasticities with respect to GNP, and the lags involved in such a process are not estimated in this analysis.

In her study of federal highway projects as countercyclical fiscal policy tools, Ann F. Friedlander has estimated the lag between increased highway expenditures and the resulting effects upon the outputs of construction materials-producing sectors.[1] Her results indicated a maximum lag of two quarters, but she was measuring the lag between the letting of contracts and output increases. Since there would probably be some period of time between letting of contracts and expenditures, these results seem to demonstrate a short lag, perhaps even less than one quarter, between highway expenditures and their effects upon material-producing sectors.

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[1]Ann F. Friedlander, "The Federal Highway Program as a Public Works Tool," in Studies in Economic Stabilization, ed. by Albert Ando, E. Cary Brown, and Ann F. Friedlander (Washington, D.C.: The Brookings Institution, 1968), pp. 103-105.

Although a completely different type of analysis, a simulation study by Ando and Goldfeld[1] of the effects of stabilization actions, also produced results indicating a short lag between fiscal policy actions and their maximum direct effects. The analysis is based upon an aggregative model of the U.S. economy and traces the effects upon various endogenous variables of policy actions, on the assumption that the changes were initiated at the end of 1964. (The model is based upon the 1950-64 period.) Rather than investigating the effects upon real output, the analysis looks at, in part, the effects of changes in government expenditures and the effective tax rate of the personal income tax upon consumption expenditures for nondurables, consumption expenditures for durables, investment expenditures for plant and equipment, and investment in inventories. The simulation results indicated that the maximum effect of a change in government expenditures would be felt within the first quarter for all but investment in plant and equipment, in which the maximum response occurred in the second quarter. For a change in the tax rate, the simulation indicated the maximum effect upon both consumption expenditure categories would occur within the first quarter, but not until the third quarter on plant and equipment investment expenditures,

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[1] Albert Ando and Stephen M. Goldfeld, "An Econometric Model for Evaluating Stabilization Policies," in Studies in Economic Stabilization, ed. by Ando, Brown, and Friedlander. Two other simulation studies of the impact of policy actions have also produced similar results. See Gary Fromm and Paul Taubman, Policy Simulations with an Econometric Model (Washington, D.C.: Brookings Institution, 1968), and Frank Deleeuw and Edward Gramlich, "The Federal Reserve--M.I.T. Econometric Model," Federal Reserve Bulletin, IX (January, 1968), 11-30.

and not until the second quarter for inventory investment. Such results for the tax rate shift would be expected, since the effects of a change in the personal income tax would take somewhat longer to affect investment. Although the results of both studies are not precisely comparable to the analysis of changes in the size of the deficit upon sectoral outputs, they provide general support for the discovery of short lags in the response by sectors to variations in the "high employment" deficit.

VII.E. General Interpretation of Empirical Results

The empirical analysis of Chapter Six investigated the empirical relationships between variations in three aggregate variables (aggregate expenditures, a monetary policy-related variable, and the deficit) and sectoral output levels. In essence, the relative size of these estimated sectoral elasticities with respect to GNP measure the differential effects which changes in the aggregate level of economic activity have upon each sectoral output. To the extent that monetary or fiscal policy actions cause changes in aggregate economic activity (aggregate expenditures in particular), such actions indirectly affect sector production levels through the effects of variations in aggregate expenditures upon sector outputs. Studying the effects of monetary and fiscal policy actions from this viewpoint--looking at the indirect "multiplier" effects upon the sectors--monetary and fiscal policy are seen to influence the output levels of all sectors with nonzero partial elasticities with respect to changes in GNP. Further, the differential size of the sectoral effects are measured by the estimated partial elasticities with respect to GNP.

Both a monetary variable and the deficit were included in the sectoral relation in order to estimate the direct effects of monetary and fiscal policy actions, in addition to their impact through the expenditures-output relation, upon sectoral output. The estimated partial elasticities with respect to changes in the monetary policy-related variable and the estimated elasticities with respect to the deficit measure gave indications that such direct effects did exist and further that there were differential effects among the sectors.[1] The differential nature of these sectoral responses were particularly notable in the results relating to the monetary policy actions, since a smaller number of sectors were found to have significant partial elasticities and the size of those elasticities were larger and varied over a much wider range than the partial elasticities with respect to changes in the deficit.

The evidence from the regression analysis suggests that monetary policy actions (as measured by variations in the rate of interest) primarily affect capital goods-related and mining sectors. In particular, those manufacturing sectors found to have the highest

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[1]It should be remembered that the assumption pertaining to the existence of differential effects among the sectors is based upon the differences in size of the estimated partial elasticities. No test of whether these coefficients are significantly different has been attempted in this study.

estimated interest elasticities (Table XXIX) were related to the production of primary metals and machinery (Primary metals, Coal, Metal mining, and Nonelectrical machinery).

The regression results indicate that fiscal policy action, which involve changes in the deficit, have relatively smaller but more widespread effects than monetary policy actions. In contrast to monetary policy, changes in the "high employment" deficit were found to have significant direct impacts upon many sectors in addition to those related to the production of investment goods.

CHAPTER VIII

CONCLUDING REMARKS

The evidence provided by the analyses in Chapters Three and Four clearly demonstrate the existence of very different patterns of cyclical fluctuation among the individual sectors. The primary contributors to the aggregate real cycle in production have been shown to be the sectors which produce durable or investment goods and closely related sectors, such as the Metal mining sector. At the other extreme, the sectors which seem to be least affected by general business conditions have been those which produce non-durables, particularly those whose products are also consumer-oriented.

Most studies have examined the effects of stabilization policy actions upon the nominal measures of economic activity. The most important finding of this study is evidence which supports the hypothesis that monetary and fiscal policy actions have direct effects upon the real output of at least some sectors, in addition to their indirect effects upon the sector through influences upon the general level of economic activity.

The relative sizes of the estimated sectoral elasticities with respect to changes in aggregate expenditures imply that the indirect effects of both monetary and fiscal policy tend to change the structure of output. For example, policy actions intended to increase aggregate expenditures and production tend to expand the production of capital goods and other durable manufactures relative to the outputs of consumer-oriented and other non-durable sectors.

However, while the direct sectoral effects of fiscal policy actions seem to be relatively widespread, the direct impacts of monetary policy actions are indicated to fall almost exclusively upon the outputs of durable goods and mining sectors, with the greatest influence upon the production of metals and machinery. Therefore, the findings of this thesis concerning the differential sectoral responses to policy actions suggest that the direct effects of monetary actions reinforce the indirect "expenditure" effects, so that the use of monetary policy as a stabilization tool leads to more distortion in the composition of output than does the use of fiscal policy.

VITA

Timothy Davis Hogan was born March 25, 1944, in Phoenix, Arizona. His early education was obtained in the San Ramon Valley Union School District. After attending St. Mary's College, Moraga, California for one year, he transferred to the University of California at Berkeley. In January, 1966, he received his Bachelor of Arts in Economics. He then began graduate study at the Davis campus of the University of California and received a Master of Arts in Economics in June, 1968. Hogan continued graduate training at Virginia Polytechnic Institute and State University and completed the requirements for a Doctor of Philosophy in Economics in July, 1970.

AN ANALYSIS OF THE SECTORAL COMPONENTS OF AGGREGATE ECONOMIC ACTIVITY

Timothy D. Hogan

Abstract

This study investigated the effects of monetary and fiscal policy actions upon the real outputs of a large number of individual economic sectors. Two main hypotheses were tested: (1) monetary and fiscal policy actions have direct effects upon sectoral outputs, in addition to indirect effects working through the influence of general economic activity; (2) monetary and fiscal policy actions have differential direct effects among the sectors, such that stabilization policy actions affect the composition of aggregate production.

Using data for the 1947-69 period, two different sets of disaggregated indexes of real production were utilized as measures of real sectoral output. Real GNP was used as an indicator of the level of aggregate economic activity. Various interest rates and two alternate definitions of the money stock were employed as monetary variables. The "high employment" deficit was utilized as a measure of the net impact of fiscal policy.

Initially, the pattern of cyclical variation in each of the individual sector output series was compared with the general business cycle in order to document a basic assumption of the study--that the sectors have experienced substantially different

variance patterns during the period. In this investigation, both simple descriptive statistical analysis and cross-spectral analysis are employed.

Once the existence of differential sectoral cycles was substantiated, regression analysis was employed to estimate the partial elasticities of the sectoral outputs with respect to changes in each of the aggregate variables. The regression results support both hypotheses tested. The estimated partial elasticities with respect to changes in the monetary variable indicates that the direct impacts of monetary policy actions fall almost exclusively on durable goods and investment-oriented sectors. The evidence suggests that fiscal policy actions have smaller but more widespread direct effects upon sectoral outputs.

The relative sizes of the estimated elasticities with respect to changes in GNP imply that both monetary and fiscal policy actions tend to change the structure of output--policy actions intended to increase aggregate production tend to expand the production of capital goods and other durables relative to the other sectors. Therefore, since the direct effects of monetary policy actions tend to reinforce the indirect effects, the findings suggest that the use of monetary policy as a stabilization tool leads to more distortion in the composition of output than does the use of fiscal policy.