DIFFERENTIAL IMPACT OF MONETARY POLICY: A SECTORAL APPROACH

by

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Chapter I

INTRODUCTION

> Value is the most invisible and impalpable of ghosts, and comes and goes unthought of while the visible and dense matter remains as it was
>
> -- W.S. Jevons

The proposition tested in the thesis is that actual money growth is not systematically related to output growth of selected manufacturing sectors. Given that money growth is found to be non-neutral, two further tests are undertaken.

First, I test the rational expectations hypothesis that only unexpected monetary changes affect output growth against the Phillips' type stabilization hypothesis that both expected and unexpected monetary growth affect output growth. Further, I examine the arguments that under different conditions the degree of association between output growth and money growth (given statistically by the magnitude of the coefficient on money growth) is not constant. The conditions tested relate to the level of capacity utilization and the phase of the business cycle.

Secondly, I test for differential sector to aggregate manufacturing output response. Non-neutrality does not imply differentiality since money growth can be significantly related to individual manufacturing sectors in an identical way. Differential effects might be argued to exist because the different structure of each sector imposes different restrictions on decisions and actions that can be undertaken. If differential effects are found to exist, a test of specific sector characteristics, which may be functionally related to the differential association, will be undertaken.

Money growth was found to be significantly related to individual sector output growth in equations unadjusted for seasonal variation. No association was found in seasonally adjusted estimations indicating that money growth is related to the seasonal amplitude and not the underlying non-seasonal structure. This supports the neutrality proposition.

Expected and unexpected money growth, in the seasonally unadjusted estimations, were found to be statistically significant in nine of the twelve industries examined. Further, these associations are strongly related to the level of capacity utilization and the phase of the business cycle.

The test of differential impact did not support the hypothesis that the incidence of money growth was unequal across sectors. Therefore, no further investigation was necessary.

Section 1.2 Organization of the paper

Section 1.3 of Chapter I sets out the objectives of the study. Section 1.4 summarizes the empirical results. Section 1.5 reviews the theoretical development as background for the model.

Chapter II develops the sectoral model to be tested in the paper. The structural equations for demand, supply and inventory adjustment are discussed in sections 2.1 through 2.3. The model is solved for the reduced form output and inventory equations in section 2.4 Appendix 2A suggests an alternative specification of the sectorial model taking explicit account of Robert Lucas' work on signal extraction from relative prices.

Chapter III describes the methodology for empirical testing. Section 3.1 sets forth the null and alternative hypotheses. Section 3.2 discusses the modification of the estimating equation. Of particular interest is the specification of the capacity utilization and business cycle interactive variables. Section 3.3 discusses the three money rules which underlie the output and inventory equations. Sections 3.4 and 3.5 discuss the test of sector characteristics and the data sets, respectively.

Chapter IV reports the empirical findings of the money rule estimations. Chapter V reports in detail the empirical findings for output and inventory estimations for each sector. Chapter VI summarizes the findings of the paper and suggests avenues for further research.

Section 1.3 Objectives of the Study

The objective of this thesis is to test the proposition that actual money is not systematically related to output growth of selected manufacturing sectors. This is the test of monetary neutrality.

Given that money growth is found to be non-neutral, two further tests are undertaken. The first tests the rational expectations hypothesis that only unexpected monetary changes affect real output, against the Phillips' type stabilization hypothesis, that both expected and unexpected monetary growth affect real output. Following, I examine the argument that under different conditions the magnitude of impact, of money growth on output, will vary. The conditions tested relate to the level of capacity utilization and the position of the business cycle.

To illustrate briefly the critical assumption of the rational expectation hypothesis, which denies a role for expected money growth to affect real output, consider a simple reduced form equation (commonly found in models of the natural rate hypothesis):

$$(1.1)\quad Y_t = Y_{nt} + \gamma(M_t - \lambda_{t-1}M_t) + \gamma_t^s$$

or equivalently as,

$$(1.2)\quad Y_t = Y_{nt} + \gamma(M_t - {}_{t-1}M_t) + \gamma(1 - \lambda)_{t-1}M_t + \gamma_t^s$$

where Y_t and Y_{nt} are actual real output and the natural rate of real output in time t, M_t is actual money growth in time t, and ${}_{t-1}M_t$ is the expectation of money growth in period t formed in period t-1. The term γ_t^s is a stochastic error term assumed to have the usually econometric properties of heteroskedasticity and non-autoregression. The equation is interpreted as follows: real output deviates form its long-run natural trend rate due to errors in predicting money growth in period t and due to random shocks to the system. Written in this manner, two conditions must be met to be consistent with the invariance of average real output to expected monetary changes.

The first is that the expectations of M_t approaches the true value of M_t as time approaches infinity. The thrust of this condition is that expectations are correct in the long-run. The second condition, that of perfect price flexibility, is that the price ajustment mechanism responds fully to fully anticipated inflation, i.e., $\lambda = 1$, and implies that the coefficient of M_t is the same as the coefficient on ${}_{t-1}M_t$. It is not sufficient, therefore, that expectations of money or inflation be correct to generate inflation or monetary neturality. If the adjustment mechanism, λ, is not unity, then output effects will occur as excess demands or supplies will exist. The question of whether a natural rate of output exists, i.e., money is neutral, depends upon whether $\lambda = 1$.

The second test, given non-neutral monetary effects, examines the hypothesis that monetary growth has differential sector to aggregate manufacturing output response. A feature of macroeconomic models conducted on a highly aggregated level is the assumption, implicit or explicit, that the response of individual sectors to monetary shocks is identical. This is disturbing in light of the vivid expositions of past and current writers who emphasize that the causal relationship between money, prices, and output is not a mechanical one, but is rather the economic consequence of the prior effect of changes in the quantity of money on the demand for commodities. John Maynard Keynes (1936) argues this is a particularly poignant manner:[1]

> Money is only important for what it will procure. Thus, a change in the monetary unit which is uniform in its operation and affects all transactions equally, has no consequences. If, by a change in the established standard of value, a man received and owned twice as much as he did before in payment for all rights and for all efforts, and if he also paid out twice as much money for all acquisitions and for all satisfactions he would be wholly unaffected. It follows, therefore, that a change in the value of money, that is to say in the level of prices, is <u>important only insofar as its incidence is unequal</u>. Such changes have produced in the past, and are producing now, the vastest social consequences, because, as we all know, when the value of money changes, it does not change equally fo all persons for all purposes. A man's receipts and his outgoings are not modified in one uniform proportion. Thus, a change in prices and rewards as measured in money, generally affects different classes unequally, transfers wealth from one to another, bestows affluence here and embarassment there and redistributes Fortune's favors so as to frustrate design and dissapoint expectation. (Emphasis is mine.)

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[1]J.M. Keynes, <u>The General Theory of Employment, Interest, and Money</u>, New York, 1936, pp. 80-81.

Aggregate analysis is void of the robustness of agents optimum expectations, their apparent rent-eliminating actions, and their microeconomic response to macroeconomic policy that are emphasized in modern theories of inflation. Aggregate analysis obscures important differences in the process of wage and price adjustments under different market and contractual arrangement. The sectoral analysis, on the other hand, provides a basis for comparison of market (sector) characteristics which reflect the institutional framework under which individuals must act. If the framework differs across sectors then a different response will be expected simply because those institutions impose different restrictions on the decisions and actions individuals can undertake. Jacob Viner, a few years before Keynes, states:[2]

> ...in addition to the many influences affecting particular commodities which operate to bring about dispersion of prices even when the price level is constant, active pervasive factors tending to affect all prices will further increase dispersion _if different commodities have varying degrees of resistance to their influence_. (Emphasis is mine.)

The second test is to shed some light on the extent to which uneven sectoral impacts are due to a sector's sensitivity to monetary policy actions. This can be illustrated in equation form by rewriting equation (1.2) in matrix notation where each element is sector specific; the matrix of endogenous and exogenous variables being column

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[2]Jacob Viner, "Review of the Behavior of Prices," _Quarterly Journal of Economics_, February 1929, p. 337.

vectors with n sector elements and the matrix of coefficients are conformable for matrix multiplication:

$$\underline{Y}_t = \underline{Y}_{mt} + \underline{\gamma}[\underline{M}_t - {}_{t-1}\underline{M}_t] + \underline{\gamma}[I - \underline{\lambda}]_{t-1}\underline{M}_t + \underline{Y}_t^s.$$

Written in this manner the test of neutrality is whether λ equals the identity matrix, I. It should be clear that non-neutrality in the sense of expected money growth being significant, does not necessarily imply differential sector impacts.[3] Differential impacts are characterized by λ for a given sector being significantly different from λ for all sectors collectively. While some sectoral effects may reflect normal economic responsiveness, others may be due to rigidities and constraints.

The importance of examining policy effects on a sectoral level is best summarized by Maurice Mann:[4]

> Sectoral effects were recognized at the time of the revitalization of monetary policy in the 1950's but were treated more as an academic curiousity than as a significant policy consideration. Recently, however, there has been

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[3]It is interesting to note that in Lucas' 1973 model, a case for differentiality can be made if θ takes on different values in distinct sectors, i.e., if the projection of sector price on aggregate price differs across sectors. This will affect the output-inflation trade-off in each sector. This is not, however, to say that a role exists for expected money growth in Lucas' model. Thus the use of the word "differentiality" in this context refers to impacts of unexpected money growth being significantly different from λ for all sectors collectively.

[4]Maurice Mann, How Does Monetary Policy Affect the Economy?" Federal Reserve Bulletin, October 1968, p. 808.

> heightened concern regarding the distribution of the burden of adjustment to changes in monetary policy among 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.

Unfortunately, a few studies have looked into the neutrality of money question beyond the use of highly aggregated variables. Bonomo (1979), and Bonomo and Tanner (1978) are two examples of the sectoral testing being undertaken in this area.[5] The latter study examines the neutrality of monetary changes using a modification of the mean-variance capital asset pricing model. The conclusion of this paper is that "whereas actual policies have had significant non-neutral price effects, systematic changes in the money supply which could be reasonably forecast did not have significant relative price effects."[6] Bonomo (1979), in his work on the neutrality of money on real personal income across states, discovered that both expected and unexpected money changes are significant determinants of real personal income.[7] The analysis in this study follows closely to that of Bonomo and Tanner (1978), especially in the testing of the neutrality/differentiality of money proposition. The test of market characteristics, should it be necessary, is closely related to that of Bonomo (1979).

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[5]Vittorio Bonomo, VPI&SU, 1979, working paper (untitled). Vittorio Bonomo and J. Ernest Tanner, "Are Monetary Changes Neutral?" VPI&SU working paper, (1978).

[6]op. cit., (1978).

[7]op. cit., (1979).

Section 1.4 Summary of Empirical Results

The first test is an examination of the neutrality of money proposition, i.e., actual money growth is not systematically related to output growth. To carry out this test, output growth of overall manufacturing was regressed against actual money growth, lagged inventory and lagged output. Actual money growth was found to be statistically significant in predicting the output growth in equations unadjusted for seasonal variation. Re-estimation of the same output equation using seasonally adjusted data eliminated the statistical relationship betwen actual money growth and output growth. This suggests that actual money growth tends to accentuate the seasonal amplitude but does not influence the underlying structure of manufacturing output growth. This supports the neutrality hypothesis.

Estimation of the output equations for the twelve manufacturing sectors produced similar results.[8] Six[9] out of twelve of the equations estimated found actual money growth to be statistically significant in predicting sector output growth in seasonally unadjusted estimations. Re-estimation using seasonally adjusted data eliminated the relationship. In the remaining six industries, money growth was not statistically significant in either seasonally unadjusted or adjusted estimations.

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[8]The twelve sectors are described in Appendix 3A.

[9]Textiles, Chemicals, Rubber and Plastic, Stone, Fabricated metals, and Non-electrical machinery.

Support for the neutrality of money proposition was found in examination of the coefficients on the residual lag equations. The residual lag equations are formed from the basic output equation by recursive substitution of the lagged output variable. The result is an output equation described by lags of money growth variables. If the neutrality of money proposition is true, the sum of the coefficients of money growth should sum to zero. Thus, a constant growth rate of money should not have any systematic relationship with output growth. The empirical results support this finding. Table 1.1 shows the mathematical sign pattern of the coefficients. The pattern of the signs of the coefficients is indicative of a balanced impact of current and lagged values of money growth on output. Further, the magnitude of the coefficients are approximately the same for each sign pair. The best example of this point is found in the output equation for Stone, Clay and Glass. The coefficients for the seasonally unadjusted equations underlain by the add-one income money rule,[10] are given below:

UMG	3.50	(3.04)
UMG1	-4.10	(-2.37)
UMG2	2.96	(1.73)
UMG3	-2.98	(-1.70)
EMG	8.49	(3.10)
EMG1	-8.07	(-2.49)
EMG2	5.65	(1.71)
EMG3	-5.87	(-1.69)

[10]This is defined in Section 3.3.

TABLE 1.1

SUMMARY OF SIGNS ON THE COEFFICIENTS OF EXPECTED AND UNEXPECTED MONEY GROWTH
(Current and Four Quarter Lags)
(Add-One, Income Rule)
Seasonally Adjusted

	Unexpected	Expected
Overall Manufacturing	+ - + - -	+ - + + +
Foods and Allied	+ + - - +	- + + - +
Textile Mill Products	+ - + - +	+ - + - +
Paper and Allied	+ - + - +	- - + - +
Chemical and Allied	+ - + - +	+ - + - +
Petroleum Products	+ + - + -	+ + - + -
Rubber and Plastic	+ - + - +	+ - + - +
Stone, Clay, Glass	+ - + - +	+ - + - +
Primary Metals	+ - - + -	+ + - + -
Fabricated Metals	+ - + - +	+ - + - +
Non-Electrical Machinery	+ - + - +	+ + + - -
Electrical Machinery	+ - + - +	+ - + - +
Transportation Equipment	+ - + - +	+ - + - +

where UMGi and EMGi are the unexpected and expected money growth variables lagged i quarters. The individual t-statistics are in the parentheses.

If money growth is not constant the rational expectations proponents would argue that the impact on output growth is a function of unexpected money growth only. Thus, only the lagged values of unexpected money growth should be significant. As the example above for Stone, Clay and Glass output demonstrates, this was not necessarily the case. The same was true of other industries as well. In all but two cases (Electrical Machinery and Rubber and Plastics) the statistical significance was found in equation unadjusted for seasonal variation. To justify the significance of expected money growth, incomplete price adjustment must exist due perhaps to implicit or explicit adjustments.

A number of examples support this point. For instance, processors of fruits and vegetables attempt to maintain a steady product movement. If a shortage exists, the cost to producers is partially absorbed to maintain the steady flow of output. In times of excess supplies, inventory buildups may occur to support the selling prices. In the paper and allied products sector, an apparently highly competitive industry, numerous charges have been filed contending price fixing. The antitrust suits affect virtually the entire industry. In the petroleum sector, the relationship between price of inputs, which may be bound by contracts and shipping delays, and the price of outputs may change at unequal rates. Therefore, demand for the product is changing at a different rate than the costs facing the producers. This implies rent seeking opportunities for producers.

The tests of differential impact of money growth did not support the hypothesis that the incidence of money growth was unequal across sectors. Given that money was found to be neutral in affecting the non-seasonal structure of output in the twelve sectors studied, it is not surprising that money growth did not affect the output growth in a given sector relative to the overall manufacturing sector.

In only one of the twelve sectors, Paper and Allied products, did money growth prove to be significant. In this case, the unexpected money growth component was the driving force of the significance of actual money growth. A summary of the equations is given below:

$$X26G = \underset{(-2.07)}{-.760MG} - \underset{(-3.08)}{.288N_{t-1}} \qquad R^2 = .111 \quad D\text{-}W = 2.03$$

$$X26G = \underset{(-2.21)}{-.879Unexpected} - \underset{(-.621)}{.378Expected} - \underset{(-2.98)}{.281N_{t-1}}$$

$$R^2 = .116 \quad D\text{-}W = 2.06$$

where X26G is the difference between Paper and Allied products growth and overall manufacturing growth, MG is actual money growth, and N_{t-1} is lagged inventory growth.

For the Foods, Textile Mill products, and Rubber and Plastic sectors, lagged inventories were statistically significant in explaining the variation of sector to total manufacturing output. The results are summarized below:

FOODS

$$X20G = \underset{(-.373)}{-.316MG} + \underset{(1.68)}{.331N_{t-1}} \qquad R^2 = .0338 \qquad D\text{-}W = 2.04$$

RUBBER AND PLASTICS

$$X30G = \underset{(.286)}{.169MG} - \underset{(-2.80)}{.324N_{t-1}} - \underset{(-1.95)}{.174X30G_{t-1}} \qquad R^2 = .182$$

TEXTILE MILL PRODUCTS

$$X22g = \underset{(.541)}{.242MG} - \underset{(-3.19)}{.308N_{t-1}} \qquad R^2 = .088 \qquad D\text{-}W = 1.95$$

For Petroleum, Rubber and Plastics, and Transportation Equipment, lagged output was found to be statistically significant. The results, including the money growth variable are presented below:

PETROLEUM

$$X29G = \underset{(-.508)}{-.331MG} - \underset{(-.11)}{.016N_{t-1}} - \underset{(-2.15)}{.211(X29G_{t-1})} \qquad R^2 = .073$$

TRANSPORTATION EQUIPMENT

$$X37G = \underset{(.396)}{.383MG} + \underset{(1.36)}{.236N_{t-1}} - \underset{(3.44)}{.3\text{-}1(X37G_{t-1})} \qquad R^2 = .131$$

For the remaining manufacturing sectors, neither money growth, lagged output, or lagged inventories were found to be statistically significant in predicting the deviation of sector from overall manufacturing output growth.

In this paper I test whether the relationship between money growth (or alternatively, its unexpected and expected components) is a function of the level of capacity utilization and/or the phase of the business cycle. The test relates to the coefficient on money growth. To test the effects of capacity utilization, for example, a simple output equation can be written as:

$$\text{Output } (z) = a + b(\text{Money growth})$$

and further, the coefficient b is hypothesized to take the following form:

$$b = c + d(\text{capacity utilization}).$$

Thus the output equation can be rewritten as :

$$\text{Output } (z) = a + c(\text{money growth}) + d(\text{capacity utilization})(\text{money growth}).$$

If the sign of the coefficient c is positive (as expected) and the sign of the coefficient d is negative, it implies that for some value of capacity utilization, given by

$$\text{capacity utilization} = \frac{c}{d}$$

the relationship between money growth and output growth is negated, i.e., the coefficient is zero.

For the overall manufacturing output growth and for eight out of the twelve sectors studied, capacity utilization was found to be statistically related to the coefficient on the money growth variables. Table 1.2 gives the critical values for these sectors. Note, as the level of capacity utilization approaches the critical value the coefficient on money growth approaches zero. The rate of adjustment to sales is technically limited, although more for increases than decreases in sales. Decreases are primarily affected by the real cost associated with production change.

At low capacity utilization levels, the ability of the firm to adjust is much greater. Technical restraints are removed and the expected cost of raising the production level is less than in the case of high rates of capacity utilization.

As discussed above, the significance of money growth and its capacity interactive term are for the equations unadjusted for seasonal variation. The exceptions are the Paper and Allied products sector and the Rubber and Plastics sector. The Paper sector operated at an average capacity utilization rate of 90.29 across the period of study. Capacity plays an important role in this sector in determining profit margins. Further this sector is marked by skepticism about further commitments for additional capacity without strong evidence of a

TABLE 1.2

CRITICAL CAPACITY UTILIZATION RATES

Seasonally Unadjusted
Add-One Incomes Money Rule

Sector	Average‡	s.d.	Expected	Unexpected
Overall Manufacturing	83.04	(4.92)	96.80	N.S.
Textile Mill Products	88.03	(6.09)	86.23	92.15
Paper and Allied	90.29	(4.65)	97.55*	N.S.
Chemicals and Allied	83.41	(4.30)	N.S.	82.70
Petroleum Products	91.76	(3.39)	95.72	92.81
Rubber and Plastic	88.30	(6.90)	107.51	96.93
Stone, Clay, Glass	81.66	(6.37)	92.77	82.66**
Primary Metals	84.37	(10.46)	92.48	N.S.
Fabricated Metals	81.56	(5.99)	N.S.	85.88

s.d. = standard deviation

*Seasonally adjusted data.

**Defined by add-one Barro money rule. Add-one incomes rule ws not significant

‡Average actual rate of capacity utilization across the period of study.

permanent shift in demand to absorb the increased output. The rubber industry operated at a capacity utilization rate of 88.3 percent. Outside of the Petroleum sector the average capacity utilization rates for paper products and rubber products were the highest of all industries.

The test of the phase of the business cycle follows closely to that of the capacity utilization results.[11] Seven of the twelve sectors studied showed the coefficient on the money growth variables to be statistically related to the phase of the business cycle. These seven sectors are textiles, paper, chemicals, rubber, stone, electrical machinery and non-electrical machinery.

Surprisingly, only expected money growth was found to be statistically related to the phase of the business cycle. The general conclusion is that in periods of contraction expected money growth is negatively related to output growth. The magnitude of the coefficient ranges from -1.19 (for the Stone, Clay and Glass sector) to -5.00 (for the non-electrical machinery sector). Table 1.3 gives a summary of the range of coefficients in the different phases.

In periods of economic expansion, expected money growth is positively related to output growth. The magnitude of the coefficients ranges from approximately zero (for the Paper and Allied sector) to 2.4

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[11]The interactive term was a dummy variable, unlike the capacity utilization interactive term.

TABLE 1.3

SUMMARY OF THE RANGE OF COEFFICIENTS FOR EXPECTED MONEY GROWTH AS A FUNCTION OF THE PHASE OF THE BUSINESS CYCLE

Sector	Contraction	Expansion
Overall Manufacturing	-1.75	1.05
Textile Mill Products	-1.92 to -2.22	.60 to .64
Paper and Allied	-1.88 to -2.04	-.03 to .20
Chemicals and Allied	-2.71	.23
Rubber and Plastic	-1.25 to -1.77	.89 to 1.69
Stone, Clay, Glass	-1.19	.70
Electrical Machinery	-3.20	1.15
Non-electrical Machinery	-5.0	2.40

(for the non-electrical machinery sector). Again, Table 1.3 summarizes these results.

Perhaps the best argument in support of the statistical significance of expected money growth is the existence of wage and other input contracts relative to the product price. For example, suppose wage contracts were negotiated and signed prior to an increase in general economic activity. As the economy moves into the period of expansion, prices rise relative to the fixed input price. Producers experiencing the outward shift in demand and knowledgeable that part of this shift is a result of expected money growth may still attempt to expand production in the short-run to take advantage of the more rapid shift in demand than in input costs, i.e., the shift in the supply curve.

Section 1.5 Background and Perspective of the Model

The ability of monetary policy to affect real output is not a recent issue. With the rediscovery of the apparent unemployment-inflation trade-off by Phillips[12,13] (1954, 1958), this relationship began to play a central role in policy discussions. The Phillips' curve (PP in Graph 1) was thought to be a stable negative relationship between inflation and unemployment. Policy makers, by plotting

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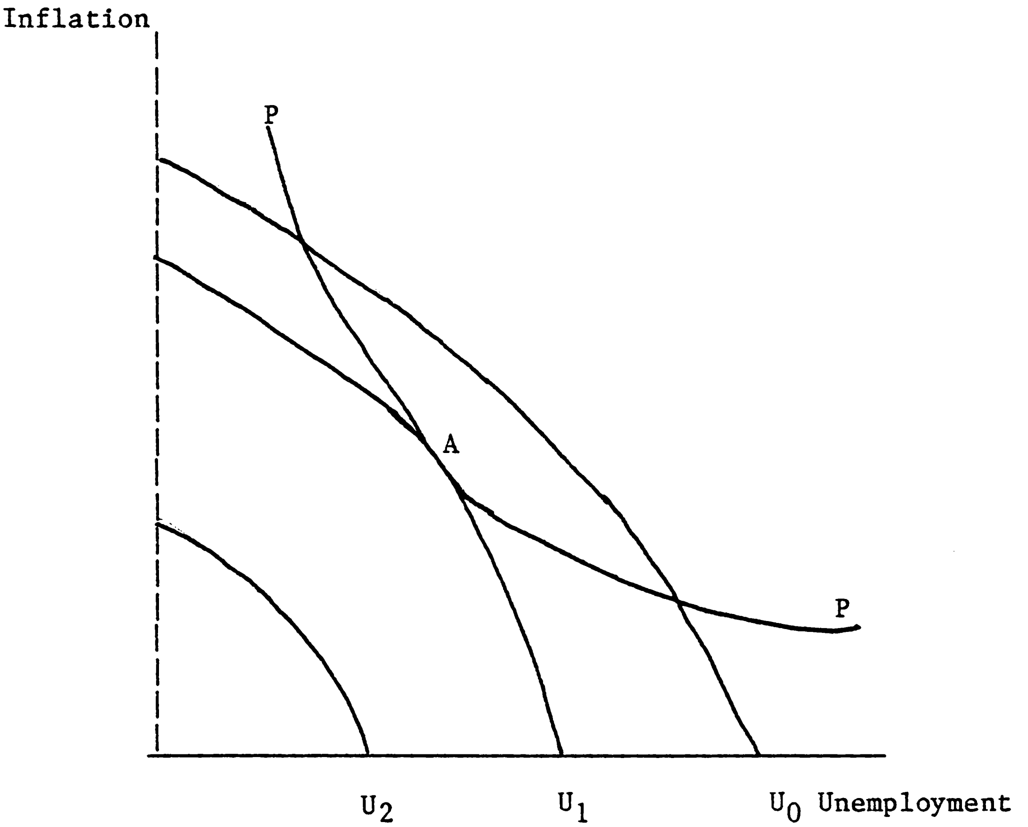
[12] W. Phillips, "Stabilization Policy in a Closed Economy," Economic Journal, 64, June 1954, pp. 290-323.

[13] __________, "The Relation Betwen Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1862-1957," Economica 25, November 1958, pp. 283-99.



GRAPH 1

THE PHILLIPS CURVE

society's indifference between inflation and unemployment (e.g., U_0 and U_1 in the graph), could attain a utility maximizing position (point A) by proper exploitation of the Phillips curve via monetary policies. Phillips argues in the concluding paragraph that "if the right type of stabilization policy is being applied continuously, comparatively small correcting forces are sufficient to hold the system near the desired position once that position has been attained. It is quite likely, therefore, that a monetary policy based on the principle of automatic regulation systems would be adequate to deal with all but the most severe disturbances to the economic system."[14]

Phillips (1958), suggested a distinction between long and short-run tradeoffs ("Phillips Loops"). This distinction led Milton Friedman (1968), and Edmund Phelps (1967) to argue that while a short-run Phillips' curve may exist, there was a long-run natural rate of unemployment which is independent of the steady rate of inflation--that is, a vertical long-run Phillips curve.[15,16]

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[14] Phillips 1954, p. 315.

[15] Milton Friedman, "The Role of Monetary Policy," American Economic Review, Vol. 58, March 1968, pp. 1-17.

[16] E.S. Phelps, et al., Microeconomic Foundation of Inflation and Employment Theory, (New York: W.W. Norton, 1970).

The natural rate of unemployment is clearly an application of Wicksell's important work on interest and prices,[17] notably, the natural rate of interest and price theory.[18] Both theories distinguish between initial and long-run effects of policy, and the important distinction between real and monetary forces.

The short-run Phillips curve effect may be described as follows: If the monetary authority increases the money supply, the supply of loanable funds increases. The commercial banks will respond to this by lowering the market rate of interest to loan out excess funds. Assuming the natural rate of interest (the return on capital) and the

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[17]Knut Wicksell, Interest and Prices, translation by R.F. Kahn (London: Macmillan, 1936). See also Sargent and Wallace, "Rational Expectations, the Optimal Monetary Instruments, and the Optimal Money Supply Rule," Journal of Political Economy, 1975a, Vol. 83, April, pp. 241-57.

[18]Wicksell concerned himself in Interest and Prices mainly in an attempt to explain evidence reported in Tooke's History of Prices which showed that changes in the money supply were historically accompanied by changes in prices and rates of interest in the same direction. To show why this relationship existed, Wicksell separated the natural rate of interest from the monetary rate. He defined the natural rate as being equal to the marginal productivity of capital at any given time and the money rate (or the market rate) as being that interest rate which equates the supply and demand of loanable funds, i.e., intended savings and investment.

Friedman's natural rate of unemployment would be that rate ground out by a Walrasian system of equation in the absence of unanticipated inflation. "The level (on unemployment) that would be ground out by the Walrasian system of general equilibrium equations, provided there is imbedded in them the actual structural characteristics of the labor and commodity markets, including market imperfections, stochastic variability in demand and supplies, the cost of gathering information about job vacancies and labor availabilities, the costs of mobility, and so on." (Friedman 1968, p. 8.)

market rate were equal before this change, the market rate is now below the natural rate. Since the cost of capital has decreased, while the return on capital has remained constant, new investment will take place. Also, since savings now is less attractive, consumption spending should increase. This disequilibrium of the money market has also caused actual nominal cash balances of individuals to be greater than their desired holdings. This will result in an increased spending in the commodity markets.[19] "In short the result of the increase in the quantity of money is a rise in the demand for commodities...with the consequence that all prices rise continuously--until cash balances stand once again in their normal relation to the level of prices."[20]

As the demand for products increase, pressure is exerted on prices and production. If selling prices adjust to unanticipated increases in nominal demand faster than wages, then real wages will fall, creating an excess demand for labor. This in turn causes an increase in the nominal wage rate. The employee, if not fully cognizant of the changes in the price level (perhaps due to the cost of gathering information), sees only the nominal wage rising, and hence evaluates the wage offered at the previous price level. In other words, for a time, the worker has wage data in time t+1 but has not gained suficient information

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[19]See Patinkin (!965), CHapter 2; see also Patinkin's "Note E" on Wicksell's monetary theory, p. 581.

[20]Wicksell, Interest and Prices, pp. 40-41.

about actual prices in time t to form the expectation of t+1 prices, i.e, ${}_tP_{t+1}$. Thus, the worker continues to deflate the nominal wage by ${}_{t-1}P_t$.[21] The employee, therefore, mistakes a general price rise affecting both prices and wages for a specific price rise on the market for his labor services.

The firm (employer) is assumed to observe the price level change but is uncertain if the change is permanent. Short-run output effects are a function of asymmetry in sources of price information for employees and employers. "The simultaneous fall *ex post* in real wages to employees and rise *ex ante* in real wages to employees in what enabled employment to increase."[22] Note that in this situation the market rate of unemployment is below the natural rate.[23]

Expectational errors, which caused the short-run effects, will not persist as individuals gather more information. Revisions of estimated

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[21]The notations ${}_tP_{t+1}$ and ${}_{t-1}P_1$ are defined as follows: the subscript preceding P refers to the period the expectation on price is formed. Expectations are based on past information up to and including the period in which they are formed. Expectations are made for a given period denoted by the subscript following P.

[22]Friedman (1968), for a detailed theoretical foundation for short-run Phillips curves see Phelps (1970). Gordon (1976) provides a good summary of these developments.

[23]Keynes wrote (*General Theory*, p. 290, 1936), "For a time at least, rising prices may delude entrepreneurs into increasing employment beyond the level which maximizes their individual profits measured in terms of the product. For they are so accustomed to regard rising sale proceeds in terms of money as a signal for expanding production, that they may continue to do so when this policy has ceased to be to their best advantage; i.e, they may underestimate their marginal user cost in the new price environment."

values of the price level occur. Employment returns to its equilibrium level and simultaneously, unemployment to its natural level.

The magnitude of impact in the short-run on prices and production depends upon the information available to economic agents and their subsequent ability to decipher those forces causing the increase in demand. Barro and Fischer note that "a necessay but not sufficient condition for money to affect real variables in the short-run is uncertainty about both money and the real economy. The additional ingredient that turns out to be needed is some limitation on current information that allows individuals to become confused between monetary and real shocks."[24]

To illustrate, if money growth is unexpectedly high, so will be prices (assuming no real shocks). Although this price rise is purely monetary in general, individuals may incorrectly attribute part of the unexpected rise to real factors. Employment and output would change as they would in accord with true real shock. Accordingly, a short-run Phillips' curve is generated between <u>unanticipated</u> money movements and output. In the long-run, the monetary disturbance is fully perceived as being caused by monetary forces and the output employment effects vanish. Thus, as Friedman and Phelps emphasized, fluctuations in output and employment are the result of expectational errors by

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[24]Barro and Fischer, "Recent Developments in Monetary Theory," <u>Journal of Monetary Economics</u>, 1976, Vol. 2, p. 158.

economic agents in predicting prices and wages in a world where predictions are rational, given the available inormation. Friedman states, "There is always a temporary trade-off between inflation and unemployment; there is no permanent trade-off. The temporary trade-off comes not from inflation per se, but from unanticipated inflation, which generally means from a rising rate of inflation."[25] If inflation is fully anticipated, Friedman asserted that people would evaluate contracts in real terms and would be unaffected by the rate of inflation. Only unanticipated money growth (and hence unanticipated inflation) has real short run effects.

A very important paper in this regard is "International Evidence on Output-Inflation Trade-Offs" by Robert Lucas.[26] A central implication of Lucas' model is that the short-run Phillips trade-off deteriorates when the variance of the rate of change in nominal income increases. In his paper, Lucas describes individual (sector) price variations as dependent upon two factors: aggregate average price movements and sector specific price movements. The variance of current average aggregate prices, P_t, from its expected value, $\overline{P}_t$, is given σ^2,

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[25]Friedman, 1968, p. 11.

[26]Robert Lucas, "Some International Evidence on Output-Inflation Trade-Offs," American Economic Review, June 1973, pp. 326-334. Lucas examines the same effect in a general equilibrium model in his (1972) paper, "Expectations and the Neutrality of Money."

i.e., $P \sim N(\overline{P}_t, \sigma^2)$. Deviation of sector prices, $P_t(z)$ from P_t is assumed to be normally distributed with mean zero and variance τ^2. Thus, total individual price variance is given by $\sigma^2 + \tau^2$. The term $\theta = \frac{\tau^2}{\sigma_2 + \tau_2}$ is defined to be the fraction of total price variance due to relative price variation.

The slope of the supply curve (aggregate supply in Lucas) is a function of the fraction θ of total individual price variation. If τ^2 is small, implying θ close to zero, individual prices near perfectly reflect aggregate price changes, implying a near vertical supply curve. The variability of the equilibrium price, for any given level of demand curve variability, will be greater the more inelastic the supply curve. Furthermore, the less variable is output under the same conditions. The more stable the general price level, implying σ^2 relatively small, sector price variations are interpreted to reflect real sector changes and the supply curve becomes more elastic.[27] This may imply that a greater share of price increases in a sector are attributed to real rather than monetary affects giving a more favorable Phillips trade-off. If different sectors exhibit different relative sector to aggretate price relations, and hence different <u>sector specific</u> θ's,

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[27]The supply curve approaches a limiting value reflecting the marginal costs of production.

output response, caused perhaps by monetary factors, will not be identical in every sector.[28]

The dependence of errors to generate short-run Phillips curve trade-offs does not mitigate the potential role of monetary policy. The widespread use of macroeconomic models using adaptive expectations led to the belief that an ever-increasing rate of inflation could keep employment above the natural rate. Proponents of this theory were called accelerationists.

Other expectation mechanisms - in paticular, rational expectations[29] - imply no useable Phillips' trade-off for policy makers. The rational expectations mechanism suggested that economic

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[28]Lucas (1973). Lucas' approach is indeed an exciting and suggestive one. It does not, however, justify the inclusion of, or provide any role for, monetary policy. Rather, the model has the appropriate homogeneity and thereore only unexpected policy changes affect real variables in the short-run. The model does provide interesting implications for the magnitude of the Phillips trade-off vis-á-vis unexpected changes. Although not central to this paper, the Lucas contributions are important. Thus, in Appendix 2A of Chapter II, I suggest a model based upon the Lucas Framework. In particular, a Lucas Supply equation is used and the signal extraction problem examined. In this model I show that if prices are assumed to fully adjust to fully anticipated monetary growth (the homogeneity of degree zero maintained), no role exists for expected monetary growth. Discussion of sector specific θ's and a method for testing them are also included in the Appendix.

[29]Credit for the initial work on rational expectations goes to Modigliano and Grunberg (1954) and notably Muth (1961).

agents based their expectations on the structure of the economy.[30] Part of this structure is knowledge of the government's policy behavior. Most importantly, individuals act as if they know the objective joint probability distribution of policy instruments and all other economic variables. Individuals will exploit this knowledge because "whatever policies are pursued, agents will not leave large, obvious economic rents unclaimed" and "for exactly the same reason...agents form forecasts of the future optimally."[31] This means that economic agents will always be at their utility- and profit-maximizing real position. Since the monetary policy and its connection to other variables is known to the public, effects of policy must already be included in the prediction of prices. Thus, any systematic (and hence predictable) change in money growth must simultaneously alter the current price level and the expectation of price level.

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[30]Muth suggested that expectations should be identical to the true mathematical expectations of future variables conditional on all current and past information of variables in the model. Muth argued that "expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant ecomomic theory," (1961, p. 316). The critical underlying assumption is that the subjective probability distribution of individuals is identical to the true conditional distribution based on all available information. This implies some extreme informational assumptions of rational expectations models. Our purpose is not to criticize the rational models of informational grounds *per se*, but rather to alter the implicit assumption of perfect price flexibility. See B. Friedman's (1979), paper on the extreme informational assumptions of rational expectations model.

[31]Robert Lucas, "Review of a Model of Macroeconomic Activity," *Journal of Economic Literature*, Vol. 8, September 1975, pp. 889-90.

Other nominal magnitudes, such as nominal income, are also simultaneously affected, and policy therefore cannot alter unemployment, output, or other real magnitudes, even in the short-run.

The above implies homogeneity of degree zero in money, prices, and expected prices. A deterministic monetary policy should have no effect, regardless of the rest of the model.[32] As essential assumption to maintain the homogeneity is that the elasticity of actual and expected prices is the same and therefore equal to the elasticity of relative prices. If prices do not adjust fully to fully anticipated changes, the elasticities are not the same and the homogeneity of degree zero does not hold. The model presented below examines explicitly the importance of this assumption.

A simple equation describing the Friedman-Phillips hypothesis can be written as:

$$(1.1') \quad Y_t = Y_{nt} + \gamma(P_t - \lambda_{t-1}P_t) + \gamma_t^s.$$

Where Y_t is the output in time t, Y_{nt} is the natural rate of output defined to be a trend line:[33]

$$Y_{nt} = a + \beta_t$$

[32]Shiller (1978), points out that even though these theories require the models to be homogeneous of degree zero in money, prices, and expected prices so that deterministic monetary policy has no effect, there is no reason to think that there should be an analogous homogeneity property for government expenditures, so there is no reason to believe that deterministic fiscal policy cannot reduce the variance of Y (output).

[33]Lucas, (1973).

P_t is the current price level and ${}_{t-1}P_t$ is the expected price level in time t form on information up to and including time t-1.[34] The γ_ts is a stochastic error term. Note the inclusion of the λ term. Written in this mannaer, two conditions must be met to be consistent with the rational expectation hypothesis discussed above. The first is that the

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[34]There are of course simple equations describing a Phillips curve trade-off that are quite different from equation 1.1. In particular, the flavor of equation 1.1' is the output today adjusts because incomplete information has caused the today's expected price to deviate from the actual price today. This is in sharp contrast to other models. For instance the financial market theory emphasizes the determination of prices of financial assets rather than the quantitites produced. The market drives today's price to equality with the price expected to prevail tomorrow. (Poole, p. 480). Barro (1976) uses this type of formulation in his macro-model. In both the Supply and Demand equations the relative price is defined to be current over expected future price. This leads to speculation by individuals and a readjustment of their current work/leisure trade-off. If prices are expected to be greater next period relative to current pruces, supply decreases today, substituting leisure today for work tomorrow. Under the same conditions, demand increases today relative to tomorrow.

Lucas' (1973), aggregate supply curve is similar (equation 7, p. 328):

$$Y_t = Y_{nt} + \theta\gamma(P_t - \overline{P}_t) + \lambda(Y_{t-1} - Y_{n,t-1}).$$

Where $\overline{P}_t$ is the expected general price level based on information assumed to be common knowledge across all sectors, θ is defined to be the ratio of relative sector price variance to total (sector price plus general price) variance. Although the relative price term is similar to today's price relative to yesterday's expectation of today's price, the essence of this term is the relation of sector price to general price in time t. In other words, the short-run Phillips trade-off is assumed to exist because economic agents in each sector cannot separate the sector price information into its real and monetary parts.

expectation of Pt approaches the true value of P_t as time approaches infinity. The thrust of this condition is that expectations are correct in the long run.[35]

The second condition is that $\lambda = 1$. Although slightly more difficult to interpret, the thrust of this condition is that the price adjustment mechanism responds fully to fully anticipated inflation. Equation 1.1 can be rewritten as:

$$Y_t = Y_{nt} + \gamma(P_t - {}_{t-1}P_t) + (1 - \lambda)\gamma P_t + \gamma_t^s.$$

Clearly, if $\lambda \neq 1$, unexpected and expected money growth affect ouput. As λ approached 1, the responsiveness of output to expected price level changes diminishes.[36]

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[35]In other words, the mean of the distribution of expectations on P_t across time will be equal to the true parameter value of P_t. There is no systematic bias which causes the mean of the distribution of expectations to deviate from the true value.

[36]If we assume that money growth and the growth of prices deviate only by a random variable (say unpredictable demand shifts), i.e., $P_t = M_t + \gamma_t^d$, then the expectation of P_t in period t-1 is:

$$ {}_{t-1}P_t = {}_{t-1}M_t$$

and thus

$$P_t - {}_{t-1}P_t = M_t - {}_{t-1}M_t + \gamma_t^d$$

which in turn implies

$$Y_t = Y_{nt} + \gamma(M_t - {}_{t-1}M_t) + (1 - \lambda)\gamma_{t-1}M_t + \gamma\gamma_t^d + \gamma_t).$$

It is not sufficient, therefore, that expectations of money or prices (or inflation) be correct to generate inflation or monetary neutrality. If the adjustment mechanism λ is not unity, then output effects will occur as excess demand or supplies will exist.[37]

Consider an extreme example:[38] equilibrium is characterized by producers and workers able to sell all their products at some price vector (equilibrium), (W*, P*). Assume this vector of prices fixed at their equilibrium values. Upon the introduction of a monetary shock (say a reduction of the money supply), at the equilibrium price vector, an excess supply of products exists, Thus sellers of products have been effectively constrained by policy imposed limits of sales. The notional supply curve must be discarded, and "rational expectations become irrelevant to the output effect of systematic policy rules."[39]

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[37]For our purposes, it is useful to rewrite 1.1 to reflect a given sector's supply function:

$$Y_t(z) = Y_{nt}(z) + \gamma(P_t(z) - \lambda_{t-1}P_t(z)) + \gamma_t(z).$$

Using matrix notation to represent all the sectors

$$\underline{Y}_t = \underline{Y}_{nt} + \underline{\gamma}[\underline{P}_t(z) - \underline{\lambda}_{t-1}\underline{P}_t(z)], + \underline{\gamma}_t(z),$$

where $\underline{Y}_t$, $\underline{Y}_{nt}$, $\underline{P}_t(z)$, ${}_{t-1}\underline{P}_t(z)$, and $\underline{\gamma}_t$ are (n x 1) vectors (given n distinct sectors), $\underline{\gamma}$ is an (n x n) matrix of coefficients, and $\underline{\lambda}$ is an (n x n) matrix. For neturality in each sector than the diagonal elements of $\underline{\lambda}$ must equal 1. Hence, for overall neturality, $\underline{\lambda}$ must be the identity matrix ($\underline{\lambda}$ = I).

[38]This example and notation is Gordon's (1976), "Recent Developments in the Theory of Inlfation and Unemployment," Journal of Monetary Economics, Vol. 2, 1976, pp. 185-219.

[39]Gordon, 1976, p. 202.

Note that this criticism does not rely on a perfectly rigid price vector. It only requires an incomplete adjustment of prices. For example, if a reduction in the money supply occurred, the price vector would have to be $(\hat{W}, \hat{P})$ to clear all marekts. Any stickiness in prices, e.g., a price vector (W', P') such that $\hat{W} < W' < W^*$ and $\hat{P} < P' < P^*$, will still impose a sales constraint.

The existence of imperfect price adjustment can be demonstrated in a slightly different manner. First, assume the monetary authority in exercising monetary policy follows a rule to set the value of the money supply. This money rule may take the form:[40]

$$\text{(A)} \quad M_t = \sum_{i=1}^{\infty} a_i U_{t-i} + \sum_{i=1}^{\infty} b_i V_{t-i}$$

where U_{t-i} and V_{t-1} represents aggregate supply and aggregate demand disturbances in periods t-i, respectively. These disturbances are assumed to be normally distributed with mean zero and constant variance. The coefficients, a_i and b_i, are the parameters used by the monetary authority in setting a target value for M_t.

The rational expectations hypothesis states that output effects are due solely to errors in expectations, e.g.,

$$\text{(B)} \quad Y_t = \delta(M_t - {}_{t-1}M_t).$$

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[40]Fischer (1977), p. 197, equation 10.

If we introduce incomplete price adjustment, in particular binding long term contracts (the life of the contract is greater than one period), the output effects would be given by (for a two period contract):[41]

(C) $Y_t = \gamma(M_t - {}_{t-2}M_t)$

where ${}_{t-2}M_t$ is the expectation of the money supply in period t formed at the time the contract was negotiated, period t-2. This term can be written as:

(D) $${}_{t-2}M_t = \sum_{i=2}^{\infty} a_i U_{t-i} + \sum_{i=2}^{\infty} b_i V_{t-i}$$

since U_{t-1} and V_{t-1} have not yet occurred and hence their expected values, ${}_{t-2}a_1U_{t-1}$ and ${}_{t-2}b_1V_{t-1}$ are equal to zero. Substracting equation (D) from (A) allows equation (C) to be rewritten as:

(E) $Y_t = \gamma(a_1U_{t-1} + b_1V_{t-1})$.

Equation (E) clearly shows that the variance of output is a function of the parameters a_1 and b_1. Furthermore, the effect of parameter a_i and b_i for $i > 2$ is nil. The intuitive reason for this result is best stated by Fischer:[42]

> ...between the time the two-year contract is drawn up and the last year of operation of that contract, there is time for the monetary authority to react to new information about recent economic disturbances. Given the negotiated second-period nominal wage, the way the monetary authority reacts to disturbances will affect the real wage for the second period of the contract and thus output.

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[41]This reduced form is similar to Fischer's equilibrium output equation. See equations (18) and (21).

[42]Fischer, (1977a) p. 199.

Note that since ${}_{t-1}M_t - {}_{t-2}M_t = a_1U_{t-1} + b_1V_{t-1}$ equation (E) can be written as

(F) $Y_t = \gamma({}_{t-1}M_t - {}_{t-2}M_t)$.

This implies that output is a function of the expectation of the money growth in t-1 since prices cannot fully adjust to this expectation due to the contractual arrangements made the period before. Past disturbances were known when the contract was signed and hence is assumed to have been included in the contracted wage setting. The disturbances U_{t-1} and V_{t-1} can be fully offset by appropriate monetary policy.

Merely showing that sticky prices and wages cures impotent monetary policy does not justify the existence of sticky wages and prices. The justification lies in microeconomic theory. In particular, the existence of contracts (implicit or explicit) must surely depend upon the transaction costs of frequent price setting, information costs, and perhaps differences in risk aversion between buyers and sellers.

Underlying the contractual theories is the observation that a great many products are sold in non-auction markets. This is especially applicable to labor services. In an auction market there is no role for a relationship between buyers and sellers. In the Walrasian tatonnement, buyers and sellers adjust the quantitites they desire to buy and sell according to a given price level without any regard to whom they will eventually acquire goods from or deliver goods to. Labor markets do not work in such a manner. Further, adjustment costs prohibit minute-by-minute changes in buying and selling of labor services. The implication of prohibiting adjustment costs is that there must exist some period short enough that the notional supply curve (equation 1.1 given $\lambda = 1$) could not possibly hold and that rational expectations would be irrelevant.

The bottom line of the current growth of contracts literature is that prices and wages will adjust slowly because it is rational for the adjustment to be slow. Two basic ideas seem to support this position: differences in risk between buyers and sellers and information costs. It is beyond the purpose of this paper to review the, sometimes highly technical, literature. Rather, I merely wish to establish that there exists reasonable criteria showing the plausibility of sticky prices and wages. The stickiness, whether implicit in unwritten buyer and seller agreements or explicitly written down, will be said to take the form of contracts.

A principle common to students of portfolio decision is diversification in order to reduce the risk of total portfolio holdings. Differences in the ability to bear risk, such as between employers and employees, immediately suggests gains from trade. In deciding upon a hiring strategy, a firm will be willing to reduce the risk of its workers. Bailey (1973), states that "risk-reducing policies are the cheapest and hence most profitable way of attracting any given work-force."[43]

The choice of a risk reducing policy will have important impacts depending upon which set of strategies - wage setting and/or employment tenure variations - are chosen by the employer. The probability of unemployment must surely be affected. Bailey has found that a pre-announced non-stochastic wage strategy will be set by the firm rather than setting an employment-tenure strategy. Fischer (1977), agreed with Bailey's conclusion. Gordon and Barro criticize this result in that the insurance argument calls for both fixed wages and fixed hours. The response to this is three-fold. Fischer (1977), argues that Barro's contracts are irrelevant in that they are unlike any seen in practice. Fischer argues that the labor contracts do take the form where the nominal wage or overtime schedule are specified and the determination of the level of output is left to the firm.

Secondly, Bailey argues that "the asymmetry between the wage and employment strategies arises because when a worker is laid off he received a non-zero income."[44] The third point is that tenure contracts do not allow for labor re-allocation. William Poole comments that, "while full employment will be sustained by the tenure contract

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[43]Martin Bailey, "Wage and Employment Under Uncertain Demand," Review of Economic Studies, 1973, p. 37.

[44]Ibid., p. 39.

in the face of a macro disturbance, the allocative inefficiencies in the face of micro disturbances will require that all firms, when negotiating contracts, offer wages lower than those that could be offered under fixed-wage contracts."[45] The employee must compare the higher wage under fixed-wage contracts to the expected costs of being unemployed. Poole concludes that "expected incomes may well be enough higher under fixed-wage contracts than under tenure contracts to persuade most employees to forego the security of tenure. The failure of tenure contracts to reallocate labor would generate large costs compared to cyclical unemployment."[46]

This discussion suggests that the fixed-wage strategy will generally be optimal. Bailey provides the best summary of this argument:[47]

> The profit-maximizing strategy for all firms together is to set a pre-announced wage path that does not respond to period-by-period fluctuations in the state variables and hence to changes in aggregate demand, price or employment. This strategy will also be profit maximizing for each single firm, provided the fluctuations in demand are not too large.

The next topic of discussion is that of information costs and clearly need not be limited to the labor sector.[48] The conclusions of

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[45] William Poole, "Rational Expectations in the Macro Model," Brookings Papers on Economic Activity, Vol. 2, 1976, p. 487.

[46] Ibid., p. 487.

[47] Bailey, p. 46.

[48] See Armen Alchian on information costs in Phelps (1970).

the optimal search literature is that the optimal amount of search will be a direct function of the dispersion of prices and an indirect function of the costs of search.[49] The important implications of this for sticky wages and prices is that since information is a scarce good and this is costly to obtain, there will be real costs to rapid changes in prices. Past quotations of prices become worthless.

To explain in a different manner why sticky prices may exist, imagine a price of P^* which equates supply and demand in an uncertain world. Assume that within some range $(P^* \pm z)$, it is too costly to adjust prices because of the confusion in the information content received by buyers. Only if a price exceeds $(|P^* + z|)$ would it be worth the change of price.

This section reviewed the background theories which the model developed in the next chapter is embodied. The central focus was on the existence of the Phillip curve and whether the trade-off of inflation for less unemployment could be exploited by policy makers, in particuar, the monetary authority. An important distinction was made between the long and short-run Phillips curves. The latter was the result of errors in expectations brought about perhaps by the confusion between real and monetary forces. The magnitude of short-run effects depends upon the extent of available information. Expectation errors could not persist

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[49]Note the comparison with the square root rule.

as more information was gathered and subsequently, the confusion between real and monetary forces dissipated. No long-run real output or employment effects were realized.

The mere existence of expectational errors did not mitigate the role of policy. Adaptive Expectations and other learning models which were developed imposed systematic errors which could be exploited by policy makers. Rational expectations noted that systematic errors would lead to economic rents that would not be left unclaimed by economic agents. This leads to the claim that any policy was impotent since knowledge of these policies would be built into expectations and behavior of agents.

Even though expectations are correct and "rational" in the long-run, a second condition, that of fully adjusting prices, must be met for expectations to have no impact on real output and employment. The existence of contracts, whether implicit or explicit, implies that prices will not instantly adjust to clear markets. The non-auction nature of most markets, the reduction of buyer and seller risk, and information costs were discussed as reasons why prices may not instantaneously adjust.

The model that is developed in the next chapter incorporates the notion that expectations are rationally made and further takes explicit account of possible incomplete adjustment of prices defined by conditions on λ. Under these conditions, the magnitude of the Phillips trade-off can be examined.

Chapter II

THE MODEL

This chapter sets forth a sectoral model. The basis of the model lies in the relationship between production decisions, Y, anticipated sales, S_t (in the sense that sales are functionally dependent upon a set of variables) and the desired change of inventories, J_t:

(2.1) $Y_t = S_t + J_t$

Ex post, this relationship holds as an identity. Ex ante, this may not hold since producers must act upon available information. Stochastic errors may force the actual values of Y, S, and J to differ from those made at the planning stage. At the planning stage each variable is considered to be functionally related to a set of independent variables and a stochastic error term (all having the usual assumed properties of ordinary least squares estimation).

Section 2.1 describes the production/supply side of the model, Y_t. Section 2.2 discusses the sales/demand side, S_t, and section 2.3 discusses the inclusion of the intended inventory in equation (2.1) and lays the functional specifications.

Section 2.1 Supply

For a given sector z, supply will be assumed to be a decreasing function of real wages.[1] In growth rates, the equation is:

$$(2.2) \quad Y_t^s(z) = \alpha(z) - \beta(z)\left({}_{t-1}W_t(z) - P_t(z)\right) + U_t^s(z)$$

where $Y_t(z)$ is the real output in sector z, ${}_{t-1}W_t(z)$ is the nominal wage in period of sector z set in period t-1, $P_t(z)$ is the price level in sector z in period t, and U_t^s is a random stock term. The bracketed term is derived from a linear production function in terms of labor only.[2] I argue that the capital stock and other production components are constant and output changes in the short-run are a function of labor changes only. The coefficient $\beta(z)$ transcribes the labor input into sector z output. I further argue that nominal wages in sector z are deflated by the price level in sector z since hiring and production decisions will be based on the perception of the real wage in the eyes of the producers.

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[1]This formulation is adapted from Fischer (1977a). The major modification is that equation 2.2 in sector specific and the real wage is assumed to be in the eyes of the producer.

[2]See Appendix 2B for the derivation of the supply curve from a linear production function.

Wages are assumed to be set according to institutional arrangements within a sector. Microeconomic theory tells us that nominal wages will be set equal to the value of marginal product. To the extent, however, that wages are set contractually--hence dependent upon expectations of future values of marginal products and prices which may not always be correct--real wages may deviate from marginal products in a given sector. Institutional parameters outside explicit contracts may cause similar deviation. Thus, the wage setting behavior may be posited to take the following form (in growth rates):

$$(2.3) \quad {}_{t-i}W_t(z) = \gamma(z) + \lambda(z)\left({}_{t-i}P_t(z)\right)$$

where $\gamma(z)$ is a scale factor (which might be viewed as reflecting the growth of marginal productivity) and $\lambda(z)$ takes into account different institutional wage setting parameters. Should $\lambda(z) = 1$, equation (2.3) says that nominal wages in period t are set in period t-1 to maintain constancy of the real wage across time (scaled by $\gamma(z)$), based upon expectations of prices in period t formed in period t-1. Note that the notation λ is consistent with the earlier discussion of the adjustment mechanism with respect to fully anticipated monetary growth. In this view, wages would be considered to completely adjust to fully anticipated money growth if $\lambda = 1$.

Equation (2.3) is sector specific, across time. The cross-sector relationship will be assumed to be $\frac{W_i}{P_i} = \frac{W_j}{P_j}$ for all sectors i and j.

Substitution of equation (2.3) into equation (2.2) gives:[3]

$$(2.4)\quad Y_t^s(z) = [\alpha(z) - \beta(z)\gamma(z)] + \beta(z)[P_t(z) - \lambda(z)_{t-i}P_t(z)] + U_t^s(z)$$

This supply equation differs from the Barro and Lucas specifications in some important ways. Lucas's (1973) supply equation takes the form:

$$Y_t(z) = \alpha + \beta t + \gamma[P_t(z) - E(P_t/I_t(z)] + \lambda Y_{c,t-i}(z).$$

The term $E(P_t/I_t(z))$ is the expectation of the general price level given information available in sector z at time t. If current sector price changes are equal to expected general price changes, no output effects, *ceteris paribus*, will be realized in sector z. To the extent that producers in z incorrectly attribute a rise in sector prices (caused by aggregate monetary changes) to relative

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[3]Alternatively, this equation might be considered as the cyclical component about a "natural rate" of output. Thus, output would be composed of the natural plus the cyclical component:

$$Y_t = Y_{nt}(z) + Y_{ct}(z)$$

where n and c refer to natural and cyclical parts. Following Lucas, we define $Y_{nt}(z) = \alpha + \beta t$, where t is a time variable. Estimation of reduced form equations include a constant and a time variable.

sector demand shifts, the actual price in z will differ from that expected to have taken place in the economy and short-run output affects will be realized.

Output changes in my supply curve are a function of wage setting behavior in each sector as described above. I have argued that specification of the model in this way provides a mechanism for expected money growth (or inflation) to have real effects. Clearly, other supply specifications exist. A respecification of the model using a relative sector to expected general price level variable is the subject of Appendix 2A. This respecification does not by itself provide a mechanism for expected money growth to have real effects. Some assumption of imperfect price response must still be made.

The supply curve (2.4) differs from Lucas in that it does not contain a lagged cyclical component. Lucas uses this to adjust for serial correlation empirically shown to exist. In my model, as is shown below, justification for the existence of this lagged term enters the model through the inventory adjustment equation.

The last important distinction is that in Lucas' model only unexpected relative price changes affect sector output. That is, the λ as defined in my model is assumed in Lucas to be equal to one.[4]

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[4]The λ in Lucas' paper and mine have different meanings. In Lucas' model, if current price quotes differ from expected

quotes, an unexpected demand shift must have taken place.[5] This shift could be due to unexpected real sector influences or unexpected aggregate pressures.[6]

Equation (2.4) differs from Barro's (1976) supply curve. Barro's supply function is (equation 1 in Barro's paper):

$$Y_t^s(z) = k_t^s(z) + \alpha_s[P_t(z) - EP_{t+1}/I_t(z)]$$

$$- \beta_s[M_t + E\Delta M_{t+1}/I_t(z) - EP_{t+1}/I_t(z)]$$

$$+ U_t^s + \varepsilon_t^s(z)$$

where α_s and β_s are the relative price and wealth elasticities. Note an important distinction in the relative price term. Barro's relative price term is current sector price to the expected general price next period. Barro states that this term

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[5]This assumes the producers are fully cognizant of the marginal costs of production, i.e., their supply curve is known.

[6]As discussed in Chapter One, the more faith that unexpected demand shifts are caused by real factors the greater the output response. This reflects the beauty of Lucas' model: that unexpected changes do not necessarily imply a Phillips curve trade-off. Rather, the slope of the Phillips curve is a function of the sector-aggregate price confusion. Appendix 2A provides evidence on this hypothesis; the Lucas type of price confusion will lead to different sectoral output responses because there is no reason to believe that different sectors will have identical predictions of the general price level. This would be true even if the general price level distribution was identical and known by each sector.

is the result of "speculation over time associated with the intertemporal substitutability of leisure."[7] To the extent that wages reflect the labor/leisure trade-off, my supply curve reflects this behavior.

There is a great controversy about the appropriateness of defining relative prices as errors in current price from last periods expectation of the current price as opposed to the errors in current from the expected future prices. The former reflects the Friedman-Phelps formulation (as well as my own) and the latter reflects efficient market formulations especially as it applies to the term structure of interest rates. For a good discussion of these distinctions see Poole (1976).[8]

The wealth term is not included in my formulation. Barro includes the term because he limits his discussion to the service sector. As money balances increase relative to the expected future price level, less output is provided as leisure is substituted for work. Since the sector model I present is not restricted to the service sectors it does not seem reasonable to include this type of wealth variable. Furthermore, the real wage term will again partially reflect this labor/leisure trade-off.

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[7]Barro (1976) p. 4

[8]Poole, William, "Rational Expectations in the Macro Model," Brookings Papers on Economic Activity, 1976, VOl. 2, pp. 463-514.

Barro's model assumes $\lambda = 1$ as defined in my model. Barro states that his "model does not include any elements of adjustment costs for price changes that would inhibit price flexibility."[9] Barro refers readers to his 1972 article on monopolistic price adjustment as affecting the flexibility of prices.

In both Lucas and Barro, the economy consists of a single good produced and sold in physically separated markets. My model is a many goods market structure. There are, in my model, as many equilibrium prices and outputs as there are sectors. This is distinct from Lucas in that his sector supply equations are aggregated and then the model solved using a single aggregate demand equation. Barro specifies sector specific demands and solves for the aggregate price level as a geometric, unweighted average of the equilibrium sector prices. (See equations 10 and 12 of Barro 1976.) Cukierman and Wachtel (1979) follow a Lucas formulation but solve for prices in a similar manner to Barro. The solution of the model in Appendix 2A follows the Cukierman and Wachtel method.

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[9] Barro (1976) Footnote 9, p. 6.

Section 2.2 Sales

The specification of a sales equation, i.e., the demand for products in sector z incorporates a wealth or real balance variable as well as a price variable (in growth rate):

$$(2.5) \quad S_t(z) = \delta_0 - \delta_1[P_t(z) - {}_{t-1}P_t(z)] - \delta_2[M_t - P_t(z)] - U_t^d(z),$$

where $S_t(z)$ is the sales in real sector z output (above or below some normal level which is not dealt with explicitly), M_t is aggregate money stock and U_t^d as a random demand shift term. The use of aggregate money reflects a simplifying (and analytically necessary assumption) that the total money possessed by participants in market z, $M_t(z)$, is always the same fraction of the aggregate money stock. Lucas (1972) models this fraction as a random variable. Barro remarks that the random disturbance term specific to each sector captures this randomness.[10]

Alternatively, one can argue for the inclusion of aggregate money by positing $M_t(z)$ to grow at an equivalent rate to the aggregate money stock; again, deviations of $M_t(z)$ from M_t is random and included in the error term. A similar assumption of equivalent growth rates can be used to support the deflation of money balances by the sector prices. However, the use of aggregate prices does not alter the main conclusions of the model.[11]

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[10]Appendix 2C addresses this point.

[11]Barro (1976); Lucas (1973). Appendix 2A illustrates this point.

The demand specification (2.5) is similar to Barro's (1976) model. As discussed above, the relative price term used by Barro is current to future expected price. On the demand side this leads to price speculation.[12] In equation (2.5) prediction errors, not speculation, lead to adjustment of current demand.

Cukierman and Wachtel specify sector demand as:[13]

$$Y_t(z) + P_t(z) = X_t + W_t(z)$$

where X_t is aggregate shocks common to all markets and $W_t(z)$ is a random shock specific to sector z. The distribution of W(z) is assumed identical across all sectors. My specification of demand, although not as general as the above equation contains an aggregate shock, via money balances as well as sector specific shocks via the relative price movements. Appendix 2A, which redefines real balances in terms of aggregate expected prices, presents an alternative formulation of the aggregate shock variable.

Sector stochastic errors in Barro is considered to be transitory. Further, Barro assumes his systematic supply term $k_t^s(z)$ is constant across all markets. Barro must specify this to insure that arbitrage results in the same ex ante distribution of

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[12]Price speculations has been shown in the efficient markets literature to be non-destabilizing. The reason is that profitable speculating will always be stabilizing and unprofitable speculation will lead to a reduction in resources for speculators who systematically make poor bets. (See Poole, p. 464.)

[13]Cukierman and Wachtel (!970), p. 597.

prices. I argue, following Lucas, that agents have the same ex ante distribution of the overall price index based upon knowledge of past aggregate demand shifts, of normal supply, and deviations from normal supply. Lucas states, "while this information does not permit exact inference of the log of the current general price level, P_t, it does determine a 'prior' distribution on P_t, common to traders in all markets."[14] This assumption of ex ante general price distribution is conceptually different than Barro's and seems more appropriate for sector models.

Section 2.3 Intended Inventories

This section investigates the role of inventories and sets out the functional relationship that is to be incorporated in the model. The absence of inventories in highly aggregated models is understandable vis-a-vis the limitation to its quantitative precision due in part to the high level of aggregation over firms. On a disaggregated level, inventories may be expected to play a more important role. Reasons for holding inventories are discussed in 2.3A. The specification of the intended inventories is described in 2.3B. Problems of production for stock and production to order are discussed in 2.3C.

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[14]Lucas (1973) p. 329.

Section 2.3A Reasons for Holding Inventories

Modigliani presents four major reasons why manfacturers hold inventories:[15]

1. procurement cost;
2. smoothing of production;
3. expected change in prices; and
4. uncertainty of demand and lag time in the procurement of materials.

The first factor relates to the economies of scale of bulk procurement. This relates to the inventories of purchased materials rather than inventories of finished goods.

The second reason relates to finished goods inventories. In light of this study, the role of inventories in smoothing production implies that inventories may take the brunt of expected and unexpected monetary changes rather than output. It might well be the case that inventories may be more sensitive to unexpected changes, acting as a buffer stock.

Real costs are involved in changing the rate of production due to such things as overtime and lay-off costs. "Costs associated with changing the level of production arise from the need to reorganize the work force and machines which may arise when production levels are changed. It is not unusual for goods to be

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[15]Modigliani, Franco, "Business Reasons for Holding Inventories and Their Macroeconomic Implications," in Problems of Capital Formation: Studies in Income and Wealth, Vol. 19, New York: National Bureau of Economic Research, 1957.

produced in runs keeping the rate of production constant in order to minimize costs of reorganization, machine set-up costs and possible hiring or discharge of workers."[16]

This is not to say that there are no costs of adjusting inventories. A simple formula of total costs can be written as:[17]

$$\text{(2.6)} \quad \text{Total Cost} = C_{y_t} + C_I(N_t^d - N_{t-1})^2 + C\Delta y(Y_t^d - Y_{t-1})^2$$

where C_y is the costs associated with production, C_I is the costs associated with changing the level of inventories from last periods inventory stock, N_{t-1} to that desired this period, N_t^d and $C\Delta y$ is the costs associated with changing the level of production from last periods output to the desired current period output, Y_t^d. The latter two costs can be interpreted as costs of fluctuation in inventories and production. Note that keeping inventories at their desired level has the associated expense of increase cost of fluctuation in production. If inventories exceed a desired level, storage costs, insurance, deterioration, and obsolescence become important cost considerations. If inventories are below the desired level, costs from the inability to service sales efficiently become important.

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[16]Rowley, J.C.R. & P.K. Trivedi, Econometrics of Investment, Wiley & Sons, 1975, p. 58.

[17]Rowley & Trivedi, Ibid, "The use of a quadratic function summetric around the minimum is, of course, a simplification." p. 58.

The third reason suggested by Modigliani, that of expected changes in prices, reflects a speculative motive for holding inventories and is relevant to all types of inventories: purchased material, work in progress, and finished goods. If relative prices are expected to increase in the future, current inventories may expand.

The fourth reason reflects the holding of inventories to avoid the undesirable consequences of not being able to satisfy unforeseeable demand. As in the case of holding inventories to smooth production the fourth reason reflects a buffer stock motive.

Section 2.3B Specification of Intended Inventories

The purpose of this subsection is to specify the functional relationship for intended inventories. The specification follows a simple stock-adjustment model. Although there is some question concerning the validity of the stock-adjustment model for those industries which produce to order, this specification seems most appropriate for this study since sales expectations are fundamental to the stock-adjustment approach. The problems of production to order will be discussed in the following section. Let r be a desired inventory-sales ratio:

$$(2.7) \quad N_t^d = rS_t$$

where N_t^d is the desired inventory. The term r is not considered a constant.[18] Although for simplicity one may assume that manufacturers try to maintain this desired ratio. Note also that N_t^d is a stock and that S_t is a flow. Thus r must depend upon the length of the period.

We are now faced with two separate approaches involving the inclusion of inventories into the model. The first is to specify the model in terms of the speed of adjustment of production as it applies to the difference between desired and actual inventory. The second begins with the premise that adjustments of inventories necessarily implies changing the rate of output. Therefore, the speed of adjustment can be applied to the difference between desired and actual output rather than to the gap between desired and actual inventory. The latter has the distinct property of justifying the inclusion of a lagged dependent variable in the equations to be estimated.

Section 2.3B.1 Speed of Adjustment of Production Applied to Inventories

I will refer to the speed of adjustment of production applied to inventories as simply the speed of adjustment of inventories with the role of production implied. Not only is this for

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[18]Especially across industries. The term r, although not denoted to be sector specific, should be viewed as such.

simplicity but it tends to emphasize the role of inventories adjusting and does not seem to get muddled in production changes which may not all be earmarked for inventory maintenance. Let the intended inventory change take the following form:

$$(2.8)\quad J_t = a_1(N_t^d - N_{t-1}).$$

Should the adjustment from last periods inventory stock to the desired be fully realized, the value of a_1 would be 1. Since that which is desired is not always equal to the actual inventory change, a_1 may take on a value other than one. I do not see any reason why a_1 should be limited to a range between zero and one, although intuitively it makes sense to do so. Rather it is in the realm of possibilities that the actual change of inventories may exceed the gap between actual and desired. Further, a_1 could take on negative values indicating that although the intended change of inventories is, say positive, for some reason the actual change is negative. The reciprocal of a_1 is the number of periods it take for adjustment to take place.[19] Thus, a_1 is defined as the coefficient of adjustment of inventories.

In general, we may expect the coefficient of a_1 to be less than one, because changing the level of production beyond a certain range is not possible without changing the level of

[19]This is not particularly appropriate for negative values of a_1.

employment or expanding capacity. Conventional and institutional factors (with associated time allowances) limit the changing level of employment. This may not be as critical a factor across quarters as it would be using monthly data. Capacity increases, however, are long-run considerations. Implicit are the real costs of any adjustment, thus a_1 necessarily reflects these changing production level costs. If production can easily (and without cost[20]) be changed, the role of inventories as a buffer disappears. Whether inventories are held depends upon the magnitude of procurement costs and speculation of price changes.

Substitution of equation (2.7) into equation (2.8) gives:

$$(2.9) \quad J_t = a_1 r S_t - a_1 N_{t-1}.$$

Substituting (2.9) into (2.1) gives:

$$(2.10) \quad Y_t(z) = (1 + a_1 r) S_t(z) - a_1 N_{t-1}$$

Equation (2.10) is the equilibrium condition in terms of Y_t and S_t.

Section 2.3B.2 Adjustment Speed as Applied to Production Gap

Let us assume that the desired production level of firms is one adequate enough to cover anticipated sales and to adjust inventories to their desired level. The latter condition is

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[20]At least relative to the cost of holding inventories.

equivalent to $a_1 = 1$. Production is viewed, therefore, as adjusting to inventory gaps and anticipated sales. In equation form, we can write this relationship as:

$$(2.11) \quad Y_t^d = S_t + N^d - N_{t-1}.$$

The actual level of production, ex poste, may not be equal to the level formed in the planning stages. The speed of adjustment coefficient can be defined as relating the gap between desired production and last periods production to the actual gap between output this period and last:

$$(2.12) \quad Y_t - Y_{t-1} = a_2(Y_t^d - Y_{t-1}).$$

Note that the adjustment coefficient a_2 implicitly includes the coefficient of adjustment of production with respect to inventories, a_1. The coefficient a_2, however, is expanded to include adjustment of production to sales. Therefore a_1 must be less than or equal to a_2.

Substitution of (2.7) into (2.11) and the result into (2.12) and rewriting:

$$(2.13) \quad Y_t = a_2(1 + r)S_t - a_2N_{t-1} + (1 - a_2)Y_{t-1}.$$

Should $a_2 = 1$, then the adjustment of production is complete and desired equals actual output.

Section 2.3C Production for Stocks vs Production For Order

Inventories are introduced into the model through a stock-adjustment mechanism. Since a primary focus of this paper is on expected and unexpected money growth (which implies that anticipations should play a major role) the stock-adjustment mechanism seems most appropriate since stocks are adjusted according to future sales expectations.

The stock adjustment model is not entirely appropriate for those industries that produce to order. Zarnovitz notes that "industries which sell mainly from future output are decidedly dominant in the composite of all durable manufactures. In contrast, production for stock apparently prevails within the aggregate of non-durable industries."[21] Inventory stocks of those firms producing to order consists mainly of finished goods waiting for shipment. Production and shipment are both lagged responses to orders placed in the past. Firms producing for stock service demand partly through current production and partly by withdrawing from accumulated inventory.

This discussion does not deny the relevance of the model. Rather we might expect to see similarities of response among non-durable industries and also among durable industries. For example, since output is a function of orders we might not expect

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[21]Zarnovitz, Victor, "The Timing of Manfacturers', Orders During Business Cycles." In Business Cycle Indicators, H.G. Voor, editor, 1961, Vol 1, P. 426.

to see a strong relationship between last periods production and this periods production, (although the variables represent flows which complicated matters). Further, we might also expect lagged inventories to not significantly effect current inventories since inventories are mainly awaiting shipment and may not be influenced by past inventories. The same is not necessarily true of lagged output on current inventories since lags in shipping may strongly connect the two.

Section 2.4 Solving the Model

This section derives two sets of reduced form equations one incorporating intended inventories adjustment and the other incorporating production gap adjustments. The equilibrium condition is given by equation (2.1), rewritten to be sector specific:

$$(2.1)\quad Y_t(z) = S_t(z) + J_t(z)$$

Section 2.4A Inventory Adjustment Reduced Forms

For convenience recall the following equations, (again rewriting to be sector specific):

$$(2.4)\quad Y_t^s(z) = [\alpha(z) - \beta(z)\gamma(z)] + \beta(z)[P_t(z) - \lambda(z)_{t-i}P_t(z)] + U_t^s(z)$$

$$(2.5)\quad S_t(z) = \delta_0 - \delta_1[P_t(z) - {}_{t-1}P_t(z)] + \delta_2[M_t - P_t(z)] + U_t^d(z)$$

$$(2.9)\quad J_t(z) = a_1 r S_t(z) - a_1 N_{t-1}$$

Substituting equation (2.4), (2.5) and (2.9) into equation (2.1) and solving for $P_t(z)$ (ignoring stochastic and intercept terms) gives:

$$(2.14)\quad P_t(z) = \frac{\beta(z)\lambda(z) + e\delta_1}{\beta(z) + e\delta_1 + e\delta_2}\, {}_{t-1}P_t(z) + \frac{e\delta_2}{\beta(z) + e\delta_1 + e\delta_2} M_t - \frac{a_1}{\beta(z) + e\delta_1 + e\delta_2} N_{t-1}$$

where $e = 1 + a_1 r$.

Assuming expectations are formed rationally, i.e., based upon information contained in the model, ${}_{t-1}P_t(z)$ is found by taking the expectations of (2.14) conditionally on information up to and including period t-i. For simplicity let i = 1, then:

$$(2.15)\quad {}_{t-1}P_t(z) = \frac{e\delta_2}{\beta(z) - \beta(z)\lambda(z) + e\delta_2}\, {}_{t-1}M_t - \frac{a_1}{\beta(z) - \beta(z)\lambda(z) + e\delta_2} N_{t-1}.$$

Substitution of (2.15) back into (2.14) gives:

$$(2.16)\quad P_t(z) = \left(\frac{\beta(z)\lambda(z) + e\delta_1}{\beta(z) + e\delta_1 + e\delta_2}\right)\left(\frac{e\delta_2}{\beta(z) - \beta(z)\lambda(z) + e\delta_2}\right) {}_{t-1}M_t + \frac{e\delta_2}{\beta(z) + e\delta_1 + e\delta_2} M_t - \frac{a_1}{\beta(z) - \beta(z)\lambda(z) + e\delta_2} N_{t-1}.$$

The money supply is assumed (for simplicity) to be set on the basis of all past aggregate demand and supply disturbances:[22]

$$(2.17)\quad M_t = \sum_{i=1}^{\infty} a_i U^s_{t-i} + \sum_{i=1}^{\infty} b_i U^d_{t-i}$$

which implies that ${}_{t-1}M_t = M_t$. Thus the price equation (2.16) can be rewritten as:

$$(2.18)\quad P_t(z) = \frac{e\delta_2}{\beta(z) - \beta(z)\lambda(z) + e\delta_2} M_t - \frac{a_1}{\beta(z) - \beta(z)\lambda(z) + e\delta_2} N_{t-1}$$

Note that if $\lambda(z) = 1$, equation (2.18) reduces to:

$$(2.19)\quad P_t(z) = M_t - \frac{a_1}{(1 + a_1 r)\delta_2} N_{t-1}$$

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[22]This is Fischer's, (1977a).

which has the well known property (assuming desired is equal to actual inventories, this causing the N_{t-1} term to fall out) that a change in the growth rate of the money stock is fully accounted for in a change in prices. Should desired inventories differ from last periods' actual stock, the N_{t-1} term becomes important. The interpretation of the term is as follows: if inventories were greater than desired last period, producers would attempt to draw down on these inventories. The introduction of these inventories on the market puts pressure on the price of those goods to fall. The degree of price change depends upon the ability of producers to adjust inventories (via the a_1 coefficients) as well as the public's ability to absorb this extra supply via the $\delta 2$ coefficient of real money balances. The lower the coefficient δ_2 the more inelastic the demand curve for sector z products with respect to changes in real balances. To illustrate recall:

$$S_t = f(-\delta_2[M_t - P_t(z)]).$$

If the price in sector falls, real balances appropriate to that sector, increase. If δ_2 is close to zero, the change in sales is small. Therefore, if N_{t-1} is greater than desired it takes a larger decrease in price to clear these excess inventories.

Equation (2.1) can be rewritten as:

(2.20) $Y_t(z) - J_t(z) = S_t(z).$

Substitution of equation (2.5) for $S_t(z)$:

$$(2.21)\quad Y_t(z) - J_t(z) = \delta_0 + \delta_{1\,t-1}P_t(z) - (\delta_1 + \delta_2)P_t(z) + \delta_2 M_t + U_t^d.$$

Substituting equation (2.15) for ${}_{t-1}P_t(z)$ and equation (2.18) for $P_t(z)$ and rewriting:

$$(2.22)\quad Y_t(z) - J_t(z) = \delta_0 + \delta_2(\beta(z) - \beta(z)\lambda(z) - \delta_1)a[M_t - {}_{t-1}M_t] + \delta_2\beta(z)\big(1 - \lambda(z)\big)a[{}_{t-1}M_t] + \delta_2 a_1 a[N_{t-1}]$$

where $a = \dfrac{1}{\beta(z) - \beta(z)\lambda(z) + e\delta_2}$.

The format of equation (2.22) nicely illustrates the relationship between output and inventory changes vis-a-vis unexpected monetary changes, and lagged inventory effects. Simply, changes in monetary growth can effect either output, inventories, or both whether the growth is expected or not. Whether output or inventories is more sensitive to unexpected (or expected) is an empirical question.

Note an interesting property of equation (2.22): If $\lambda(z) = 1$, i.e., prices fully adjust to fully anticipated monetary growth, the expected money term falls out of the equation. Unexpected changes affect output and/or inventory change, as does lagged inventory. The coefficient of lagged inventory reduces to $\frac{a_1}{(1 + a_1 r)}$ when $\lambda(z) = 1$. Note that if desired inventories are equal to last periods inventories the N_{t-1} term would fall out of this equation entirely (J_t being equal to zero) and we are left with the result that only unexpected monetary growth affects real output.

Section 2.4A.1 <u>The Output Equation</u>

Recall equation (2.10):

$$(2.10) \quad Y_t = (1 + a_1 r)S_t(z) - a_1 N_{t-1}.$$

Once again substituting equation (2.5) for $S_t(z)$ we obtain:

$$(2.23) \quad Y_t = e\delta_0 + e\delta_2(\beta(z) - \beta(z)\lambda(z) - \delta_1)a[M_t - {}_{t-1}M_t]$$

$$+ e\delta_2\beta(z)\big(1-\lambda(z)\big)a[{}_{t-1}M_t]$$

$$+ a_1\beta(z)[\lambda(z) - 1]a[N_{t-1}].$$

If prices adjust completely there is no output response to expected money growth or to last periods inventory stock, since $\lambda(z) = 1$. If $\lambda(z) < 1$ there is a positive output response to expected money growth and a negative response to last periods inventory stock. Once again, if last periods inventory stock is greater than desired, production in period t would be less, made up in part by the inventory adjustment. The importance of this depends upon $\beta(z)$, the coefficient of real wages and the inventory adjustment coefficients. The greater $\beta(z)$ the more impact N_{t-1} has on Y_t, i.e., real costs are saved by cutting down on production (and hence the wage bill) by substituting current inventory excesses.

The coefficients on lagged output and expected money will differ in absolute value due to the influence of a_1. Assuming that $\lambda(z) \neq 1$ and that $0 < a_1 < 1$, one would expect the coefficient on the expected money term to be larger in absolute value than lagged inventories since the money term is partly a product of e (which is equal to $1 + a_1 r$) whereas the inventory variable is a product of a_1.[23] The reason for this is that output is affected by anticipated sales and desired inventories. Part of desired inventories is related to actual inventories and anticipated sales. Thus output is affected by anticipated sales related to the adjustment inventory as well as anticipated sales related to marketing decisions.

Section 2.4A.2 <u>The Inventory Equation</u>

Rewriting equation (2.1) once again:

$$(2.24) \quad J_t(z) = Y_t(z) - S_t(z).$$

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[23]An example may help to clarify this: Let $r = .2$ and $a_1 = .7$. Thus the expected money and inventory coefficient become $1.14\delta D$ and $-.7\delta D$ respectively, where $D = (\beta(z))(1-\lambda(z))a$ which must be positive since $0 < \lambda < 1$. The difference between these two is clearly illustrated in equation 2.10.

Substituting (2.4) for $Y_t(z)$ and (2.5) for $S_t(z)$ and further substituting (2.15) for ${}_{t-1}P_t(z)$ and (2.18) for $P_t(z)$ we can write $J_t(z)$ as a function of expected and unexpected money growth as well as lagged inventory stock as follows:[24]

$$(2.25)\quad J_t(z) = a\delta_2[(e-1)\beta(z) + \beta(z)\lambda(z) + \delta_1][M_t - {}_{t-1}M_t]$$

$$+ [(\delta_2\beta(z)(1-\lambda(z))a)(e-1)_{t-1}M_t]$$

$$- a_1 a[\delta_2 - \beta(z)[\lambda(z) - 1]]N_{t-1}$$

where $e = 1 + a_1 r$.

Note that not only will the expected money term fall out if $\lambda(z) = 1$ but also if $e = 1$. The latter is unlikely, however, unless the desired inventory to sales ratio is zero.

If prices adjust instantly there is no supply induced change in intended inventory brought about by last periods inventory stock.[25] This is not of course true of equation (2.25) where, if $\lambda(z) = 1$, the coefficient reduces to $-a_1$, i.e., the negative of the coefficient of adjustment from actual last periods inventory to desired inventory. The negative sign reflects the influence of sales on inventory.

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[24]The constant term has been dropped for simplicity. For empirical examinations this equation is modified to read:

$$N_t^1 - (Y_t + N_{t-1}) - S_t,$$

i.e., current end of period inventories is equal to the total stock of goods available in period t less what is sold across this period.

[25]One can readily see this by substituting (2.18) and (2.15) into equation (2.4) and examining the coefficient of lagged inventory stock.

Section 2.4B Production Adjustment Reduced Forms

The process of solving for the reduced forms is the same as that described above. The equations of importance are, (rewritten to be sector specific):

$$(2.13)\quad Y_t(z) = a_2(1 + r)S_t - a_2N_{t-1} + (1-a_2)Y_{t-1}$$

$$(2.4)\quad Y_t^s(z) = [\alpha(z) - \beta(z)\gamma(z)] + \beta(z)[P_t(z) - \lambda(z)_{t-1}P_t(z)] + U_t(z)$$

$$(2.5)\quad S_t(z) = \delta_0 - \delta_1[P_t(z) - {}_{t-1}P_t(z)] + \delta_2[M_t - P_t(z)] + U_t^d(z).$$

Substitution of (2.4) and (2.5) into (2.13) and solving for prices gives:

$$(2.26)\quad P_t(z) = \frac{1}{\beta(z) + q\delta_1 + q\delta_2}\Big[\big(\beta(z)\lambda(z) + q\delta_1\big)_{t-1}P_t(z)$$

$$+ q\delta_2M_t - a_2N_{t-1} + (1 - a_2)Y_{t-1}\Big]$$

where $q = a_2(1 + r)$.

Taking the expected value of equation (2.26) and rearranging:

$$(2.27)\quad {}_{t-1}P_t(z) = q\delta_2T({}_{t-1}M_t) - a_2T(N_{t-1}) + (1 - a_2)T(Y_{t-1})$$

where $T = \dfrac{1}{(\beta(z) - \beta(z)\lambda(z) + q\delta_2)}$

Substituting (2.27) back into (2.26) the equilibrium price level is obtained:

$$(2.28)\quad P_t(z) = q\delta_2T(M_t) - a_2T(N_{t-1}) + (1 - a_2)T(Y_{t-1})$$

Section 2.4B.1 <u>The Output and Inventory Equations</u>

Recalling the relationship, (2.20), $Y_t(z) - J_t(z) = S_t(z)$ and by substituting (2.27) and (2.28) into (2.5) and the result into (2.20) we write:

$$(2.29)\quad Y_t(z) - J_t(z) = \delta_0 + \left[(\delta_2(\beta(z) - \beta(z)\lambda(z) - \delta_1 q))T\right]\left[M_t - {}_{t-1}M_t\right] + \delta_2\beta(z)[1 - \lambda(z)]T[{}_{t-1}M_t] + \delta_2 a_2 T(N_{t-1}) - \delta_2(1 - a_2)T(Y_{t-1})$$

By arranging (2.29) and making the appropriate substitutions for $J_t(z)$, the output equation can be written as:

$$(2.30)\quad Y_t(z) = q\delta_0 + q\left[(\delta_2(\beta(z) - \beta(z)\lambda(z) - \delta_1 q))T\right]\left[M_t - {}_{t-1}M_t\right] + q\delta_2\beta(z)[1 - \lambda(z)]T[{}_{t-1}M_t] + \left(a_2\beta(z)\right)[\lambda(z) - 1]T[N_{t-1}] + \beta(z)(1-a_2)(1-\lambda(z))T(Y_{t-1})$$

The inventory equation is found by writing $J_t(z) = Y_t(z) - S_t(z)$ and making the appropriate substitutions for $Y_t(z)$ and $S_t(z)$ and ${}_{t-1}P_t(z)$ and $P_t(z)$:

$$(2.31)\quad J_t(z) = \text{CONSTANT} + \delta_2 T(\beta(z)(q-1) + \beta(z)\lambda(z) + \delta_1 q)(M_t - {}_{t-1}M_t) + [\beta(z)\delta_2 T(1 - \lambda(z))(q - 1)][{}_{t-1}M_t] - a_2 T[\delta_2 - \beta(z)(\lambda(z) - 1)]N_{t-1} + \delta_2(1 - a_2)T(\beta(z)(1 - \lambda(z)) + 1)Y_{t-1}.$$

Equations (2.30) and (2.31) differ from equations (2.23) and (2.25) in the Y_{t-1} term and the difference of interpretated of a_2 from a_1. The adjustment of production hypothesis justifies the inclusion of the lagged output variable. Other reasons why this variable might be included for empirical reasons will be discussed in Section 3.2 of Chapter 3. The notable property of the coefficient on lagged output is the $(1 - a_2)$ component, which implies that if adjustment of production is complete, last periods output would not effect either current output or inventories. In other words adjustment from last periods production is complete and no lagging influences on current supply exists. This is further emphasized by the $\lambda(z)$ term which implies that if prices fully adjust there is no lagged output influence since past excess supplies are cleared as prices adjust. The remainder of the variables in the reduced form equation have the same properties as before, the most important relating to whether $\lambda(z) = 1$.

The above analysis can be written in matrix notation. This is most easily accomplished by dropping the "(z)" notation and interpreting the matrix of endogenous and exogenous variables as column vectors with n elements, each specific to a given sector z. The coefficients are matrixes which are by definition conformable for matrix multiplication.

$$
\begin{aligned}
(2.30) \quad Y_t = q\delta_0 &+ q[\delta_2(\beta - \beta\lambda - \delta_1 q)T[M_t - {}_{t-1}Mt] \\
&+ q\delta_2\beta[I - \lambda]T[{}_{t-1}M_t] + a\beta[\lambda - I]T[N_{t-1}] \\
&+ \beta[I - a_2][I - \lambda]T[Y_{t-1}]
\end{aligned}
$$

and

$$(2.31)\quad J_t = \delta_2 T(\beta(q - 1) + \beta\lambda + \delta_1 q)[M_t - {}_{t-1}M_t]$$

$$+ [\beta\delta_2 T(I - \lambda)(q - 1)][{}_{t-1}M_t]$$

$$- a_2 T(\delta_2 - \beta)(\lambda - I)N_{t-1}$$

$$+ \delta_2(1 - a_2)T(\beta(I - \lambda) + I)(Y_{t-1})$$

Written in this manner, the test of neutrality is whether λ equals the identity matrix, I. It should be clear that non-neutrality does not necessarily imply differential sector impacts. Differential impacts are characterized by $\lambda(z)$ for a given sector being significantly different from λ for all sectors collectively. In other words, differentiality necessarily implies non-neutrality, but non-neutrality (in the sense of expected money growth being significant in explaining the variation of output) does not imply differentiality.

Section 2.5 Summary

This chapter has set forth a sectoral model in a rational expectation framework. The equilibrium condition for solving the model is that current output is equal to current sales plus current inventory change.

The supply side of the model was determined by real wages under the assumption that short term fluctuation in output is accomplished by adjustments of labor. The demand/sales side of the model is characterized by relative prices (current to last periods price) and real money balances. The latter is sector specific in that nominal money balances are deflated by sector z's price level.

Inventories are incorporated into the model in two ways. The first is a stock-adjustment mechanism translating the gap between desired inventory stock and last periods actual stock into the current change in inventories. The second incorporates inventories as part of the adjustment mechanism between desired output and last period's output. Production is therefore viewed as adjusting to inventory gaps and anticipated sales.

Chapter III

METHODOLOGY

The chapter describes the empirical tests of the model. The tests are broken down into two blocks: the test of neutrality/non-differentiality effects across sectors and the test of the influence of sector characteristics on the coefficients of expected and unexpected money. The equations are specified in growth rates and should be interpreted as such unless otherwise noted.

Section 3.1 Test of Differential Impact of Money on Real Sector Output

The first test examines the neutrality of actual money growth. The test is whether actual money growth adds significantly to the explanatory power of the output equation. This is done by comparing the sum of squares regression in the equation excluding money growth with the equation including actual money growth as an independent variable. The letter estimation does not constrain the value of the coefficient on money growth to be zero as in the case of the former estimation. The sum of squares regression must be greater in the equation including the money growth variable. An F-test indicates whether this increase is statistically significant.

The influence of actual money growth on each of the twelve manufacturing sectors (see Appendix 3A) was examined. Further, following Bonomo and Tanner (1979), I test whether, on average, the sum of squares regression has increased significantly across all sectors.[1*]

Should money growth be found significant, two sets of equations are to be tested empirically. The first is related to the inventory

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[1*] In Bonomo and Tanner's words, this process of averaging is "in order to abstract from the eccentricities of individual cases." op cit, p. 10.

adjustment mechanism, the second to the production gap method. The null hypothesis of the first set takes the form:

$$(3.1)\quad \text{Null A:}\quad Y_t(z) = \alpha_0 + \alpha_1[M_t - {}_{t-1}M_t] + U_t(z)$$

$$(3.2)\quad \text{Alternative B:}\quad Y_t(z) = \beta_0 + \beta_1[M_t - {}_{t-1}M_t] + \beta_2[{}_{t-1}M_t] + \beta_3[N_{t-1}] + U_t(z)$$

and

$$(3.3)\quad \text{Null A':}\quad N_t(z) = \alpha'_0 + \alpha'_1[M_t - {}_{t-1}M_t] + \alpha_2 N_{t-1} + U_t(z)$$

$$(3.4)\quad \text{Alternative B':}\quad N_t(z) = \beta'_0 + \beta'_1[M_t - {}_{t-1}M_t] + \beta'_2[{}_{t-1}M_t] + \beta'_3[N_{t-1}] + U_t(z)$$

Note that N_{t-1} is not included in Null A. If prices fully adjust the N_{t-1} term would fall out of the equation. This is not true of Null A' where even if prices fully adjust there may still be some demand induced change in inventories.

The null and alternative hypothesis of the second set takes the form:

$$(3.5)\quad \text{Null C:}\quad Y_t(z) = \gamma_0 + \gamma_1[M_t - {}_{t-1}M_t] + U_t(z)$$

$$(3.6)\quad \text{Alternative D:}\quad Y_t(z) = \gamma_0 + \gamma_1[M_t - {}_{t-1}M_t] + \gamma_2[{}_{t-1}M_t] + \gamma_3[N_{t-1}] + \gamma_4[Y_{t-1}] + U_t(z)$$

and

(3.7) Null C': $N_t(z) = \gamma'_0 + \gamma'_1[M_t - {}_{t-1}M_t] + \gamma'_2[N_{t-1}]$

$$+ \gamma'_3[Y_{t-1}] + U_t(t)$$

(3.8) Alternative D': $N_t(z) = \gamma'_0 + \gamma'_1[M_t - {}_{t-1}M_t] + \gamma'_2[{}_{t-1}M_t]$

$$+ \gamma'_3[N_{t-1}] + \gamma'_4[Y_{t-1}] + U_t(z)$$

In words, the null hypothesis is β_2, β'_2, γ_2, and γ'_2 equal zero against the alternative that the null is not true.

For each sector, the null equations are regressed testing whether the addition of the expected money term (and other variables in equation B and D) add significantly to the explanatory power of the null equation. This is similar to a stepwise regression. The cross-equation test statistic has an F-distribution. A discussion of this F-test is contained in Appendix A, part 2. In general, if the addition of the expected money term proves to be significant, i.e., its coefficient significantly different from zero and the F-test across equations is significant, then both expected and unexpected money growth systematically affect the particular sector's output and money is non-neutral.

To assess whether the impact of money affects sectors differentially, the test is whether the estimated coefficients of expected (and unexpected) money growth for each sector differs significantly from the estimated coefficients of the equation using pooled data from all sectors. To illustrate if the coefficient of expected money growth of a sector is significantly different from the "market" coefficient it implies that the sector is more or less sensitive (depending on the sign of the difference) to anticipated money growth than the overall market.[2*]

Differentiality implies a marginal relationship between the output of a given sector and the collective of sectors. Thus, the dependent variable is modified by subtracting out the rate of growth of the collective. The result is the difference between the rate of growth of a sector and that of the collective sectors. For example, if the growth rate of a sector was three percent and the average growth of all sectors was four percent, relative to the average, the growth in the specific sector is minus one percent. Thus, although the growth in that sector is positive, it is growing slower than the "market" rate. The test is whether money growth is affecting this marginal difference. If money growth affects sector output relative to the movements in

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[2]An alternative way to test the differential impacts is to specify the dependent variables as the ratio of sector output to overall market output, or to regress sector output on expected and unexpected money with the overall market as a separate explanatory variable. These methods are discussed in Bonomo and Tanner (1978).

overall output, the coefficients of the money terms should be significantly different from zero, hence, there are differential impacts of money. Recall that differentiality implies non-neutrality although the converse is not necessarily true.[3]

Section 3.2 <u>Modification of Model</u>

This section discusses modification of the estimating equations. Sub-section 3.2A discusses the inclusion of lagged output as an explanatory variable. Section 3.2B discusses the influence of the capacity utilized on the ability of firms to adjust output and inventory. Section 3.2C examines the role of money growth (both expected and unexpected) during phases of the business cycle. Section 3.2D discusses adjustments for seasonality and trend, and section 3.2E discusses the use of growth rates and problems of autocorrelated.

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[3]Note the similarity of this modified equation to the modified capital asset pricing model of Bonomo and Tanner (!978):

(A) $R_i = a_i + B_i R_m + g_i DM + e_i$.

Where R_i is the return on an asset (say industry i), R_m is the market rate of return of asset i to market movements. DM is money growth and e_i is a random error term.

Section 3.2A Lagged Dependent Variable

As mentioned, the set of hypothesis derived from the production gap mechanism has the advantage of justifying the inclusion of the lagged output. Studies on a more aggregated level have added the lagged dependent variable as an empirical necessity rather than derived from a structural equation. The major reason for the inclusion of the lagged dependent variable in these studies is to take into account the high serial correlation in aggregate employment and output data. For instance, Sargent (1973, 1976a) specified the following equation:

$$U'_t = - \alpha(P_t - {}_{t-1}P_t) + \sum_{i=1}^{n} \delta_i U'_{t-i} + \gamma_i$$

where $U'_t = U_t - U_{nt}$ (U_{nt} considered to be the trend of the series). Lucas (1973) similarly specified an output equation to read:

$$(3.9) \quad Y'_t = \gamma(P_t - {}_{t-1}P_t) + \delta_1 Y'_{t-1} + \gamma_t$$

where $Y'_t = Y_t - Y_{nt}$. Sargent's expression, for a large enough n, can exhibit any autocorrelation pattern with the appropriate δ_i. Lucas chose an arbitrary Koych lag pattern. Note that these modifications do not affect the results that policy action is impotent and preserves the Sargent and Wallace conclusions that the distribution of output in period t is independent of deterministic monetary policy. Thus, the inclusion of lagged dependent variables is consistent with the modification by rational expectations proponents. The lagged dependent variable formulation can be shown to be consistent with stable wages and price theories.

The lagged dependent variable will also be assumed to capture technological change except current innovations. Any technological shock occurring after t-1, will be unexpected, hence not capable of being modeled as a separate explanatory variable of sector output in period t.

One can also argue for the inclusion of the lagged dependent variable vis-a-vis the structure of the money rule. For example, suppose output in time t is a function of money growth in time t alone, and hence output in time t-1 is a function of money growth in time t-1. The money rule specifies money growth as being dependent upon lagged money growth and other exogenous variables. Hence, through recursive substitution, output becomes a function of lagged output, and depending upon the extent of the substitution, lagged money growth.

Section 3.2A.1 Residual Lag Equations

The lagged dependent variable of equation 3.6 or equation 3.8 allows a further modification of the equations to be estimated. In particular, by substituting:

$$Y_{t-1} = \delta'_0 + \delta'_1[M_{t-1} - {}_{t-2}M_{t-1}] + \delta'_2[{}_{t-2}M_{t-1}] + \delta'_3[N_{t-2}]$$

$$+ \delta'_4[Y_{t-2}] + U_{t-1}$$

and

$$N_{t-1} = \gamma'_0 + \gamma'_1[M_{t-1} - {}_{t-2}M_{t-1}] + \gamma'_2[{}_{t-2}M_{t-1}] + \gamma'_3[N_{t-2}]$$

$$+ \gamma'_4[Y_{t-2}] + U_{t-1}(z)$$

into equations 3.6 and 3.8 for Y_{t-1} and N_{t-1}, respectively, we can write:

$$Y_t(z) = \delta_0 + \delta'_0 + \delta_1[M_t - {}_{t-1}M_t] + \delta_2[{}_{t-1}M_t]$$

$$+ \delta_4\delta'_1[M_{t-1} - {}_{t-2}M_{t-1}] + \delta_4\delta'_2[{}_{t-2}M_{t-1}]$$

$$+ \delta_3[N_{t-1}] + \delta_4\delta'_3[N_{t-2}] + \delta_4\delta'_4Y_{t-2} + U_t(z)$$

$$+ U_{t-1}(z)$$

and

$$N_t(z) = \gamma_0 + \gamma'_0 + \gamma_1[M_t - {}_{t-1}M_t] + \gamma_2[{}_{t-1}M_t]$$

$$+ \gamma_3\gamma'_1[M_{t-1} - {}_{t-2}M_{t-1}] + \gamma_3\gamma'_2[{}_{t-2}M_{t-1}]$$

$$+ \gamma_4Y_{t-1} + \gamma_3\gamma_4Y_{t-2} + \gamma_3\gamma'_3[N_{t-2}] + U_t(z) + U_{t-1}(z)$$

Writing the equations in this manner allows one to examine the lag pattern of unexpected and expected money growth.

Section 3.2B Role of Capacity Utilization

Recall from the discussion of Section 2.3B.1 that a_1 was the coefficient of adjustment between desired and actual inventories. As discussed, there exist conventional and institutional factors which may limit the ability of producers to fully adjust inventories. An important factor is the extent of unused capacity.[4] When production exceeds capacity, the rate of adjustment to sales is technically limited, although more for increases than decreases in sales. Decreases are primarily affected by the real cost associated with production change.

When production is below capacity, the ability of the firm to adjust is much greater. Moriguchi (1967) argues that not only are technical constraints removed but also that "a production cut in anticipation of decrease in sales might be done more freely....since the expected cost of raising the production level is less than the over-capacity case. In other words, the cost of changing the level of production is higher in the over-capacity case than in the below-capacity case."[5]

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[4]See in particular Rowley and Trivedi, Econometrics of Investment, Wiley, 1975; and Moriguchi, Busines Cycles and Manufacturer Short-term Production Decisions, North-Holland, 1967.

[5]Ibid.

To illustrate, recall equation (3.2):

$$(3.2)\quad Y_t(z) = \beta_0 + \beta_1[M_t - {}_{t-1}M_t] + \beta_2[{}_{t-1}M_t] + \beta_3[N_{t-1}] + U_t(z).$$

The hypothesis tested in whether β_1 or β_2 are affected by changing levels of capacity utilization. In simple terms, we can write B_1 as a function of capacity utilization:

$$(3.11)\quad \beta_i = b_{0i} + b_{1i}C + \text{Error}, \qquad \text{for } i = 1, 2.$$

where C is a measure of capacity utilizations. Substituting (3.11) into (3.2):

$$Y_t(z) = \beta_0 + b_{01}[M_t - {}_{t-1}M_t] + b_{11}[M_t - {}_{t-1}M_t]*C + b_{02}[{}_{t-1}M_t]$$

$$+ b_{12}[{}_{t-1}M_t]*C + b_3[N_{t-1}] + U_t(z)$$

The terms multiplied by C are interactive variables. A priori we expect the coefficient on the interactive variables to be negative, implying that the higher the capacity that is utilized, the less output (in this case) responds to a given change in the independent variables. Given that b_{1i} is negative, the effect of the independent variable will be zero when capacity is equal to the ratio of b_{0i} to b_{1i}.[6]

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[6]For the independent variable to have no association with the dependent variable, the coefficient in equation (3.2) must be zero. From equation (3.11) this implies $0 = b_{0i} + (b_{i0})(C)$. Rewriting,

$$C = \frac{b_0}{b_{1i}} .$$

The following example may help to illustrate this point. Consider the following estimated equation for the total manufacturing industries:[7]

$$\underset{}{XO2G} = \underset{(3.39)}{.745} + \underset{(2.10)}{26.59UMG} - \underset{(-1.99)}{.301U*C} + \underset{(1.57)}{7.91E} - \underset{(-1.34)}{.081E*C}$$

Rewriting the two unexpected terms as (26.59 -(.301)(C)) * UMG, it becomes obvious that if C takes on a value of 88.34 (approximately eighty-eight percent of total capacity), the coefficient on UMG would be zero and unexpected money growth would not be associated with output growth. If capacity were above 88.34 percent, the impact of unexpected money would have a negative impact. Clearly, the further the level of capacity is from this critical value, the greater the impact of unexpected monetary changes.

Note also that the critical value on the expected money variable is 97.65.[8] This analysis suggests that even though monetary changes may have rationally been forecasted, full adjustment in response may not be possible due to the technical conditions of the industry. *A priori*, one might expect the critical value of the expected money terms

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[7]This equation was estimated using non-seasonally adjusted data. Lagged output and inventory variables were not included. For a full discussion see section 5.3A.

[8]The individual t-test sheds some doubt as to the accuracy and significance of this value.

to be higher than the unexpected money terms because unexpected changes may have more of an instantaneous effect (hence less time to adjust at all levels of capacity) than that of expected changes.

The capacity utilization variable used was last period's measure. The reason for this is that this coincides with decisions made at the planning state. Further, adjustments of production depend upon the capacity at the end of last period, since the production in the period affects this period's capacity rather than vice versa. As a general rule, I will report the critical values where expected or unexpected money growth have no impact as a result of the influence of the level of capacity utilization. The reader should carefully weigh the meaning of these figures in light of the standard error of regression coefficient.

Section 3.2C <u>Business Cycle Effects</u>

Phases of the business cycle may influence the ability (or perhaps willingness is a better word) of producers to adjust output or inventories. Manufacturers, producing mainly for stock, rely heavily on sales expectation. The degree of uncertainty about expectations may vary according to the phase of the cycle. In a contractionary phase, businesses may be skeptical about their expectations of future demand and would become less willing to produce on the basis of anticipation.[9]

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[9] Moriguchi, p. 48.

Using dummy variables, we can test for differing responses of output and inventories to different phases of the business cycle. The method is identical to that employed with capacity utilization except in this case zero-one dummy variables are used for the interactive term.

Section 3.2D <u>Seasonality and Trend</u>

Section 3.2D.1 <u>Seasonality</u>

A difficulty arises in considering adjustment for seasonality in the data. Seasonality is defined to be a systematic, although not necessarily regular, oscillatory intrayear movement in economic time series.[10] Actual data values consist of the underlying structure that the analyst wishes to explain, deseasonalization is important. In estimating equations, if the seasonal variation is additive, e.g., $Y_t = \tilde{Y}_t + D_{ty}$ where Y_t is the actual value and D_{ty} is the seasonal deviation, it operates to shift the intercept term.[11] Seasonality is therefore considered to be an error in the variable and should be eliminated. The use of a dummy variable on the intercept would take this into account.[12]

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[10]Maddala. <u>Econometrics</u>, McGraw-Hill, 1977, p. 338.

[11]Following Kmenta, p. 424: given $Y_t = \tilde{Y}_t + D_{ty}$, estimation of the deseasonalized values for Y_t would take on the form:

$$\tilde{Y}_t = \alpha + \beta X + \varepsilon_t \text{ which implies } Y_t = (\alpha + D_{ty}) + \beta X_t + \varepsilon_t$$

[12]Kmenta, p. 422, $Y_t = \alpha + \beta X_t + \alpha_2 Q_{t2} + \alpha_3 Q_{t3} + \alpha_4 Q_{t4} + \varepsilon_t$
where Q_{ti} = 1 if t is the second, third, or fourth quarters for i = 1, 3, 4, respectively,
= 0 otherwise for i = 2, 3, 4,

The difficulty arises, however, when seasonal patterns are fluctuating. Disentangling the seasonal and non-seasonal factors becomes difficult. If the seasonal deviation is multiplicative, i.e., $Y_t = \tilde{Y}_t D_{ty}$, it implies different magnitudes of affect of the independent variable upon the dependent variable.[13] Because of seasonal cycles the influence of monetary changes may impact upon sectors differently, aggrevating some seasonal cycles and smoothing others. Further, a monetary change may well be interpreted as real cyclical changes by producers in a given sector. Thus, seasonality may alter the ability of sectors to project sector prices on aggregate prices. In Lucas' terminology, the seasonality may alter the sector specific θ's and hence improve the Phillips curve trade-off.

Adjustment for seasonality eliminates the distinction between those manufacturers that tend to smooth the flow of output against the oscilating demand from those manufacturers who do not. For the former, they may reflect a cost saving measure since extra equipment would not have to be purchased (and subsequently lain idle) to service the busy season. The implication is that the inventory to sales ratio is not

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[13]Kmenta, p. 425. Given $Y_t = \tilde{Y}_t D_{ty}$ where D_{ty} is a seasonal index whose production across all quarters is defined to equal one, the seasonal regression can be written as:

$$\frac{Y_t}{S_{ty}} = \alpha + \beta X + \varepsilon_t \text{ or } Y_t = \alpha S_t Y + \beta S_{ty} X + S_t g \varepsilon_t.$$

Note the coefficient on X is now a function of Y's seasonality.

constant (i.e., r is not constant). If this ratio changes so must the impact of money growth on output given by the influence of r in equations (2.23) and (2.25). During the peak season, r would fall, implying both unexpected and expected money growth would have less influence on output since sales would exceed production and inventories would take up the slack. During the off season, inventories are built up for the peak season, hence r would rise and so would the impact of money growth.

Numerous methods of seasonal adjustment exist. One method is the inclusion of seasonal dummies as both intercept and interactive variables.[14] This is equivalent to splitting the sample by quarters. A second method for seasonal adjustment is to smooth the time series. This provides different information than that derived from dummies in the sense that the use of dummy variables addresses the question of sensitivity to seasonal patterns, i.e., that is if the coefficients or the constant is significantly different in one quarter from a specified quarter, whereas smoothing the data addresses the sensitivity to the underlying (non-seasonal) structure.

Because of the conflicting views on deseasonalization, the estimations of the output and inventory equations were conducted using both non-seasonally and seasonally adjusted data. The results are

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[14]The method is identical to that employed with capacity utilization except in this case zero-one variables are used for the interactive terms. The inclusion of seasonal dummies further decreases the problem of autocorrelation in the error term of the equation.

reported in the empirical chapters. Seasonal adjustment was done with both seasonal dummies and conversion of the original data into a deseasonalized series. The conversion was done using Fourier or Spectral analysis.[15**]

The Fourier technique decomposes time series data into a sum of sinusoidal components. A sinusoid of frequency ω (in radians/unit time) or period $\frac{2\pi}{\omega}$, may be written as

$$f(t) = R\cos(\omega_t + \theta)$$

where R is the amplitude and θ is the phase. Any continuous function over time can be described by:

$$\text{(A)} \quad f(t) = \sum_{j=-\infty}^{\infty} A(\omega_j)e^{i\omega_j t},$$

where $A(\omega_j)$ is the range of frequencies, and $e^{i\omega_j t} = \cos\omega_j t + i\sin\omega_j t$ i.e., the sum of real and imaginary (i) sinusoidal components. To convert to frequencies we write equation (A) as:

$$\text{(B)} \quad A(\omega_j) = \frac{1}{T}\int_0^T f(t)e^{-i\omega_j t}dt,$$

where T is the period (defined as $f(t + T) = f(t)$ for all t).

15** I am indebted to Warren Weber for the use of his spectral analysis deseasonalization program.

In discrete time (B) would be written as:

$$\text{(C)}\quad A(\omega_j) = \frac{1}{N} \sum_{n=0}^{N-1} f(n\tau)e^{\frac{-i2\pi jn}{N}},$$

where t in (B) is equal to $n\tau$, with τ as the sampling internal and N as the sample size and where $\frac{i2\pi jn}{N} = i\omega_j t$. Computations are made by a Fast Fourier Transform which essentially computes, for integers (or complex numbers) a_0, a_1, $a_2 \ldots a_{N-1}$,

$$\text{(D)}\quad A_k = \sum_{j=0}^{n-1} a_j e^{2\pi i \frac{jk}{N}}$$

where j and k act, in a sense, as rotors about the unit circle.

Sinusoids under <u>sampling</u> (that is, observing a function of the continuous variable t at an equally spaced set of values t_0, $t_1 \ldots$) will cause problems for if the sampling interval is Δ, the sinusoids $R\text{COS}(\omega_1 t + \theta)$ and $R\text{COS}(\omega_2 t + \theta)$ are indistinguishable if $\omega_1 - \omega_2$ is a multiple of $\frac{2\pi}{\Delta}$. All frequencies shifted by integer multiples are called aliases. For quarterly data the harmonic frequencies are $\frac{1}{2}\pi$ and π. These seasonal frequencies are set to zero. This eliminates the deterministic frequencies associated with intrayear oscillations. To ensure the deterministic seasonal component was removed, a small band of frequencies was removed about the two frequencies given above. Adjustment of this band did not have any noticeable effect on the estimated equations.

The data were run back through the Fourier Transformation after zeroing the appropriate frequencies. Thus the data were converted out of the frequency domain and into the time domain (time series) which has no cyclical (seasonal) components.[16*]

Section 3.2D.2 Trend

Detrending is important because of the rational expectations specification that the deviations caused by unexpected policy variables are with respect to the natural or trend rate. In Lucas (1973) the natural rate of output is defined to be $Y_{nt} = \alpha + \beta_t$ where t is a time

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[16]For further reading on spectral analysis see:

Bonomo and Schotta, "A Spectral Analysis of Post-Accord Federal Open Market Operations," The American Economic Review, Vol 69, March 1969, #1, pp. 50-61.

Hinich, M., Introduction to Fourier Analysis of Data, Naval Warfare Analysis Group, Department of the Navy, CNA Research Contribution #130, November 1969.

Bloomfield, Peter, Fourier Analysis of Time Series: An Introduction, Wiley-Interscience, 1978.

For further reading on seasonal adjustments see:

Sims, Christopher, "Seasonality in Regression," Journal of the American Statistical Asociation, September, 1974, pp. 618-26.

Pierce, David, "A Survey of Recent Developments in Seasonal Adjustment," The American Statistician, August, 1980, Vol. 34, #3.

Bowerman and O'Connell, Forecasting and Time Series, Duxbury Press, 1979, see especially Part III.

variable. Thus, in estimating the output and inventory equations, a time variable was included as an independent variable.

Section 3.2E Use of Growth Rates and Problems of Autocorrelation

The reduced form equations were estimated as first differences, i.e., growth rates. The reason for this is because we are concerned with the marginal relationship between money growth (expected and unexpected) and output. This implies the use of first differences. We would also expect the marginal relationship of money growth and inventories output to be more sensitive to the capacity utilization measure and business cycle effects.

A problem arises, however, when the dependent variable is in growth rates. This is due to the marginal changes of the dependent variables being highly volatile. In other words (as can readily be seen in the graphs of output growth across time presented in Appendix C, Section3), the growth rate of the output series are highly variable. Therefore, the degree of this variation accounted for by the set of independent variables may be expected to be low (the R^2 statistic of the equation would tend to be small). Further, if prices fully adjust, i.e., $\lambda = 1$, then lagged output and inventories, and expected money growth would not be significant explanatory variables. Thus, much of the variation observed in output growth is due to the stochastic error term.

The F-statistic will be correspondingly low, although Kmenta points out that "if any one of the estimated regression coefficients....is significantly different from zero according to the t-test....then the value of the F-statistic....will also be significantly different from zero, providing the tests are carried out at the same level of significance and against the same alternative."[17] We could follow Barro or Barro and Rush by specifying the dependent variable in terms of natural logs rather than growth rates but the marginal influence is lost in favor of high R^2 statistics.

It has been observed (Hall, 1974; Sargent, 1973; Lucas 1976a; and others) that autocorrelation exist in output. The use of quarterly data further aggrevates this problem. However, the use of first differences reduces the highly positive autocorrelation in the error term.[18] If autocorrelation still exists, the coefficient of the lagged output variable in the output equations will be biased (upward, if the autocorrelation of the random term is positive). The estimated coefficient on the lagged dependent variable may be "statistically significant" but there is no way to tell whether this affects the true parameter value or is just the autocorrelation.

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[17] Kmenta, Elements of Econometrics, p. 367.

[18] This is true only if R is greater than a third. See Moriguehi Appendix A, Section 5, for a more complete discussion of autocorrelation and autoregression patterns.

Section 3.3 Money Rules[19]

The estimation of the null and alternative hypothesis equations critically depend upon the expected money variable. Further, the results of the tests may depend upon the specific money equation (rule) that is used. Therefore, to test the robustness of the output equations, it is necessary to test the null and alternative hypothesis equations using different money rule specifications. Before specifying the actual equations used, the method of generating expected values will be examined.

Expected money growth can be viewed as the prediction that would obtain given our best guess of the systematic relationship between money and the set of underlying independent forces. In general, assume that money at time t is generated by:[20]

$$(3.12)\quad M_t = \sum_{i=1}^{\infty} (\beta_i M_{t-i} + \gamma_i Z_{t-i+1} + \theta_i a_{t-i+1})$$

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[19]The notation and methodology in this section is Weber's (1978), "Notes on Rational Expectations," mimeo.

[20]The specification of (3.12) using lagged values, particularly lagged error terms and an infinite summation is strictly formal. Note that

$$M_{t-1} = \sum_{i=2}^{\infty} (\beta_i M_{t-i} + \gamma_i Z_{t-i+1} + \theta_i a_{t-i+1})$$

can be rewritten as

$$M_{t-1} = \sum_{i=2}^{\infty} (\beta_i M_{t-1} + \gamma_i Z_{t-i+1}) - \sum_{i=3}^{\infty} a_{t-i+1} = \theta_2 a_{t-1}$$

substituting $\theta_2 A_{t-1}$ gives:

$$M_t = (B_1 + 1)M_{t-1} + \gamma_1 Z_t + \theta_1 a_t.$$

This means that all past information is included in M_{t-1}.

where $\theta = 1$, M_{t-1} is the natural log of the nominal money stock with lag i; Z_{t-i+1} are economic variables (in logs) assumed to be exogenous to the determination of M_t. The terms a_{t-i+1} are white noise, i.e., independently and identically distributed (normal) random variables with mean zero and variance σ_a^2.

As with previous chapters, the expectation of M_t when the expectation is made in time, t-j is denoted as ${}_{t-j}M_t$. Similarly, ${}_tM_{t+j}$ denotes the expectation of money in t+j made in period t. For j+1, the expectation of M_t formed in t-1 is found by taking the expectation of both sides of (3.12):

$$(3.13) \quad {}_{t-1}M_t = \sum_{i=1}^{n} (\beta_i \; {}_{t-1}M_{t-i} + \gamma_i \, {}_{t-1}Z_{t-i+1} + \theta_i \, {}_{t-1}a_{t-i+1}).$$

The values of current and past M's are known and constant, Thus,

$$(3.14) \quad {}_{t-1} \sum_{i=1}^{n} M_t = \sum_{i=1}^{n} M_{t-i}.$$

Next, assume that all future, current and past values of Z are known; thus:

$$(3.15) \quad {}_{t-1} \sum_{i=1}^{n} Z_{t-i+1} = \sum_{i=1}^{n} Z_{t-i+1}$$

By the nature of the a's defined above, the expected value of future a's is zero, and since the current and all previous a's have occurred, they are known and constant; thus:

$$(3.16)\quad {}_{t-1}a_{t-i+1} = \begin{cases} \sum_{i=2}^{n} a_{t-i+1} \\ 0 \text{ for } i=1 \end{cases}$$

Substituting (3.14), (3.15), and (3.16) into (3.13):

$$(3.17)\quad {}_{t-1}M_t = \sum_{i=1}^{n} \left[\beta_i M_{t-i} + \gamma_i Z_{t-i+1} + \theta_{i+1} a_{t-i}\right].$$

Note that if the values of Z_{t+j}, $j = 0....m$ are not know, they would be replaced by their expectations in (5.12).

The actual value for M_t minus the expectation of M_t formed in period t gives the prediction error, or in different terms, unexpected M_t. This is equivalent to substracting (3.17) from (3.12). The result is:

$$(3.18)\quad M_t - {}_{t-1}M_T = \theta_1 a_t.$$

The expectation of ${}_{t-2}M_t$ is formed similarly with the results:

$$(3.19)\quad M_t - {}_{t-2}M_t = \theta_1 a_t + (B_1\theta_2 + \theta_2)a_{t-1}$$

As would be expected, the difference between actual money in t and its expected value in period t formed in t-2 is the random errors, or unexpected money between period t-2 and t-1, i.e., a_{t-1} and between period t-1 and period t, i.e., a_t.[21]

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[21]Equation (3.19) is derived as follows:

$$\text{(A)}\quad M_t = \sum_{i=1}^{n} (\beta_i M_{t-1} + \gamma_i Z_{t-i+1} + \theta_i a_{t-i+1})$$

$$\text{(B)}\quad {}_{t-2}M_t = \beta_1\ {}_{t-2}M_t + \sum_{i=2}^{n} \beta_i M_{t-i} + \sum_{i=3}^{n} \gamma_i Z_{t-i+1} + \sum_{i=3}^{n} \theta_i a_{t-i}$$

(since ${}_{t-2}a_{t-1}$ and ${}_{t-2}a_t$ are zero).

$$\text{(C)}\quad {}_{t-2}M_{t-1} = \sum_{i=2}^{n} (\beta_i M_{t-i} + \gamma_i Z_{t-i+1} + \theta_{i+1} a_{t-i})$$

$$\text{(D)}\quad M_{t-1} = \sum_{i=2}^{n} (\beta_i M_{t-i} + \gamma_i Z_{t-i+1} + \theta_i a_{t-i+1})$$

$$\text{(E)}\quad {}_{t-1}M_t = B_1, M_{t-1} + \sum_{i=2}^{n} \beta_i M_{t-i} + \sum_{i=1}^{n} \gamma_i Z_{t-i+1} + \theta_2 a_{t-1} + \sum_{i=3}^{n} \theta_1 a_{t-i+1}$$

Substracting (B) from (A):

$$\text{(F)}\quad M_t - {}_{t-2}M_t = \beta_1 [M_{t-1} - {}_{t-1}M_{t-1}] + \theta_1 a_t + \theta_2 a_{t-1}$$

where the term in brackets is equal to $\theta_2 a_{t-1}$. Substracting (C) from (D) and substitution into (F) to give equation (3.19).

Alternatively, the same result obtains by appropriate addition and subtraction of equations (A) - (E):

$$\text{(G)}\quad M_t - {}_{t-2}M_t = [M_t - {}_{t-1}M_t] + [{}_{t-1}M_t - {}_{t-2}M_t].$$

The values of the expectational variables, such as equation (3.17), can be obtained only if the values of β_i, γ_i, and θ_i are known. By regression analysis, estimates of these coefficients can be obtained. A time series of expected values can be generated by multiplying these estimated coefficients by the appropriate[22] values of M and Z.[23]

The money equation is viewed as a policy rule which monetary authorities are assumed to follow in setting the stock of money each period. The money equations generally appearing in the literature reflect simple proportional feedback rules.[24] Barro (1976) specifies the money rule to be:

$$M_t = \alpha_0 + \alpha_1 M_{t-1} + \alpha_2 M_{t-2} + \alpha_3 FEDV + \alpha_4 \left(\frac{u}{1-u}\right)_{t-1} + \gamma_t$$

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[22]Appropriate meaning with respect to the time-scripts of the equation.

[23]Recall that (3.12) can be written as:

(A) $M_t = (B_1 + 1)M_{t-1} + \gamma_1 Z_t + \theta_1 a_t$

since $\theta_1 a_t$ is unknown and hence ${}_{t-1}\theta_1 a_t = 0$, ${}_{t-1}M_t$ is a function of β_1 and γ, only. By obtaining estimates of β_1, and γ_1, by regression of equation (A) and multipl $\hat{\beta}$ $\hat{\gamma}$:; of M_{t-1} and Z_t, respectively (assuming again that Z_t is known), and summing the result, the value of ${}_{t-1}M$ is obtained.

[24]The systematic feedback rule contains lagged values of money growth. The object of this is to reflect the endogeneity of policy influences (except for random errors). Actions by the monetary authority do not take the form of specific actions but rather appear as a sequence of actions for the present as well as the future.

where M_t, M_{t-1} and M_{t-2} are the quarterly growth rates of current, and two lagged values of the M_1 concept of money. $FEDV_t$ is a measure of current government expenditures relative to "normal" and $(u/1-u)_{t-1}$ is a measure of lagged unemployment. Barro argues for the inclusion of the measure of current government expenditure by stating that such expenditures are financed by a combination of taxes and money issue. Both revenue components involve administrative and other similar costs. The long-run expenditures for each component is determined by cost minimization. Barro argues that tax raising involves "institutional apparatus" which does not fluctuate in the short-run. Temporary (meaning divergence from the long-run trend) expansions of the government budget will, therefore, be financed by an increase in the growth of money.

Barro argues that the lagged unemployment variable is appropriate; money being viewed as either reflecting a countercyclical policy response to unemployment or reflecting lower real income (and real money balances) and hence a reduced amount of government revenue from money issue for a given value of the money growth rate. The lagged money terms capture lagged adjustment and serial correlations not picked up by the other variables.

The term γ_t is a random error term interpreted as that portion of the money supply which cannot be controlled by the authorities. Thus, the money growth rate which obtains in priod t will vary unpredictably from that value anticipated by the authorities. This anticipation is written as:[25]

$$M^e_t = \hat{\alpha}_0 + \hat{\alpha}_1 M_{t-1} + \hat{\alpha}_3 FEDV_t + \hat{\alpha}_4 \left(\frac{u}{1-u}\right)_{t-1}$$

where the estimated coefficients $\hat{\alpha} i$, i = ...4, can be obtained through least-squares estimation and are used to generate the expected value of money growth across time series M^e.

Different money rules or methods of computation give different time series data. Thus, the results of output and inventory equation which are estimated using this data may produce very different results. Natural Rate proponents argue that the parameters of the money rule, once known, should not influence real output growth. Thus, theoretically the rule used should not matter; practically this may prove untenable. To deal with this problem, three separate money rules were estimated using two separate estimating techniques. The data sets created from these rules were each used in estimating the output and inventory equations.

The first major money rule specifications, which reflects the counter-cyclical policy response of money, is suggested by Nefti and

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[25]This is the Barro and Rush money rule.

Sargent (1975a).[26]

$$(3.18)\quad M_t = \sum_{i=1}^{n} M_{t-} + \sum_{i=1}^{n} Y_{t-i}$$

This equation was estimated with n = 8; thus current money growth is a function of eight quarter lags in growth of Gross National Product and money growth.

The second major money rule, suggested by Weintraub (1978) argues that short-term interest rates are used as the target of monetary policy by the authorities. The equation can be described as:[27]

$$(3.19)\quad M_t = \beta_0 + \beta_1 \Delta TBR_{t-1} + \beta_2 M_{t-1} + \beta_3 M_{t-2}$$

where ΔTBR is the change in the treasury bill rate. For our purposes, a four quarter lag on the short term rates and a six quarter lag on money growth was used.

The third rule follows that specified by Barro and Rush:[28]

$$(3.20)\quad MG_t = a_0 + \alpha_1 \sum_{i=1}^{6} MG_{t-i} + \alpha_7 CHEBEV + \alpha_{j+7} \sum_{j=1}^{3} CLUN_{t-i}$$

where M_g is money growth, CHEBEV is real high employment budget expenditure relative to normal. Following Barro, the normal high

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[26]Sargent, T.J., and N. Wallace, "Rational Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule," Journal of Political Economy, Vol. 83, April, 1975a, pp. 241-57.

[27]Weintraub, R.E. "Congressional Supervision of Monetary Policy," Journal of Monetary Economics, 4 (1978), pp. 341-63.

[28]Barro and Rush, "Unanticipated Money and Economic Activity--Results From Annual and Quarterly U.S. Data," mimeo September 1978. This equation was suggested to me by Vittorio Bonomo.

employment budget expenditure is an exponentially declining weighted average. CLUN is the log of Barro's unemployment measure, i.e., the log of unemployment rate divided by one minus the unemployment rate. The three quarter lag follows Barro and Rush.

Two methods are employed in estimation of the money rule. The first follows Barro and others in estimating the money rule across the entire period of observation. This implicitly assumes that the economic structure of the entire period is known by agents. If the structure perceived by agents when making predictions does not change over time, then it may be valid to use the entire period estimation results.

If the structure changes, in the sense that the parameter estimates over the entire period are not equal to the estimate of the same parameters over a sub-period, then the use of the overall estimates would be inappropriate for obtaining the values of expectations during the sub-period. In other words, what would be predicted using the estimated coefficients of the α's and β's across the entire period, may not be an accurate portrayal of expectations when they are actually formed.

This bias could be avoided by estimating β using data through the previous period only. This, of course, requires as many estimations as there are observations. One approach to remedy this problem is to use moving regressions: starting with an initial block of observations, the money rule is estimated.[29] Next periods forecasted value is determined using the estimated coefficients. This forecast becomes the first observation in the expected money growth time series. Next, an observation is added to the front of the block, the money rule equation is re-estimated and the next periods forecast is calculated. This forecast becomes the second observation in the series. This process continues with the last observation in the series being the forecasted value across the entire period (with the exclusion of the last quarter).

A slightly different moving regression adds an observation on the front and drops one off the back of the block. This method was rejected because if past values play an insignificant role when forming expectations, then the existence of these past observations will play an insignificant role in estimation of the money rule equation. More importantly, however, is that the former moving regression takes all past information in forecasting the money growth in the future. Unlike the full period method of creating the expected money series, this method does not use future observations.

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[29]The initial starting block of observations was set arbitrarily at twenty quarters. Data limitations force this decision upon us.

A third method[30] of separating the expected components of money growth involves elimination of the deterministic portion of the series in the frequency domain. By processing the data via the Fast Fourier Transform, the money growth time series is broken down into frequencies reflecting cyclical movements of the series. Trend is eliminated as well as a band about the seasonal frequencies. Furthermore, other deterministic portions accounting for greater than one percent of the total sum of periodogram values was eliminated, i.e., these frequencies were zeroed and the series was processed back through the transform to give the adjusted series. The resulting series, if all the deterministic components have been removed, is a white noise series. This represents the unexpected money growth series. The expected money growth series is found in the same manner by eliminating all the white noise frequencies, leaving only the deterministic components. By construction, the unexpected and expected money growth series are orthogonal to each other.

Section 3.4 Test of Sector Characteristics

If the test above reveals differential sectoral response to monetary growth, then several sector characteristics are examined which may have influenced the differential impact. The estimated beta coefficients of equation (3.2) relate the degree to which expected and

[30] I am indebted to Warren Weber for references and useful comments in this area.

unexpected money growth will systematically affect $Y_t(z)$. The tests of sector characteristics which may influence the systematic relationship between money growth and output.

The test is simply regressing (cross-sectionally) the coefficients of expected and unexpected money (from each estimated sector output and inventory equation) against a number of sector characteristics. Note that we are only examining the association between sector characteristics and the money growth coefficients, and not causality. The test of causality of sector characteristics and monetary influences is beyond the scope of this paper and would call for a different modeling structure than that presented above.

Characteristics which are of interest are the degree of unionization, relative sector to aggregate price variance (Lucas' θ), the average capacity utilization, and durable versus non-durable products.

Section 3.5 Basic Data

The two most important data sets, which can be used in different tests of neutrality, are sectoral indexes of output by two digit Standard Industrial Classification (SIC) codes and Wholesale Price Indexes (WPI). For most sectors, these series are available from 1947I to 1979IV. The output data source is *Industrial Production*, a publication of the Board of Governors of the Federal Reserve System.

The price data source is the Statistical Supplement to the Survey of Current Business. Table III.1 provides a list of data collected on industrial sectors. Manufacturing sectors were chosen largely due to the limitation of available data on other sectors of the economy. Problems, such as defining output in the service sector, inhibit adequate data collection. Appendix 3A briefly describes the industries examined as defined in the Standard Industrial Classification Manual.

The price series is not constructed by SIC or any other standard code. Rather the series are constructed by end use rather than point (sector) of origin. To make the series as consistent as possible with the SIC categories, weighted average and weighted average separations were necessary.

Miscellaneous data sets include the money supply (M_1), the unemployment and the full-employment rate, gross national product (GNP) in constant dollars, the GNP price deflator, high employment budget expenditures, prime commercial paper rate, and the corporate Aaa bond yield. These data sets were obtained from the St. Louis Federal Reserve Bank. The degree of unionization is found in the Handbook of Labor Statistics. With the exception of the degree of unionization, these data were available from 1948I-1979IV. The degree of unionization is available for the years 1968, 1970, 1972. Concentration ratio are obtained from the Census of Manufacturers, Vol. 1, 1963, 1972, and 1977.

LIST OF INDUSTRIAL SECTOR DATA AND YEARS AVAILABLE

CODE	NAME	OUTPUT	PRICES
00	all commmodities	1947-1979[1]	1947I-1976IV
01	manufacturing	1947-1979[2]	1947I-1976IV
02	industrial	1947-1979[3]	1947I-1976IV
20	food	1947I-1919IV	1947I-1976IV
21	tobacco	1947I-1979IV	NA
22	textile mill products	1947I-1979IV	1947I-1976IV
23	apparel products	1947I-1979IV	1947I-1976IV
26	paper and products	1947I-1979IV	1947I-1976IV
28	chemicals and products	1947I-1979IV	1947I-1976IV
29	petroleum products	1947I-1979IV	1947I-1976IV
30	rubber and plastic products	1947I-1979IV	NA
32	clay, glass, stone products	1947I-1979IV	1947I-1976IV
33	primary metals	1947I-1979IV	1947I-1976IV
34	fabricated metal products	1947I-1979IV	1947I-1976IV
35	non-electrical machinery	1947I-1979IV	1947I-1976IV
36	electrical machinery	1947I-1979IV	1947I-1976IV
37	transportation equipment	1947I-1979IV	NA

[1]Data are available monthly from 1919-1975.

[2]See note 1.

[3]Data are available monthly from 1939-1975.

CHAPTER IV

MONEY RULES

This chapter presents the results from estimating the money rule equations. A summary of the results are found in Tables IV.1, IV.2 and IV.3 and IV.4 Figure IV.1 presents a plot of money growth against time. The method of estimation was ordinary least squares.

Section 4.1 Interest Rate Rule

The interest rate rule, equation 3.19, was estimated using seasonally adjusted quarterly data for the United States over the period 1950-1979IV. The lagged money variables are in growth rates; the lagged interest rate variables are in first differences. The results are found in Table IV.1 Figure IV.2 contains a plot of actual and predicted (from the interest rate rule) quarterly money growth. Visually, the predicted or expected values appear to track the actual values quite well. The R-squared statistic of .4591, however, leaves us feeling somewhat deceived. The examination of the unexpected money growth (Figure IV.3) reinforces the belief that all the deterministic components in money growth have not been removed especially in the earlier part of the series. The results of this R-squared is, however, consistent with other findings, e.g., Bonomo and Tanner estimating a Treasury bill equation report an $R^2 = .308$.[1]

Last periods money growth is a highly significant predictor of the variation of current money growth. The only other money growth variable that is significant is the one with a six quarter lag. It is significant at the seven percent level.[2] The fact that only the first

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[1] Op. cit., Bonomo and Tanner (1978), p. 7.

[2] The probability of a type one error is approximately seven percent. That is, if the null hypothesis is that the coefficient of MG(t-6) is equal to zero, than, given the sample, the probability of rejecting the null and being incorrect (in the population) is, in this case, approximately seven percent. In other words, the probability of making a type one error is approximately seven percent. (A type one error is rejecting the null based upon a sample when in fact the null is true in the population from which the sample is drawn.)

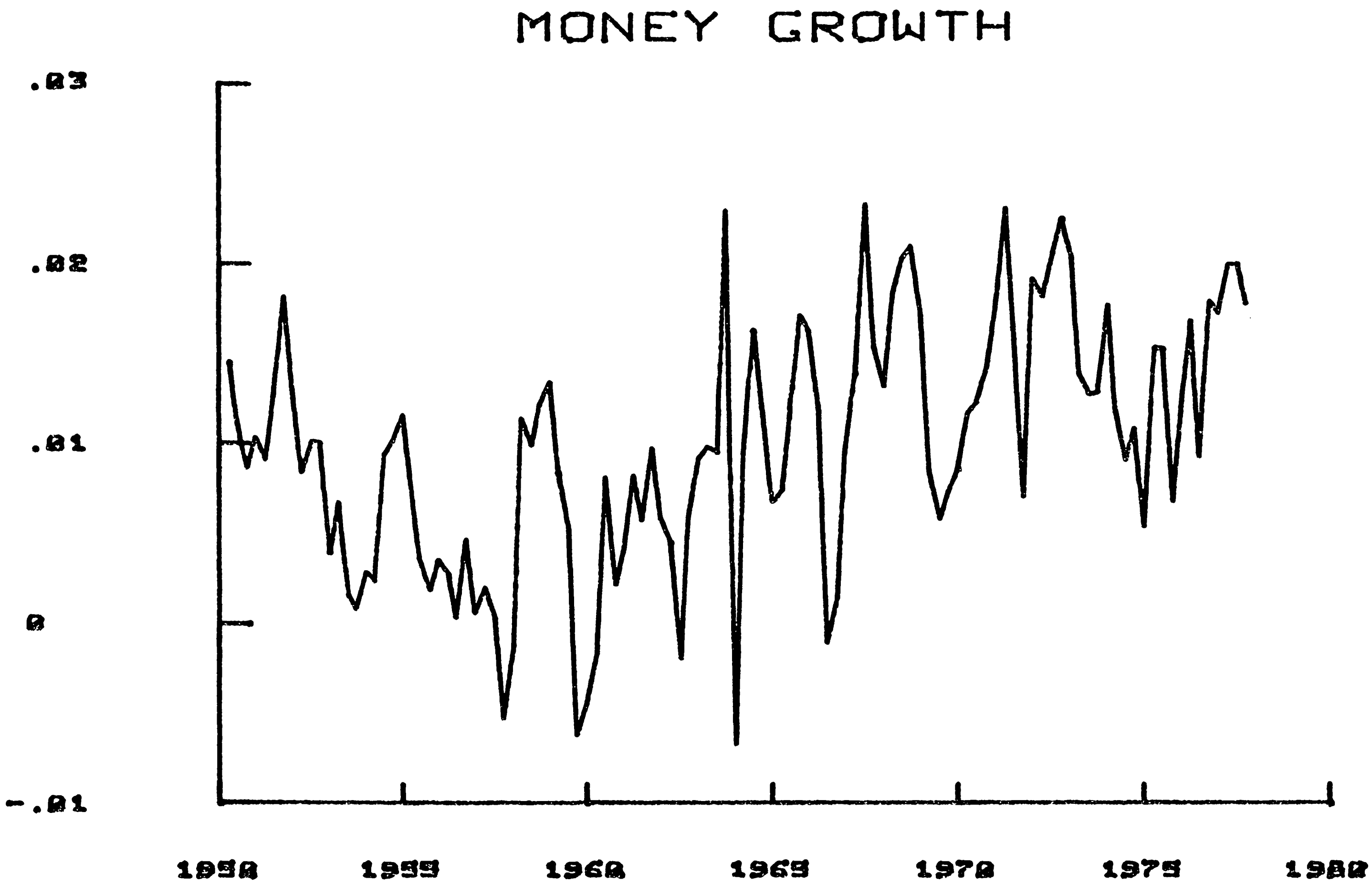

FIGURE IV.1

MONEY GROWTH

TABLE IV.1

Interest Rate Money Rule

Dependent variable: Money Growth

Independent Variable	Estimated Coefficient	t-Statistic
constant	.0020	1.77
Money Growth$_{t-1}$	.4767	4.92
Money Growth$_{t-2}$	.1145	1.04
Money Growth$_{t-3}$	.0998	.94
Money Growth$_{t-4}$	.0657	.61
Money Growth$_{t-5}$	.0312	-.30
Money Growth$_{t-6}$	.1916	1.86
Money Growth$_{t-7}$	.0345	-.32
Money Growth$_{t-8}$	.0292	-.30
Short Term Interest$_{t-1}$	.0033	-3.55
Short Term Interest$_{t-2}$	.0003	.32
Short Term Interest$_{t-3}$	.0007	-.71

$R^2 = 0.4591$

F-Statistic 8.26 (with 107 degrees of freedom)

Durbin-Watson 1.9921

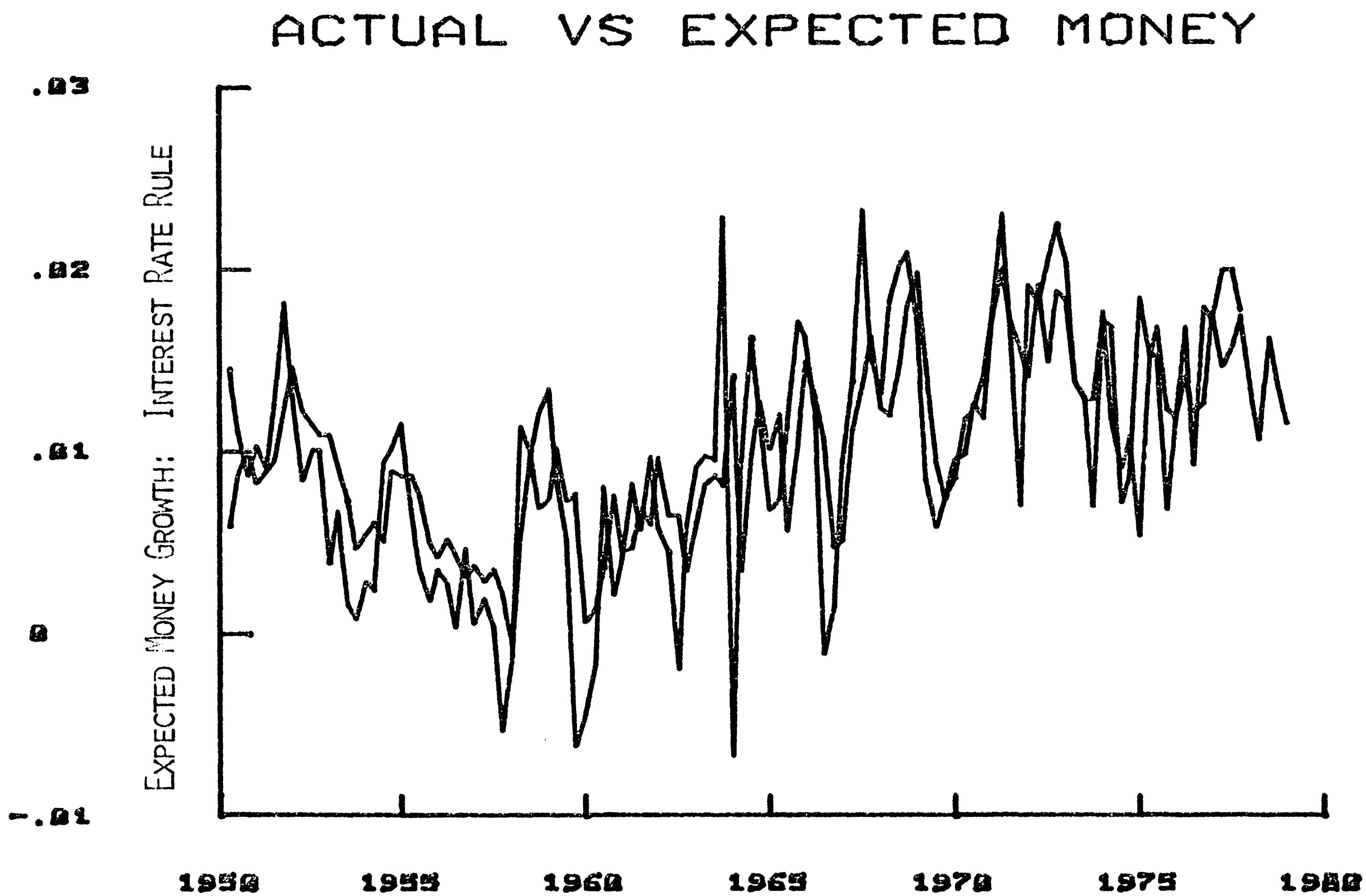

FIGURE IV.2

ACTUAL VS EXPECTED MONEY

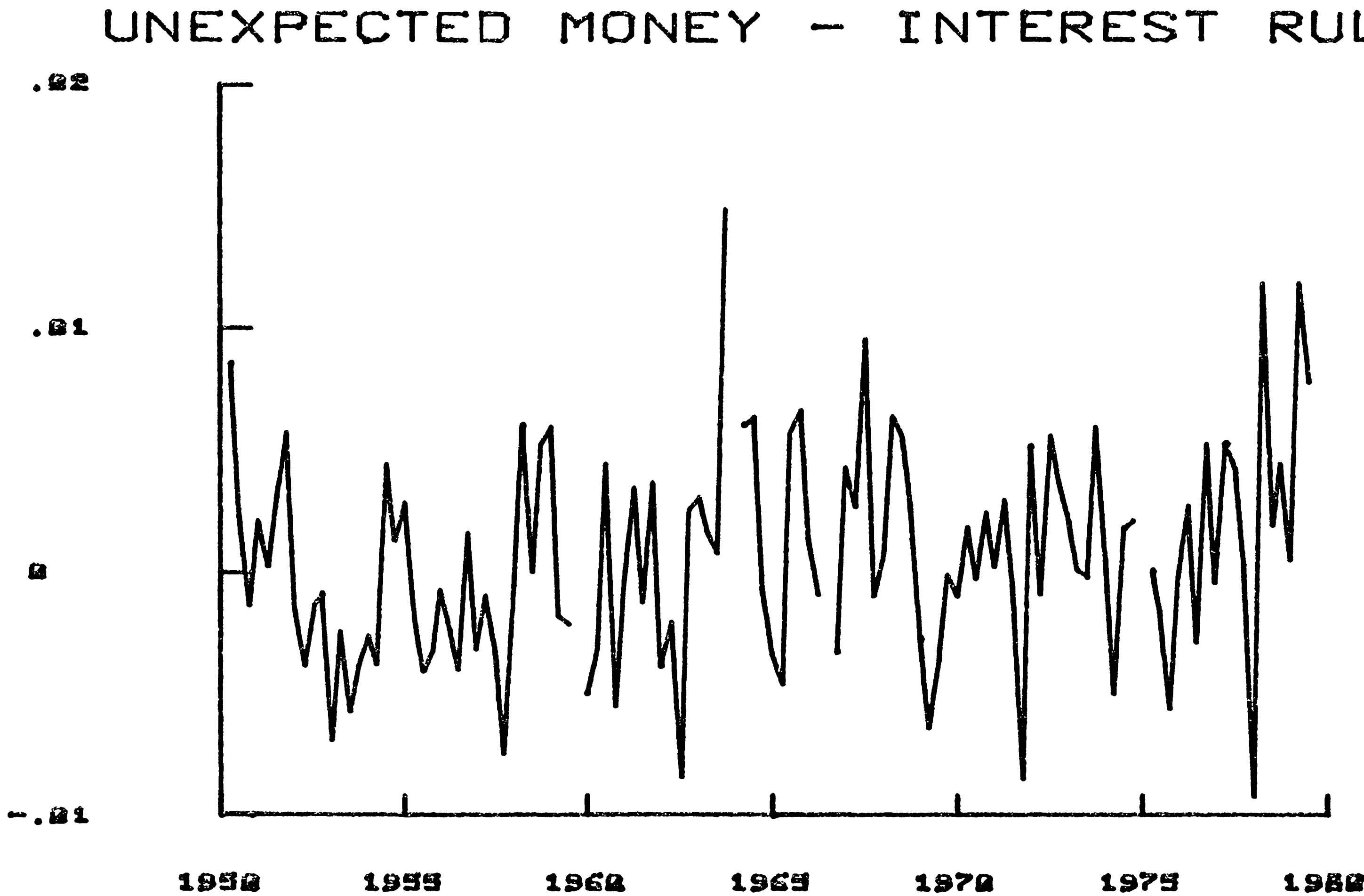

FIGURE IV.3

UNEXPECTED MONEY - INTEREST RULE

and sixth quarter lags on money growth are significant may be due to the presence of first order autocorrelation. Thus the effect of the first quarter lag tends to wash out the effects of other lags. To the extent that we are concerned with the ability of the equation to predict current money growth and not necessarily interested in explaining the individual significance of the variables this problem does not pose major problems. This is not to say however, that the individual influences are not important in another context, and when possible, I will highlight some of the more interesting results.

The short term interest rate variable, lagged one quarter, is strongly significant (one percent level) and has a negative impact on current money growth. Interpretation of this impact of interest rates on money growth is not straightforward. First, the direction of causality between interest rates and money growth is unclear: On one hand, a restriction of the money supply will reduce the funds available for banks to lend out, causing interest rates to rise. On the other hand, other forces which may reduce the supply of loanable funds (risk, actual, and expected inflation) will raise the interest rates, decrease the money available for loans and hence diminish the ability of banks to create money. Both these theories imply movement in the supply of loanable funds. Regardless of the causality, the relationship of interest and money growth is negative (since movements of the supply curve trace out the demand curve).

In the spirit of the money rule as a formula followed by the monetary authority, one might argue that the adjustment of the money supply in the opposuite direction to changes in short term interest rates is an effort to combat inflation. Alan Blinder points out in a criticism of the Barro and Rush money rule, that "according to the estimated equation, the Fed fights unemployment, but no inflation. This is doubly puzzling since, as we know, if the Lucas-Sargent-Wallace-Barro view of the world is correct, any monetary rule can only be effective against inflation, not against employment. Doesn't the Fed have rational expectations?"[3]

Two final notes: The ability to accurately predict events may be of dubious relation to causal events. In other words, economic agents may find it much easier to predict than to explain the implied causal relationships of their model. Secondly, the coefficient is small relative to the coefficient on money growth, e.g. -.0033 on the former versus .4767 on the latter.

Section 4.2 Income Money Rule

The second general rule estimated money growth as a function of six quarter lags of gross national product (in constant 1972 dollars) and of money growth. The estimated coefficients are reported in Table IV.2. As in the Barro and interest rate equations the first quarter lag on money growth dominates while the sixth quarter lag is of

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[3]Blinder, comment on the Barro and Rush paper, "Unanticipated Money and Economic Activity," in Rational Expectations and Economic Policy, edited by Stanley Fischer, 1980 Chicago Press, p. 51.

marginal significance. The sign of the coefficient are all positive but the complete lack of statistical significance makes dubious any interpretation of sign changes. Figure IV.4 plots actual against predicted money growth. Figure IV.5 plots the unexpected money growth against time.

One quarter lag of GNP is marginally significant. The probability of rejecting the hypothesis, that the coefficient is greater than zero and being incorrect, is approximately 13 percent. In the spirit of the policy rule as a guide to monetary adjustments the positive sign on the one quarter lag of GNP is surprising. One would expect that if GNP was growing at a slow rate (relative to some target rate of growth) the monetary authorities might be expected to stimulate the rate of growth of the money supply. Hence, a negative sign on the coefficients would be expected. The overall impact of GNP, i.e., the sum of the coefficients of all the lagged GNP variables is in fact negative, -.0461.[4]

Section 4.3 Barro's Money Rule Equation

A rule equation similar to that described by Barro and Rush (1980), was estimated.[5] The results appear in Table IV.3. The plot of

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[4]Conclusions about the overall impact of GNP should be viewed in the light of the fact that only the first quarter lag is significantly different from zero.

[5]Barro and Rush, op. cit. 1980. Strictly speaking, the equation estimated in this paper is not comparable to that estimated by Barro and Rush, since I estimated the equation over the period 1949III-1979IV, whereas Barro and Rush estimate the equation over the period 1949III-1978I (with adjustments across the war years).

TABLE IV.2

Incomes Money Rule

Dependent Variable: Money Growth

Independent Variables	Estimated Coefficient	t-Statistics
constant	.0028	2.11
Money $Growth_{t-1}$	.4468	4.51
Money $Growth_{t-2}$	.0306	0.28
Money $Growth_{t-3}$	.0832	0.75
Money $Growth_{t-4}$	.0785	0.71
Money $Growth_{t-5}$	.0029	.03
Money $Growth_{t-6}$	.1549	1.51
Income Growth (Y)t-1	.0874	1.52
Income Growth (Y)t-2	-.0345	-0.58
Income Growth (Y)t-3	-.0471	-0.81
Income Growth (Y)t-4	-.0578	-0.99
Income Growth (Y)t-5	-.0006	-0.01
Income Growth (Y)t-6	.0065	.12

R^2 = .4118

F-Statistic = 6.19 (with 106 degrees of freedom)

Durbin-Watson statistic 1.98

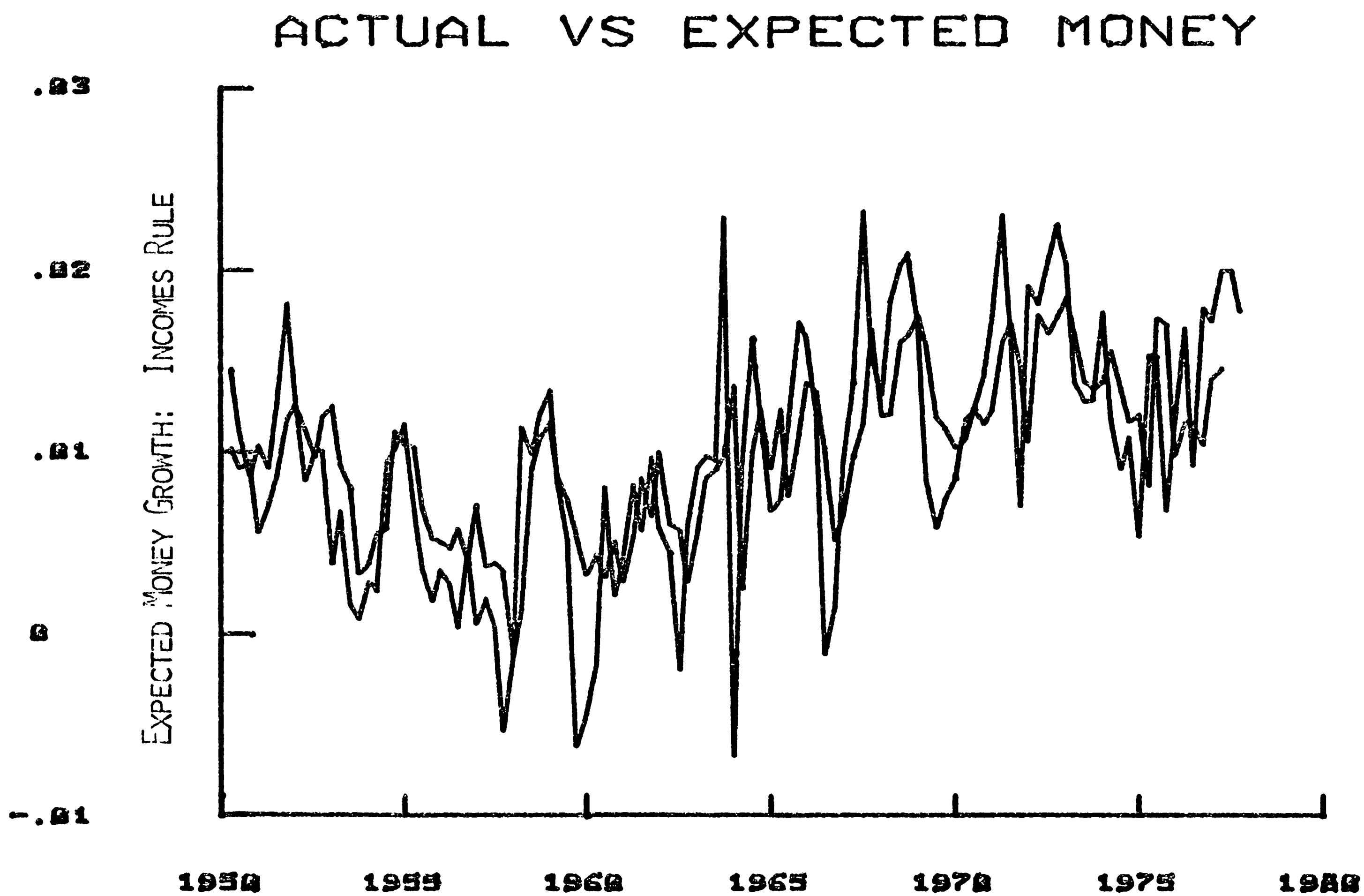

FIGURE IV.4

ACTUAL VS EXPECTED MONEY

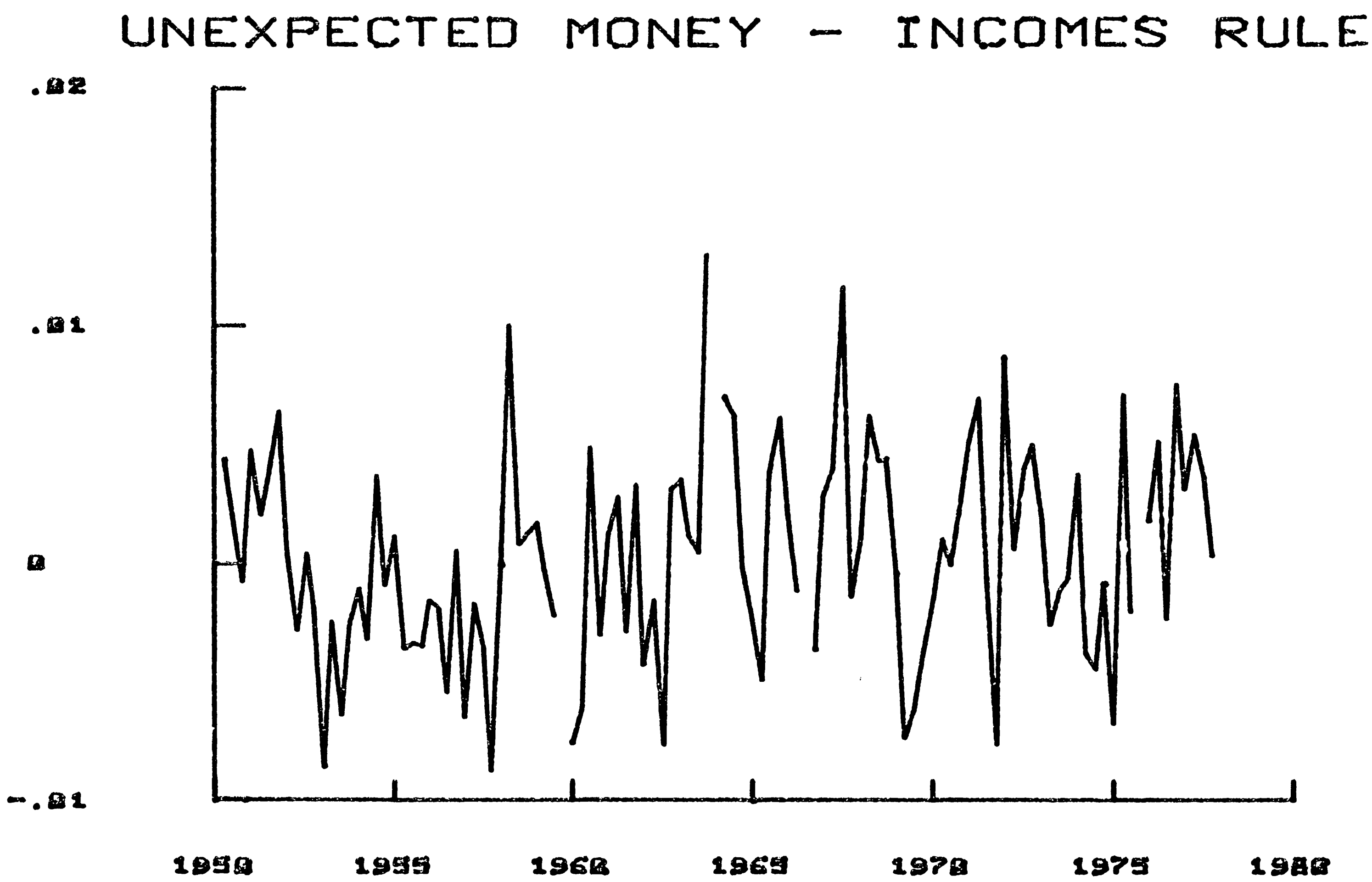

FIGURE IV.5

UNEXPECTED MONEY - INCOMES RULE

the predicted values of money growth from this equation and the actual money growth appear in Figure IV.6. Again, visually the track of predicted on actual is good, although the R^2 is .4397. Barro and Rush (1980), do not report the R^2. Hafer (1979),[6] reports an R^2 of .594 on a modified version of Barro's rule estimated over a slightly smaller sample size. This version is similar to the second Barro rule discussed below. Figure IV.7 is a plot of the Barro unexpected money against time. The similarities with other rules are obvious.

The lagged money growth variables show a similar pattern to the interest rate rule although the sixth quarter lag is not statistically significant. Unlike Barro and Rush, the measure of real federal spending is not significant. (The probability of a type one error is approximately 17 percent). This result may in part be due to the exclusion of the war years in this study.

The significance of the lagged measures of unemployment are comparable to that found by Barro and Rush although the coefficients are slightly larger. Barro and Rush argue that the negative coefficient on the third lag is indicative of the impact of the change in unemployment across the second and third lag as well as the level of unemployment in the second lag.[7]

An alternative specification of the Barro and Rush money rule involves substitution of the federal deficit scaled by real gross

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[6]Hafer, Rik, "An Empricial Comparison of Autoregression and Rational Models of Price Expectations," Dissertation; Virginia Polytechnic Institute and State University. 1979, p. 54.

[7]Ibid., p. 33.

TABLE IV.3

Barro's Money Rule

Dependent Variable: Money Growth

Independent Variable	Estimated Coefficient	t-Statistic
constant	-.0053	-.352
Money $Growth_{t-1}$	.4124	4.25
Money $Growth_{t-2}$	-.0100	-.09
Money $Growth_{t-3}$	.0144	.13
Money $Growth_{t-4}$	.0365	.33
Money $Growth_{t-5}$	.0621	-.56
Money $Growth_{t-6}$	.1208	1.13
FEDV	.0035	1.38
Unemployment t-1	-.0124	-1.43
Unemployment t-2	.0256	1.88
Unemployment t-3	-.0124	-1.60

R^2 = .4397

F-Statistic = 8.48 (with 108 degrees of freedom)

Durbin-Watson statistic 1.99

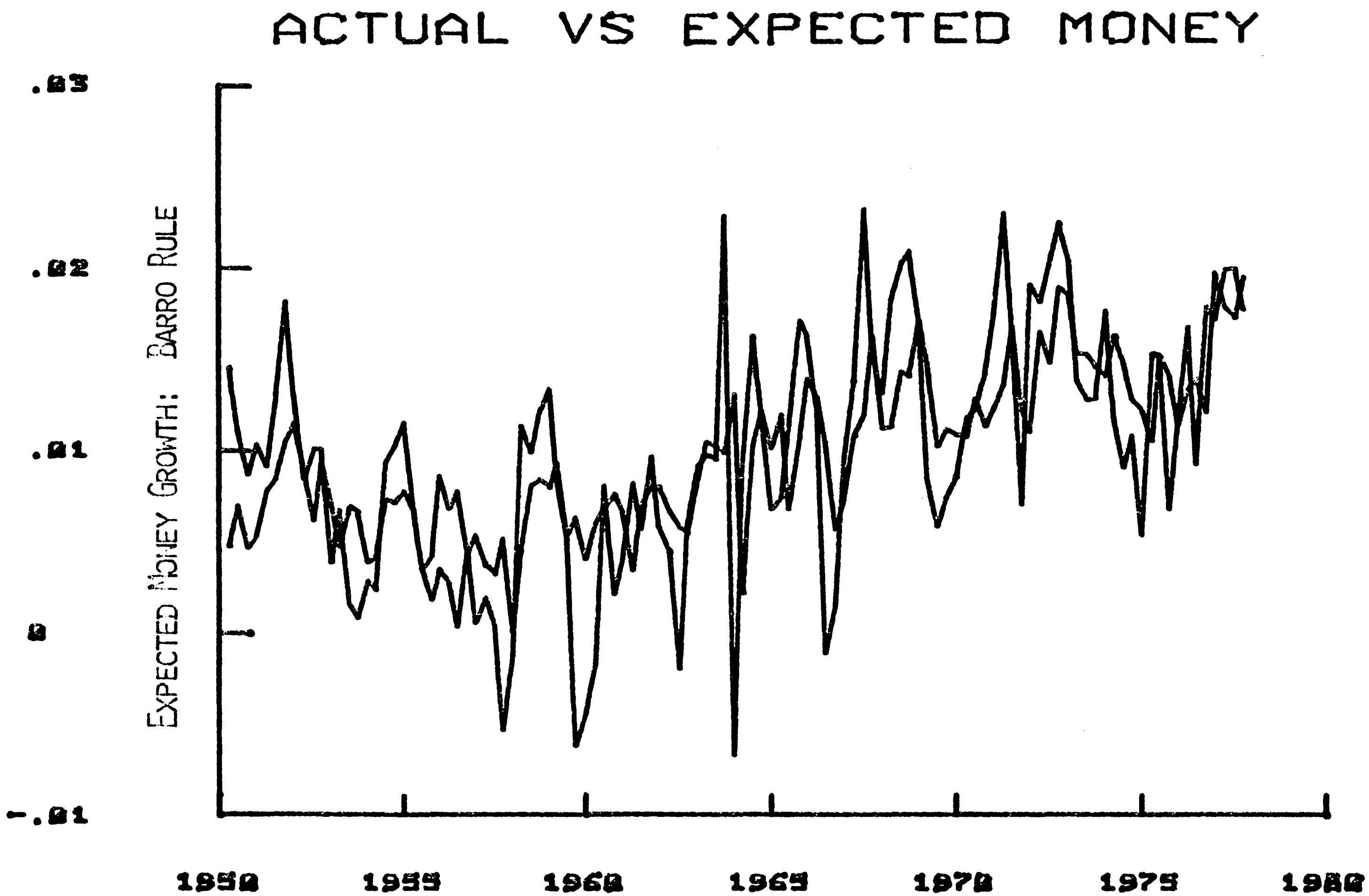

FIGURE IV.6

ACTUAL VS EXPECTED MONEY

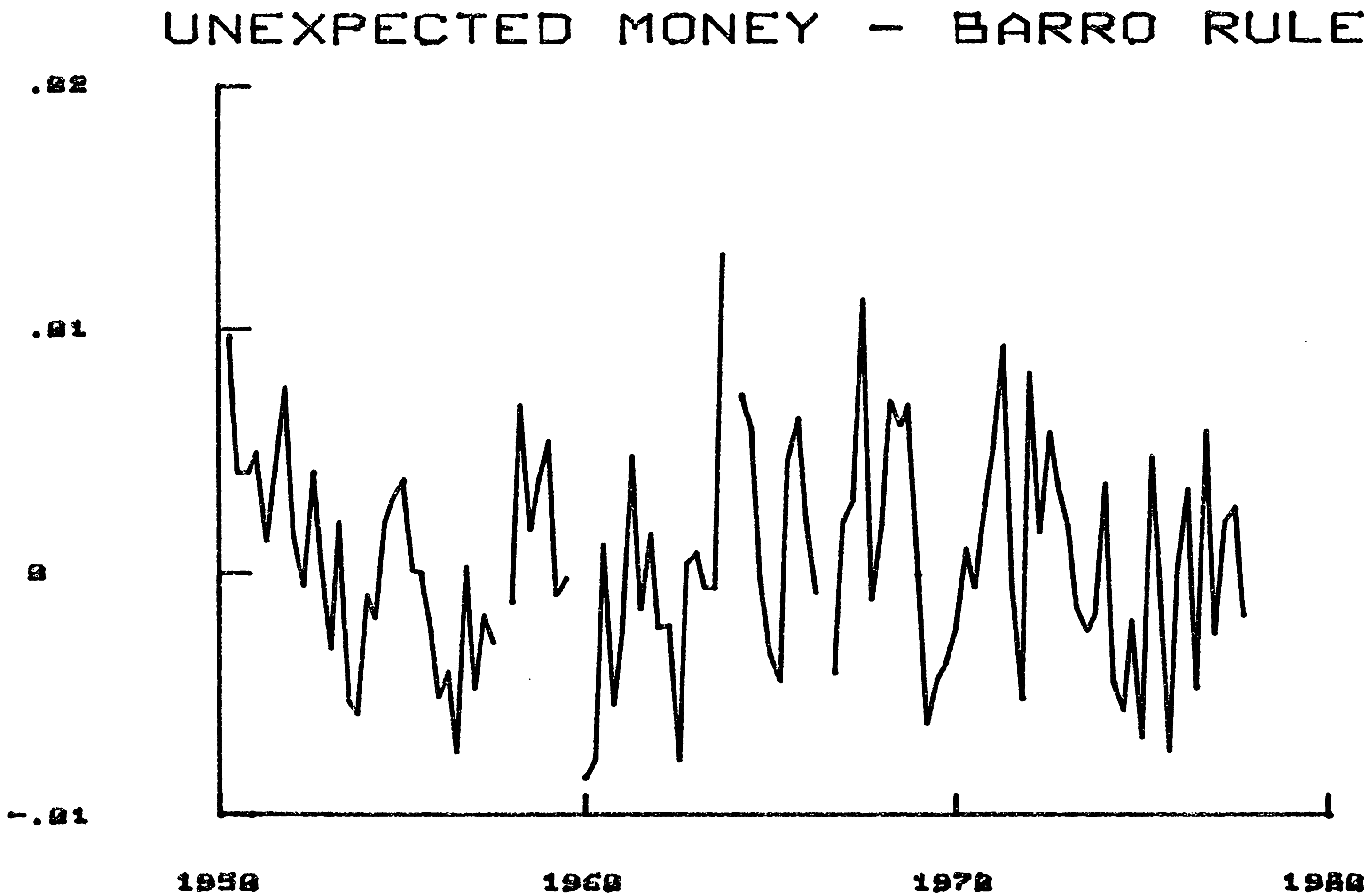

FIGURE IV.7

UNEXPECTED MONEY - BARRO RULE

national product. The results of estimating this equation are found in Table IV.4. Note that the sixth quarter lag comes in stronger (the probability of a type one error is approximately 13 percent) although it is still not significant at a reasonable level. The deficit variable is highly significant although the influence on the dependent variable is small (coefficient on (defY/)t-1 is .000549). The positive sign of the coefficient is appropriate since the greater the deficit relative to GNP, the greater the role of money creation in servicing expenditures and in maximizing government revenue. Substitution of the deficit variable decreases the standard error of the regression and increases the overall explanatory power of the equation.

TABLE IV.4

Second Barro Rule

Dependent Variable: Money Growth

Independent Variable	Estimated Coefficients	t-Statistic
constant	.0101	1.74
Money $Growth_{t-1}$	.4830	5.01
Money $Growth_{t-2}$	.0154	0.14
Money $Growth_{t-3}$	.0697	0.64
Money $Growth_{t-4}$	-.0254	-0.24
Money $Growth_{t-5}$	.0375	0.35
Money $Growth_{t-6}$	.1501	1.54
$Deficit/GNP_t$	-.0001	-.53
$Deficit/GNP_{t-1}$	.0005	2.31
$Unemployment_{t-1}$	-.0104	-1.35
$Unemployment_{t-2}$	.0250	1.95
$Unemployment_{t-3}$	-.0123	-1.67

R^2 = .4802

F-Statistic = 8.32 (with 99 degrees of freedom)

Durbin-Watson statistic 2.03

CHAPTER V

EMPIRICAL RESULTS

This chapter discusses the empirical results of the output and inventory equations. Section 5.1 discusses the overall tests of neutrality and differentiality. Section 5.2 discusses further the differential sector impacts. Desction 5.3 discusses the results of the output and inventory equations for each separate industry.

Section 5.1 Overall Tests of Neutrality and Differentiality

The tests of sector differentiality and monetary neutrality will be summarized in three sub-sections. The first describes the test of whether money growth adds significantly to the explanatory power of the output equation estimated under the restriction that the coefficient on money growth equals zero. Second, I summarize the test of the rational expectation hypothesis that the significance of money growth is due to the unexpected monetary component. Third, I summarize the tests of hypothesis described in the methodology chapter (Section 3.1). These tests examine whether the price adjustment mechanism λ, is equal to one.

In each of these sub-sections the question of differential response is discussed. There are two types of differentiality defined in this paper. The first is whether individual sectors are associated with actual money growth (or its unexpected and expected components) in a different way than the overall manfacturing industry. In other words, is there a differential response of individual sector to aggregate manufacturing to money growth.

The second question of differentiality addresses whether sector response to monetary changes is identical across all manufacturing sectors. Following Bonomo and Tanner,[1] I test whether the money growth

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[1]Bonomo and Tanner, "Are Expected Monetary Changes Neutral?" June, 1979.

variables, on average, significantly reduce the sum of squared errors.[2] This overall result is compared to the individual sector test of whether money growth variables significantly reduce the sum of squared errors.

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[2]This is sometimes referred to as the sum of squared residuals. The test is an F-test described in Appendix 3B. A note on efficiency and simultaneity: Ordinary least squares (OLS) estimators are considered to be unbiased, consistent and efficient. Given that, I am regressing a set of equations with a common predetermined variable, namely the money growth variable, the equations are related and the disturbances of the equation are correlated. This implies that across equations the estimators are not efficient using OLS, although they are unbiased and consistent. Zellner's seemingly unrelated regression (SUR) takes the correlations of the residuals into account using the variance covariance matrix in the second stage of a generalized least squares procedure. The gains in efficienty of SUR estimators over ordinary least squares increases directly with the correlation between the disturbances from different rquations. Tables 5.1 and 5.2 present the correlation matrix of residuals for the twelve output equations and the twelve sectors to aggregate output equations. Note that only a few correlations exceed ± .5. Further the average correlation (an absolute value) is .3718 for the output equations and .3062 for the sector to aggregate output equations. This implies the gain in efficiency using SUR would not be substantial over using OLS. Bonomo and Tanner found the SUR and OLS estimations to be almost identical and opted to use OLS in further analysis. Further they found the use of SUR to use 100 minutes of computer time for each set compared to 50 seconds of time with OLS. The SUR package they used was at Tulane University.

TABLE 5.1

CORRELATIONS OF RESIDUALS OF OUTPUT EQUATIONS
SAMPLE SIZE: 126

	R20	R22	R26	R28	R29	R30	R32	R33	R34
R22	-0.25147								
R26	-0.38937	0.65378							
R28	0.00162	0.65378	0.36120						
R29	0.66581	-0.06998	-0.33160	0.20536					
R30	-0.29831	0.52662	0.52514	0.45855	-0.23345				
R32	0.65041	0.11699	0.01043	0.45632	0.52840	-0.03801			
R33	-0.48943	0.39506	0.50546	0.31816	-0.34770	0.28076	-0.12641		
R34	0.33587	0.35465	0.36598	0.36439	0.16807	0.42399	0.42796	0.21783	
R37	-0.35210	0.45166	0.57771	0.31554	-0.40181	0.58271	-0.08957	0.53849	0.51680

Average correlation: .3718
(in absolute value)

TABLE 5.2

CORRELATIONS OF RESIDUALS OF SECTOR TO OVERALL MANUFACTURING OUTPUT SECTORS
SAMPLE SIZE: 126

	DR20	DR22	DR26	DR28	DR29	DR30	DR32	DR33	DR34
DR22	-0.27527								
DR26	-0.27207	0.50925							
DR28	0.11234	0.31122	-0.00264						
DR29	0.76735	-0.11928	-0.19701	0.32122					
DR30	-0.33728	0.22635	0.30484	0.00556	-0.30357				
DR32	0.64962	-0.13329	-0.22916	0.35678	0.51381	-0.32048			
DR33	-0.66516	0.05699	0.07145	-0.23123	-0.55860	-0.06603	-0.41578		
DR34	0.45645	-0.27189	-0.14698	-0.45281	0.17872	-0.01424	0.25200	-0.33757	
DR37	-0.58060	0.02611	0.11569	-0.43560	-0.70044	0.29848	-0.47626	0.37946	0.01658

Average correlation: .3062
(in absolute value)

Section 5.1A <u>Money Growth Neutrality</u>

Table 5.3 summarizes the association of money growth with overall sector output and the twelve indvidual sectors' output. Table 5.4 gives the critical t-and F-values for reference. Overall manufacturing output was associated with money growth at the 2.5 percent level of significance. Further, the addition of money growth significantly reduced the sum of squared errors at the one percent level. Seven industries were found to have significant t-statistics and add significantly to the explanatory power of the equation. Fabricated metal products was significant at the 2.5 percent level, textile mill products, stone and clay , and non-electrical machinery at the five percent level, and chemicals, rubber and plastic, and electrical machinery at the ten percent level.

The results shown in the tables were for equations unadjusted for seasonal variation. Adjustment of the data and re-estimation eliminated the significent association between money growth and sector output in all equations. This implies that money growth is non-neutral only to the extent that it affects the cyclical amplitude and is neutral in its association with the underlying structure of the output series.

Testing whether, on average, money growth significantly reduced the sum of squarred errors across all equations, produced a

Table 5.3

Test of the Significance of Actual Money Growth by Individual Sector

(unseasonally adjusted)

		t-statistics	
		coef.	t-stat
X02:	Overall Manufacturing	1.02	2.56
X20:	Foods and Allied	0.78	1.07
X22:	Textile Mill Products	1.31	2.11
X26:	Paper and Allied	0.24	0.54
X28:	Chemicals and Allied	0.78	1.78
X29:	Petroleum Products	0.52	0.95
X30:	Rubber and Plastics	1.29	1.71
X32:	Stone, Clay & Glass	2.06	2.19
X33:	Primary Metals	0.68	0.37
X34:	Fabricated Metals	1.26	2.42
X35:	Non-Electrical Machinery	0.98	2.16
X36:	Electrical Machinery	1.14	1.88
X37:	Transportation Equipment	1.54	1.25

Table 5.4

Critical t-values and F-values

	t-values	F-values (1,120)	F-values (2,120)	F (3,120)
1%	2.6174	6.8510	4.7865	3.9493
2.5%	2.2699	5.1524	3.8046	3.2270
5%	1.9799	3.9201	3.0718	2.6802
10%	1.6576	2.7478	2.3473	2.1300
25%	1.1559	1.3362	1.4024	1.3873

Source: Graybill, Franklin. An Introduction to Linear Statistical Models
Vol. 1 1961 McGraw-Hill pp. 424-427

F-statistic (1,118) of 2.225, which is statistically significant at the 25 percent level. The lack of strong significance in the F-test across sectors is in constrast to the overall manufacturing output which showed money growth to significantly add (one percent level) to the explanatory power of the equation. The overall manufacturing output variable includes many more sectors than the isolated twelve in this study. The twelve sectors do however strongly suggest that (in seasonally unadjusted equations) the statistical association varies between individual sectors and that aggregate analysis may tend to wash out some of this relationship.

In the tests of differentiality, money growth was shown to be statistically associated with sector output relative to overall manufacturing output in only one sector, Paper and Allied Products. The individual t-statistic was 2.01, significant at the five percent level. Money growth, on average, did not add significantly to the explanatory power across all equations. The F-statistic (1,118) was .3412. Table 5.5 summarizes the tests of adding money growth to the output equations.

Section 5.1B Unexpected Versus Expected Money Growth

Rational expectations proponents argue that the significance of actual money growth is due to the unexpected monetary growth component.

TABLE 5.5

F-TEST (1,123)

The Significance of Adding Money Growth to Relative Sector to Overall Manufacturing Output Equations

Across the 12 industries: F (1,118) = .3412088

Sector	F-statistic
Foods	0.81
Textile Mill Products	1.10
Paper and Allied	4.07
Chemicals	1.08
Petroleum	1.44
Rubber and Plastics	0.70
Stone and Clay	2.32
Primary Metals	0.29
Fabricated Metals	0.76
Non-Electrical Machinery*	0.26
Electrical Machinery*	0.88
Transportation Equipment	0.98

*F (1,195)

Tables 5.6, 5.7, and 5.8 summarizes the F-tests for the Barro, Incomes, and Interest rate rule respectively. The first column is the F-test for whether the addition of unexpected money significantly reduces the sum of squared errors, restricting the coefficient on expected money growth to zero. The second column tests whether the addition of expected money growth adds significantly to the equation with the coefficient on unexpected money growth unconstrained.

Under the interest rate rule, unexpected money growth in six of seven equations (in which money growth was significant) was significant at the ten percent level. The same was true of the equation underlain by the Barro money rule. Under the incomes rule five out of seven were significant at the ten percent level. In constrast, the expected money growth variable was significant in only five equations: one underlain by the interest rate rule and four underlain by the incomes money rule.

The F-test across all the sectors indicated that unexpected money was significant in reducing the sum of squared errors. The equations defined by the incomes rule had an F-statistic of 3.02, significant at the ten percent level; the Barro rule had an F-statistic of 6.09, significant at the 2.5 percent level; and the interest rate rule had an F-statistic of 4.31, significant at the five percent level. The F-test

TABLE 5.6

F-Tests: Barro Money Rule
(seasonally Unadjusted output Equations)

Sectors	Unexpected Money Growth	Expected Added to Unexpected
Textiles	5.08	0.73
Chemicals	5.46	0.18
Rubber and Plastics	2.24	1.46
Stone and Clay	6.34	0.30
Non-Electrical Machinery	3.66	2.62
Electrical Machinery	3.00	2.44
Fabricated Metals	5.46	1.06
Average Reduction of Sum of Squared Errors from the Addition of the Variable:		
F-statistic	6.09	0.43

Critical F (1,118) at

10% = 2.7478

5% = 3.9201

2.5% = 5.1524

TABLE 5.7

F-Tests: Incomes Money Rule
(seasonally unadjusted output equations)

Sectors	Unexpected Money Growth	Expected Added to Unexpected
Textiles	3.78	2.16
Chemicals	3.38	1.10
Rubber and Plastics	1.50	3.62
Stone and Clay	4.78	1.32
Non-Electrical Machinery	3.04	3.12
Electrical Machinery	2.20	3.24
Fabricated Metals	3.06	3.92
Average Reduction of Sum of Squared Errors from the Addition of the Variable:		
F-statistic	3.02	1.82

Critical F (1,118) at

10% = 2.7478

5% = 3.9201

2.5% = 5.1524

TABLE 5.8

F-Tests: Interest Rate Money Rule
(seasonally unadjusted output equations)

Sectors	Unexpected Money Growth	Expected Added to Unexpected
Textiles	2.54	3.60
Chemicals	4.68	0.82
Rubber and Plastics	2.92	1.92
Stone and Clay	5.26	0.94
Non-Electrical Machinery	3.04	2.42
Electrical Machinery	3.52	1.78
Fabricated Metals	5.06	1.58
Average Reduction of Sum of Squared Errors from the Addition of the Variable:		
F-statistic	4.31	0.94

Critical F (1,118) at

10% = 2.7478

5% = 3.9201

2.5% = 5.1524

for expected money growth across all equations did not prove to be significant at the ten percent level. Only for the equations underlain by the incomes rule did expected money add significantly at the 25 percent level. This comparison suggests that unexpected money growth has systematic effects on sector output but expected money growth does not.

Section 5.1C Tests of Hypotheses

The methodology chapter set forth tests of hypotheses derived from the model and with respect to the price adjustment mechanism. The results are presented in Table 5.9. For the inventory adjustment mechanism, the F-test across all sectors is significant only at the 25 precent level. This implies the price adjustment mechanism is approximately equal to one. Clearly, there are individual cases where apparently λ does not equal one and induced output growth vis-á-vis lagged inventory growth exists.

The F-test across all sectors for the output adjustment mechanism is significant at the ten percent level indicating that the price adjustment mechanism may not equal unity. Recall that the output adjustment mechanism includes the inventory adjustment mechanism and apparently the combination of effects is the reason for the significance. In particular, the individual F-statistic significance for textiles, paper, and rubber and plastic is due to lagged inventories growth; the F-statistic significance for non-electrical

Table 5.9

F-Tests for Hypotheses on Price Adjustment Mechanism

(seasonally unadjusted data)

Sector	Inventory Adjustment	Output Adjustment
Foods	1.08	0.72
Textiles	5.60	3.96
Paper	19.63	13.00
Chemicals	0.18	0.17
Petroleum	1.52	2.00
Rubber and Plastics	4.27	2.85
Stone and Clay	0.45	0.73
Primary Metals	2.10	1.75
Fabricated Metals	0.81	2.96
Non-Electrical Machinery	0.84	6.19
Electrical Machinery	2.56	0.76
Transportation Equipment	0.20	2,40
F-Test Across All Sectors	1.99	2.16
Critical F-Values	Degrees of Freedom: (2,115)	Degrees of Freedom: (3,114)
25%	1.40	1.39
10%	2.35	2.13
5%	3.07	2.68

machinery, fabricated metals, and transportation equipment is due to lagged output growth. Note that the former group are all classified as non-durable goods sectors and the latter as durable gods sectors.

Section 5.2 Tests of Differentiality

The tests of differential impact of money growth did not support the hypothesis that the incidence of money growth was unequal across sectors. In only one of the twelve sectors did money growth prove to be statistically significant in explaining the variation of sector output relative to total manufacturing output. The sectors of importance is paper and allied products. In this case the unexpected money growth component was the driving force of the significance of actual money growth. A summary of equations is given below:[3]

PAPER AND ALLIED PRODUCTS

$$X26G = \underset{(-2.07)}{-.760MG} - \underset{(-3.08)}{-.288J_{t-1}} \qquad R^2 = .111 \qquad D\text{-}W = 2.03$$

$$X26G = \underset{(-2.21)}{-.879Unexpected} - \underset{(-.621)}{.378Expected} - \underset{(-2.98)}{.281J_{t-1}}$$

$$R^2 = .116 \qquad D\text{-}W = 2.06$$

For the foods, textiles, and rubber and plastics, lagged inventories were statistially significant in explaining the variation

[3]The different money rules did not affect the significance of these variables. For the Barro rule the coefficient on unexpected money growth was -.734 (t-statistic = -1.76) and for the interest rate the same coefficient was -.910 (t-statistic = -1.76).

of sector to total manufacturing output. The results are summarized below:

FOODS

$$X20G = \underset{(-.373)}{-.316MG} + \underset{(1.68)}{.331J_{t-1}} \qquad R^2 = .0338 \qquad D\text{-}W = 2.04$$

RUBBER and PLASTICS

$$X30G = \underset{(.286)}{.169MG} - \underset{(-2.80)}{.324J_{t-1}} - \underset{(-1.95)}{.174X_{t-1}} \qquad R^2 = .182$$

TEXTILES

$$X22G = \underset{(.541)}{.242MG} - \underset{(-3.19)}{.308J_{t-1}} \qquad R^2 = .088 \qquad D\text{-}W = 1.95$$

The positive sign on the coefficient of lagged inventories in the food output equation is consistent with the previous results. The negative sign on lagged inventories of Textiles and Rubber and Plastics is consistent. The negative sign can be interpreted as follows: A large increase in inventories the previous period leads to cutbacks in production and in these two cases, the rate of production in the sector falls faster than that of overall manufacturing.

For Tobacco, Petroleum, Rubber and Plastic, and Transportation equipment, lagged output was found to be statistically significant. The results, including the money growth variable are contained below:

TOBACCO

$$X21G = \underset{(-1.33)}{-.915MG} - \underset{(-.572)}{.001J_{t-1}} - \underset{(-2.93)}{.274X_{t-1}} \qquad R^2 = .094$$

PETROLEUM

$$X29G = \underset{(-.508)}{-.351MG} - \underset{(-.117)}{.016J_{t-1}} - \underset{(-2.15)}{.211X_{t-1}} \qquad R^2 = .073$$

TRANSPORTATION EQUIPMENT

$$X37G - \underset{(.396)}{.383MG} + \underset{(1.36)}{.236J_{t-1}} - \underset{(-3.44)}{.301X_{t-1}} \qquad R^2 = .131$$

The negative sign of lagged output indicates that a large expansion one period leads to an output change the following period of less than overall manufacturing.

The analysis of the individual sector growth equations that follows in the next section shows that many of the influences found in the overall manufacturing output equation are also characteristic of many of the industries analyzed. The individual sectors reveal some very interesting points about the relations between money growth and output and how that relationship is changed by the phase of the business cycle or the level of capacity utilization.

Section 5.3 Empirical Results by Individual Sector

This part of Chapter V describes the results of estimating the output and inventory equations for each sector. The influence of adding interactive terms to analyze business cycle and capacity utilization effects is also discussed. The industries are ordered as follows:

Section 3.5A Overall Manufacturing

Actual money growth was found to be a statistically significant predictor of the variation of overall manufacturing output, unadjusted for seasonal patterns. The basic equation can be written as:

$$\text{(A)}\quad X02G = \underset{(2.56)}{1.02MG} - \underset{(-3.19)}{.486N_{t-1}} \qquad R^2 = .141 \quad F = 6.27$$

where X02G is the growth of manufacturing output, MG is actual money growth and N_{t-1} is inventories lagged one period. The individual t-statistic on the coefficients is enclosed by parentheses.

Adjustment for seasonal variation in the data and re-estimation of the above equation gave the following equation:

$$\text{(B)}\quad X02G = \underset{(.602)}{.313MG} - \underset{(-3.18)}{.197N_{t-1}} + \underset{(2.80)}{.315X_{t-1}} \qquad R^2 = .093 \quad F = 2.93$$

where X_{t-1} is lagged output. The lack of significance on the money growth variable strongly suggests the tie between money growth and output growth is in effecting the magnitude of the seasonal cycles.

The residual lag estimations, i.e., regressing output growth on current and lagged values of unexpected and expected money growth, and lagged values of inventories and output, support the above finding. Table 3.5A.1 summarizes these results. Current unexpected and expected money growth were strong (five percent) predictors of output variations, using unadjusted data. Seasonal adjustment eliminated the statistial significance. Other equations underlain by different money rules showed (for seasonally adjusted data) some lags on expected and unexpected money growth to be significant. The inconsistency across equations makes dubious the association between the money growth variables and output.

Capacity Utilization appears to have an important influence on the association between expected money growth and output growth variability. This is true regardless of seasonal adjustments. The critical values, i.e., those values of capacity utilization which reduce the coefficient on money growth to zero, are given in Table 3.5A.2. The results of the capacity utilization estimations are in Table 5.3A.3.

Unexpected money growth and its capacity utilization interaction variable was found to be significant in only one equation (underlain by the straight interest rate rule). The critical capacity utilization value for this equation is 88.34.

Given that the average capacity utilization value across the period of study was 83.04 percent, we should expect to see a coefficient on current expected money growth to range between 3.16 and 3.90. This is true of the output equation (seasonally adjusted) defined by the straight incomes rule. The coefficient on current expected money growth was 3.21.[4] The coefficients on the expected money variable in the seasonally unadjusted equations were 3.58 and 3.74 for the equations underlain by the add-one and the straight income rule, respectively.

Marginal support for the contention that the phase of the business cycle affected the relationship between the money growth variables and output growth was found in the output equations unadjusted for seasonal patterns. In periods of economic contraction the expected money variable has an approximate value of -1.75. The coefficient of expected money growth was found to be significantly different in periods of expansion than in periods of contraction. The value of the coefficients in periods of expansion is approximately 1.05. Thus a one percent rise in expected money growth will lead to a decrease of 1.75 percent in output in periods of contraction and a 1.05 percent increase in output in periods of expansion. The strong business cycle effects can be graphically seen in Figures V.3A.1 and V.3A.2.

The test of business cycle influence in seasonal adjusted equations did not support the above conclusions. This again reflects the effect of money growth on the amplitude of the seasonal effects and not the underlying trend.

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[4]The residual lag equation defined by the add-one incomes money rule had a coefficient of 1.61 and had a t-statistic of 1.40.

Lagged inventories plays an important role in explaining the variation of seasonally adjusted output growth. This is clear in equations (A) and (B) above and especially in the residual lag equations. The oscillating signs and magnitude of the coefficients imply that if inventories grow at a constant rate across the year there will be no output adjustments.[5]

In the estimation of the inventory equations, little support is found to reject the hypothesis that the growth in the money supply does not affect overall manufacturing intentories. A summary of the estimated equations are contained in Table 5.3A.4

The "add 1," seasonally adjusted, inventory equation provides the only support for the influence of unexpected monetary growth on inventories. The underlying money rules are Barro's and the income rule. The sign of the coefficient is negative as would be expected since a sharp unexpected decrease in money growth would cause short-run reductions in consumer purchases leading to accumulation of inventories.[6]

The impact of lagged inventories on current inventory growth provides a good illustration of the influence of seasonal patterns. Without seasonal adjustment, the sign of the coefficient on lagged

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[5]The sum of the lagged coefficients is -.86, implying that a one percent increase in inventories across the year leads to a .86 decrease in current output growth.

[6]This is obvious from equation 2.22.

inventories is positive and highly significant (t-statistic: 9.80). the coefficient in the same equation re-estimated using the seasonal adjustment was negative and significant.[7] Since seasonal swings take place across a number of months, the inventory growth of the previous period will be associated with the current periods inventory growth. The strength of the association depends upon the strength of the seasonal pattern. The removal of the seasonal component may be interpreted as indicating a reaction of producers to maintain a given level of inventories. The coefficient ranges from -.18 to -.21, indicative of fine tuning of inventories.

Lagged output growth is a strong predictor of the variation in inventory growth, but due most likely to the effect of seasonal fluctuations. Lagged output was not significant in the same equations adjusted for seasonal patterns.

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[7]The t-statistics ranged from -2.46 to -2.51. [The approximate probabilty of being in the tails (i.e., plus or minus 2.46 and 2.51 standard errors from zero) is .0270 and .0120 respectively.] The coefficients on lagged inventories for the add one equation have a negative sign but are not significant. It is interesting to note that lagged inventories are not significant in the equation using actual money growth. This is most likely due to multi-collinearity between money growth variable and lagged inventories.

TABLE 5.3A.1

Residual Lag Equations
for Overall Manufacturing
(add-one incomes rule)

Dependent Variable: Output Growth

Independent* Variable	Seasonally Unadjusted	Seasonally Adjusted
constant	1.04 (2.38)**	.907 (2.70)
UMG	1.20 (2,21)	+
UMG1	-	+
UMG2	+	-
UMG3	-	+
UMG4	-	-
EMG	3.58 (2.66)	+
EMG1	-	+
EMG2	+	-
EMG3	+	+
EMG4	+	+
N1	-	-.302 (-3.96)
N2	-	-.203 (-2.04)
N3	+	+.104 (1.11)
N4	-	.529 (6.08)
N5	+	-.212 (-2.65)
Output t-6	.256 (2,34)	.184 (1,66)
	R^2 = .3813	R^2 = .6110
	D-W = 2.13	D-W = 1.82
	F = 2.76	F = 7,02

*UMG i (for i = 0 to 4) = Unexpected Money Growth lagged i quarters

EMG i (for i = 0 to 4) = Expected Money Growth lagged i quarters

N i (for i = 1 to 5) = Inventories lagged i quarter

Output t-6 = Sixth quarter lag on output

**t-statistics in parentheses

TABLE 5.3A.2

Capacity Utilization Critical Values
for Expected Money Growth

	Incomes	Barro
Seasonally unadjusted	96.80	95.90
Seasonally adjusted	99.25	96.17

Average capacity utilization across period of study is 83.04; standard deviation is 4.92.

TABLE 5.3A.3

CAPACITY UTILIZATION

		RULE	Unexpected		UC		Expected		EC		J		X_{t-1}		R^2
			Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-			
UNADJUSTED	STRAIGHT	EMG	26.59	2.10	-.301	-1.99	7.91	1.57	-.081	-1.34					.114
			16.99	1.37	-.185	-1.25	6.50	.51	-.047	-.31	-.061	-2.45			.213
	ADD 1	EMGYM	14.48	1.38	-.154	-1.24	29.91	2.22	-.309	-1.91	-.144	-4.26	-.207	-1.75	.2966
		EMGBM	14.32	1.23	-.15	-1.09	25.70	1.91	-.268	-1.68	-.133	-3.44	-.124	-1.03	.2268
ADJUSTED	ADD 1	EMGYM	8.73	.93	-.088	-.79	23.82	2.05	-.24	-1.74	-.128	-4.76			.3216
		EMGBM	7.37	.73	.073	-.60	23.08	2.02	-.24	-1.75	-.134	-4.50			.295
	SPECTRAL														
		MARG	.279	1.98	-.0033	-1.97	-.048	-.34	.0009	.50	-.080	-3.65^2			.2101

[2] Lagged output and capacity inactive term on lagged inventories were not significant.

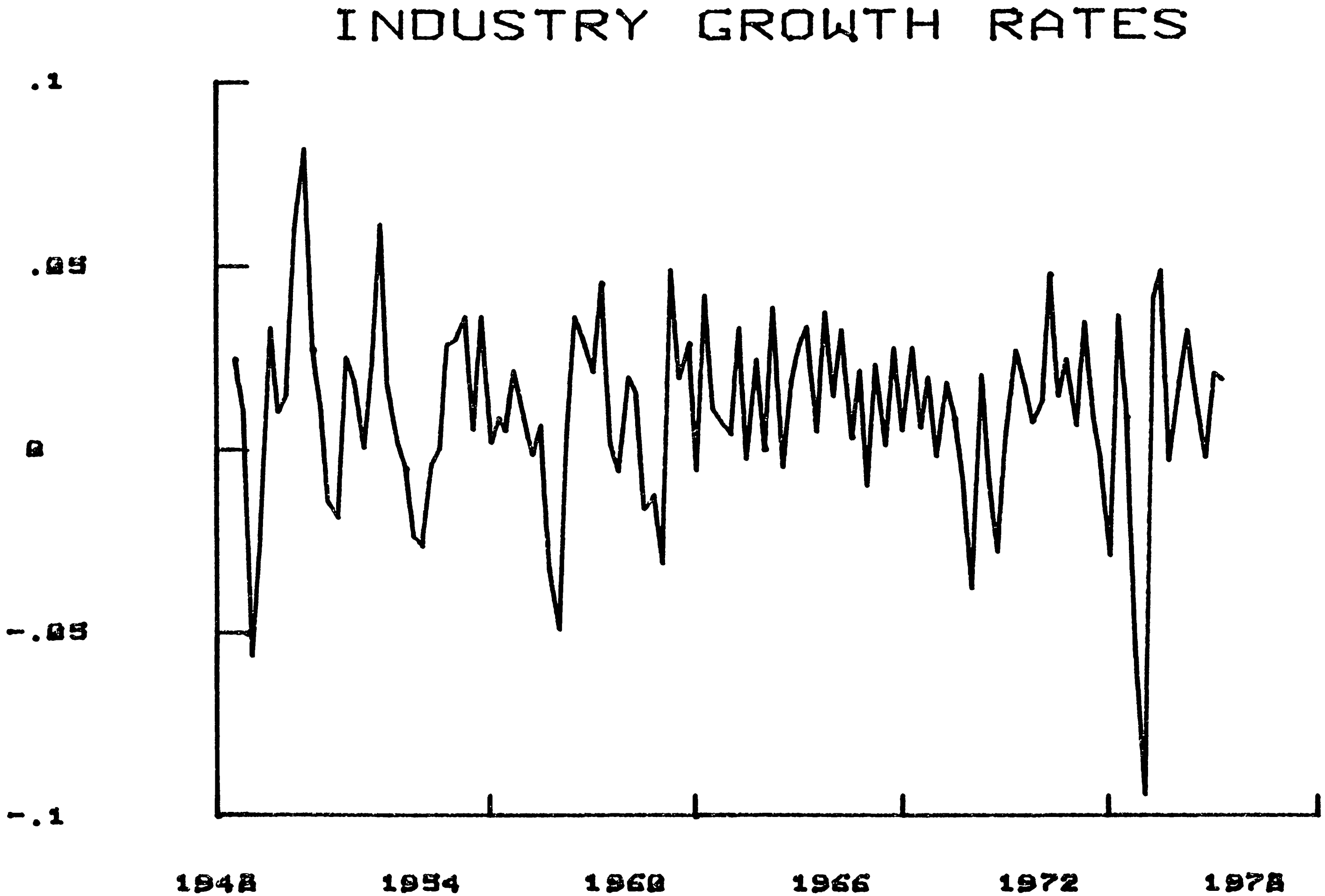


FIGURE V.3A.1

INDUSTRY GROWTH RATES

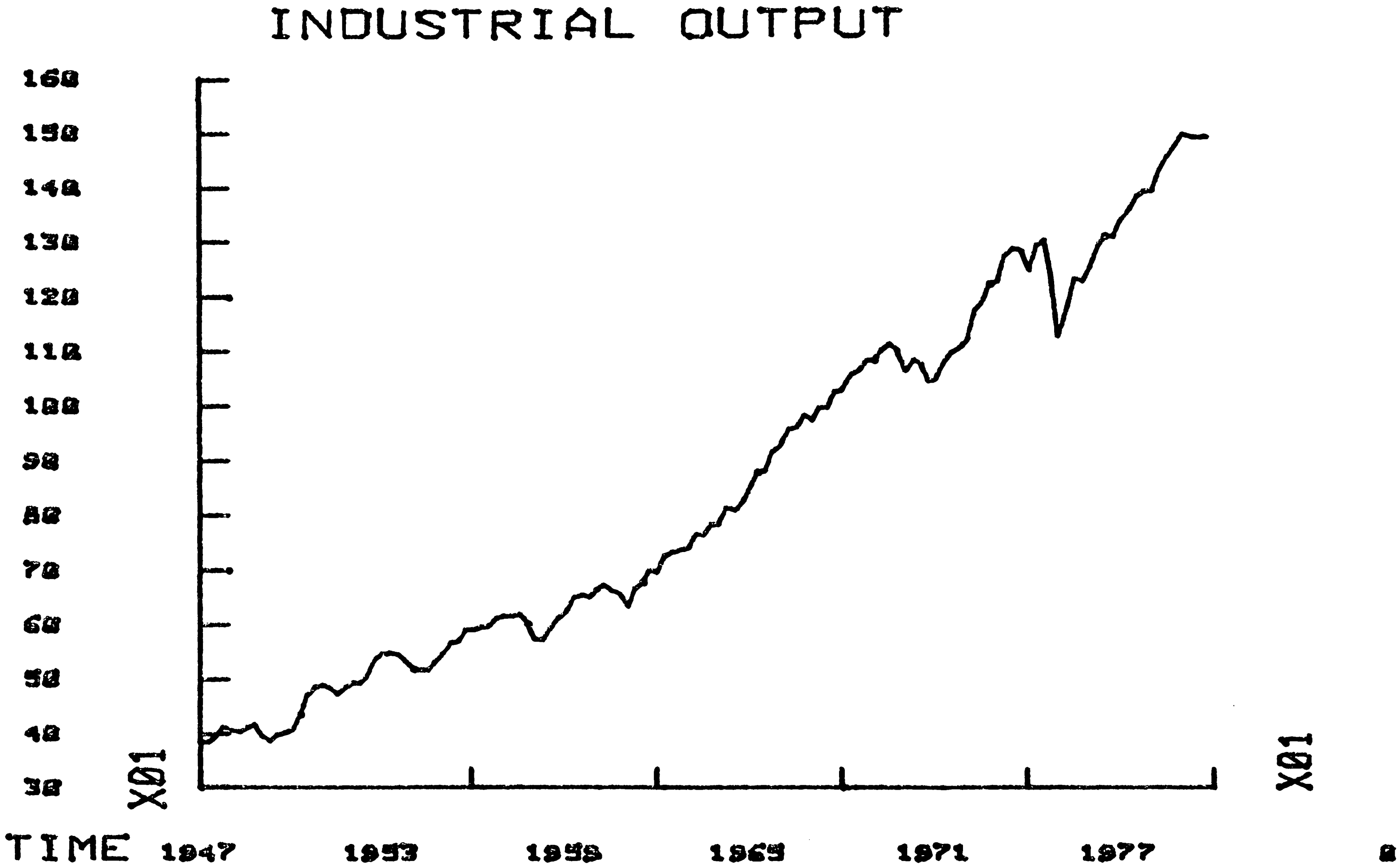


FIGURE V.3A.2

INDUSTRIAL OUTPUT

TABLE 5.3A.4

INVENTORY EQUATIONS FOR OVERALL MANUFACTURING

		RULE	Unexpected		Expected		J_{t-1}		X_{t-1}		MG		R^2	F	df
			Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-			
SEASONALLY ADJUSTED	ADD 1	EMGYM	-1.02	-1.65[1]	-.156	-.208	-.142	-1.37					.060	1.42	89
		EMGBM	-1.19	-1.85[2]	-.161	-.240	-.138	-1.34					.068	1.61	114
	STRAIGHT	EMG	-1.31	-1.22	.065	.055	-.180	-2.51					.072	2.20	116
		EMGY	.02	.02	-.732	-.457	-.210	-2.46					.054	1.67	116
		EMGB	-.51	-.37	-.020	-.013	-.211	-2.49					.054	1.65	116
							-.105	-1.01	-.205	-1.67	-.591	-.739	.075	2.31	
ADJUSTED	ADD 1						.650	8.98	.134	4.04	.0325	.232	.529	25.0	90
	STRAIGHT						.651	9.97	.169	4.57	-.026	-.153	.516	30.4	115

[1] The approximate probability of being in the tails, plus or minus 1.65 standard errors, is .0990.

[2] The approximate probability of being in the tails, plus or minus 1.85 standard errors, is .0644.

Section 5.3B Food Industry

Money does not appear to be a significant predictor of growth of output in the food industry. Adjustment for seasonal patterns slightly improves the explanatory power of the equation, largely due to the significance of lagged output. The results of these equations are:

Unadjusted Data: $$X20G = C + \underset{(1.07)}{.78MG} + \underset{(1.51)}{.259N_{t-1}} - \underset{(-.12)}{.01X_{t-1}}$$

$$R^2 = .034 \quad D\text{-}W = 1.99$$

Seasonally Adjusted: $$SX20G = C - \underset{(-.534)}{.167MG} + \underset{(.892)}{.437N_{t-1}} - \underset{(-3.156)}{.377X_{t-1}}$$

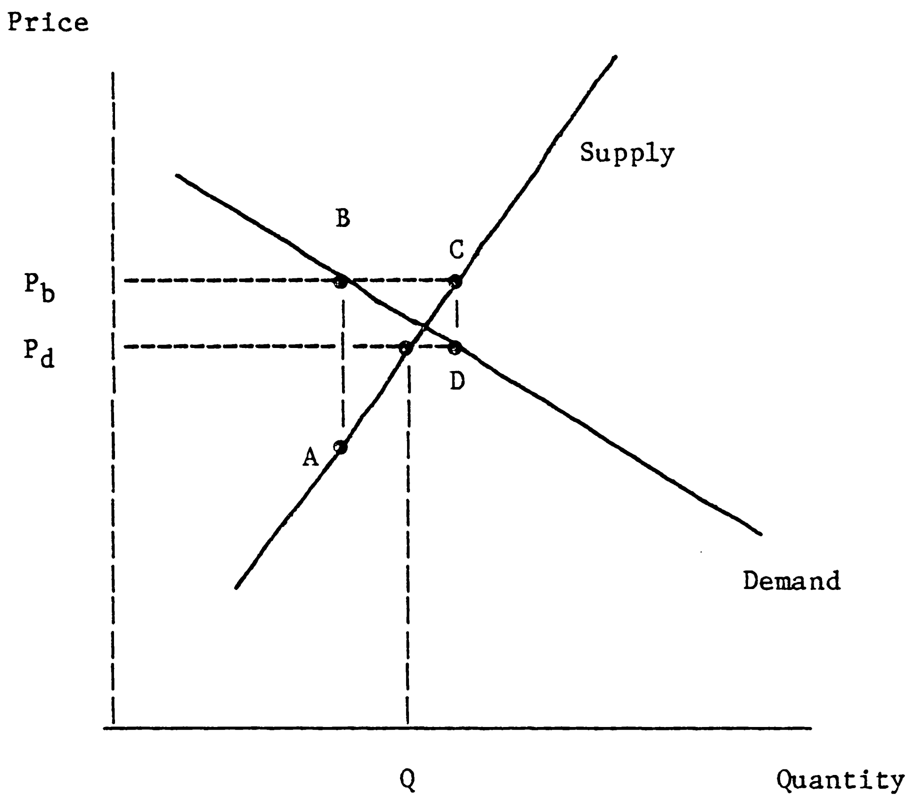
$$R^2 = .144 \quad D\text{-}W = 2.19$$

Table 5.3B.1 gives the results of the residual lag equations. Residual lag refers to the recursive substitution for lagged output such that the output equation is a function of current and lagged values of expected and unexpected money growth. Only the signs of the coefficients, not found to be significant (at the ten percent level of confidence), are reported. THe income money rule underlay the output estimations.

The results are interesting. Output is very sensitive to the conditions one year prior. Both expected and unexpected money growth lagged four quarters are significant (five percent level) but at opposite signs. This may imply adjustments, in the planting season for instance, in response to conditions during last years planting season for instance, in response to conditions during last years planting season which may may appear obvious to producers. The six quarter lag on ouput which has a negative sign reflects adjustments, again in the planting season for example, based upon the output of prior years.

The negative coefficients on the lagged output variable might be rationalized in a Cobweb model. A lag existing between production decisions and actual sales of the product may cause variance in price changes over time to clear inventories. For instance, a production decision results in a fixed (for simplicity) output in period t, say at point A on graph 5.3B.1. The price that would clear the excess demand in the market is P_b. Next periods production decision will in part be a function of the current price. In anticipating that this price will hold constant over the next period, producers may be inclined to produce at point C in time t+1. In period t+1, assuming demand remains constant, a price of P_d is necessary to clear available supplies. Next periods production decisions would be a function of P_d and production will result in output Q_e. Notice the negative relationship of output growth. Strong growth in one period is followed by a cutback in the next period.

There is evidence in the separate industries making up the foods sector to support these results. Corn production and fruits and vegetables are very sensitive to the weather conditions during the spring planting season. For corn the weather has an important effect on final seedings. For fruits and vegetables, the producer attempt to smooth production, but because of the averse affect of extreme weather



GRAPH 5.3B.1

THE COBWEB MODEL

imbalances producers may tend to increase plantings as a precaution. Richard Bogachi, a food processing analyst, comments that "when production is excessively large, sizable inventory carryovers reduce production needs in the following year, but tend to push down selling prices in the initial production year. Consumer purchases may tend to pick up, but not necessarily in proportion to the price reductions."[8]

Beef production follows an inventory pattern which takes about ten years to complete.[9] Excess supply of beef signals producers to liquidate herds which both further increases current supplies and reduces future supplies as the smaller herds produce fewer calves. More cows and heifers are kept for breeding, rather than the market, thus further restricting output. The breeding cycle may take years to significantly increase supply.[10]

The estimated equations imply some price inflexibility. Processors of fruits and vegeables attempt to maintain steady product movement. If a shortage exists, the cost to producers is partially absorbed to maintain the steady flow of output. In times of excess supplies, inventory build-ups may occur to support the selling prices. Higher carrying charges may result, however.[11]

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[8]Bogachi, Richard, "Food Processing: Basic Analysis," Standard and Poors Industry Surveys, 1978.

[9]Ibid., p. 21.

[10]Ibid., p. 21.

[11]Ibid., p. 26.

The influence of the federal government may play a role in incomplete price adjustment through price supports for milk and sugar and other argicultural products. Tariffs and other trade restrictions may also affect pricing policies. A recent example of this was the Carter administration's willingness to support the domestic sugar price at 15.8 cents a pound, up from 15 cents. Other pressure for domestic and international sugar agreements are being levered. The result is that "profits are not derived by maintaining margins between the selling prices and purchase costs, but rather by the absolute price for sugar. This, in turn, reflects conditions in world markets, where the price bears little relation to the cost factors of producing beet sugar in the U.S."[12]

Lagged inventories would not be expected to have a significant impact on output if prices rapidly adjust. A priori, the sign of the inventories variable is unclear because of the lag in initial production and the final output. In the seasonally adjusted estimations of the residual lag equations (Table 5.3B.1) the one year inventory lag is positive while the previous quarter and the fifth quarter are negative, indicative of normal output response to previous high inventories.

The inventory equations reveal much the same as the output estimations. A summary of the estimation is found in Table 5.3B.2. Lagged inventories play a small role in statistically explaining the

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[12]Ibid., p. 23.

variation in current inventory growth.[13] The addition of lagged output sharply reduced the statistical significance of lagged inventories, but in only one instance (the interest rate rule) was lagged output significant. The most appropriate equation depends upon the reader's bias toward the inventory adjustment aproach or the production gap approach as described in Chapter II.

Actual money growth was not a significant determinant of inventory growth. Unexpected money growth in one instance showed marginal significance with a coefficient of -1.21 and an individual t-statistic of -.63.[14]

Capacity utilization did not come in statistically significant nor did it improve the explanatory power of money growth. This is somewhat surprising since the period of study was marked by production facilities which required large capital investments and resistance by producers to make such an investment without a strong indication of long-term gains.[15]

Business cycle dummies did not play a significant role in predicting output or inventory growth in foods. This is not surprising. While many industries may adjust in anticipation of a weakening economic condition, demand for food products remains nearly constant. Growth in food products, given by Figure V.3B.1 is due largely to the strong

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[13]These resulta are for the seasonally adjusted equation. No variables were significant in the unadjusted equation.

[14]The associated two-tailed level of significance ± 1.63 standard errors away from zero is approximately .1074.

seasonal patterns. Food output indexes, Figure V.3B.2, also reveal steady growth and strong seasonal patterns with no great changes during recessionary periods.

TABLE 5.3B.1

INVENTORY EQUATION: FOOD SECTOR

		RULE	Unexpected		Expected		J_{t-1}		X_{t-1}				R^2	F	df
			Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-			
SEASONALLY ADJUSTED	ADD 1	EMGBM	-1.21	-1.63	-.081	-.010	-.128	-1.23					.048	1.12	89
	STRAIGHT	EMG	-.969	-.102	.038	.037	-.157	-1.99					.047	1.41	114
			-1.03	-1.10	.090	-.088	-.005	-.043	-.510	-1.86			.075	1.84	113
		EMGY	-.096	-.09	-.687	-.545	-.179	-2.04					.038	1.16	114
		EMGB	-.693	-.636	.096	.079	-.177	-2.02					.039	1.19	114
	SPECTRAL	MMG	-.0045	-.383	-.005	-.500	-.178	-2.03					.041	1.24	116

Table 5.3B.2

Dependent Variable; Output Growth of Food Sector

Independent Variables	Incomes Rule (straight) Seasonally Unadjusted	Seasonally Adjusted
UMG	+	-
UMG1	+	+
UMG2	-	+
UMG3	-	-
UMG4	2.06 (2.50)	1.76 (2.49)
EMG	-	-
EMG1	+	+
EMG2	+	+
EMG3	-3.86 (-1.99)	-3.43 (-2.06)
EMG4	2.33 (2.12)	1.72 (1.82)
N1	+	-1.26 (-3.54)
N2	-	-
N3	+	-
N4	-	.2997 (10.67)
N5	+	-1.49 (4.73)
Output t-6	-.899 (-26.81)	+

Notes: Figures in parentheses are t-statistics.

UMGi is unexpected money growth lagged i quarters.

EMGi is expected money growth lagged i quarters.

Ni is inventories lagged i quarter.

Output t-6 is output lagged 6 quarters.

Seasonally Unadjusted	Seasonally Adjusted
R^2 = .8903	R^2 = .6171
F = 49.17	F = 9.77
D-W = 2.49	D-W = 2.37

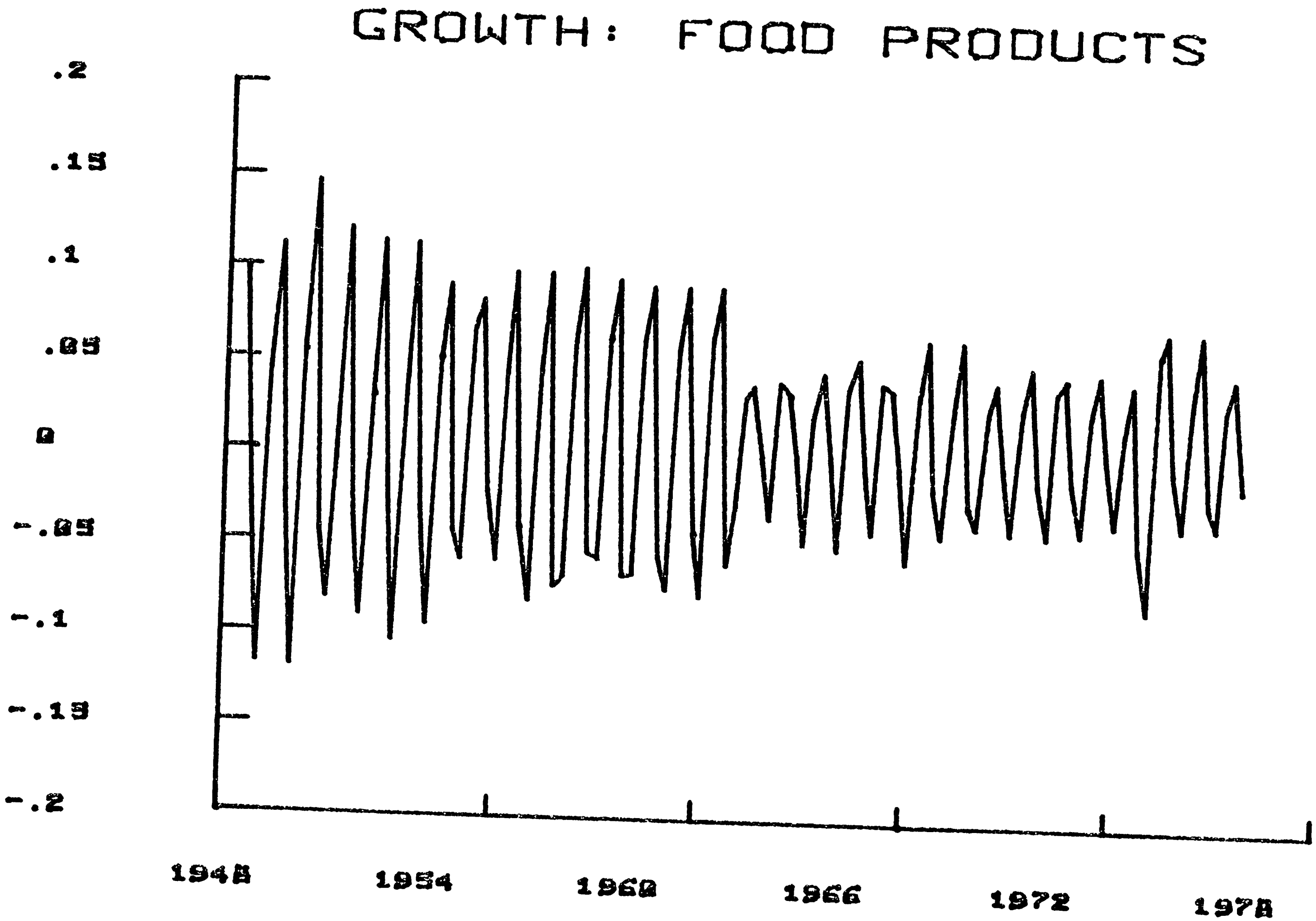

FIGURE V.3B.1

GROWTH: FOOD PRODUCTS

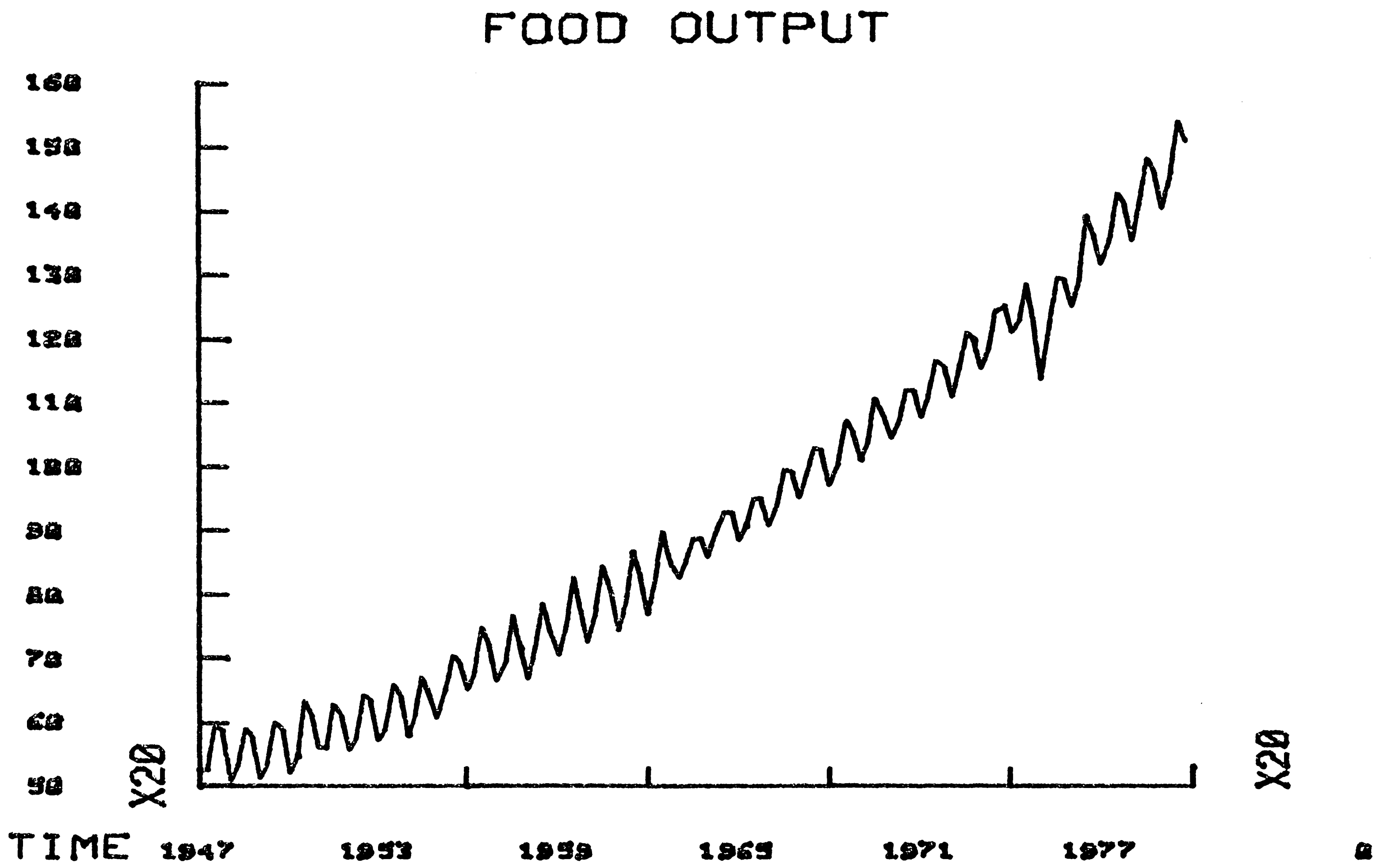

FIGURE V.3B.2
FOOD OUTPUT

Section 5.3C Textiles

Actual money growth was found to be statistically significant (five percent) in explaining the variation of textile mill output growth. The equation was unadjusted by any seasonal component. Re-estimation of the equation after deseasonalization of the data eliminated the statistical association. This implies a connection between money growth and the amplitude of the seasonal pattern.

Estimation of the residual lag showed that current unexpected money growth was significant (ten percent) in predicting output behavior. The effect of deseasonalization did not entirely eliminate this association although a greater inconsistency was found across the equations (defined by different money rules) than with the unadjusted equations. A summary of the residual lag equations is found in Table 5.3C.1.

As is quite clear from the graph of textile mill output indexes and growth rates (Figures V.3C.1 and V.3C.2 respectively), that textile mill products seems to be affected by the phase of the business cycle. The demand for apparel products, for instance, is strongly influenced by cyclical swings, seasonal factors, changing styles, and the consumer balance sheet.[15]

The most obvious example of the association of output growth to the phase of the business cycle is the 1974-75 recession. This reflected the fact that rapid expansion in the early 1970's was not in the right

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[15] Rudy Macher, "Textiles: Basic Analysis," Industry Surveys, Standard and Poors, p. T54.

direction. More efficient controls, a strengthened product line and improvement in inventory turnover was a consequence of the recessionary impact.[16]

Testing for the possibility that the association between money growth variables and textile output growth is functionally related to the phase of the business cycle was done using dummy variables. For seasonally adjusted equations, expected money was found to be negatively associated with output growth in the contractionary phase of the business cycle and positively associated with the output growth in the expansionary phase. The magnitude in the former ranges from -1.92 (for the equation defined by the Barro rule) to -2.22 (for the equation defined by the incomes rule). On the expansionary side the magnitude of the coefficient is much smaller ranging from + .60 to .64 (for the equations defined by the incomes and Barro rule, respectively). A summary of the equations is found in Table 5.3C.2.

Capacity utilization was shown to be important in affecting the coefficient on both expected money growth and unexpected money growth. The equations were seasonally unadjusted. Seasonal adjustment in all but one case (defined by the spectral money rule) eliminated the statistical association. The critical capacity utilization values on unexpected money range from 90 (for the equation defined by the spectral rule) to 94.19 (for the equation defined by the Barro rule). Given that the average capacity utilization across the period of study is 88.03 this range is well within one standard deviation, 6.89 percent. This

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[16]Ibid., p. T51.

implies that during seasonal downswings unexpected money is expected to have a greater impact. This seems reasonable since a positive unexpected money growth would mitigate some of the downswing effects. On the upswing, a similar positive unexpected money growth will not have as great effect due to the added cost of taxing capacity. See Table 5.3C.2.

Further, it might be argued that some of the real demand shifts in periods of seasonal upswing may be incorrectly attributed to money growth and we would see a negative impact (exceeding the critical capacity value) of money growth on output. The sign on unexpected money growth and its associated capacity inveractive term support this claim. The same is not true of expected money growth where the signs are reversed. Note further that the critical values on expected money growth, i.e., 86.23 and 87.20 (for the equations defined by the Incomes and Barro rules, respectively) are below the average level of capacity utilization. Thus on average the value of the expected money growth variable ranges from .44 to .68. The coefficient on unexpected money growth ranges from .96 to 2.29 based on the average capacity level.

Lagged inventories and output were found to be statistically significant (one percent). This was true for inventories regardless of seasonal adjustment. Lagged output was not significant in unadjusted equations. Two examples will illustrate the magnitude of the coefficients and their statistical significance:

Seasonally Unadjusted: $X22G = 1.41U + .947E - .432N_{t-1}$
(add-one Barro rule $\qquad (1.83) \quad (1.18) \quad (-2.31)$

$R^2 = .1117 \qquad F = 2.80 \qquad D\text{-}W = 1.99$

Seasonally adjusted: (add one interest rate rule)

$$X22G = .086U + .71E - .380N_{t-1} + .44X_{t-1}$$
$$(.15) \quad (1.21) \quad (-3.21) \quad (4.52)$$

$$R^2 = .255 \qquad F = 6.03 \qquad D\text{-}W = 1.86$$

Where X = output, U = unexpected money growth, E = expected money growth, and N_{t-1} = lagged inventories.

The sign of the coefficient on lagged inventory implies that if inventory growth is low output will increase to partially rebuild inventories and perhaps to satisfy demands which may have drawn dowm inventories.

In the residual lag equations the pattern of coefficient values and their oscillating signs reflect a strong connection between inventories growth and output growth. Constant inventory growth across the year will lead to near constant output growth. Lagged output was significant (ten percent level) in only a few equations seasonally unadjusted.

Estimation of the inventory equations provided no support for the relationship between money growth and inventories. Some evidence was found to support the association between unexpected money and inventories but this result is too closely tied to the particular money rule used.

The lagged inventories variable was significnat in the unadjusted equations. This was not true of the seasonally adjusted estimations. Lagged output was highly significant in the unadjusted equations and marginally significant in the seasonally adjusted equations. The sign on both the lagged output and inventory variable is positive. The magnitude of the coefficient slightly favors the lagged inventory variable.

TABLE 5.3C.1

Residual Lag
Summary of Equations
(straight incomes rule)

Dependent Variable: Output Growth

Independent Variables	Seasonally Unadjusted	Seasonally Adjusted
constant	+	.871 (2.35)
UMG	1.55 (1.89)*	+
UMG1	+	-
UMG2	3.14 (1.69)	+
UMG3	+	2.69 (1.71)
UMG4	+	-
EMG	+	+
EMG1	-	+
EMG2	+	-
EMG3	-	+
EMG4	+	-
N1	-.576 (-3.55)	-.308 (-3.50)
N2	.493 (1.89)	-
N3	+	-
N4	-	.453 (3.96)
N5	+	-.186 (-2.16)
Output t-6	-.155 (-1.74)	+
	R^2 = .2688	R^2 = .4125
	D-W = 2.08	D-W = 1.74
	F = 2.23	F = 4.25

FIGURE V.3C.1

TEXTILE MILL PRODUCTS

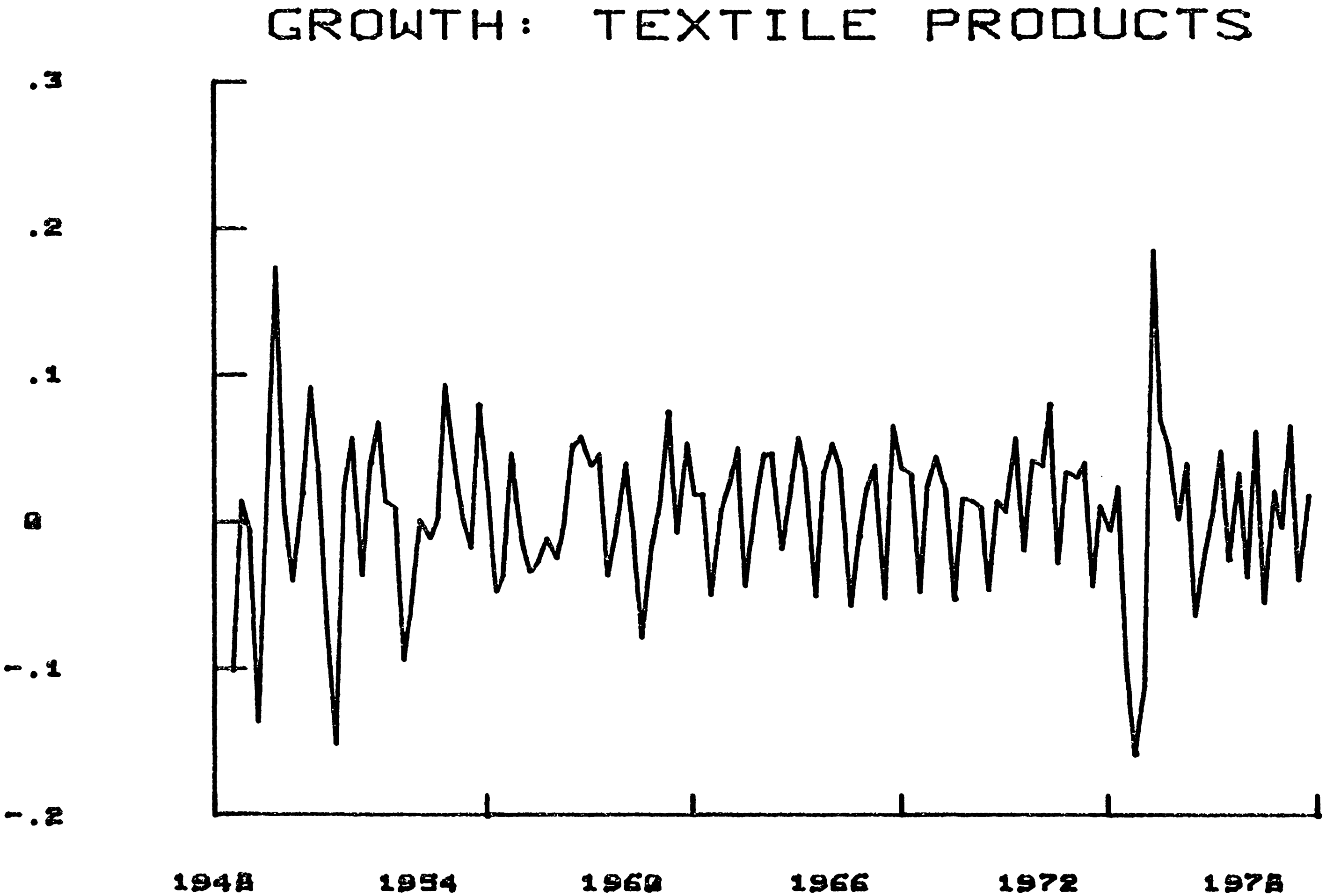

FIGURE V.3C.3

GROWTH: TEXTILE PRODUCTS

TABLE 5.3C.2

Business Cycle Interactive Terms
Summary of Equations
for Textile Mill Products
(add-one, seasonally adjusted)

Dependent Variable: Output Growth

Independent Variable	Money Rules		
	Incomes	Barro	Interest Rate
constant	.111 (1.87)	.139 (1.85)	.135 (1.80)
Unexpected Money Growth (U)	-.812 (-.540)	-1.10 (-.639)	-2.05 (-1.46)
U* Dummy Variable	1.26 (.81)	1.51 (.846)	2.27 (1.54)
Expected Money Growth (E)	-2.22 (-2.01)	-1.92 (-1.88)	-1.60 (-1.50)
E* Dummy Variable	2.82 (2.78)	2.58 (2.70)	2.49 (2.49)
Lagged Inventories	-.373 (-3.20)	-.374 (-3.25)	-.352 (-3.04)
Lagged Output	.364 (3,50)	.363 (3.55)	.370 (3.56)
Time	-.00007 (-1.86)	-.00007 (-1.84)	-.00007 (-1.82)
	R^2 = .310	R^2 = .307	R^2 = .311
	F = 5.53	F = 5.43	F = 5.55
	D-W = 1.92	D-W - 1.90	D-W =1.88

TABLE 5.3C.3

Critical Capacity Utilization Value
for Textile Mill Products

Money Rule (straight)	Unexpected Money	Expected Money
Incomes	92.15	86.23
Barro	94.19	87.20
Spectral	90.00	--

TABLE 5.3C.4

Capacity Utilization
Summary of Equations
for Textile Mill Products
(straight money rules: unadjusted data)

Dependent Variable: Output Growth

Independent Variables	Money Rules Incomes	Barro	Spectral
constant	.812 (1.91)*	1.02 (2.36)	--
Unexpected Money Growth (U)	29.12 (2.44)	34.85 (2.77)	.315 (2.11)
U* Capacity Utilization	-3.16 (-2.36)	-.37 (-2.65)	-.0035 (-2.04)
Expected Money Growth (E)	-33.2 (-2.20)	-28.6 (-1.95)	-.089 (-0.72)
E* Capacity Utilization	.385 (2.24)	.328 (1.95)	.001 (.745)
Lagged Inventories	-.052 (-1.00)	-.081 (-1.53)	-.102 (-1.95)
	R^2 = .2067	R^2 = .2173	
	F = 3.64	F = 3.89	
	D-W = 1.88	D-W =1.88	D-W = 1.89

*t-statistics in parentheses

Section 5.3D Paper and Allied Products

Money growth is not a significant determinant of the variation in output of paper and allied products. Furthermore, the residual lag equations, regressed using unajusted data, showed unexpected and expected money growth to have little influence on output variation. (See Table 5.3D.1.) Those lagged quarters of money growth that were significant in one equation defined by one money rule were not significant in other equations defined by other rules. Seasonal adjustment of the data eliminated all traces of money growth as a significant variable.

There is reason to believe, however that the impacts of money growth are a function of both the phase of the business cycle and of the degree of capacity utilization. This is not surprising since the production of paper, paperboard, and newsprint is highly correlated to the overall level of domestic economic activity (measured by real gross national product). However, the consumption of paper products is more responsive to changing economic conditions in the non-durable goods sector than the durable goods sector.[17]

One factor affecting the overall usage of newsprint is advertising. Robert Masterson, a paper industry analyst, writes: "Since many companies have a greater propensity to increase their advertising budgets in times of economic expansion and cut back on these expenditures during economic contraction, it follows that the vitality

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[17] Robert Masterson, "Paper: Basic Analysis," Industry Surveys, Standard and Poors, November 15, 1979, p. P9.

in the domestic economy is an important determinant of overall demand for newsprint."[18]

Using business cycle dummy variable (and seasonally adjusted data) some evidence was found to suggest that the association between expected money growth and output growth of paper and allied products is different in the contractionary phase from that in the expansionary phase. The impact in the contractionary phase ranged from -1.88 to -2.04; for the expansionary phase -.03 to +.20. The influence of the business cycle can be seen in the graphs of output growth and output indexes, Figures V.3.D.1 and V.3D.2, respectively.

Capacity utilization appears to play a key role in assessing the influence of expected money growth (unexpected growth was not significant). These results were for the seasonally adjusted equations only. The initial capacity utilization values are:

Interest Rate Rule:	96.82
Incomes Rule:	97.55
Barro Rule:	100.00

The average capacity utilization rate across the period of study was 90.29 percent with a standard dviation of 4.65. Table 5.3D.2 provides further details.

Supportive of the importance of capacity utilization, Robert Masterson writes, "Earnings for paper producers have generally fluctuated more widely than quantitative changes in production. The

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[18]Ibid., p. P18.

high degree of operating leverage typically employed in the industry dictates that high utilization rates of productive capacity be reached before producers can break even and make a profit. Historically, periods of weak demand and for overcapacity have resulted in intense competition and price discounting, which has cut into margins and impacted profitability." Capacity growth has slowed from 3.8 percent (for 1960-69) annually to 2.1 perent (1970-79). This is due in part to the capital-intensive nature of the industry and the rising cost of capital. Furthermore, the increased capacity throughout the 1960s, which resulted in the price discounting and low profits, have made industry leaders cautious about commitments for additional capacity."[19] Also, costly expenditures for pollution control equipment has held down capacity additions and in some cases reduced overall capacity because certain facilities could not meet the guidelines.[20] The effect is a high level of capacity utilization and hence a small (given by the coefficient) association between expected money growth and output growth.

The significance of expected money growth must, if the association is not spurious, be tied to incomplete price adjustments. Despite the apparent high competitive nature of the paper industry, the sector has been confronted with numerous price fixing charges in recent years. The antitrust suits affect virtually the entire industry. Quite often

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[19]Ibid., p. P10.

[20]Ibid., p. P26.

companies will plead no contest and settle out of court arguing that while they are innocent, long delays and costly legal fees would be more financially damaging.

Lagged inventories dominate the output equations regardless of seasonal adjustment. The oscillating signs of the coefficients of lagged inventories (in the residual lag equations) and the similar absolute value of the coefficients is suggestive of the importance of inventory control in relation to output. In other words, constant inventories across the year imply no output adjustment.

Estimation of the inventory equations support the conclusions concerning money growth and output as discussed above. Lagged inventories was highly significant (one percent) in predicting the variation in current inventories, in equations unadjusted for seasonal variation. The sign of the coefficients is positive with value of approximately .48, strongly suggestive of seasonal patterns. Seasonal adjustment eliminated the statistical significance of lagged inventories. The sign of the coefficients is negative as expected.

TABLE 5.3D.1

Residual Lag Equations
Summary of Results
for Paper and Allied Products
(add one incomes money rule)

Dependent Variable: Output Growth

Independent Variable	Seasonally Unadjusted	Seasonally Adjusted
UMG	+	+
UMG1	-	-
UMG2	+	+
UMG3	-1.51 (-1.67)	+
UMG4	+	-
EMG	-	+
EMG1	-	+
EMG2	+3.17 (1.79)	-
EMG3	-3.37 (-1.83)	-
EMG4	+	-
N1	-.788 (-4.49)	-.331 (-4.91)
N2	.805 (2.66)	-
N3	-	+
N4	+	.510 (6.44)
N5	-	-.194 (-2.90)
Output t-6	-.293 (-2.85)	-
	R^2 = .4721	R^2 = .6245
	D-W = 2.28	D-W = 1.91
	F = 4.00	F = 7.44

TABLE 5.3D.2

Capacity Utilization
Summary of Equations
for Paper and Allied Products
(add one, seasonally adjusted data)

Dependent Variable: Output Growth

Independent Variable	Money Rules* Incomes	Barro
constant	.672 (3.77)	.826 (4.48)
Unexpected Money Growth (U)	5.31 (.38)**	-.56 (-.04)
U* Capacity Utilization	-.05 (-.32)	.012 (.07)
Expected Money Growth (E)	32.19(2.00)	32.20 (2.18)
E* Capacity Utilization	- 33 (-1.85)	-.322 (-2.00)
Lagged Inventories	-.10 (-2.97)	-.116 (-3.56)
Lagged Output	+.172 (1.69)	.199 (2.05)
	R^2 = .2690	R^2 = .3076
	D-W = 2.02	D-W = 2.01
	F = 4.52	F = 5.46

The expected money growth variable was not significant at the 10% level for the interest rate rule. The coefficient for E is 22.56 (1.48) and for E Capacity -.233 (-1.40).

**T-statistics are in parentheses.

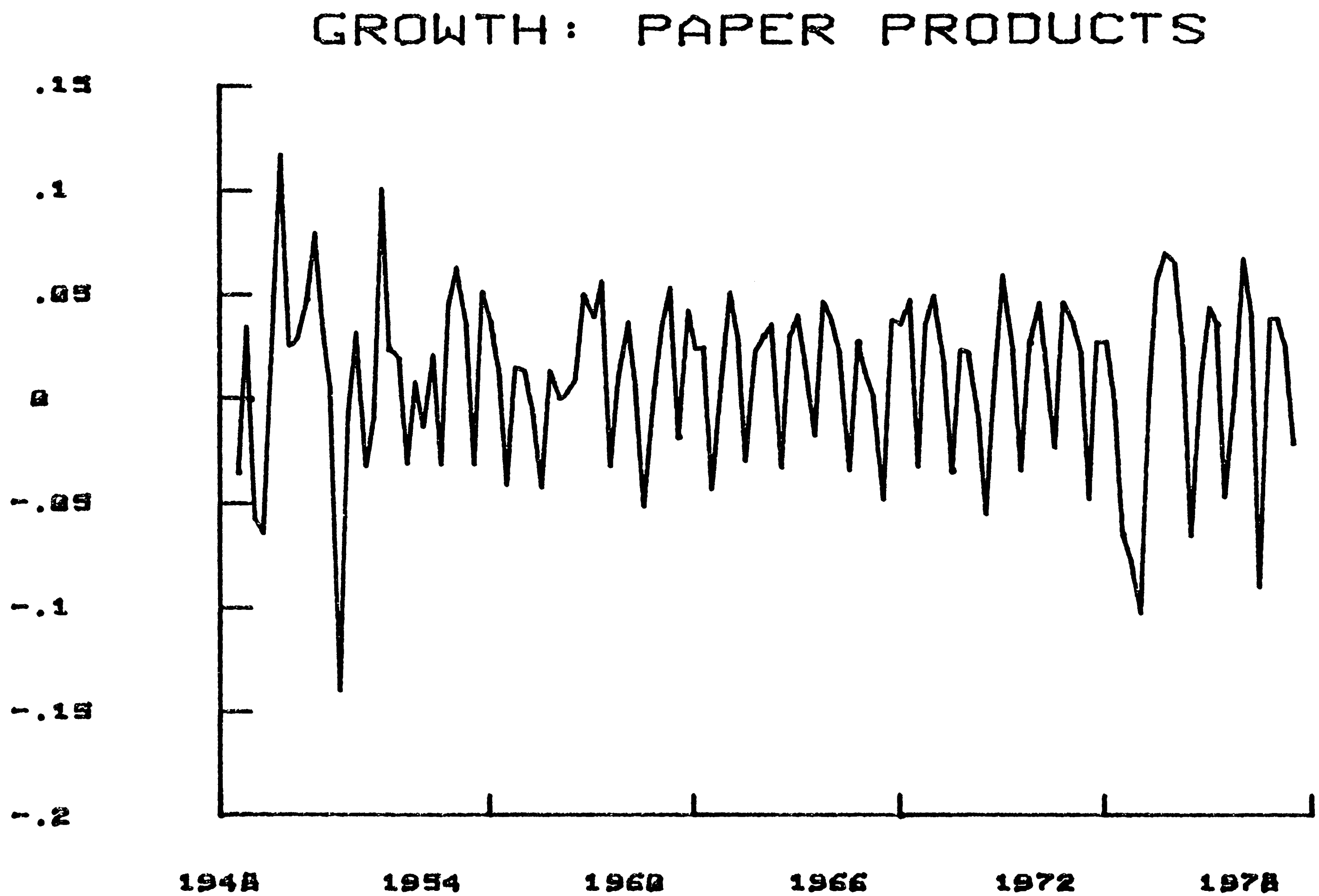

FIGURE V.3D.1

GROWTH: PAPER RPODUCTS

FIGURE V.3D.2

PAPER AND PAPER PRODUCTS

Section 5.3E Chemicals and Allied Products

Unexpected money growth was found to be a statistically significant predictor (five percent level) of chemicals and allied products in equations unadjusted for seasonal patterns and underlain by money rules estimated across the entire period. Expected money growth, in the current period, although not found to be significant in the standard output equation, was found to be significant (ten percent level) in the residual output equations. The results of the standard output regressions and the residual lag estimations are found in Tables 5.3E.1 and 5.3E.2, respectively.

The significance of the money growth variables seems to be a result of the seasonality in the output series. Re-estimation of the equations using seasonally adjusted data eliminated the statistical association of money growth to chemical output.

Evidence exists to suggest that in asociation with the seasonal effects of money growth, the effect of expected money growth depends upon the phase of the business cycle. In contractionary periods the influence of expected is greater by about three to one relative to the expansionary impact. The coefficient on expected money growth in a contractionary phase in approximately -2.71; in an expansionary phase the coefficient is approximately .23. Unexpected money growth was not found to be significant in these estimations. The equation below is an example of the business cycle effects. It was estimated using unseasonally adjusted data, straight interest rate money rule. Other money rule equations were comparable.

$$X28G = \underset{(.160)}{.245U} + \underset{(.499)}{.824} (U*DUM - \underset{(-2.53)}{2.71E} + \underset{(3.49)}{3.09E*DUM} - \underset{(-3.38)}{.344N_{t-1}}$$

$$R^2 = .247 \qquad F = 6.11 \qquad D\text{-}W = 2.07$$

Some marginal evidence exists to show that unexpected money growth, in equations seasonally adjusted, will have a significant impact on chemical output growth depending upon the level of capacity utilization. The following equation is underlain by the spectral money rule:

$$X28G = \underset{(2.31)}{.909} + \underset{(1.77)}{.662U} - \underset{(-1.76)}{.088U*Capacity} - \underset{(-.101)}{.32E} + \underset{(1.47)}{.0001E*Capacity}$$

$$- \underset{(-2.33)}{.097N_{t-1}} - \underset{(-2.71)}{.232X_{t-1}}$$

$$R^2 = .1619 \qquad F = 2.71$$

Note that the critical value of capacity utilization where unexpected money would have no impact on chemical output is 82.7. Given that the average capacity utilization across the period of study was 83.5 (standard deviation of 4.30), it is not surprising that, in the absence of the capacity interactive term, unexpected money growth had no statistical effect in the seasonally adjusted equation.

Past inventories in all estimations play a dominant role in explaining chemical output growth. This holds regardless of seasonal adjustment. The signs of the lag structure in the residual lag equation oscillate back and forth, perhaps indicative of attempts to maintain inventories at a specified level. This would be charactristic of product for stock rather than for order.

The significance of lagged output is somewhat inconsistent across estimations. The sign is negative underscoring the output behavior as a result of lagged inventories.

In the estimation of the inventory equations actual money growth is not a significant predictor of inventories of chemicals and allied products in either equations adjusted and unadjusted for seasonal patterns. Unexpected money, as defined by the add 1 Income and Barro rule are marginally significant ($P(T_I) = .0784$ and $P(T_B) = .07180$) in the seasonally adjusted equations only.

Lagged output is significant in the seasonally adjusted equations but not in the unadjusted equations. The sign on the significant coefficients is negative, and the magnitude ranges from -.242 to -.364. The lagged inventory variable is significant in the estimated equations (seasonally adjusted) only when lagged output is not included as an independent variable. The sign of the inventory variable is negative in the absence of the output variable, and is positive with its inclusion in the equation. The magnitude stays roughly the same.

In the unadjusted equations, however, lagged inventories dominate regardless of the output variable. The sign is positive and roughly twice the magnitude of that found in the seasonally adjusted equations.

Table 5.3E.1
Residual Lag Estimations
for Chemical Output Growth
(add-one incomes rule)

Independent Variables	Unadjusted	Seasonally Adjusted
UMG	1.42 (2.37)	+
UMG1	-1.80 (-1.91)	-
UMG2	+	+
UMG3	-	+
UMG4	+	-
EMG	3.92 (2.58)	+
EMG1	-	-
EMG2	+	-
EMG3	-	+
EMG4	+	-
N1	-.472 (-3.76)	-.239 (-3.50)
N2	.593 (3.02)	+
N3	-.355 (-1.77)	-
N4	.397 (2.00)	.655 (7.73)
N5	-.206 (-1.60)	-.365 (-5.54)
Output t-6	-.309 (-3.11)	-
	R^2 = .3687	R^2 = .6044
	D-W = 2.22	D-W = 1.83
	F = 2.61	F = 6.83

Table 5.3E.2
Output Equations
for Chemical and Allied Products

Part A	Unadjusted	Adjusted
Money Growth	.778 (1.78)	-.109 (-.124)
Lagged Inventories	-.426 (-4.13)	-.307 (-3.38)
	R^2 = .157	R^2 = .093
	D-W = 1.97	D-W = 2.35

Part B

	Unadjusted		
	Interest Rate	Incomes	Barro
Unexpected Money	1.19 (2.00)	1.02 (1.77)	1.15 (1.97)
Expected Money	.296 (.459)	-.0003 (-.0004)	-.09 (-.14)
Lagged Inventory	.418 (-4.04)	-.444 (-4.73)	-.451(-4.35)
	R^2 = .165	R^2 = .182	R^2 = .187
	D-W = 1.98	D-W = 1.94	D-W = 1.89

Section 5.3F Petroleum and Related Products

Actual money growth was not found to be a significant variable in explaining the variation of petroleum and related products. However, estimation of the residual lag output equation revealed in the second and third quarter lags of both expected and unexpected money growth to be significant (five percent) predictors of seasonally unadjusted output growth. Adjustment for seasonal patterns did not entirely negate the influence of these variables but the results were inconsistent across the equations defined by the different money rules. A summary of results is given in Table 5.3F.1. The sign on the second quarter lag is negative. On the third quarter lag the sign was positive. The significance of these particular quarters may be related to the high seasonal demands for some petroleum products which forces the industry to build up sizeable additional inventories in anticipation of demand.

Support for this argument is found in the significance of the lagged inventory variables in the seasonally adjusted equations. The oscillating signs and the similarity of the value of the coefficients reflect the importance of inventory management. In other words, if the growth of inventories across the year remains constant, there would be no associated change in output growth.

Capacity utilization appears to influence the effect of expected and unexpected money growth on output. A summary of the capacity utilization effects across the different money rules is found in Table 5.3F.2.. The influence of capacity utilization is related to the seasonal patterns and not to the underlying trend. This makes sense in light of the above discussion. Large build-ups of inventories may press capacity above normal operating levels, which, given by the average of capacity utilization across the period of study, was 91.76 percent of total capacity. The critical capacity utilization values for unexpected money ranged from 92.62 percent for the equation defined by the Barro rule, to 92.81 percent for the equation defined by the incomes money rule. Thus, in periods of high capacity utilization, perhaps to build up inventories, reaction to unexpected money changes will be very small, and for capacities exceeding the critical values will actually be negative.

The same is true of expected money growth, although the connection between output and this money variable must come from incomplete price adjustments. This may exist if the relationship between prices of inputs and products change at unequal rates. This may be true especially in the 1970s as the world price of crude petroleum reflected decisions made by OPEC nations. If capacity is well below the critical values for expected money growth (ranging from 95.72 (interest rule) to 98.89 (incomes rule)) producers may take advantage of the price of crude petroleum bound by existing contracts with oil-producing nations and the price of refined products.

The high average rate of capacity utilization, especially in the last fifteen years, may be due to the unwillingness of the industry to build new refineries and petrochemical complexes. The delays in new construction are a result of the crude oil allocation and entitlement program which requires shared domestic production, price controls, uncertainty about tax actions, increased foreign competition, and opposition from the environmental groups for new sites.[21]

The results of the inventory equations are consistent with the output estimations. Actual money growth does not appear to be strongly related to the variation in inventory growth of petroleum and allied products. Unexpected money growth, however, does appear to be significantly related. The sign of the coefficient is negative as would be expected. The positive sign on the coefficient of expected money growth is positive (although not significant), and is the probable cause of the lack of statistical significance of the actual money growth variable. The significance of unexpected money is robust, maintaining good strength regardless of seasonal adjustment, changes in the method of calculating the expected and unexpected series. The magnitude of the coefficients seems to be greater in those estimations using seasonally adjusted data.

Lagged inventories is significant in both adjusted and unadjusted estimations. Seasonal adjustment does, however, reduce the level of confidence that the true influence of lagged inventories is greater than zero. Lagged output is significant only for the seasonally adjusted equations. A summary of the results appears in Table 5.3F.3.

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[21] Mineral Facts and Problems, p. 803.

TABLE 5.3F.1

Residual Lag Equations
for Petroleum and Related Products
Incomes Money Rule (straight)

Dependent Variable: Output Growth

Independent Variable	Seasonally Unadjusted	Seasonally Adjusted
UMG	+	+
UMG1	+	-
UMG2	-2.54 (-1.76)*	-1.59 (1.74)
UMG3	4.07 (2.54)	2.25** (2.17)
UMG4	-	-
EMG	+	+
EMG1	+	+
EMG2	-9.30 (-2.55)	-4.97** (-2.07)
EMG3	5.99 (1.75)	+
EMG4	-	-
N1	-	-.180 (-5.12)
N2	-	.167 (3.41)
N3	+	-.103 (-1.92)
N4	+	.289 (9.28)
N5	-	-.183 (-6.09)
Output t-6	-.567 (-6.98)	-
	R^2 = .4008	R^2 = .6108
	D-W = 2.86	D-W = 2.49
	F = 4.05	F = 9.51

*t-statistics are in parentheses

**Significance was inconsistent across equations defined by different money rules.

TABLE 5.3F.2

Capacity Utilization Effects
for Petroleum and Related Products
(add-one money rules, unadjusted data)

Dependent Variable: Output Growth

Independent Variable	Money Rules: Barro	Money Rules: Interest	Money Rules: Incomes
Unexpected Money (U)	36.03 (1.82)*	18.59 (.854)	34.34 (1.86)
U* Capacity Utilization	-.389 (-1.79)	-.194 (-.816)	-.3706 (-1.83)
Expected Money (E)	21.49 (1.74)	23.93 (2.06)	21.46 (1.69)
E* Capacity Utilization	-.22 (-1.67)	-.25 (-2.00)	-2.17 (-1.59)
Lagged Inventories	N.S.**	N.S.	N.S.
Lagged Output	N.S.	N.S.	N.S.
	R^2 = .073	R^2 = .061	R^2 = .076
	D-W = 2.13	D-W = 2.15	D-W = 2.14

*t-statistics in parentheses

**N.S. = not significant.

TABLE 5.3F.3

INVENTORY EQUATIONS FOR PETROLEUM AND PRODUCTS

		RULE	Unexpected Coef.	Unexpected t-	Expected Coef.	Expected t-	J_{t-1} Coef.	J_{t-1} t-	X_{t-1} Coef.	X_{t-1} t-	MG Coef.	MG t-	R^2	F	df
SEASONALLY ADJUSTED							.188	1.74	-.598	-2.57	-.858	-1.187	.103	2.56	89
	ADD 1	EMGM	-1.27	-1.46	-.432	-.478	.187	1.73	-.567	-2.40			.110	2.19	88
		EMGYM	-1.51	-1.83	.251	.253	.181	1.69	-.581	-2.52			.129	2.60	88
		EMGBM	-1.71	-1.97	.054	.061	.181	1.70	-.557	-2.41			.133	2.70	88
	STRAIGHT	EMGM	-2.51	-2.13	.621	-.489	.026	2.67	-.410	-1.89			.094	2.35	88
UNADJUSTED	STRAIGHT	EMG	-1.51	-2.00	.686	1.11	.400	4.79					.218	7.96	114
		EMGY	-1.51	-2.10	1.04	1.61	.413	5.00					.237	8.98	114
		EMGB	-1.12	-1.99	.86	1.38	.417	5.02					.229	8.63	114
							.414	4.87	.040	.566	-.303	-.705	.188	6.61	115

Section 5.3G Rubber and Plastic Products

Estimation of the output equation for rubber and plastic products proved to be one of the most interesting. Actual money growth was a significant (ten percent) predictor of output growth in equations unadjusted for seasonal variation. The equation took the form:

$$X30G = \underset{(1.71)}{1.29MG} - \underset{(-2.84)}{.419N_{t-1}} \qquad R^2 = .0899 \qquad D\text{-}W = 2.17$$

Estimation of the residual lag output equations which breaks down actual money growth into current and lagged values of expected and unexpected money growth, indicated an influence, albeit a somewhat inconsistent one, of the money growth variables on output growth of rubber and plastic products. Only the current value of unexpected money growth remained significant in four of the six output equations (each one underlain by different money rule). The significance of the unexpected money growth variable remained intact.[22]

Current expected money was significant for the residual lag equations defined by the interest rate and the Barro money rule. Similarly for these two rules, the four quarter lag was significant. Both current and the four quarter lag were positive with a ten percent level of significance. A summary of the residual lag equations appears in Table 5.3G.1

Capacity utilization appears to be a very influential factor in the strength of association (given by the coefficient) between enexpected

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[2]The money rule equations that underlay these equations were the add-one rules for all three rules, i.e., incomes, Barro's and the interest rate rule.

and expected money growth and rubber and plastic output growth. In all equations, regardless of the money rule or the method of estimating the money rule, and using seasonally adjusted data, the expected and unexpected money variables and their associated capacity utilization interactive terms were significant. Table 5.3G.2 summarizes these equations. The critical capacity utilization values are given in Table 5.3G.3. Note that the critical values for unexpected money growth are much lower than those of expected money growth. This means that as capacity utilization increases, expected money growth will always have a stronger impact on output growth.

This is supported by the coefficients of the money variables in the residual lag equations. For example, using the Barro rule equation (add one) a capacity utilization of 92 percent will yield an unexpected output coefficient of approximately 1.81, equal to the coefficient on the current unexpected money variable in the residual lag equation. Further the 92 percent capacity utilization implies a coefficient on expected money growth of 6. This compares to the sum of the residual lag coefficient of current and lagged (four quarters) expected money growth of 8.4. Given that the average capacity across the period of study is 88.3 percent with a standard deviation of 6.9, the capacity utilization results seem quite consistent.

The phase of the business cycle appears to effect the magnitude of expected money growth on rubber and plastics output. Consistency of results is greater for the seasonally unadjusted equations. As is the case in other industries examined in this paper, the effect of expected money growth is negative in periods of contraction (with a coefficient range of 1.25 to 1.77 for unadjusted equations and .89 to 1.69 for seasonally adjusted equations).

The strong business cycle effect is easily seen in the output growth and the output index graph, Figures V.3G.1 and V.3G.2, respectively. The strong tie between the auto industry and the tire manufactures suggest the effect of the business cycle is not surprising. "Most non-tire operations of the rubber companies are connected to industrial markets, although certain of them, such as tennis balls, footwear, and flooring, are made for purchase directly by the consumer. Demand for industrial products depends importantly on the level of national economic activity. Accordingly, the market for these products, especially the market for original equipment tires, is essentially cyclical in nature."[23]

Lagged inventory is a strong predictor of the variation in rubber and plastics output. The coefficient is negative and takes on a value of approximately -.45, implying a one percent increase in last quarter's inventory growth leads to a .45 percent reduction in the current growth of output.

Estimation of the inventory equation rejected money growth as a significant predictor of inventory growth in rubber and plastic products. Lagged output showed inconsistent results as sample size and seasonal adjustments were made.

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[23]"Rubber Industry," Industry Surveys, Standard and Poors.

TABLE 5.3G.1

Residual Lag Equations
for Plastic and Rubber Products
(underlying Barro (add-one) money rule)

Dependent Variable: Output Growth

Independent Variables	Seasonally Unadjusted	Seasonally Adjusted
UMG	1.90 (1.93)*	1.81 (2.13)
UMG1	-	-
UMG2	+	+
UMG3	-	+
UMG4	+	+
EMG	+	4.70 (1.94)
EMG1	-	-
EMG2	+	+
EMG3	+	-
EMG4	+	3.70 (1.77)
N1	-.447 (-1.95)	-.376 (-3.11)
N2	-	-
N3	+	+
N4	+	.966 (6.37)
N5	-.370 (-1.80)	-.593 (-5.20)
Output t-6	-	-
	R^2 = .3206	R^2 = .5955
	D-W = 2.27	D-W = 2.14
	F = 2.11	F = 6.58

TABLE 5.3G.2

Capacity Utilization Output: Plastics and Rubber Output

(seasonally adjusted)

Dependent Variable: Output Growth

Independent Variables	Underlying Money Rule Equations: Barro (add-one)	Incomes Rule (straight)
Unexpected Money Growth (U)	31.30 (2.14)*	71.50 (2.40)
U* Capacity Utilization	-.32 (-1.99)	-.780 (-2.33)
Expected Money Growth (E)	40.96 (2.45)	64.99 (2.02)
E* Capacity Utilization	-.384 (-2.09)	-.632 (-1.75)
Lagged Inventories	-.186 (-3.81)	-.187 (-2.77)
Lagged Output	N.S.**	-.325 (-3.58)
	R^2 = .2934	R^2 = .2300
	F =4.39	F = 3.73

*t-statistics in parentheses

** N.S. = not significant

TABLE 5.3G.3

Critical Capacity Utilization Values
for Rubber and Plastics Output

(Seasonally Adjusted Data)

Money Rules	Add 1 Rules Expected	Add 1 Rules Unexpected	Straight Rules Expected	Straight Rules Unexpected
Income	107.51	96.93	102.51	91.67
Barro	106.67	97.81	107.56	90.91
Interest	102.64	98.65		
Spectral			90.67	91.45

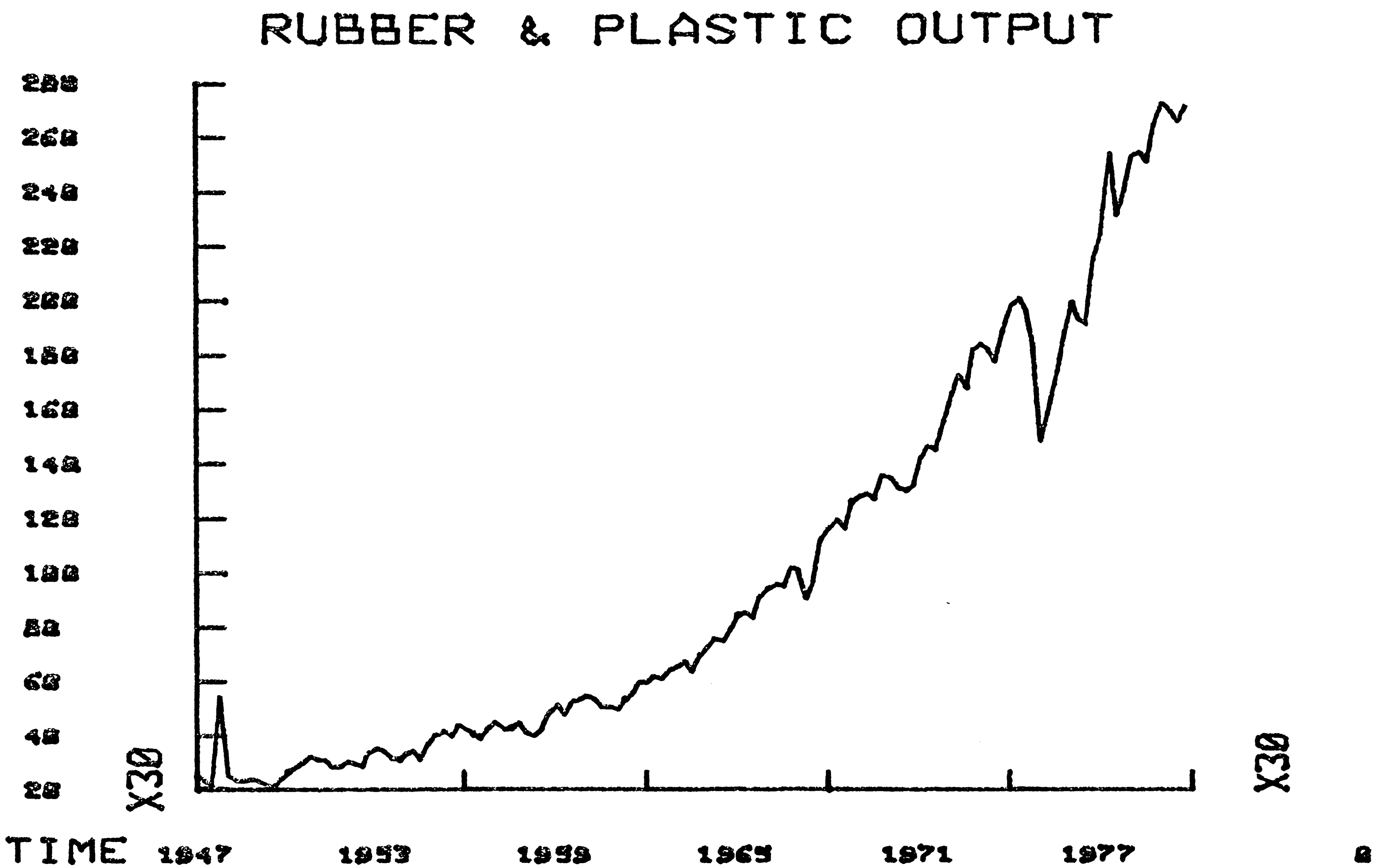

FIGURE V.3G.1

RUBBER AND PLASTIC OUTPUT

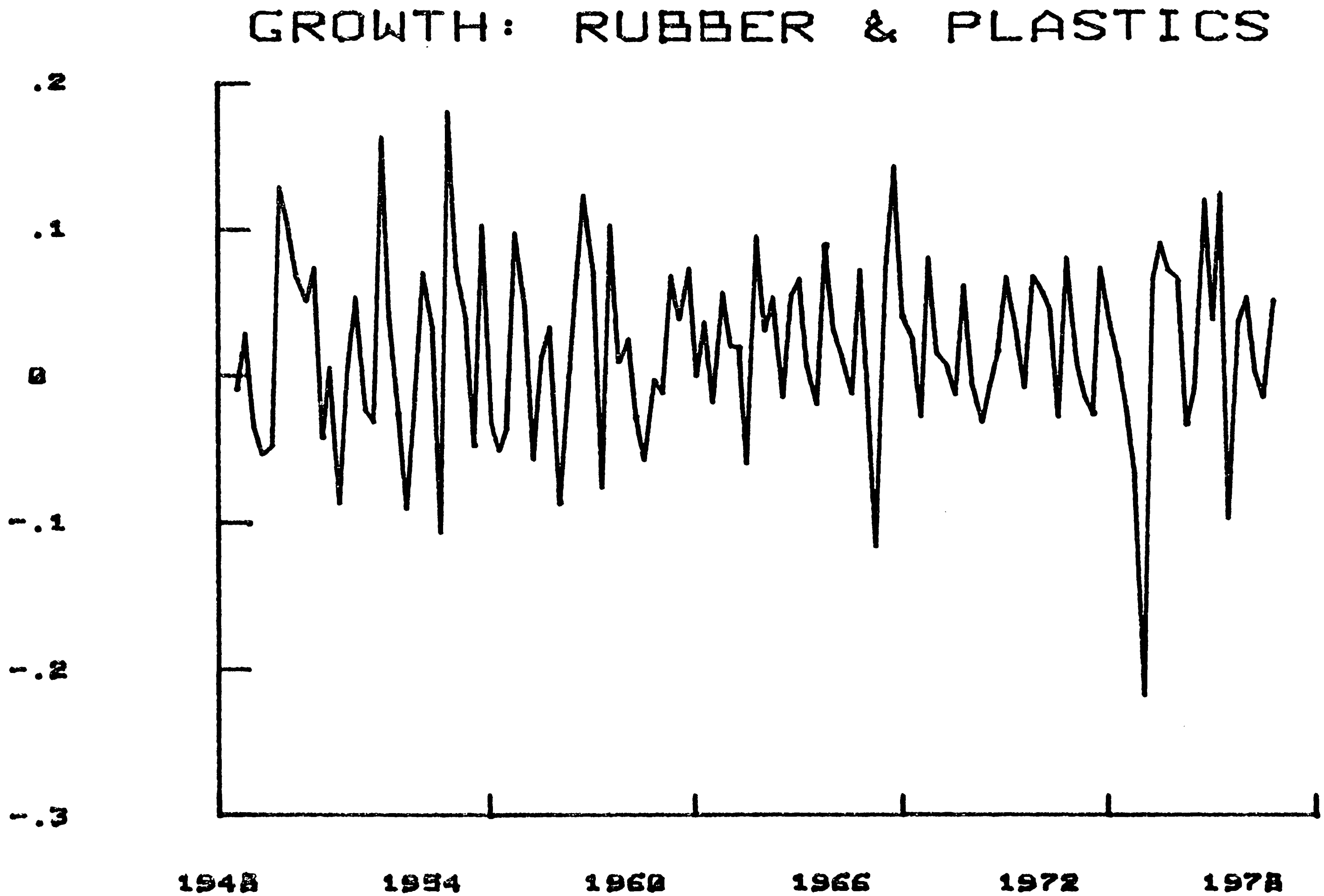

FIGURE V.3G.2

GROWTH: RUBBER AND PLASTICS

Section 5.3H Stone, Glass, and Clay

In the equations estimated using seasonally unadjusted data, unexpected money growth was found to be a significant predictor (five percent level) of stone, glass, and clay output. This is not true of equations estimated using seasonally adjusted data (except for the spectral money rule equation). This may imply that the unexpected money growth affects the amplitude of the seasonal cycle but does not affect the underlying trend of the variable. The magnitude of impact of unexpected money growth is between 2.27 percent and 3.32 percent. These results are reported in Table 5.3H.1

The effect of unexpected money on the seasonal cycles alone is supported by the results of the residual lag estimations as well. A summary of the results for the seasonally adjusted and unadjusted residual lag equations (defined by the add-on income money rule) is presented in Table 5.3H.2. The results are quite striking. First, across all estimations using different money rules, the current expected money variable is significant at the five percent level. Other lagged values are significant but are not consistently as money rules change.

Secondly, the significance of the money growth variables disappear (in all but a few cases) using seasonally adjusted data. The exceptions are the equations defined by the straight money rule. The coefficients for these are in Table 5.3H.3.

Lagged inventory variables are significant and account for a greater share of variability of seasonally adjusted output than all the money growth variables and lagged output on unseasonally adjusted output. The negative signs of the previous two quarters are as expected: high previous inventories reduce current output, satisfying current sales from past inventories, Note that if inventories remained constant throughout the year there would be no impact on current output since the sum of the significant lagged inventory coefficients is nearly zero.

The high Durbin-Watson statistic indicates the presence of negative autocorrelation. This may be tied to the strong significant and negative coefficient on lagged (six quarters) output and the significance of the expected money terms. Note that with seasonal adjustment this autocorrelation is sharply reduced; output is no longer significant.

A final note on the significance of the money growth variables: the oscillating signs from quarter to quarter of the expected and unexpected money variables. Note also that the magnitude of the coefficients (in negative and positive pairs) is roughly equal, perhaps indicating that a constant growth of money may not led to increased cyclical (seaonal) amplitudes.

Estimation of output equations with capacity utilization variables for the clay, glass and stone industry was meet with mixed results similar to the previous findings. The unexpected money growth variables were found to be significant predictors of output; the conditions were seasonally unadjusted data, and straight money rules. Under the same conditions expected money growth was not significant. However, under the conditions of seasonally unadjusted data with underlying Add 1 money rules, expected money growth was significant at the ten percent level and its associated capacity was very marginally significant with the probability of being in the tails beyond the t-statistic of 1.55 approximately twelve percent.

The expected money growth variables were significant under the following conditions: seasonally adjusted, straight Barro and Income rules. Unexpected was also significant using the Barro rule. The critical capacity utilization values are given below.

Critical Capacity Utilization Values

	Money Rules	Unadjusted Expected	Unadjusted Unexpected	Adjusted Expected	Adjusted Unexpected
Straight	Interest	N.S.	85.02	N.S.	N.S.
	Incomes	N.S.	84.17	91.67	N.S.
	Barro	N.S.	83.85	106.94	82.27
ADD 1	Interest	89.92	N.S.	N.S.	N.S.
	Incomes	92.77	N.S.	N.S.	N.S.
	Barro	90.20	82.66	N.S.	N.S.

N.S. = Coefficient was not statistically significant.

Output of clay, glass, and stone appears to be more sentitive (and in a positive direction) to expected money growth in period of overall economic expansion.[24] The magnitude of effect is approximately .7 percent, i.e., a one percent increase in expected money growth leads to a .7 percent increase in output. The magnitude of effect during contractionary periods is negative and approximately 1.19 percent.

That clay, glass, and stone output is responsive to different positions of the business cycle is not surprising since production is strongly tied to construction activity.[25] Fluctuation in demand depends mostly on the general economic condition of the nation and government policy thus affecting the availability of money for construction activities.[26]

The movement of output in periods of expansion and contraction can be seen graphically in Figures V.3H.1 and V.3H.2. Note also the appearance of seasonal cycles in the data.

Results of the inventory estimations are consistent with the above output equations. Actual money growth was significant at the ten percent level of confidence in estimation without seasonal adjustment. This significance is largely due to the unexpected money component as evidence in Table 5.3H.4. Seasonal adjustment sharply reduced the significance of the actual money growth variable. No evidence was found

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[24]Estimated using seasonally adjusted data.

[25]Mineral Facts and Problems, p. 10377

[26]Brinton E. BRown, p. 215.

to show that unexpected money in the seasonally adjusted equations was associated with inventory growth.

Lagged output was not significant in predicting the variation of inventories. Lagged inventories was highly significant (one percent level) in the seasonally adjusted estimations. The sign of the coefficient was positive.

Table 5.3H.1

Residual Lag Estimation
for Clay, Glass, and Stone Output

Independent Variables	Seasonally Unadjusted	Seasonally Adjusted
C	N.S.	N.S.
UMG	3.50 (3.04)	+
UMG1	-4.10 (-2.37)	+
UMG2	2.96 (1.73)	-
UMG3	-2.98 (-1.70)	-
UMG4	3.28 (1.90)	-
EMG	8.49 (3.10)	+
EMG1	-8.07 (-2.49)	+
EMG2	5.65 (1.71)	+
EMG3	-5.87 (-1.69)	-
EMG4	+	-
N1	-	-.307 (-3.89)
N2	+	-1.65 (-1.79)
N3	-	+
N4	.935 (1.80)	.475 (5.51)
N5	-	-
Output t-6	-.605 (-6.97)	+
	R^2 = .5098	R^2 = .5684
	D-W = 3.01	D-W = 1.79
	F = 4.65	F = 5.89

t-statistics are in parentheses
underlying money rule: add-one income money rule
+ and - : not significant; sign of coefficient

TABLE 5.3H.2

SUMMARY OF OUTPUT EQUATIONS

		RULE	Unexpected Coef.	Unexpected t-	Expected Coef.	Expected t-	Nt-1 Coef.	Nt-1 t-	X_{t-1} Coef.	X_{t-1} t-	R^2	F	D-W
SEASONALLY UNADJUSTED	STRAIGHT	EMG	3.32	2.61	.673	.488	N.S.	N.S.	N.S.	N.S.	.508	2.36	2.16
		EMGY	2.91	2.41	.705	.490	-.227	-.989			.0566	2.25	2.22
		EMGB	2.99	2.40	.760	.546	-.232	-.101			.0570	2.25	2.22
	ADD-ONE	EMGM	2.27	1.83	2.31	1.77	-.787	-1.85			.095	2.33	2.24
		EMGYM	2.42	2.03	2.05	1.39	-.802	-1.92			.0953	2.34	2.25
		EMGBM	2.76	2.20	1.76	1.34	-.811	-1.96			.099	2.46	2.25
SEASONALLY ADJUSTED	STRAIGHT	EMG	.591	.952	.580	.863	-.111	-3.03	.274	2.797	.111	2.82	2.20
		EMGY	.897	1.36	.220	.278	-.155	-4.05	.339	3.07	.1475	3.98	2.19
		EMGB	.563	.830	.696	.909	-.153	-4.00	.329	2.99	.144	3.88	2.17
		MMG	.013	1.84	-.004	-.603	-.154	-4.06	.334	3.08	.1581	4.32	2.19
	ADD-ONE	EMGM	.40	.74	.99	1.78	-.159	-1.86	.271	2.46	.1307	2.65	2.04
		EMGYM	.43	.83	1.196	1.83	-.158	-1.86	.240	2.13	.134	2.71	2.01
		EMGBM	.412	.76	1.02	1.76	-.16	-1.88	.249	2.23	.130	2.64	2.00

TABLE 5.3H.3

USING SEASONALLY ADJUSTED DATA

	Money Rules		
	Barro	Income	Interest
Unexpected Money Growth (t)	N.S.	.756 (1.67)	1.07 (2.15)
Expected Money Growth (t)	5.46 (3.85)	2.64 (1.75)	N.S.

N.S. = Not significant at ten percent.

t-statistics are in parentheses.

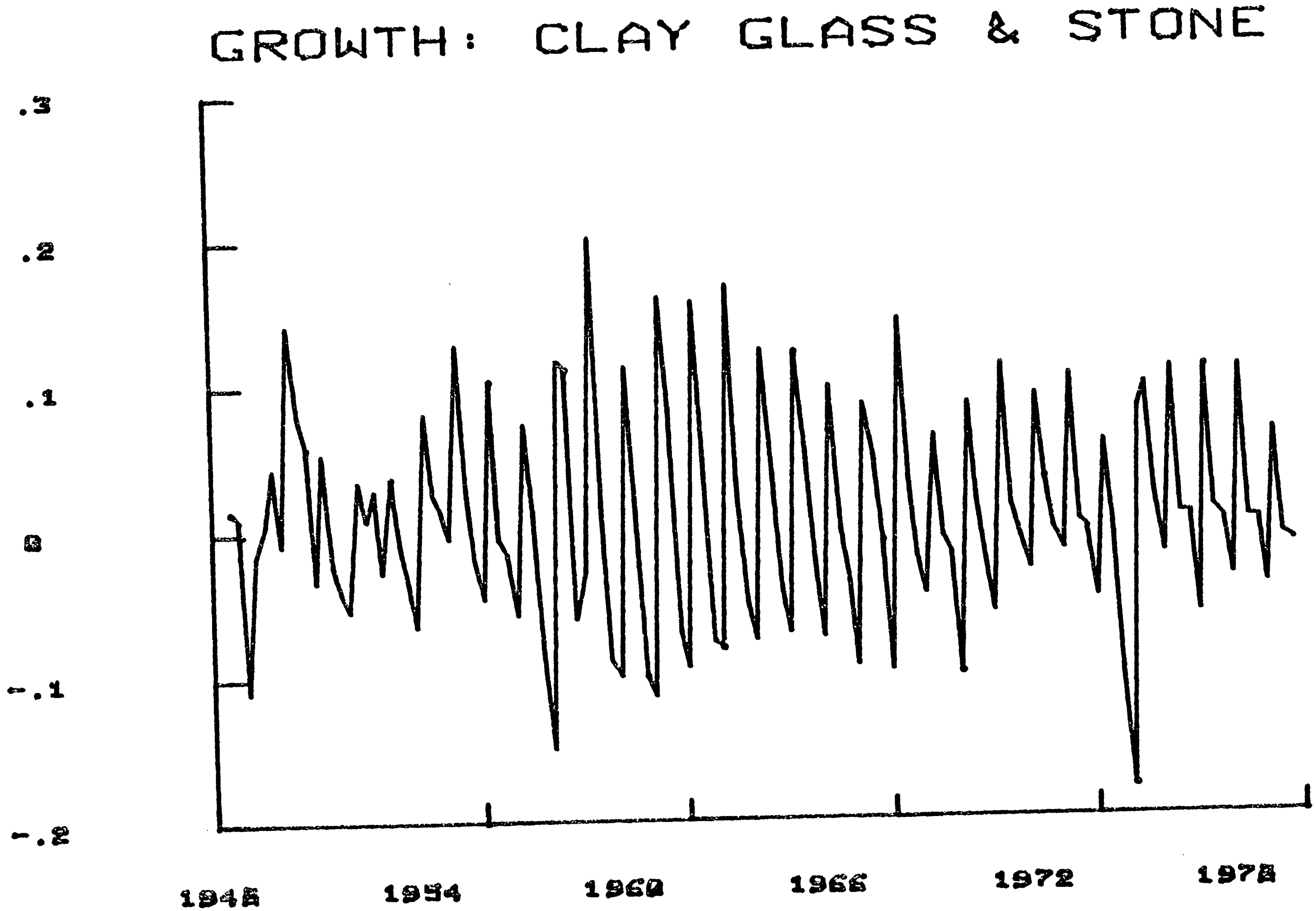

FIGURE V.3H.1

GROWTH: CLAY, GLASS AND STONE

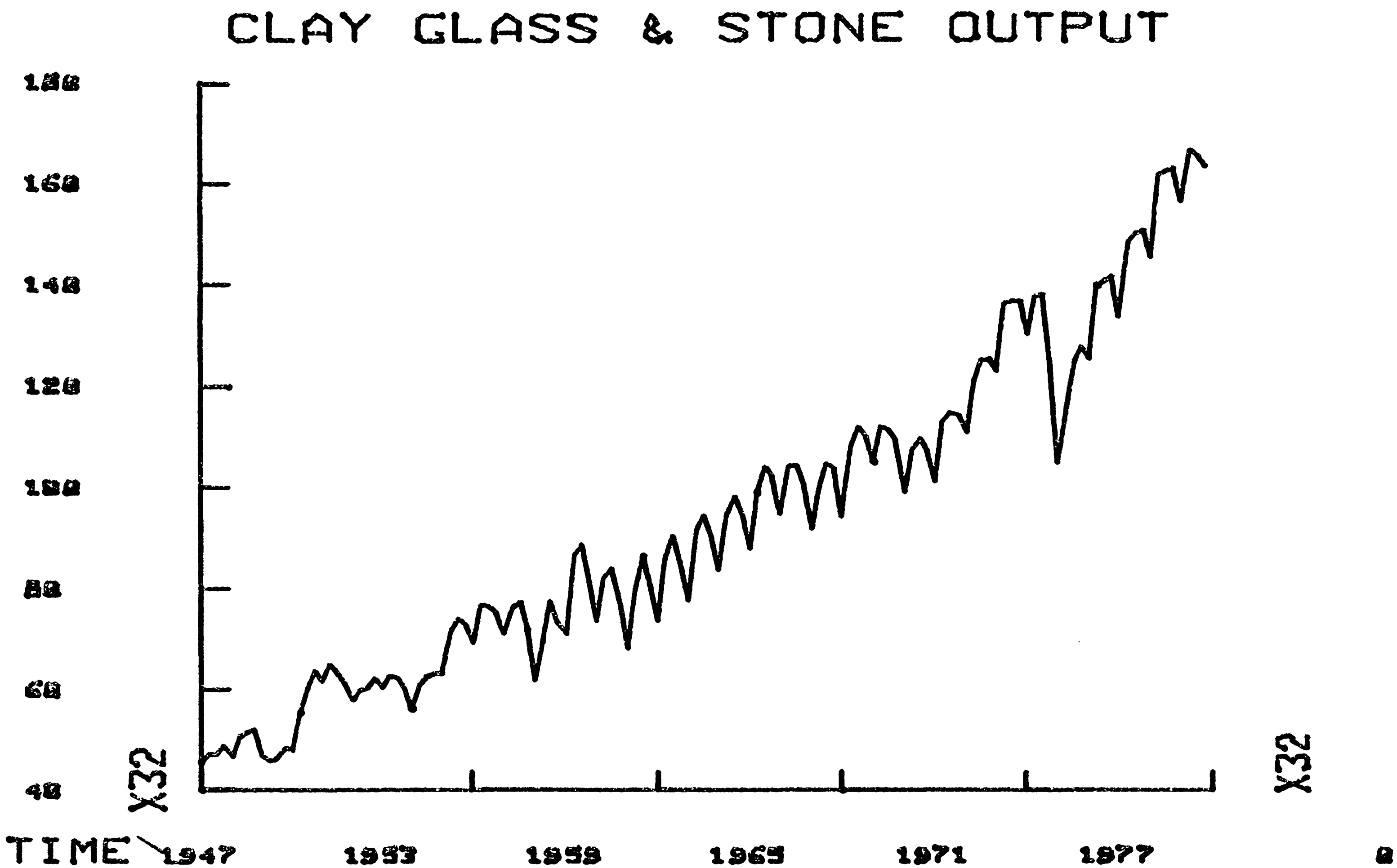

FIGURE V.3H.2

CLAY, GLASS AND STONE OUTPUT

TABLE 5.3H.4

INVENTORY EQUATIONS FOR STONE, GLASS AND CLAY

		RULE	Unexpected		Expected		J_{t-1}		X_{t-1}		MG		R^2	F	df
			Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-			
SEASONALLY ADJUSTED							-.132	-1.18	-.083	-1.02	-1.02	-1.707	.075	1.81	89
	ADD 1	EMGM	-1.08	-1.53	-1.10	1.50	-.157	-1.50					.072	1.72	89
		EMGYM	-1.32	-1.96	-.068	-.82	-.152	-1.49					.077	1.86	89
		EMGBM	-1.57	-2.22	-.552	-.75	-.147	-1.44					.087	2.12	89

Section 5.3I Primary Metals

Money growth is not significantly related to the growth of output in the Primary Metals and Allied Products industry. Lagged inventories is significant at the ten percent level of confidence but only in those equations estimated using unadjusted data. This output equation is given below:

$$X35G = \underset{(.369)}{.675MG} - \underset{(-1.87)}{.682N_{t-1}} \qquad R^2 = .0381 \qquad D\text{-}W = 2.31$$

The output growth across the period of study seems to be dominated by the governments actions in stockpiling and in environmental protection regulations. For example, lead is considered to be a strategic material. Stockpiling of lead took place from 1950 to 1958 under the Defense Production Act of 1950. The Public Law 85-701, enacted in 1958, extended the lead stockpiling and exploration support, under the Office of Minerals Exploration, until 1962.[27] Copper was also under the auspices of the Strategic Materials Act of 1939 and the Defense Production Act of 1950. The latter act provided the "mechanism to grant a large number of loans, purchase contracts, floor price contracts, tax amortizations agreements, and other forms of assistance to stimulate production."[28]

Tariffs imposed in the mid-1960s and early seventies combined with the declining yield of copper and iron ores in the U.S. have increased

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[27]J. Patrick Ryan and John Hague, "Lead," Mineeral Facts and Problems, p. 602.

[28]Harold J. Schroeper, "Copper," Minerals Facts and Problems, p. 803.

the reponsiveness of this industry to international economic conditions. The increasing worldwide demand for higher iron content has caused processing requirements to change leading to higher costs of production.

Air pollution regulations have had an impact on production and capacity utilization in the 1970s. "The 1972-73 shortage of capacity to process available concentrates appeared to be partly due to a curtailment of maximum operation to comply with existing pollution regulations and to delay in expansion of facilities owing to uncertainties regarding resolution of the pollution problem."[29] The capacity utilization of the four quarters in 1973 are 93.0, 94.9, 102.1, 102.5. Estimation of the output equations with capacity interaction terms provided supporting evidence. Unadjusted equation estimations, with only unexpected and expected money variables and their associated capacity interaction terms as independent variables, revealed expected money growth to be a significant predictor of output variability subject to the effects of capacty. The critical capacity values are:

Money Rule	Expected Money Growth
Incomes	92.48
Baro	91.91
Interest Rate	88.58

The average capacity utilization across the period of study is 84.37 with a standard deviation of 10.46. The wide range of capacity

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[29]Ibid., p. 296.

utilization values combined with the critical capacity values may be the reason why inconsistent results are found in the straight output and the residual lag output equations.

Strong business cycle effects are obvious in the graph of growth rates (-.9 percent to .4 percent) in comparison to overall manufacturing output growth (-.1 to .1) in Figures V.3I.1 and V.3I.2. Estimation with business cycle dummy variables as interactive terms with unexpected and expected money growth did not however provide any support to the business cycle effect.

In the inventory equations, actual money growth is significant at the two percent level in explaining the variation of primary metal inventories (using seasonally adjusted data). Money growth was marginally significantly (approximately the ten percent level) in the seasonally unadjusted estimation, although this is strongly tied to the sample size. Both expected and unexpected money are significant and negative in the seasonally adjusted estimations. The magnitude of the coefficients is slightly larger for the expected money variable, as are the levels of significance. This is the only case in all inventory equations where the expected money variable is significant for all underlying money rules. Neither expected money growth or unexpected money growth was significant in the unadjusted estimations.

Lagged output was not found to be statistically related in any of the estimations. The influence of lagged inventories is confusing. In the seasonally adjusted estimations with 89 degrees of freedom, lagged output was negative but not statistically different from zero. An increase of the degrees of freedom by twenty-five resulted in a highly significant (one percent level) and negative coefficient. In the unadjusted estimations, the coefficient on lagged inventories is significant (t-statistic of 4.41 with 90 degrees of freedom; t-statistic of 1.75 with 115 degrees of freedom), but the sign is positive. Lagged output was significant and negative in the seasonally adjusted equations. This reversal of signs may reflect strong seasonality of inventories in this sector. Table 5.3I.1 summarizes the inventory results.

TABLE 5.31.1

INVENTORY FOR PRIMARY METALS EQUATION

		RULE	Unexpected Coef.	Unexpected t-	Expected Coef.	Expected t-	J_{t-1} Coef.	J_{t-1} t-	X_{t-1} Coef.	X_{t-1} t-	MG Coef.	MG t-	R^2	F	df
SEASONALLY ADJUSTED							-.077	-.754	-.015	-.336	-1.63	-2.49	.085	2.07	89
	ADD 1	EMGM	-1.40	-1.81	-1.93	-2.39	-.085	-.821					.088	2.14	89
		EMGYM	-1.46	-1.96	-1.98	-2.17	-.080	-.784					.087	2.12	89
		EMGBM*	-1.45	-1.85	-1.88	-2.77	-.085	-.821					.086	2.10	89
SEASONALLY UNADJUSTED							.16	1.75	.015	.68	-.771	-1.68	.062	1.88	115

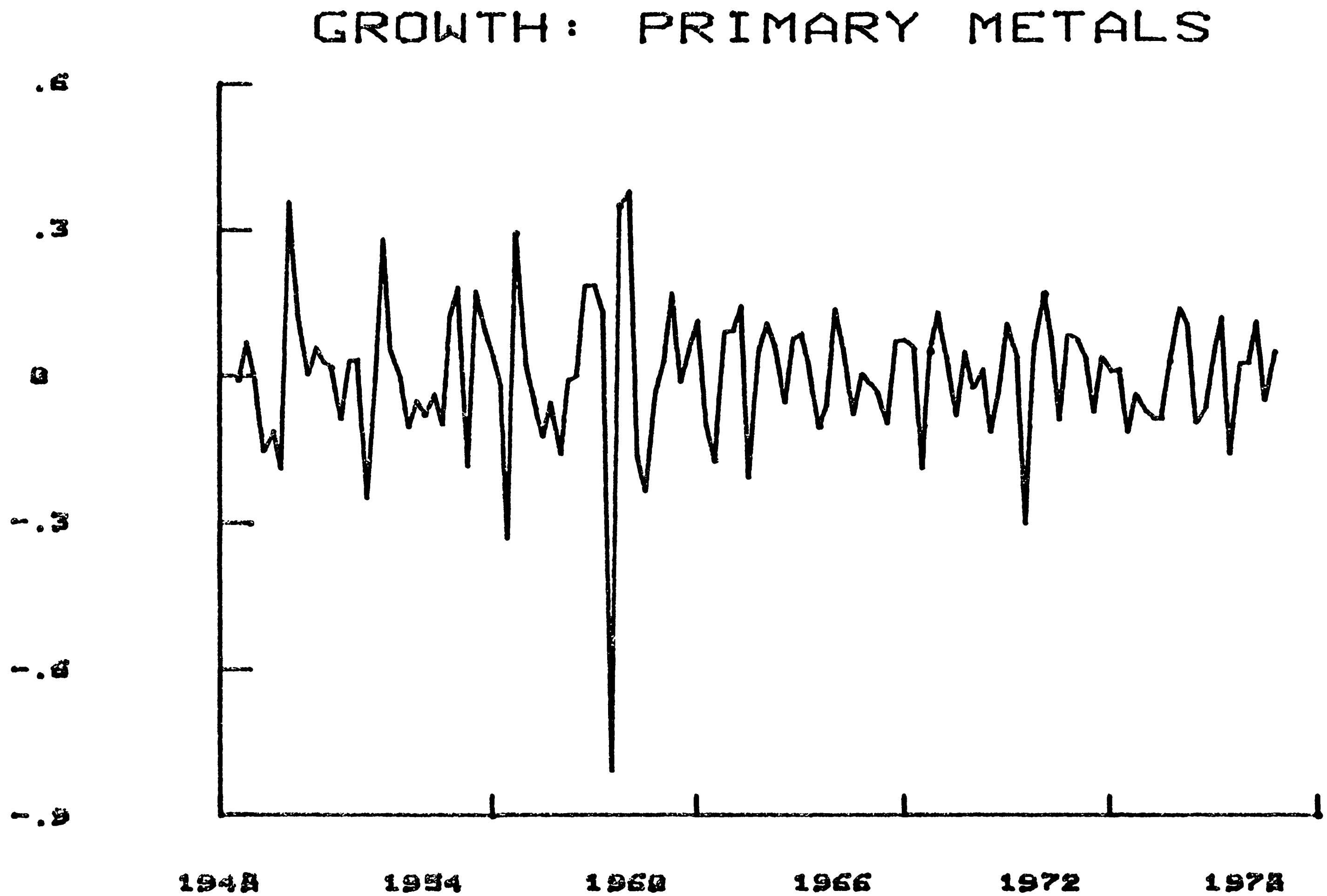

FIGURE V.3I.1

GROWTH: PRIMARY METALS

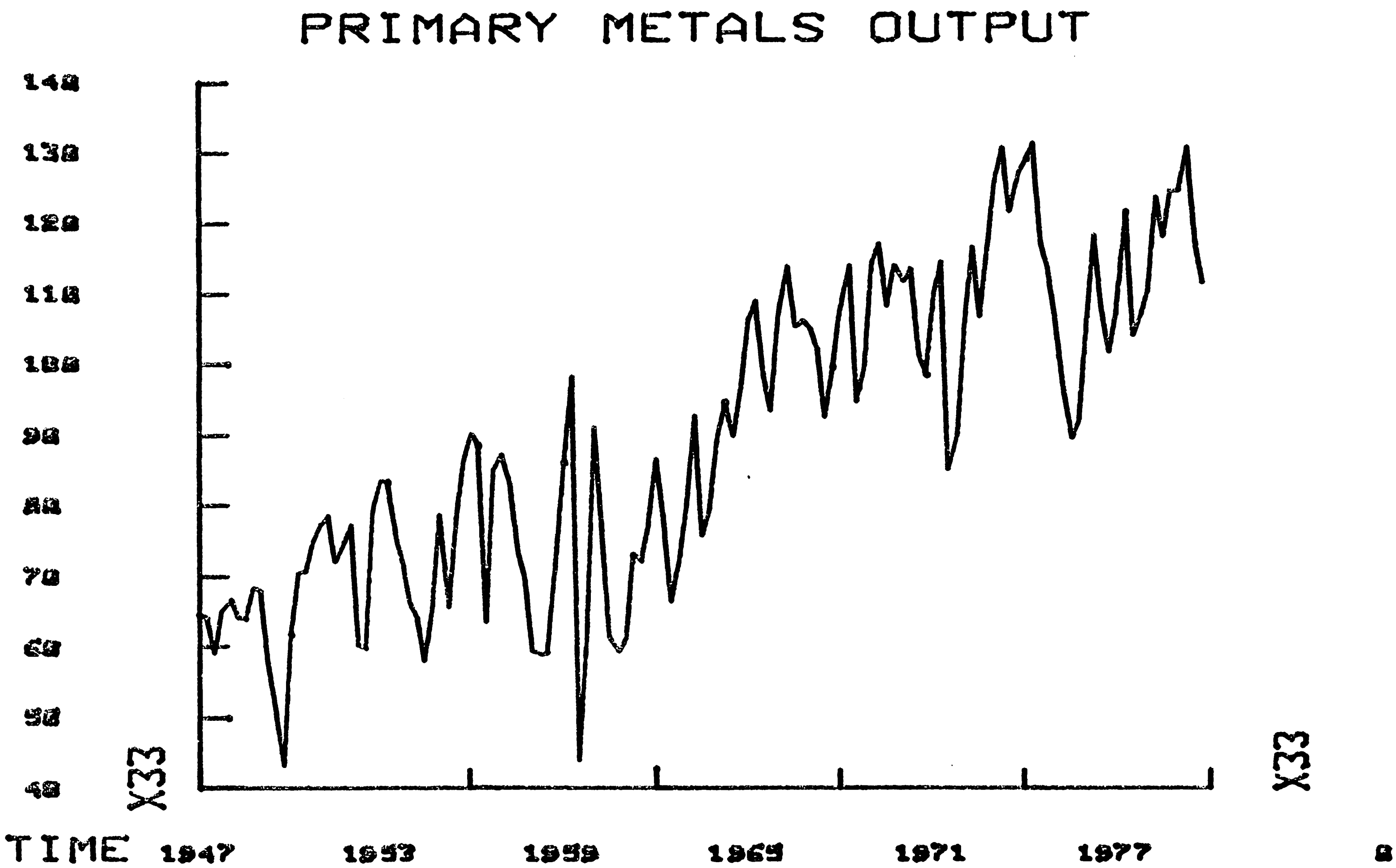

FIGURE V.3I.2

PRIMARY METALS OUTPUT

Table 5.3I.2

SUMMARY OF OUTPUT EQUATIONS

		RULE	Unexpected Coef.	Unexpected t-	Expected Coef.	Expected t-	LAGGED INVENTORY Coef.	LAGGED INVENTORY t-	LAGGED OUTPUT Coef.	LAGGED OUTPUT t-	R^2	D-W
SEASONALLY UNADJUSTED	STRAIGHT	RS	1.82	2.58	.590	.770	-.098	-.971	.235	2.64	.1166	1.96
		Y	1.09	1.60	1.64	2.02	-.092	-.934	.195	2.16	.1045	1.93
		B	1.43	2.04	1.18	1.52	-.092	-.935	.212	2.36	.1029	1.95
	SPECTRAL	MMC	.02	2.12	.004	.57	-.084	-.845	.220	2.51	.1037	1.99
	ADD 1	RS	1.37	2.26	.806	1.29					.048	1.87
		Y	.716	1.23	1.769	2.51					.0779	1.92
		B	1.06	1.73	1.14	1.79					.059	1.89
	ADD 1	Y	.038	.065	1.480	2.09					.019	1.80

Section 5.3J Fabricated Metals

Money growth is a significant predictor (five percent level) of the variation in fabricated metal products in equations estimated with seasonally unadjusted data. This result did not hold true in seasonally adjusted estimations. This implies, as before, the influence of money growth is on the amplitude of seasonal cycles rather than influencing the underlying trend of fabricated metal production. The output equations can be written as:

Unadjusted:
$$X34G = \underset{(2.42)}{1.26MG} - \underset{(-.910)}{.922N_{t-1}} + \underset{(2.53)}{.224X_{t-1}}$$

$$R^2 = .1057 \qquad D\text{-}W = 1.94$$

Seasonally Adjusted:
$$SX34G = \underset{(1.13)}{.587MG} - \underset{(-1.95)}{.069N_{t-1}} + \underset{(3.01)}{.291X_{t-1}}$$

Table 5.3J.1 summarizes the output equations with unexpected and expected money growth. It is interesting to note that the expected money variable as defined by the income money rule is significant in both seasonally and unseasonally adjusted output equations. Unexpected money growth (as defined by the Barro and the interest rate money rule) is a significicnat determinate[30] of fabricated metal products output growth.

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[30]Interest money rule: (straight) one percent level of significance and (add 1) five percent level of significance.

Barro's money rule: (straight) five percent level of significance and (ad 1) ten percent level of significance.

The residual lag equation reflect the difference in significance between seasonally adjusted and unadjusted equations. The pattern of expected and unexpected money growth is clearly tied to the money rule underlying the equation. No single lagged quarter in either money series is consistently significant across all equations.

The graph of output indexes and output growth rates for fabricated metal output (Figures V.3J.1 and V.3J.2) show strong responses to the phase of the business cycle. Some evidence is found to support this in the equations estimated using business cycle dummies. These results are summarized in Table 5.3J.2. Expected money growth was significant in only seasonally adjusted equation, as defined by the (straight) interest rate rule. The results of this single equation were consistent with the equations estimated using the unadjusted data. Unexpected money growth was significant <u>only</u> in the equation defined by the (straight) interest rate, unadjusted/for seasonal patterns.

There is some marginal evidence that capacity utilization affects the magnitude of impact of unexpected money growth. The coefficients of the unexpected and capacity interactive term (unexpected times the lagged value of capacity utilization) are given below:

	Unexpected	U* Capacity
<u>Seasonally adjusted</u>		
Barro money rule (straight)	18.42 (1.74	-.218 (-1.67)
<u>Unadjusted</u>		
interest rate rule (straight)	23.80 (1.79)	-.272 (-1.65)
incomes rule (straight)	16.66 (1.68)	-.194 (-1.59)

The critical capacity utilization values, i.e., those capacity utilization values where unexpected money growth has no effect, are 84.50 percent for the seasonally adjusted estimation and 87.50 and 85.88 percent respectively for the interest and incomes rule. Given that the average capacity utilization value across the period of study was 81.56 percent (standard deviation of 5.99) the unexpected money growth would have a range of impacts from .6 percent (for the seasonally adjusted equation) to 1.93 percent (for the interest rate rule).

The influence of capacity utilization may partially explain the inconsistencies in the significance of the expected and unexpected money growth variables in the residual lag-output equations. One final note on capacity utilization: The declining value of the dollar has increased the competitive position of the fabricated metal products and aided in some current capacity expansion.

Estimation of the inventory equation provided some interesting results. First, adjustment of data to remove seasonal patterns also removes any statistical association of actual money growth, lagged output and lagged inventories. This is consistent with the output equations.

Secondly, only in one estimated equation, underlain by the spectral money rule, was the lagged inventory variable statistically significant. This is somewhat surprising since in periods of relatively constant economic conditions the inventories of fabricated metals, for instance steel mill products, is relatively constant.[31] Thus, a high growth of

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[31]Horace T. Reno and Donald H. Desy, Iron and Steel.

inventories one period might be followed by a low growth of inventories the next period. The coefficient on the lagged inventories for the spectral rule output equation did have a negative sign, -.22 (t-statistic -2.57).

This inventory behavior was also present in the seasonally adjusted residual lag output equations. The first quarter inventory lag was highly significant (one percent) and consistent across all money rule output equations. The coefficient ranged from -.190 to -.198. The fourth quarter lag was also highly significant and consistent, with coefficient ranging from .24 to .26.

The third interesting feature of the inventory equations (unadjusted) is the significance (five percent) of expected money growth, with magnitude of -1.25 to -1.58. This might be explained by the fact that "in times of threatened shortage such as an impending labor strike or in times of a large imbalance between supply and demand, producers, service centers, and consumers all tend to build up their inventories.[32] The inventory equations are summarized in Table 5.3J.3

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[32]Ibid., p. 562.

TABLE 5.3J.1

SUMMARY OF OUTPUT EQUATIONS

		RULE	Unexpected Coef.	Unexpected t-	Expected Coef.	Expected t-	LAGGED INVENTORY Coef.	LAGGED INVENTORY t-	LAGGED OUTPUT Coef.	LAGGED OUTPUT t-	R^2	D-W
SEASONALLY UNADJUSTED	STRAIGHT	RS	1.82	2.58	.590	.770	-.098	-.971	.235	2.64	.1166	1.96
		Y	1.09	1.60	1.64	2.02	-.092	-.934	.195	2.16	.1045	1.93
		B	1.43	2.04	1.18	1.52	-.092	-.935	.212	2.36	.1029	1.95
	SPECTRAL	MMG	.02	2.12	.004	.57	-.084	-.845	.220	2.51	.1037	1.99
	ADD 1	RS	1.37	2.26	.806	1.29					.048	1.87
		Y	.716	1.23	1.769	2.51					.0779	1.92
		B	1.06	1.73	1.14	1.79					.059	1.89
	ADD 1	Y	.038	.065	1.480	2.09					.0519	1.80

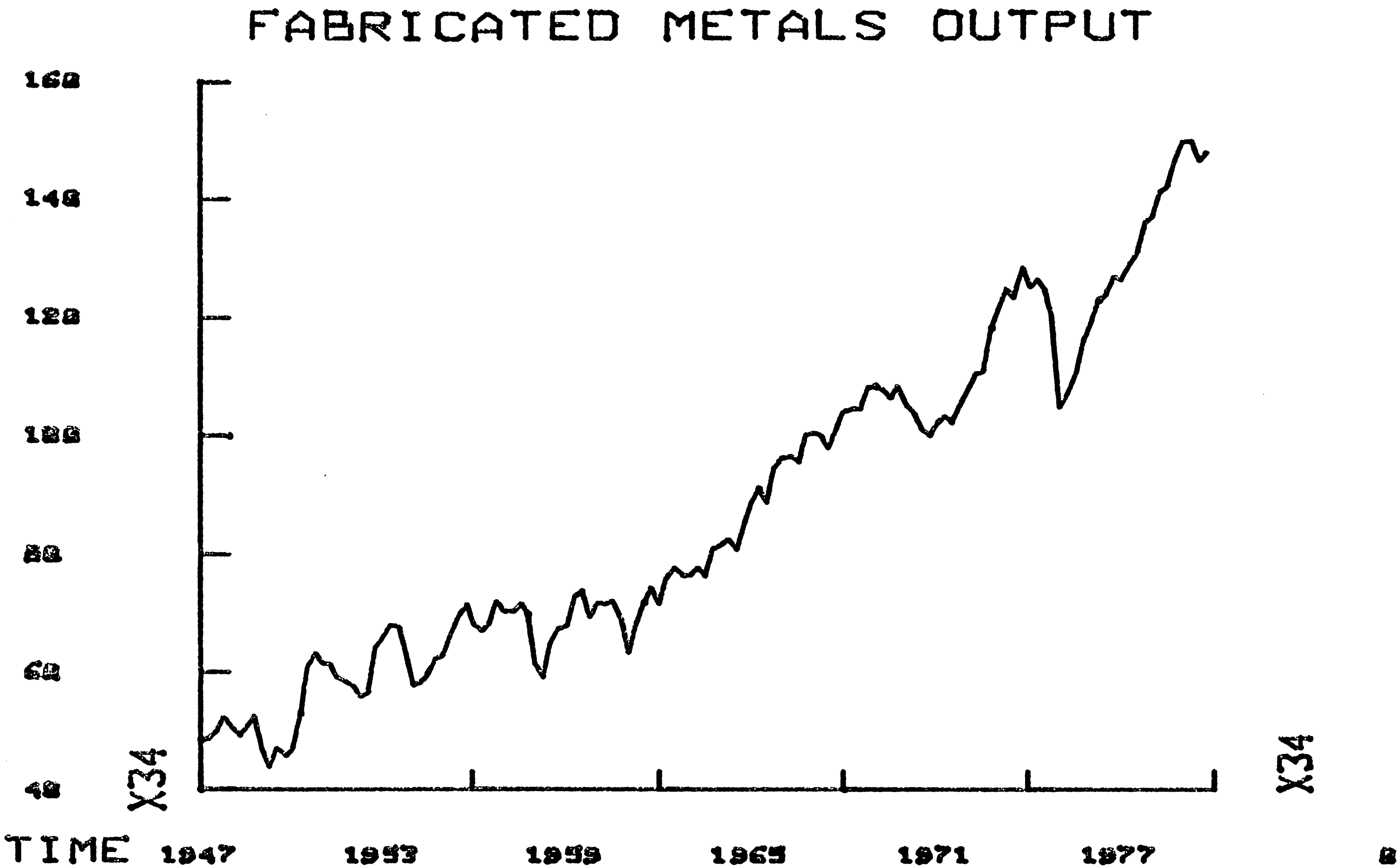

FIGURE V.3J.1

FABRICATED METALS OUTPUT

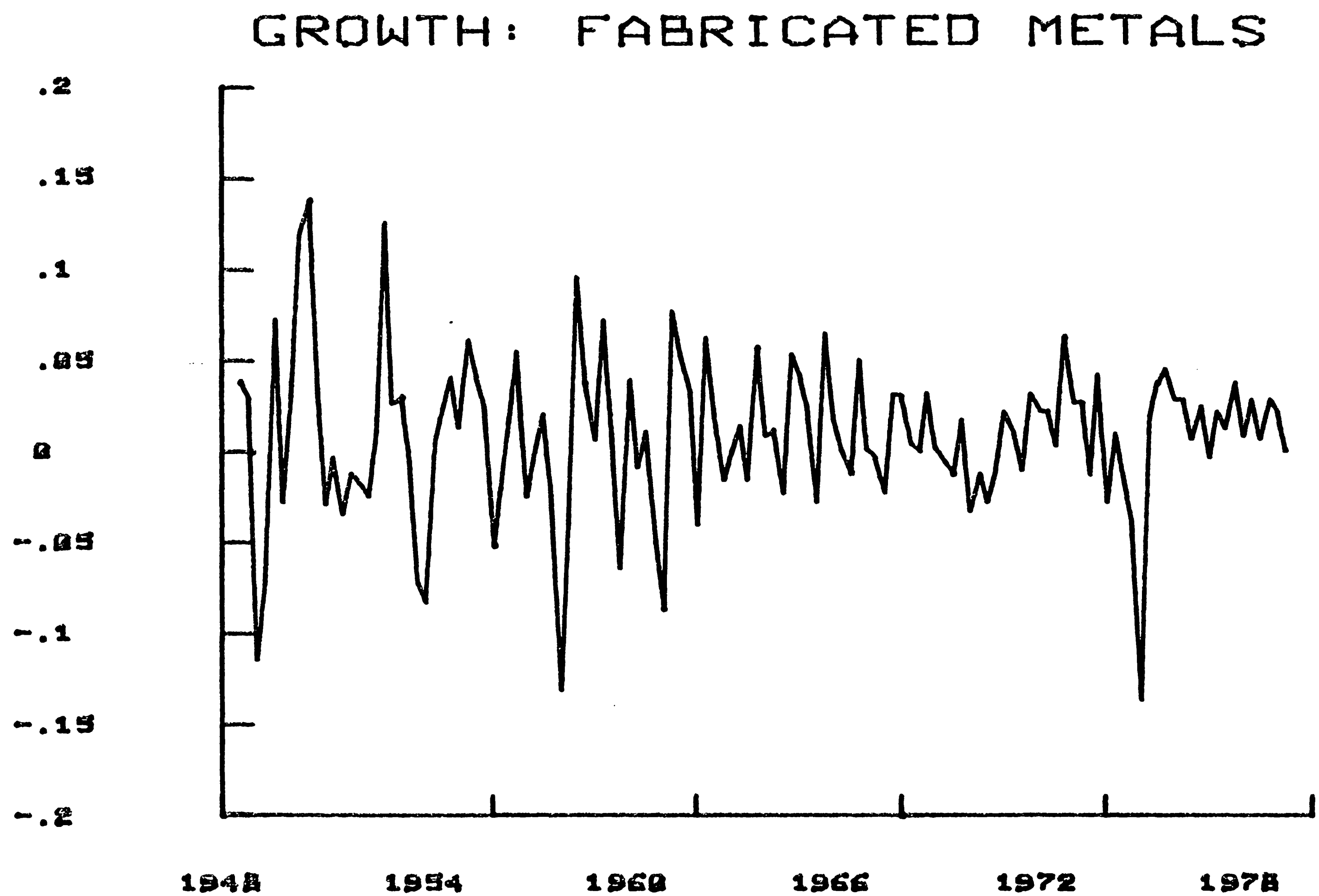

FIGURE V.3J.2

GROWTH: FABRICATED METALS

Table 5.3J.2

Business Cycle Effects

on Fabricated Metal Output

Independent Variables	Unadjusted add-one	Unadjusted straight	Seasonally Adjusted straight
UMG	2.26 (1.56)	4.46 (2.50)	1.86 (1.02)
UDUM	-1.46 (-.95)	-3.56 (-1.84)	-1.91 (-.966)
EMG	-2.37 (-2.19)	-2.30 (-1.85)	-2.25 (-1.74)
EDUM	3.51 (3.62)	3.10 (2.93)	3.07 (2.82)
N_{t-1}	N.S.	-.047 (.486)	-.048 (-1.41)
X_{t-1}	N.S.	.162 (1.87)	.203 (2.09)
	R^2 = .227	R^2 = .230	R^2 = .172
	F = 5.17	F = 4.75	F = 3.29
	D-W = 2.15	D-W = 1.97	D-W = 2.15

TABLE 5.3J.3

INVENTORY EQUATIONS FOR FABRICATED METAL PRODUCTS

		RULE	Unexpected		Expected		J_{t-1}		X_{t-1}		MG		R^2	F	df
			Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-			
SEAS		MMG	.0006	-.08	.003	.436	-.222	-2.57					.056	1.70	116
							.091	.861	.016	.616	-.962	-1.94	.059	1.39	90
SEASONALLY UNADJUSTED	ADD 1	EMGM	-.645	-1.10	-1.25	-2.07	.100	.967					.064	1.51	89
		EMGYM	-.610	-1.09	-1.51	-2.20	.092	.890					.070	1.68	89
		EMGBM	-.381	--.654	-1.58	-2.57	.071	.680					.085	2.07	89

Section 5.3K Non-Electrical Machinery

The results of estimating the output equation for the non-electrical machinery are mixed. Actual money growth is significant in equations unadjusted for seasonal patterns. This variable is not significant in adjusted equations.

$$\text{Unadjusted:}\quad X35G = C + \underset{(2.16)}{.991MG} + \underset{(1.12)}{.004N_{t-1}} + \underset{(3.85)}{.362X_{t-1}}$$

$$R^2 = .189 \qquad F = 5.53$$

$$\text{Adjusted:}\quad SX35G = C + \underset{(1.25)}{.626MG} - \underset{(-1.34)}{.048N_{t-1}} + \underset{(3.11)}{.31X_{t-1}}$$

$$R^2 = .1267 \qquad F = 3.23$$

Lagged output dominates the equation in explaining the variation of the growth of non-electrical machinery output. The addition of this variable increases the significance of unexpected money growth and at the same time reduces the significance of expected money growth and lagged inventories. Equation A is the estimated output equation in the absence of lagged output. Barro's rule underlies the money growth variable. Equation B includes the lagged dependent variable.[33]

$$A\quad X35G = C + \underset{(.81)}{.541U} + \underset{(1.76)}{1.36E} - \underset{(-1.65)}{.005N_{t-1}}$$

$$R^2 = .073 \qquad F = 1.87$$

$$B^{34}\quad X35G = C + \underset{(1.51)}{.965U} + \underset{(1.32)}{.97E} - \underset{(-1.44)}{.004N_{t-1}} + \underset{(3.79)}{.363X_{t-1}}$$

$$R^2 = .196 \qquad F = 4.58$$

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[33]Both equations are seasonally unadjusted using the "straight" money rules.

[34]The probability of an event being greater than 1.51 standard errors to the right of zero is .0655. This implies a level of significance on a two tailed test of .1310.

Although diminished in significance with the addition of the lagged output variable, expected money growth remains an important determinant of seasonally adjusted output growth of non-electrical machinery. The strength of the results is improved using the "add 1" money rule technique to separate the expected and unexpected money growth terms. The results are summarized in Table 5.3K.1.

The residual lag estimations add little knowledge to the above results. In the seasonally unadjusted equations, current expected and unexpected are statistically significant in explaining the variation of output. This is not true of the seasonally adjusted equations implying the effect of the money growth variables is related to the amplitude of the seasonal fluctuations.

Lagged output remains a strong predictor of current output variation. In contrast to the above output impact. Third quarter lagged inventories is significant and negative, perhaps implying that production, say in the spring quarter, is a function of the inventories in last summer's quarter, which was the result of last spring's production. In other words, if last spring's production was responsible for the inventory accumulation in summer, then action will be taken this year to prevent a recurrence of last year's results.

The constant term in the residual lag estimations was significant with a value of approximately .8. This consistent growth may be tied to regulations of environmental control. "During the 1960s and 1970s the protection of the environment became a matter of national concern, culminating in federal legislation designed to drastically improve the quality of our air and water. With business forced to comply with the standards mandated by the government, the pollution control industry expanded rapidly."[35]

The output in non-eletrical machinery is strongly influenced by the business cycle. This is evident in both the graph of output indexes, Figure V.3K.1, as well as the growth of output charts, Figure V.3K.2. Wide peaks and troughs are clearly evident and are usually more acute than those of the overall economic condition. Rockwell and Correia state that "the wide fluctuations in orders, shipments, and ultimately profits have caused many problems for machine tool comapnies. For instance, in bad years, employees have been laid off. In boom years, workers must be rehired, but associated training costs can be very high, so margins may not increase in line with volume. Also, many companies may not be able to weather the "bust" cycle and could find it necessary to close down."[36]

Sensitivity to the position of the business cycle is a function of the level of economic activity abroad, since most machinery companies have large foreign operations.[37] The strength of the dollar must certainly have an impact.

The re-estimation of the output equations using business cycle dummies supported the above discussion. Interestingly, expected money

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[35]Steve Rockwell (machinery analyst) and Thomas COrreia (rail equipment specialist), "Machinery" Industry Surveys, Standard and Poors, 1978, p. M18.

[36]Ibid., p. M26.

[37]Ibid., p. M15.

growth was found to have a significant and negative impact on output growth in the necessary stages of the business cycle. For a one percent increase in expected money growth, output growth declines approximately five percent. In the expansionary phase of the business cycle the effect of expected money growth is positive with a magnitude of impact on output of 2.4 percent. Table 5.3k.2 summarizes the results.

The significance of the expected money variable and its greater impact in recessionary periods may be tied to the cost associated with capacity utilization. Rockwell and Correia point out that "In the past, substantial new orders were triggered as the operating rate approached 80 percent and industry found it necessary to begin to add to capacity."[38] Given that the mean capacity utilization across the period of study was 81.3 percent (standard deviation of 8.3) adjustment in capacity qua output demand seems very important. Unfortunately, estimation of the output equations with capacity interactive terms did not provide evidence to support this theory.

Actual money growth as well as the individual components of money growth is not statistically significant in explaining the variation of inventory growth of non-electrical machinery. This result holds regardless of seasonal adjustment of data.

Lagged inventories is significant and negative in equations using seasonally adjusted data and highly significant and positive in unseasonally adjusted estimations. This is indicative of seasonal

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[38]Ibid., p. M26.

patterns as previously discussed. Lagged output is significant and positive only in the unadjusted estimations. Again, a result most likely due to the seasonal patterns in the sector. A summary of the two relevant equations can be found in Table 5.3K.3.

Table 5.3K.1

Business Cycle Effect
for Non-Electrical Machinery Output

Independent Variables	Seasonally Unadjusted coefficient	t-	Seasonally Adjusted coefficient	t-
UMG	-4.56	(-.89)	-3.45	(-.89)
UDUM	5.89	(1.10)	4.10	(1.01)
EMG	-5.07	(-1.56)	-6.15	(-2.65)
EDUM	7.48	(2.82)	7.81	(4.08)
N1	.379	(.180)	.015	(0.37)
X1	-.408	(-4.15)	-.200	(-1.95)
	R^2 = .239		R^2 = .179	
	D-W = 2.14		D-W = 1.94	
	F = 3.86		F = 2.68	

UMG = Unexpected Money Growth (as defined by incomes rule)

UDUM = Dummy Variable on UMG 1: = expansion 0: = contraction

EMG = Expected Money Growth

EDUM = Dummary Variable on EMG

N1 = Inventories lagged one quarter

X1 = Output lagged one quarter

D-W = Durbin-Watson statistic

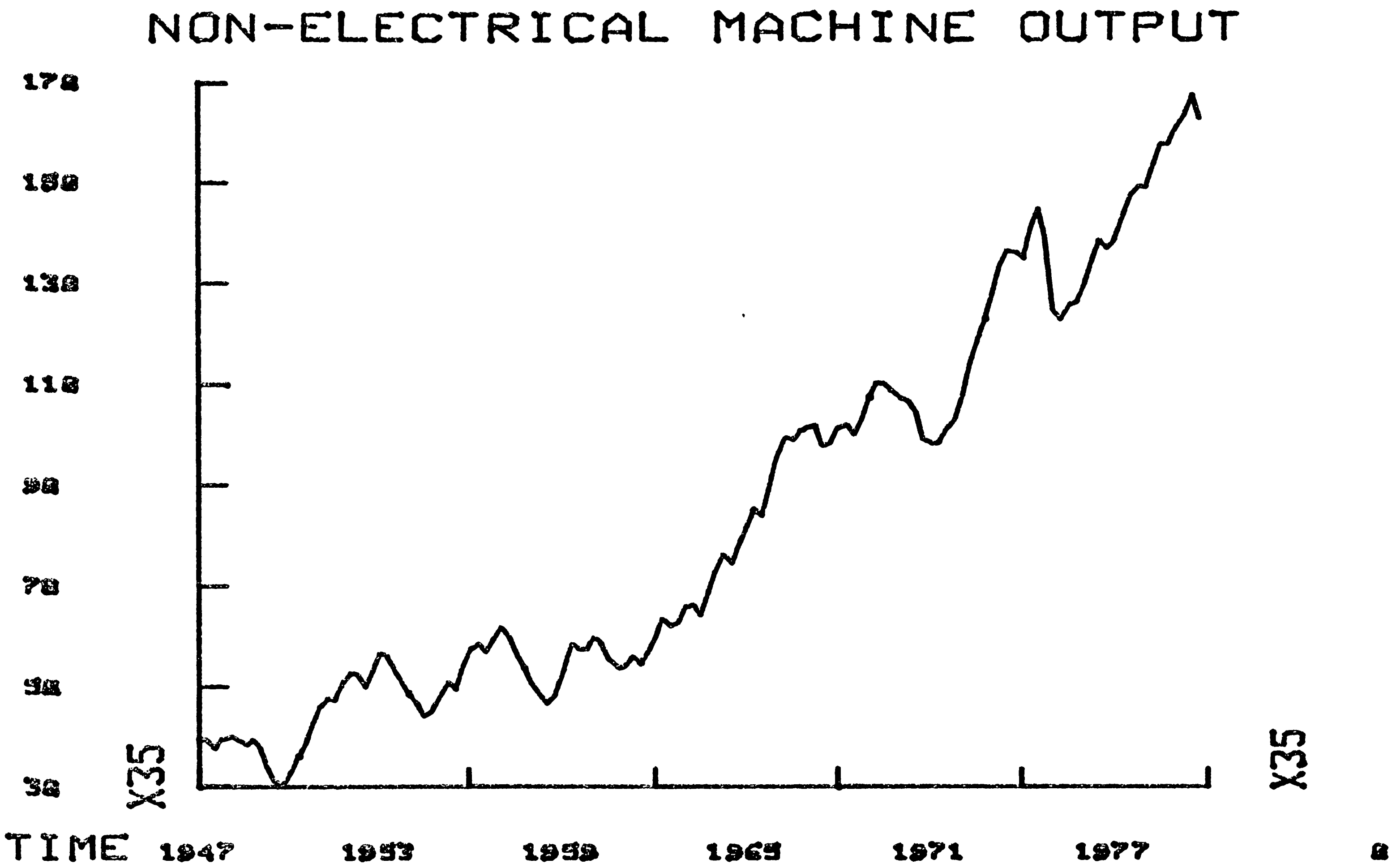

FIGURE V.3K.1

NON-ELECTRICAL MACHINE OUTPUT

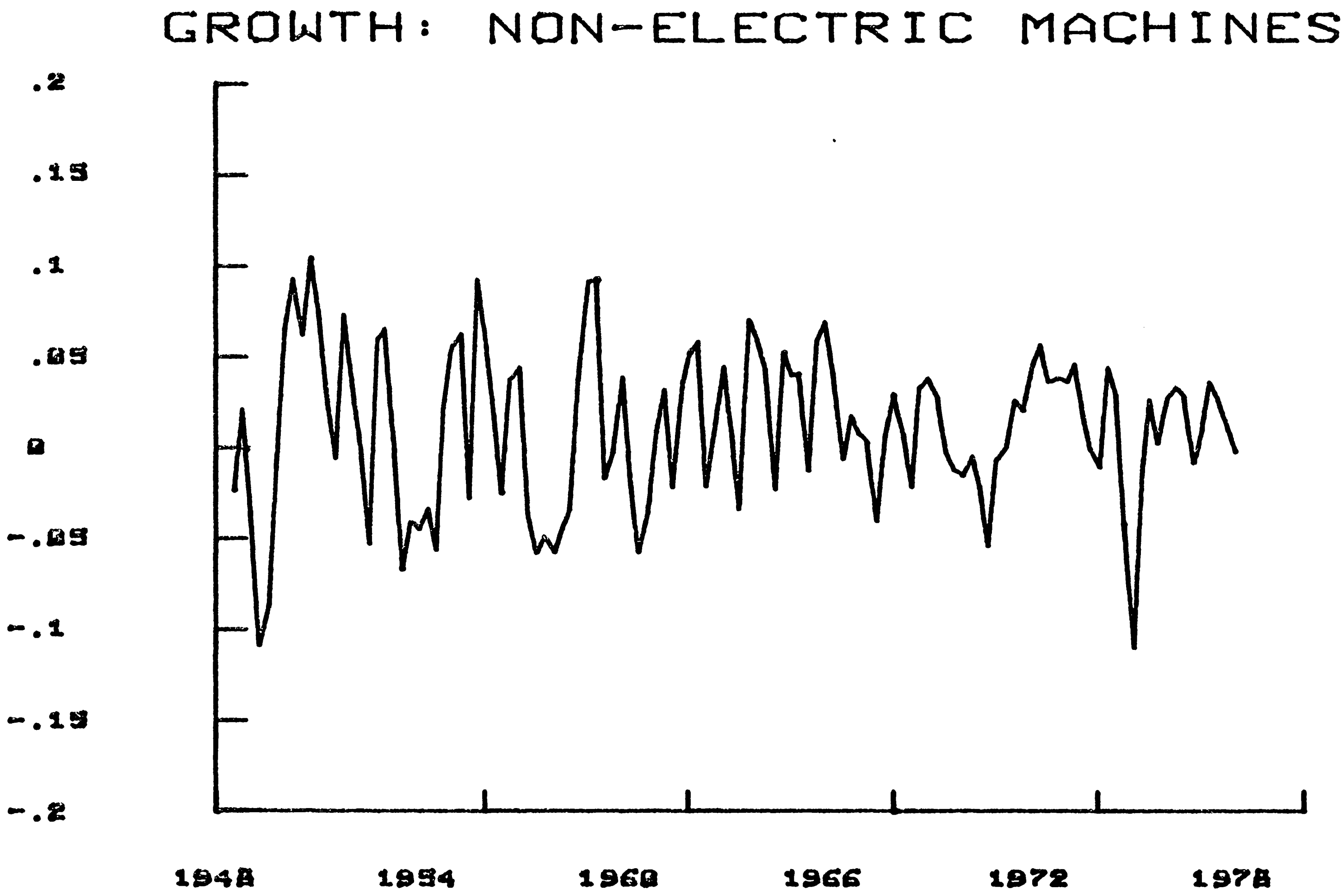

FIGURE V.3K.2

GROWTH: NON-ELECTRIC MACHINES

TABLE 5.3K.2

OUTPUT EQUATIONS: SEASONALLY ADJUSTED

		RULE	Unexpected Coef.	Unexpected t-	Expected Coef.	Expected t-	LAGGED INVENTORY Coef.	LAGGED INVENTORY t-	LAGGED OUTPUT Coef.	LAGGED OUTPUT t-	R^2	D-W
SEASONALLY ADJUSTED	STRAIGHT	EMGY	.088	-.140	1.296	1.69	-.032	-1.22	.305	2.64	.149	3.29
		EMGB	-.297	-.045	1.13	1.49	-.034	-1.32	.309	2.16	.143	3.14
	ADD 1	EMGYM	.16	.274	1.39	2.00	-.034	-.93	.289		.150	3.11
		EMGBM	.113	.187	1.18	1.91	-.04[illegible]	-1.18	.295		.148	3.07

Expected money growth as defined by the interest rate rule was not statistically significant. For the straight rule the coefficient was .936 with a t-statistic of 1.32. For the add 1 rule the coefficient was .800 with a t-statistic of 1.30.

TABLE 5.3K.3

INVENTORIES EQUATIONS FOR NON-ELETRICAL MACHINERY

	RULE	Unexpected		Expected		J_{t-1}		X_{t-1}		MG		R^2	F	
		Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-	Coef.	t-			
SEASONALLY ADJUSTED						-.196	-1.89	.212	-2.57	-.241	-.165	.045	1.05	89
SEASONALLY UNADJUSTED						.592	8.17	.223	-2.40	.329	1/36	.543	26.49	90

Section 5.3L Electrical Machinery

The results of estimating output equations for the electrical machinery sector are mixed. Actual money growth was not found to be statistically significant. The breakdown of money growth into unexpected and expected components provide some interesting, although mixed, results. This is most clearly seen in the results of the residual lag equations summarized in Table 5.3L.1.

Note first the significance of the constant indicating an approximately one percent growth per period. An example is the semiconductor industry, which, over the past thirty years has shown strong growth.[39] This sharp growth can easily be seen in Figures V.3L.1 and V.3L.2.

In the seasonally unadjusted estimations the current values of expected and unexpected money growth are important determinants of output variation. This does not hold true estimating the same equation with seasonally adjusted data. The second quarter lag on unexpected is significant (five percent) and positive regardless of seasonal adjustment as is the second and third quarter lag on expected money growth. This is somewhat surprising in that the electrical machinery output, which is strongly tied to electronic equipment, is highly competitive. The oscillating signs on the coefficients may indicate sensitivity to the variability of general economic activity. This may be evidenced by the fact that the components industry has outperformed the growth of the overall economy in periods of economic expansion and

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[39]Standard and Poors "Components Market," Industry Surveys, p. E12.

declines at a faster rate in periods of economic contraction.[40] Further, high rates of innovation in technology which cause obsolescence limit the benefits of high levels of production (which is critical to yields).[41] This leads to greater variability of output. The output equations, with business cycle dummies on the unexpected and expected money growth variables, were reestimated. In the seasonally unadjusted equation underlain by the interest rate rule expected money growth was found to be significant and negative. The coefficient was -3.20 indicating a 3.2 percent decrease in output given a one percent change in expected money growth in periods of economic contraction. The coefficient on expected money growth was 4.35 with an individual t-statistic of 3.71. This indicates that this coefficient is significantly different than that in contraction any phase. The magnitude of effect during the expansionary phase is 1.15 percent. This is substantially less than the contracting phase impact, and can be visually seen in the graph of the growth rate of output.

Estimation of the inventory equations found lagged inventory and output to be highly significant (one percent level) variables in explaining the variation of inventory growth of electrical machinery. Adjustment for seasonal variations in the data eliminated the explanatory power of these variables.

Actual money growth was not significant, nor were its individual components. The sign of the coefficients was negative as would be

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[40]Ibid., p. E14.

[41]Ibid., p. E!4.

expected. The only inventory equation of significance can be written as:

$$J36G = \underset{(-.167)}{.049MG} + \underset{(4.61)}{.392J_{t-1}} + \underset{(4.88)}{.239X_{t-1}}$$

$R^2 = .377$ $F = 13.5$ (Unadjusted data: t-statistics in parentheses.)

Table 5.3L.1

Residual Lag Estimation

for Electrical Machinery Output*

Independent Variable	Seasonally Unadjusted coefficient	t-	Seasonally Adjusted coefficient	t-
constant	1.04	(3.14)	.841	(2.64)
UMG	2.27	(2.88)	+	
UMG1	-		+	
UMG2	3.07	(2.69)	2.80	(2.33)
UMG3	-		-	
UMG4	+		+	
EMG	4.78	(2.54)	+	
EMG1	-		-	
EMG2	5.60	(2.59)	5.96	(2.53)
EMG3	-3.92	(-1.76)	-3.86	(-1.60)
EMG4	+		+	
N1	+		-	
N2	+		.133	(2.00)
N3	-		-.132	(-2.16)
N4	+		-.100	(-1.96)
N5	-		+.07	(0.99)
Output t-6	-.234	(-2.16)	-.242	(-2.13)

R^2 = .3637

D-W = 2.09

F = 2.52

*The underlying money rule is the add-one incomes rule. The results were reasonably consistent across equations defined by other money rules.

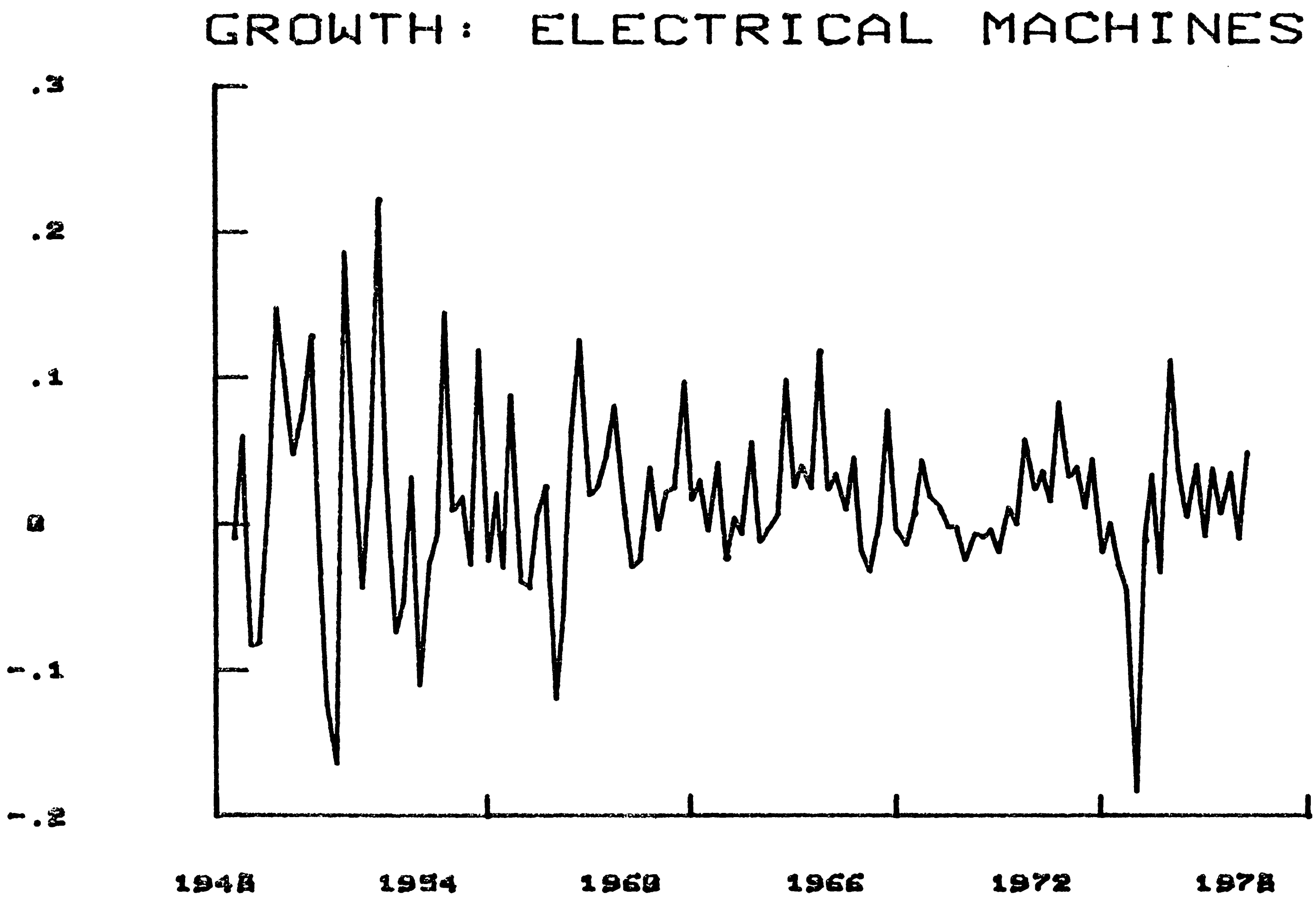

FIGURE V.3L.1

GROWTH: ELECTRICAL MACHINES

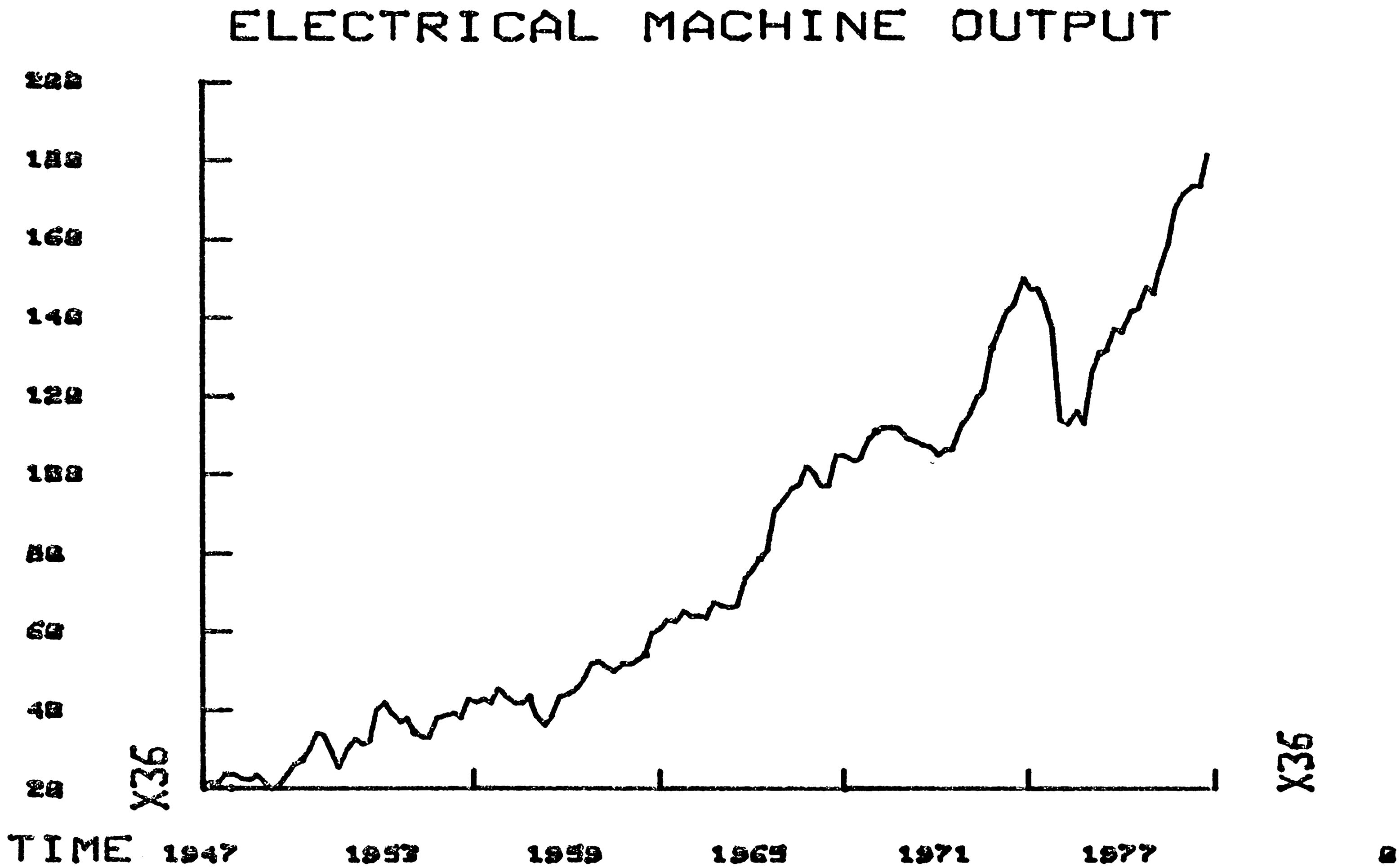

FIGURE V.3L.2

ELECTRICAL MACHINE OUTPUT

Section 5.3M Transportation Equipment

Actual money growth was not a significant predictor of output growth of transportation equipment. A breakdown of actual money growth into its unexpected and expected components produced similar results. Adjustment for seasonal variation did not affect these results. Lagged output proved to be a strong prediction of variation in current output. The sign of the coefficient is negative, perhaps indicative of production for stock rather than production to order. The domination of this major group by motor vehicles and motor vehicle equipment may be responsible for this sign on the coefficient. The following equation includes the money growth variable as well as lagged inventories.

$$\underset{}{X37G} = \underset{(-1.69)}{-.363} + \underset{(1.67)}{.0002Time} + \underset{(1.25)}{1.54MG} + \underset{(.534)}{.118N_{t-1}} - \underset{(-2.67)}{.238X_{t-1}}$$

$$R^2 = .096 \qquad F = 3.01$$

The residual lag estimations did not provide us with much additional information. A few lagged money growth variables were significant but not consistent across the equations defined by the different money rules. This is true for both seasonally adjusted and unadjusted data.

The strong business cycle effect is quite obvious from examination of Figures V.3M.1 and V.3M.2. Donald Baker, auto analyst, states that "Passenger car sales will continue to primarily reflect general business conditions, as evidenced by consumer disposable income. Moreover, fluctuations will be accentuated by the fact that the portion of income spent for cars tends to diminish in periods of economic sluggishness and to expand during periods of economic strength."[42]

The current situation, for example, reflects earnings, resulting from price rebates, efficiency gains, and a greater foreign contribution to earnings more than offset by inflationary impacts on wages, materials, and other operating costs, and heavier depreciation and interest charges.[43] Trailer truck assemblies are highly responsive to the business cycle. Government outlays for mass transit have tended to make the production of buses less sensitive to the general business conditions although the output of buses relative to the overall transportation industry is small.

None of the independent variables in the model (actual money growth, lagged inventories, and lagged output) were significant in predicting the variation of inventories of transportation equipment in equations estimated using seasonally adjusted data. Only lagged inventories was significant (and positive) in identical equations

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[42]Donald Baker, Standard and Poors, "Transportation," Industry Surveys, August, 1978, p. A138. Among other factors that Standard and Poors list as affecting demand is auto prices in relation to all other consumer prices. This may be picked up by the Lucas θ tests described in Appendix 2A. Further, availability of credit, which is integral to the business cycle, will influence new car demand.

[43]Ibid., p. A137.

estimated with seasonal adjustment of data. The relevant equation can be written as:

$$J37G = \underset{(-.026)}{-.011MG} + \underset{(7.39)}{.566J_{t-1}} + \underset{(1.30)}{.040X_{t-1}}$$

$R^2 = .334$ $F = 14.3$ $D\text{-}W = 2.02$
(unadjusted; t-statistics in parentheses;
D-W = Durbin-Watson statistic)

The close association of current to lagged inventories again may reflect production for stock rather than production to order.

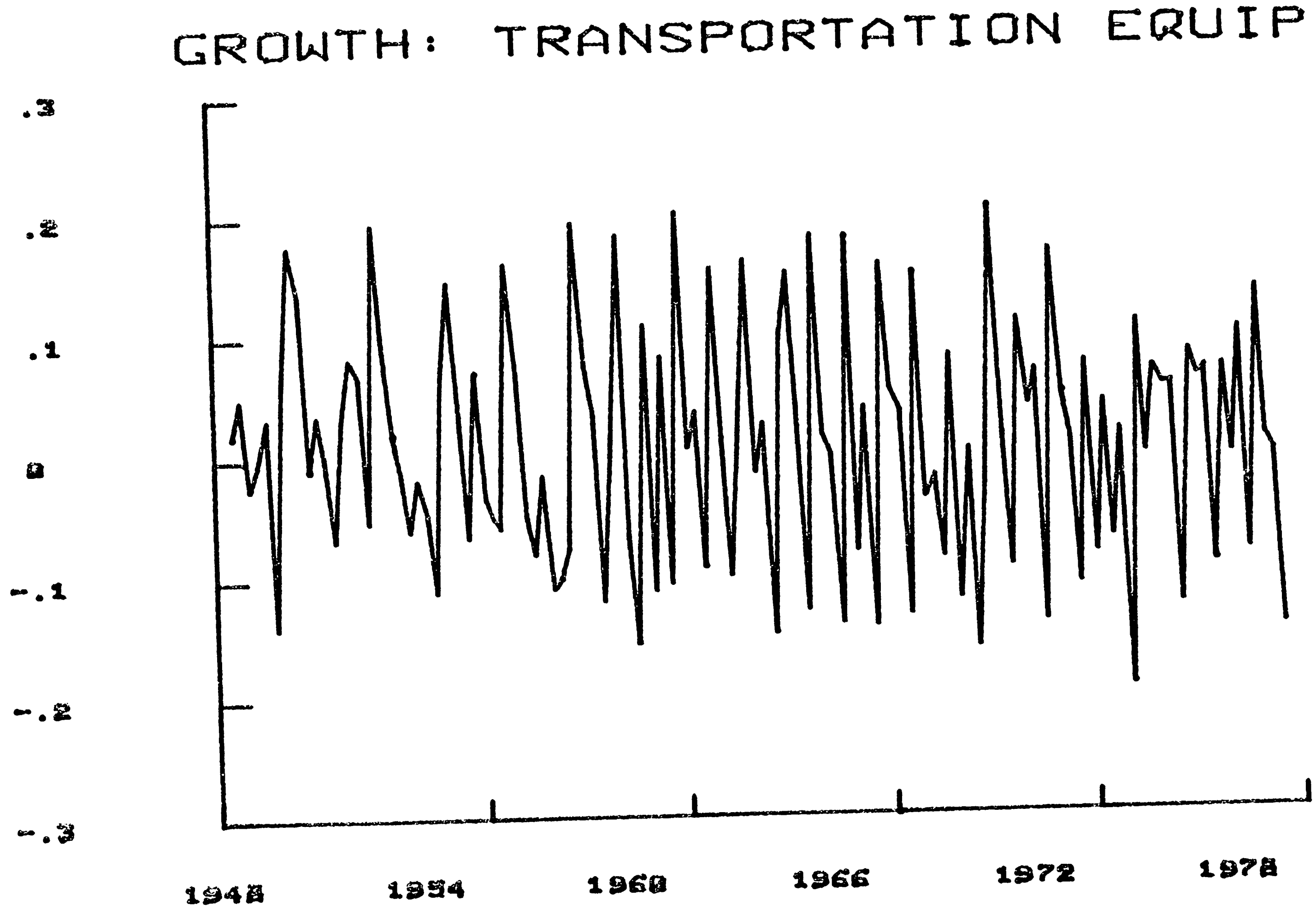

FIGURE V.3M.1

GROWTH: TRANSPORTATION EQUIPMENT

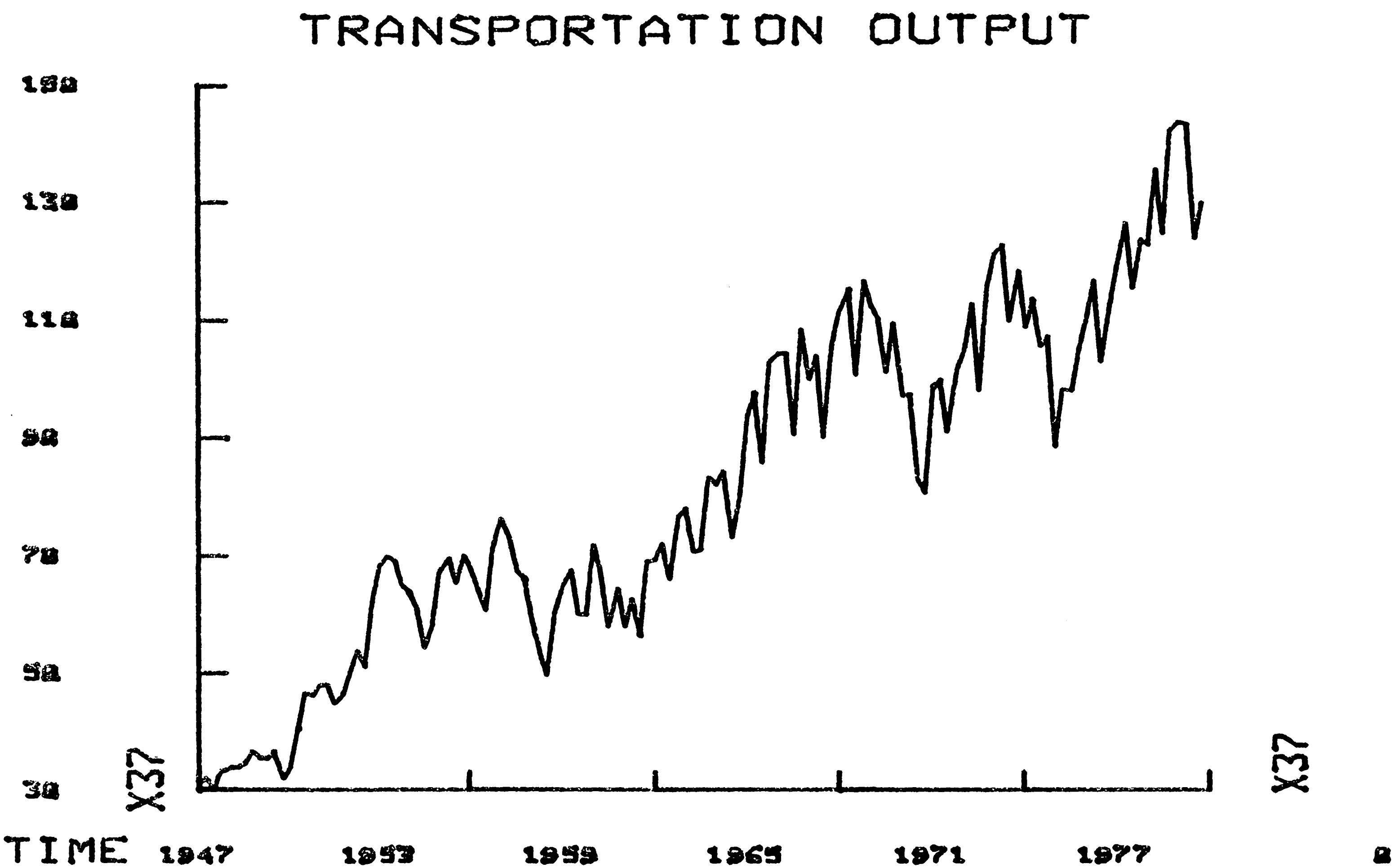

FIGURE V.3M.2

TRANSPORTATION OUTPUT

CHAPTER VI

CONCLUSIONS

This chapter draws conclusions and suggests avenues for further research. Section 6.1 summarizes the results on the question of monetary neutrality. Section 6.2 reviews the results on the test of sector differentiality. Section 6.3 offers suggestions for further research.

Section 6.1 Conclusions on the Neutrality of Money

The main objective of this paper was to test the neutrality of money proposition, i.e., actual money growth is not systematically related to output growth or inventory growth. I conclude that actual money growth is not associated with the underlying, non-seasonal, structure of output growth. This is true of the overall manufacturing industry as well as the twelve individual manufacturing sectors. This supports the neutrality of money hypothesis.

There is evidence to suggest that actual money growth, as well as the unexpected and expected money growth, are related to the seasonality in individual sectors. In six sectors, textiles chemicals, rubber and plastics, stone and clay, fabricated metals, electrical machinery, and non-electrical machinery, money growth was found to be statistically significant in predicting sector output growth using seasonal unadjusted data. These equations are summarized in Table 6.1.

The inventory equation estimations supported the neutrality hypothesis. Money growth was found to be significant (ten percent) in only one estimation (primary metals inventory growth) estimated using unadjusted data. The money growth variable was not significant in any seasonally adjusted equation. The estimated equation for the primary metals sector is given below:

$$N33G_t = \underset{(-1.68)}{-.771MG} + \underset{(1.75)}{.161N33G_{t-1}} \qquad R^2 = .062 \qquad D\text{-}W = 1.98$$

TABLE 6.1

SUMMARY OF OUTPUT EQUATIONS
(Unadjusted for Seasonality)

SIC Code	Sector	Money Growth		Lagged Inventories		Lagged Outputed		R^2	D-W
		Coef-	t-stat	Coef-	t-stat	Coef-	t-stat		
-	Overall Manufacturing	1.02	(2.56)	-.486	(-3.19)	NS*		.141	1.81
22	Textile Mill Products	1.31	(2.11)	-.366	(-2.74)	NS		.108	1.84
28	Chemicals and Allied	0.78	(1.78)	-.426	(-4.31)	NS		.157	1.97
30	Rubber and Plastics	1.29	(1.71)	-.419	(-2.84)	NS		.090	2.17
32	Stone, Clay, and Glass	2.06	(2.19)	-.206	(-0.84)	NS		.048	2.15
34	Fabricated Metals	1.26	(2.42)	-.922	(-0.91)	.224	(2.53)	.106	1.94
35	Non-Electrical Machiney	1.14	(1.88)	.001	(0.19)	NS		.039	1.80
36	Electrical Machinery	.99	(2.16)	.004	(1.12)	.362	(3.85)	.189	1.84

T-Statistics in parentheses. Critial t-values (120 degress of freedom): 1.658 (ten percent), 1.980 (five percent), 2.356 (two percent), 2.617 (one percent).

*NS = not significant; equation statistics reported in absence of this variable.

where $N33G_t$ and $N33G_{t-1}$ are current and lagged inventory growth and MG is money growth.

The lag pattern of the money growth variable (in particular lagged unexpected and expected money growth) provide insight into the neutrality question. The estimating equation in lags on the money variable is formed by recursive substitution of the lagged output variable. These equations I have called the residual lag equations.

For money to be neutral, the sum of the coefficient should equal zero. This implies that across time the expected value of the money growth impact on output or inventory growth is zero. The empirical results tend to support this finding. An example of this point is found in the residual lag equation for stone, clay and glass. The coefficients for the seasonally unadjusted equations underlain by the add-one income money rule are given below:

UMG	3.50	(3.04)
UMG1	-4.10	(-2.37)
UMG2	2.96	(1.73)
UMG3	-2.98	(-1.70)
EMG	8.49	(3.10)
EMG1	-8.07	(-2.49)
EMG2	5.65	(1.71)
EMG3	-5.87	(1.69)

where UMGi and EMGi are the unexpected and expected money growth lagged i quarters.

The lack of statistical significance of lags in other equations makes it difficult to adequately assess whether the coefficients sum to zero. Examination of the signs on the coefficients, however, indicates a deadening of monetary effects across time. In nine of the twelve sectors examined, the signs on the coefficients for unexpected money growth alternate each quarter. The same was true of the coefficients on expected money growth in eight estimated equations. A summary of these sign patterns is presented in Table 6.2.[1] The alternating sign is indicative of a temporary impact, which is balanced by temporary effects in the opposite direction in other periods.

The significance of expected money growth (as illustrated in the above example and prevalent in many other equations seasonally and unadjusted) is disturbing in light of the rational expectation hypothesis that temporary monetary effects are a result of unexpected money growth only. Note, however, that the Phillips type stabilization policy suggests that expected money growth should have a permanent impact on output growth. The signs of the coefficient, given in Table 6.2, do not support this hypothesis. Further the lack of statistical significance in equations estimated using seasonally adjusted data, is not indicative of a permanent Phillips trade-off.

Also, the F-test across the twelve sectors showed that, on average, unexpected money growth was significant but expected money growth was not. The F-statistic for unexpected money as defined by the incomes rule was 3.02, significant at the 10 percent level; the Barro

[1]Identical to Table 1.1

rule had an F-statistic of 6.09, significant at the 2.5 percent level; and the interest rate rule had an F-statistic of 4.31, significant at the 5 percent level. The F-statistics for the addition of expected money to the equation including unexpected money growth, was 0.42, 1.82, and 0.94 for equations defined by the Barro, incomes and interest rate rule, respectively.

Section 6.2 Conclusions on Sector Differentiality

The test of differentiality was conducted by redefining the dependent variable as the difference between sector output growth and overall manufacturing output growth. Thus, the effect of money growth on the overall manufacturing industry is substracted out. If money has differential effects, the coefficients on money growth will be significantly positive or negative depending on whether that sector is more or less sensitive that the overall market.

The results of the tests did not support the hypothesis that the incidence of money growth was unequal across sectors. In only one of the twelve sectors, paper and allied products, did money growth prove to be significant. In this case, the unexpected money growth component was the driving force of the significance of actual money growth. A summary of the equations is given below:

$$X26G = \underset{(-2.07)}{-.76MG} - \underset{(-3.98)}{.288N_{t-1}} \qquad R^2 = .111 \qquad D\text{-}W = 2.03$$

$$X26G = \underset{(-2.21)}{-.879Unexpected} - \underset{(-.621)}{.378Expected} - \underset{(-2.98)}{.28IN_{t-1}}$$

where X26G is the difference between paper and allied products growth and overall manufacturing output growth, MG is actual money growth, and N_{t-1} is lagged inventory growth. The negative sign indicated that paper products are less sensitive to monetary growth than the overall manufacturing sector.

For the foods, textile mill products, rubber and plastics, and paper and allied products sectors, lagged inventory growth was statistically significant in explaining the variation of sector to total manufacturing output. The results are summarized below:

FOODS:

$$X20G = \underset{(-.373)}{-.316MG} + \underset{(1.68)}{.331N_{t-1}} \qquad R^2 = .0338 \qquad D\text{-}W = 2.08$$

RUBBER and PLASTICS:

$$X30G = \underset{(.286)}{.169MG} - \underset{(-2.80)}{.324N_{t-1}} - \underset{(-1.95)}{.174X30G_{t-1}} \qquad R^2 = .182$$

TEXTILE MILL PRODUCTS:

$$X22G = \underset{(.541)}{.242MG} - \underset{(-3.19)}{.308N_{t-1}} \qquad R^2 = .088 \qquad D\text{-}W = 1.95$$

The sign of lagged inventory for foods is consistent with the output estimations discussed in Chapter V. It may reflect strong seasonal cycles. For the other industries, the sign of the coefficient of lagged inventories is negative. This reflects a strong connection between output and inventory management, perhaps indicative of industries producing for stock rather than for order. Large buildups of inventories leads to cut-backs in production. Current sales are satisfied through accumulated inventories.

Section 6.3 Suggestion for Further Research

Capacity utilization and the phase of the business cycle were shown to influence the degree of association (given by the coefficient on the money growth variables) between monetary change and output growth. Rather than reiterate the influence of these variables I would like to take the lesson learned from their significance and offer a third interactive variable to be analyzed in future studies.[2] This variable is the variance of relative sector to aggregate price, to total price variation, i.e., the Lucas θ as defined by his 1973 American Economic Review paper.[3]

As is evident from Appendix 2A, which reformulated the model to incorporate the Lucas θ, there is theoretical support that the degree to which different sectors are able to project sector prices on aggregate prices may affect the magnitude to which these sectors respond to monetary changes (unexpected money changes in Lucas). As Figure VI.1 demonstrated for electrical machinery, textile mill

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[2]A summary of the influence of capacity utilization and the business cycle is contained in Chapter 1, section 4.

[3]Lucas, 1973, op cit, $\theta = \frac{\tau^2}{\sigma^2 + \tau^2}$

products, and fabricated metals, the θ's vary over a wide range.[4] Further, implications concerning the relation between the variance of money growth, the θ', and the growth of sector output can be investigated. Figure VI.2, the variance of money growth, offers an intruiging contrast to the θ's in Figure VI.1.

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[4]The θ's were calculated by taking an initial block of twenty observations (quarters) and calculating the variance of relative sector to aggregate prices. The variance of aggregate prices was also calculated and the ratio τ was formed. One observation was added and one dropped off the back and the theta recalculated. This process was repeated forming a time series on θ.

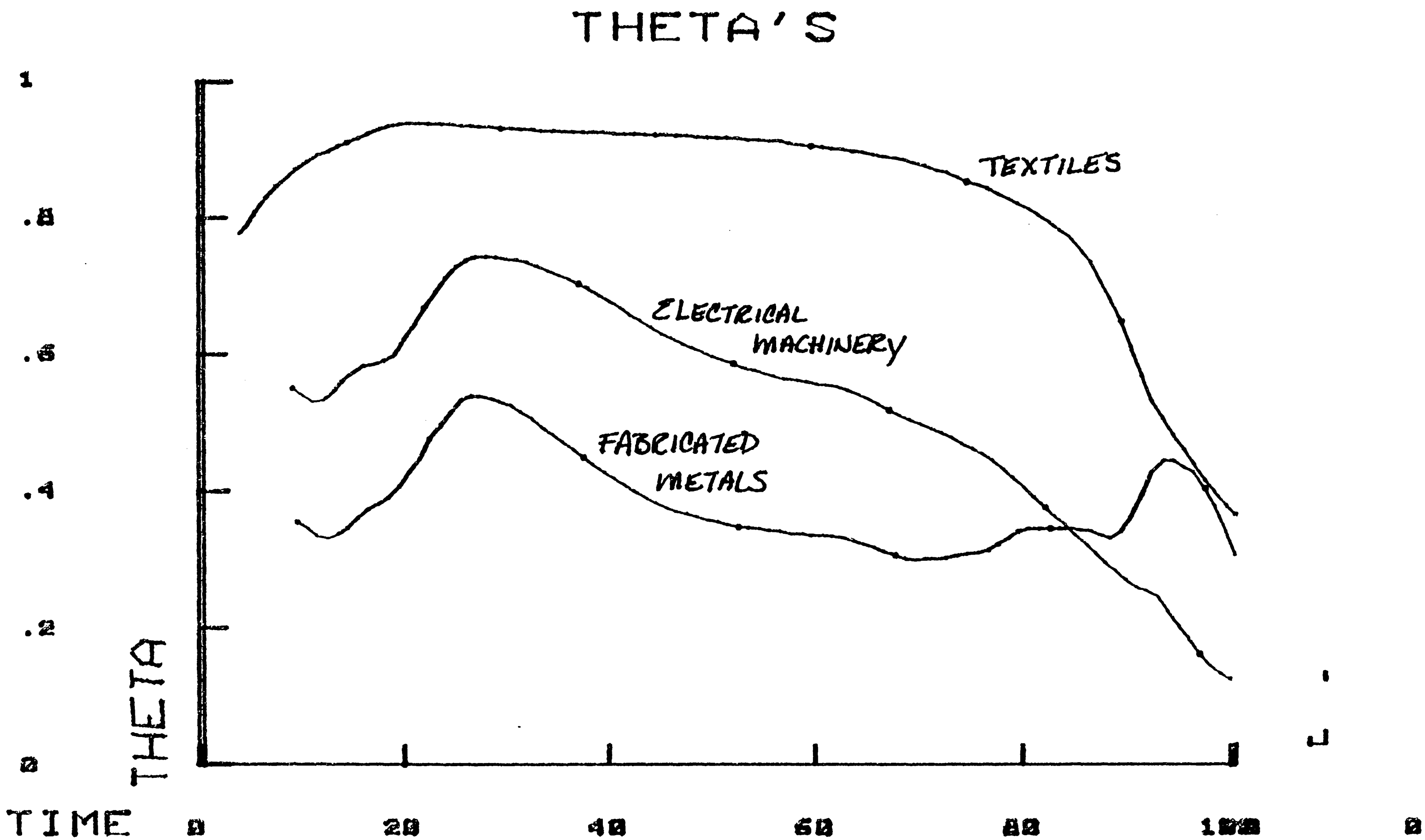

FIGURE VI.1

THETA'S

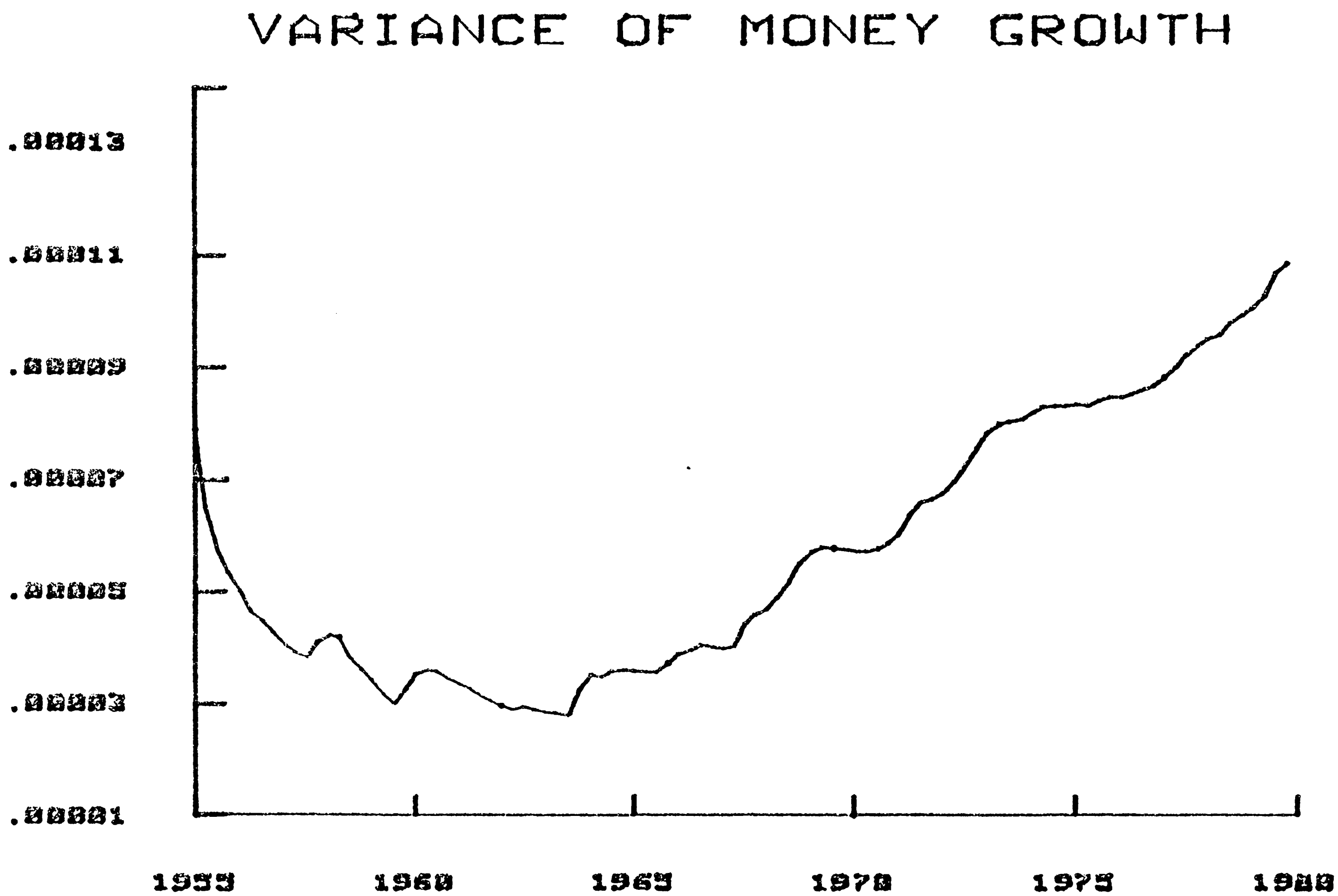

FIGURE VI.2

VARIANCE OF MONEY GROWTH

BIBLIOGRAPHY

Alchian, A., "Information Costs, Pricing, and Resource Unemployment," in Microeconomic Foundations of Inflation and Employment Theory, E.S. Phelps, Editor, New York: W.W. Norton, 1970.

Archibald, G.C., and R.G. Lipsey, "Monetary and Value Theory: A Critique of Lange and Patinkin," Review of Economic Studies, Vol. 26, pp. 1-2, 1958.

Azariadis, C., "Implicit Contracts and Underemployment Equilibria," Journal of Political Economy, Vol. 82, October, 1975.

Baily, Martin N., "Wages and Employment Under Uncertain Demand," Review of Economic Studies, 1973, pp. 37-50.

Baird, Charles W., "Knut Wicksell on the Integration of Monetary and Value Theory," Swedish Journal of Economics, 1970.

Barro, Robert J., "Rational Expectations and the Role of Monetary Policy," Journal of Monetary Eonomics, Vol. 2, 1976, pp. 1-32.

_______________, "Long-Term COntracting, Sticky Prices, and Monetary Policy," Journal of Monetary Economics, Vol. 3, 1977, pp. 305-16.

_______________, "Unanticipated Money Growth and Unemployment in the United States," American Economic Review, March, 1977.

_______________, "Second Thoughts on Keynesian Economics," American Economic Review, Vol. 69 #2, May, 1979.

Barro, Robert J., and Stanley Fischer, "Recent Developments in Monetary Theory," Journal of Monetary Economics, Vol. 2, 1961, pp. 133-67.

Barro, Robert J. and H. Grossman, "A General Disequilibrium Model of Income and Employment," American Economic Review, MArch, 1961, pp. 82-93.

Barro, Robert J. and Mark Rush, "Unanticipated Money and Economic Activity - Results from Annual and Quarterly U.S. Data," mimeo Sept., 1978. Appears in Rational Expectations and Economic Policy, ed. by Stanley Fishcer under the title "Unanticipated Money and Economic Activity."

Blinder, Alan, comment on the Barro and Rush paper, "Unanticipated Money an Economic Activity," in Rational Expectations and Economic Policy, Stanley Fischer, editor, 1980, Chicago Press, p. 51.

Bloomfield, Peter, Fourier Analysis of Time Series: An Introduction, John Wiley and Son, c. 1976.

Board of Governors of the Federal Reserve System, Federal Reserve Measures of Capacity and Capacity Utilization, February, 1978, pp. 1-40.

________________________, Industrial Production, 1976, December, 1977, pp. 1-258.

Bonomo, Vittorio, untitled working paper, 1979, Virginia Polytechnic Institute and State University.

Bonomo, Vittorio, and Charles Schotta, "A Spectral Analysis of Post-Accord Federal Open Market Operations," American Economic Review, Vol. 59, March 1969.

Bonomo, Vittorio, and Ernest J. Tanner, "Are Monetary Changes Neutral?" Virginia Polytehcnic Institute and State University, 1979, working paper.

Bowerman, Bruce and Richard O'Connell, Forecasting and Time Series, Duxbury Press, 1979.

Childs, Gerald, Unfilled Orders and Inventories: A Structural Analysis, North-Holland, c. 1967.

Cukierman, Alex, "Rational Expectations and The Role of Monetary Policy," Journal of Monetary Economics, #5, 1979, pp. 213-29.

__________, "The Relationship Between Relative Prices and the General Price Level: A Suggested Intrepretation," American Economic Review, Vol. 69 #3.

Cukierman, Alex and Paul Wachtel, "Differential Inflationary Expectations and the Variability of the Rate of Inflation: Theory and Evidence," American Economic Review, Vol. 69 #4, Sept., 1979.

Curtin, Richard T., "Consumer Perceptions of Inflation and Expectations," paper delivered at the Eastern Economic Association, May, 1980.

Dobson, Steven W., "Inflation -- The Role of Market Structure," Federal Reserve Bank of Dallas Review, June 1977.

Domberger, "Price Adjustment and Market Structure," Economic Journal, March, 1979, pp. 96-119.

Eckstein, Otto, The Econometrics of Price Determination Conference, Editor, Federal Reserve Board, Washington, 1972.

Eckstein, Otto and David Wyss, "Industry Price Equations," The Econometrics of Price Determination Conference, October, 1970, pp. 133-56.

Executive Office of the President: Office of Management and Budget, Standard Industrial Classification Manual, 1972, (1972).

Friedman, Benjamin M., "Optimal Expectations and The Extreme Information Assumptions of 'Rational Expectations' Macromodels," Journal of Monetary Economics 5(1979), pp. 23-41.

Friedman, Milton, "The Role of Monetary Policy," American Economic Review, Vol. 58, March, 1968, pp. 1-17.

______________, "The Optimum Quantity of Money," in, The Optimum Quantity of Money and Other Essays," Chicago: Aldine, pp. 1-50.

Fischer, Stanley, "Long-Term Contracting, Rational Expectations and the Optimal Money Supply Rule," Journal of Political Economics, Vol. 85 #1, 1977a, pp 191-205.

______________, "Long-Term Contracting, Sticky Prices, and Monetary Policy: A Comment on Barro," Journal of Monetary Economics, Vol. 3, 1977b, pp. 317-23.

______________, Rational Expectations and Economic Policy, National Bureau of Economic Research, The University of Chicago Press, 1980.

Fisher, Irving, "A Statistical Relation Between Unemployment and Price Changes," International Labour Review, Vol. 13, June, 1926, pp. 785-92, Reprinted in Journal of Political Economy, Vol. 81, March/April, pp. 496-502.

Gordon, Robert J., "Recent Developments in the Theory of Inflation and Unemployment," Journal of Monetary Economics, 1976, Vol. 2, pp. 185-219.

Gray, J.A., "Wage Indexation: A Macroeconomic Approach," Journal of Monetary Economics, Vol. 2, #2, pp. 221-235.

Grossman, Herschel, "Why Does Aggregate Employment Fluctuate?", American Economic Review, Vo. 69, #2, May 1979, pp. 64-69.

Hafer, Rik., "An Empirical Comparison of Autoregression and Rational Models of Price Expectations," Dissertation, Virginia Polytechnic Institute and State University, 1979.

Hall, Robert E., "The Rigidity of Wages and the Persistence of Unemployment," Brookings Papers on Economic Activity, Vol. 2, 1975, p. 301.

Hammermesh, Daniel S. "Wage Bargain, Threshold Effects, and the Phillips Curve," Quarterly Journal of Economics, pp. 500-17.

Hinich, Melvin J., Introduction to Fourier Analysis of Data, Center for Naval Analysis, Research Contribution #130, Nov. 1969.

Kmenta, Jan. Elements of Econometrics, New York: Macmillian Publishing Company, 1971.

Leiderman, Leonardo, "Marcoeconomic Testing of the Rational Expectations and Structural Neutrality Hypothesis for the United States," Journal of Monetary Economics, Vol. 6, 1980, pp. 69-82.

Lucas, Robert E., Jr., "Econometric Testing of the Natural Rate Hypothesis," The Econometrics of Price Determination Conference, Oct., 1970, pp. 50-59.

____________________, "Expectations and the Neutrality of Money," Journal of Economic Theory, Vol. 4, April 1972b, pp. 103-24.

____________________, "Some International Evidence on Output-Inflation Tradeoff," American Economic Review, June, 1973, pp. 326-34.

____________________, "Review of a Model of Macroeconomic Activity," Journal of Economic Literature, Vol. 8, Sept., 1975, pp 889-90.

Lucas, Robert E., Jr., and L.A. Rapping, "Real Wages, Employment, and Inflation," Journal of Political Economy, Sept/Oct, 1977.

McCallum, B.T., "Rational Expectations and the Natural Rate Hypothesis: Some Consistent Estimates," Econometrica, Vol. 44, #1, Jan., 1976.

______________, "On the Observational Inequivalence of Classical and Keynesian Models," Forthcoming in the Journal of Political Economy.

McCallum, B.T., "Price-Level Stickiness and the Feasibility of Monetary Stabilization Policy with Rationl Expectations," Journal of Political Economy, Vol. 85, 1977, pp. 627-34.

______________, "Monetarism Rational Expectations, Oligopolistic Pricing, and the MPS Econometric Model," Journal of Political Economy, Vol. 87, #1, 1979.

Maddala, G.S., Econometrics, McGraw-Hill, 1977.

Mann, Maurice, "How Does Monetary Policy Affect the Economy?" Federal Reserve Bulletin, Oct., 1968, pp. 803-14.

Mayers, David and Richard Thaler, "Sticky Wages and Implicit Contracts: a Transactional Approach," Economic Inquiry, Vol. 17, Oct., 1979.

Modigliani, Franco, "Business Reasons for Holding Inventories and Their Macroeconomic Implications," in Problems of Capital Formation, Studies in Income and Wealth, Vol. 19, New York: National Bureau of Economic Research, 1957.

Modigliani, Franco and Emil Greenberg, "The Predictability of Social Events," Journal of Political Economy, Vol. 62, Dec., 1954, pp. 465-78.

Modigliani, Franco and Robert J. Shiller, "Inflation, Rational Expectations and the Term Structure of Interest Rates," Economica, Feb., 1973, pp. 12-42.

Moriguchi, Chikashi, Business Cycles and Manufacturers' Short-Term Production Decisions, North-Holland, c. 1967.

Mussa, Michael, "Adaptive and Regressive Expectations in a Rational Model of the Inflation Process," Journal of Monetary Economics, Vol. 1, 1975, pp. 423-42.

Muth, J.F., "Rational Expectations and the Theory of Price Movements," Econometrica, Vol. 19, July, 1961, pp. 315-35.

Neftci and Sargent, "A Little Bit of Evidence on the Natural Rate Hypothesis," Journal of Monetary Economics, Jan., 1978, pp. 315-19.

Niehans, Jurg, The Theory of Money, The John Hopkins University Press, 1978.

Nordhaus, William D., "Recent Developments in Price Dynamics," The Econometrics of Price Determination Conference, Oct., 1970, pp. 16-49.

Patinkin, Don., Money, Interest, and Prices, Harper and Row, Publishers, 1965.

Phelps, E.S., et.al., Microeconomic Foundations of Inflation and Employment Theory, New York: W.W. Norton, 1970.

Phelps, E.S. and John Taylor, "Stabilizing Powers of Monetary Policy Under Rational Expectations," Journal of Political Economy, Vol. 85, 1977, pp. 163-90.

Phillips, A.W., "Stabilization Policy in a Closed Economy," Economic Journal, Vol. 64, June, 1954, pp. 290-323.

______________, "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1862-1957," Economica, Vol. 25, November, 1958, pp. 283-99.

Phillips, Llad, and John Pippenger, "Preferred Habitat vs. Efficient Market: A Test of Alternative Hypotheses," Federal Reserve Bank of St. Louis Review, May 1976.

Pierce, David., "A Survey of Recent Developments in Seasonal Adjustment," The American Statistician, Vol. 34 #3, August, 1980.

Pierson, Gail, "The Effect of Union Strength on the U.S. Phillips Curve," American Economic Review.

Prescott, Edward C., "Efficient of the Natural Rate," Journal of Political Economy, Vol. 83 #6, 1975.

Poole, William, "Rational Expectations in the Macro Model," Brookings Papers on Economic Activity, V01. 2, 1976, pp. 463-514.

Rowley, J.C.R., and P.K. Trivedi, Econometrics of Investment, John Wiley and Sons, c. 1975.

Sargent, T.J. and N. Wallace, "Rational Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule," Journal of Political Economy, Vol. 81, April, 1975a, pp. 214-57.

____________________________, "Rational Expectations and the Theory of Economic Policy," Studies in Monetary Economics, Federal Reserve Bank of Minneapolis, Minnesota.

Sargent, Thomas J., "A Classical Macroeconomic Model for the United States," Journal of Political Economy, Vol. 84, April, 1976, pp. 207-38.

________________, "The Observational Equivalence of Natural and Unnatural Rate Theories of Macroeconomics," Journal of Political Economy, Vol. 84, #3, 1976b.

Sharpe, William, "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk," Journal of Finance, Vol. 19, Sept., 1964, pp. 425-42.

Shiller, Robert J., "Rational Expectations and the Dynamic Structure of Macroeconomic Models," Journal of Monetary Economics, Vol. 4, 1978, pp. 1-44.

Sims, Christopher A., "Seasonality in Regression," Journal of the American Statistical Association, Vol., 69 #347, Sept., 1974, p. 618.

Standard and Poors, Standard and Poors Industry Surveys, Vol I and II, Quarterly Publication, (New York).

Taylor, J., "Monetary Policy During a Transition to Rational Expectations," Journal of Political Economy, Oct., 1975, pp. 1009-1022.

U.S. Bureau of Mines, Mineral Facts and Problems, U.S. Department of Interior, U.S. Printing Office, 1956-1970, 1976.

U.S. Department of Commerce, Bureau of the Census, "Census of Manufacturers: Concentration Ratios in Manufacturing," Part 1, August, 1970.

Viner, Jack, "Review of the Behavior of Prices," Quarterly Journal of Economics, Feb., 1929, p. 337.

Vining, Daniel R., and Thomas Elwertowski, "The Relationship Between Relative Prices and the General Price Levels," American Economic Review, Vol. 66 #4, Sept., 1976, p. 699.

Weber, Warren E., "Notes on Rational Expectations," 1978 mimeo.

________________, "Notes on Observational Equivalence and Inequivalence," March, 1979, mimeo.

Weintraub, Robert E., "Congressional Supervision of Monetary Policy," Journal of Monetary Economics, #4, pp. 341-62.

Wicksell, Knut, Interest and Prices, translated by R.F. Kahn, London: Macmillan, 1936.

Zarnovitz, Victor, "The Timing of Manufacturers' Orders During Business Cycles," in Business Cycles Indicators, G.H. Voor, editor, Vol. 1, 1961, p. 426.

APPENDIX 2A

ALTERNATIVE SPECIFICATION OF MODEL

This Appendix examines a model similar to that presented in the text but the supply equation follows that proposed by Robert Lucas.[1] The purpose of this appendix is to show explicitly how the Lucas methodology can be integrated into my model and most importantly to show that the contributions of Lucas apply only to the unexpected money growth variable and not the expected money variable if prices fully adjust to expected changes. Although this may appear obvious to many readers, a central purpose of this paper is to test whether expected money growth affects industrial sector output, and to be able to test this we must justify the inclusion of the expected money variable in the reduce form equations to be estimated. The Lucas contribution, although extremely interesting, does not justify the inclusion of this variable.

The reformulation of the model to incorporate the ideas of Lucas involve very different assumptions and should therefore be viewed in this light. How critical the distinctions are between this model and the above model largely depends upon the bias of the reader.

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[1]Lucas, 1972, 1973

We begin by positing a Lucas supply equation of the form:

A.1 $Y_t^s = \beta(P_t(z) - \lambda EP_t) + \alpha_0 + \alpha_1 t + U_t^s$

where EP_t is the expectation of the current general price level, based on information available to agents in each sector. This includes information common to all markets, e.g., past demand shifts, output trends, and past deviations from trend, and allows agents to determine a general price distribution:[2] $P_t \sim N(\overline{P}_t, \sigma^2)$. Market specific information is also transmitted through the equilibrium sector price observed in time t.

The $\alpha_0 + \alpha_1 t$ term reflects the secular components of output.[3] The λ term, as before, reflects the adjustment of prices vis-a-vis expected monetary changes. Equation A.1 depicts sector supply as an increasing function of the relative sector to aggregate price in the eyes of the suppliers in that market.

Following Lucas, sector prices are assumed to deviate from the aggregate price level by a percent, z:

(A.2) $P_t(z) = P_t + z$ where $z \sim N(0,\tau^2)$

and is assumed independent of P_t. Suppliers, as well as demanders, calculating expected real balances, utilize this knowledge of the

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[2]The information common to all markets would therefore be summarized by $\overline{P}_t$.

[3]For simplicity, the model will be solved ignoring this secular component.

distribution of P_t and make optimal predictions of the general price level by minimizing the expected mean square error of the prediction:[4]

$$\text{(A.3)} \quad E(P_t/P_t(z), \overline{P}_t) = (1 - \theta)P_t(z) + \theta\overline{P}_t \text{ where } \theta = \frac{\tau^2}{\sigma^2 + \tau^2}$$

The demand curve in each market is posited to take the form:[5]

$$\text{(A.4)} \quad Y_t^d(z) = \delta_0 - \delta_1(P_t(z) - {}_{t-1}P_t(z)) + \delta_2(M_t - EP_t) + U_t^d$$

The equation is identical to equation 2.5 except that purchasing power is defined by the expected aggregate price level rather than actual sector price. This reflects the fact that consumers must attempt to project the sector prices they face as well as common aggregate price knowledge to formulate guesses about the general price level and hence their (expected) real balances. The expected sector price variable remains the same since purchasing decisions are more likely to be affected by deviations from the price one expected to pay than by the relative spread of sector to aggregate prices.

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[4]The variance is $\theta\sigma^2$. Ian Kmenta, Elements of Econometrics, MacMillan Publishing Co., Inc., New York, 1971, p. 210.

[5]Lucas (1973) uses an aggregate demand curve of the form $Y_t + P_t = X_t$ where X_t is an exogenous shift variable. Cukierman and Wachtel suggest a demand curve of the form: $Y_t(z) + P_t(z) = X_t + W(z)$ where X_t is an aggregate exogenous shift variable and $W_t(z)$ is a sector specific shift variable.

The inventory equation and equilibrium condition remains unchanged:

$$\text{(A.5)} \quad J_t(z) = a_1 r Y_t^d - a_1 N_{t-1}$$

$$\text{(A.6)} \quad Y_t^s(z) = Y_t^d(z) + J_t(z)$$

Substitution of A.4 into A.5 gives:

$$\text{(A.7)} \quad Y_t^s(z) = eY_t^d(z) - a_1 N_{t-1} \text{ where } e = (1 + a_1 r)$$

The system is solved for $P_t(z)$ by substitution of A.3 into A.1 and A.4, then substituting the result into A.7:[6,7]

$$\text{(A.8)} \quad P_t(z) = \frac{1}{\beta - \beta\lambda(1 - \theta) + e\delta_1 + e\delta_2(1 - \theta)} \left[e\delta_0 + (\beta\lambda - e\delta_2)\theta\overline{P}_t \right.$$

$$\left. + e\delta_1 {}_{t-1}P_t(z) + e\delta_2 M_t - a_1 N_{t-1}\right]$$

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[6]Note there are as many equilibrium conditions as there are sectors. This is in contrast to Lucas and as Cukierman and Wachtel point out, this modification implies the variance of relative prices is not constant, but is systematically related to the variance of the general price level. Further, since the model is not aggregated and involves fewer terms than Lucas', we can solve the model directly rather than use the method of undetermined coefficients.

[7]Ignoring stochastic and secular components.

Since the expectation of $P_t(z)$ is based upon the structure of the model, ${}_{t-1}P_t(z)$ is found by taking the mathematical expectation of equation A.8:

$$(A.9)\quad {}_{t-1}P_t(z) = \frac{1}{\beta - \beta\lambda(1 - \theta) + e\delta_2(1 - \theta)} \left[e\delta_0 X + (\beta\lambda - e\delta_2)\theta X\overline{P}_t + e\delta_2 X({}_{t-1}M_t) - a_1 X N_{t-1}\right]$$

where $X = \frac{1}{\beta - \beta\lambda(1 - \theta) + e\delta_2(1 - \theta) + e\delta_2}$

Substitution of A.9 back into A.8, and assuming equation 2.17 holds, i.e., ${}_{t-1}M_t = M_t$ gives:

$$(A.10)\quad P_t(z) = \frac{1}{\beta - \beta\lambda(1 - \theta) + e\delta_2(1 - \theta)} \left[(\beta\lambda - e\delta_2)\theta\overline{P}_t + e\delta_2 M_t - a_1 N_{t-1}\right]$$

An important implication of equation A.10 is that for $\lambda = 1$, the coefficient on the money growth variable is:

$$(A.11)\quad \frac{e\delta_2}{(\beta - e\delta_2)\theta + e\delta_2} \quad \text{where } \theta = \frac{\tau^2}{\sigma^2 + \tau^2}$$

As θ approaches zero, i.e., the variance τ^2, of sector price is small relative to the variance, σ^2, of the general price level,[8] the coefficient on money growth approaches 1. Thus, in the limit (θ = 0), the familiar condition of neutrality holds for sectors as well as economy wide. If θ is close to one, the coefficient approaches a limit of $\frac{e\delta_2}{\beta}$ and the neutrality condition on the sector level is violated. The magnitude of the money variable depends upon whether the relative price effect on output (as perceived by suppliers) is greater than the real balance effect (as perceived by demanders). In the absence of inventory adjustment, implying $r = 0$ thus $e = 1$, equal effects should produce the same results as the neutrality of money would predict, although whether this is a strict form of neutral money is open for debate.

The value of θ also affects the coefficient on inventories. This implies some production adjustment due to the inability of producers to correctly separate the information of sector prices into the real and monetary parts.

To solve for equilibrium output, substitute the equilibrium price solution A.10, the expected sector price, A.9 and the

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[8]This implies that individual price changes are virtually certain to reflect general price movements. See Lucas (1972), p. 328.

projection of the general price level, A.3, into the demand equation A.4.

$$(A.12)\quad Y_t(z) = \frac{1}{\beta - \beta\lambda(1-\theta) + e\delta_2(1-\theta)}$$

$$[(\beta - \beta\lambda(1-\theta))\delta_2 - \delta_1\delta_2 e)(M_t - {}_{t-1}M_t)$$

$$+ (\beta - \beta\lambda(1-\theta)\delta_2)_{t-1}M_t - \beta\delta_2\theta\overline{P}_t + \delta 2(1-\theta)a_1N_{t-1}]$$

Before addressing the importance of this equation, let us look at the properties of the average general price level $\overline{P}_t$.

Following Cukierman and Wachtel, assume the general price level is a weighted average of sector price:

$$(A.13)\quad P_t = \sum_z U(z)P_t(z).$$

Substitution of the equilibrium price in each sector

$$(A.14)\quad P_t = \frac{1}{\beta - \beta\lambda(1-\theta) + e\delta_2(1-\theta)}[\beta\lambda - e\delta_2)\theta\overline{P}_t + e\delta_2 M_t$$

$$- \sum_z U(z)a_2N_{t-1}(z)]$$

Taking the expected value of A.14 and rearranging:

$$(A.15)\quad \overline{P}_t = \frac{e\delta_2}{\beta - \beta\lambda + e\delta_2}\,{}_{t-1}M_t - \frac{1}{\beta - \beta\lambda + e\delta_2}\sum_z U(z)a_2N_{t-1}(z)$$

Note that if $\lambda = 1$, the equation reduces to

$$(A.16)\ \overline{P}_t = {}_{t-1}M_t - \frac{1}{e\delta_2} \sum_z U(z)a_2N_{t-1}(z)$$

Substitution of A.16 into A.12 allows us to rewrite the equilibrium output condition as $(\lambda - 1)$:

$$(A.17)\ Y_t(z) = \frac{1}{\beta\theta + e\delta_1(1-\theta)} \Big[(\beta\theta\delta_2 - \delta_1\delta_2 e)(M_t - {}_{t-1}M_t) + \delta_2(1-\theta)a_1N_{t-1} + \frac{\beta\theta}{e} \sum_z U(z)a_2N_{t-1}(z)\Big]$$

Note that the expected money term has dropped out of the equation. If $\lambda = 1$, expected monetary growth has no effect on sector output.[9]

The sector demand specified above is an important modification of Lucas' model. In Lucas, for $\theta > 0$ (implying some variation of relative sector to aggregate prices) there is an unambiguous positive response of supply. As θ approaches one, the response of cyclical output to policy changes--coefficient π on ΔX_t in Lucas--approaches a limit $\frac{\gamma}{1+\gamma}$, where γ is the elasticity of relative sector to expected general prices. For $\theta = 0$ no output response exists.

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[9]This can be seen in a slightly different (though not technically correct) manner: <u>If</u> ${}_{t-1}M_t = P_t$, the combined coeficients on ${}_{t-1}M_t$ and P_t in A.12 reduces to:

$$\frac{\delta_2\beta(1-\theta) - \beta\lambda(1-\theta)}{\beta - \beta\lambda(1-\theta) + e\delta_2(1-\theta)}$$

It is easily seen that for $\lambda = 1$, this term equals zero. Also for $\theta = 1$, this term will also drop out.

In my model, for $\theta = 0$ the output response is given by the elasticity of relative sector to last periods expected sector price, $-\delta_1$. The relative sector to general price term in the supply equation and the real balance term in the demand equation do not affect equilibrium output since sector prices fully reflect aggregate price movements and the supplier or consumer is not fooled by aggregate policy changes.

For $\theta = 1$, the supply response is given by $\frac{\delta_2(\beta - \delta_1 e)}{\beta}$. Clearly, if $\beta > \delta_1 e$ (or if no inventory response exists $\beta > \delta_1$) this term is positive and greater than the output response when $\theta = 0$. For $\beta < \delta_1 e$, the output response is negative but still may be greater than $-\delta_2$ (when $\theta = 0$). The condition for the output response to be increasing as θ approaches one is[10] $\beta > \frac{c}{1 + c} \delta_2 e$ where c is

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[10]If $\theta = 1$, the coefficient on unexpected money reduces to $\delta_2(\beta - \delta_1 e)/\beta$ which is equivalent to that specified above regardless of the value of λ. For $\theta = 0$, the coefficient on unexpected money in equation A.12 reduces to:

$$\frac{\delta_2\beta(1 - \lambda) - \delta_1 e}{\beta(1 - \lambda) + e\delta_2}$$

If $\beta > \frac{c\delta_2}{1 + c - c(1 - \lambda)}$ the coefficients on unexpected money is greater when θ takes on a value of one than when θ takes on a value of zero. Note that as λ approaches zero, $\beta > c\delta_2 = \delta_1$. This implies a greater restriction on the elasticity of supply as a function of relative aggregate to sector price ratio than when λ is equal to one.

If $\theta = 1$, the coefficient on expected money in equation A.12 (in conjunction with the P_t term given by equation A.16) goes to zero. For $\theta = 0$, the coefficient on expected money becomes:

$$\frac{\delta_2\big(\beta(1 - \lambda)\big)}{\beta(1 - \lambda) + e\delta_2}$$

defined to be some constant relationship between δ_1 and δ_2, i.e., $\delta = c\delta_2$. For example, if $\delta_1 - \delta_2$, (c = 1) then, $\beta > \frac{1}{2}\delta_2 e$. If this condition does not hold, the output response may not increase as θ approaches one as implied by Lucas.

In the concluding chapter, I suggest for future research an examination of the relationship between the θ's for each industrial sector and the coefficients on expected and unexpected money growth. The θ's for three industries are plotted in Figure 6.1.

An important aspect of Lucas' paper is that the variance of money growth is related to the slope of the Phillips curve: the greater the variance the steeper the slope. In Lucas' paper, equation (13) describes the inverse relationship between output and the magnitude of income policy. I have partially discussed the inverse relationship between θ and the money growth variables. The connection between the variance of money growth and the magnitude of affect will be developed below.

Current money stock can be written as the sum of last periods money stock and the change in the money stock from the last period:

(A.18) $M_t = M_{t-1} + \Delta M_t$

where $\Delta M_t \sim N(0, \sigma_m^2)$

Thus:

(A.19) $M_t = M_{t-1} + \delta^* + \varepsilon_t$

Substitution of this result into the equilibrium price equation (A.10) gives:

$$(A.20)\ P_t(z) = \frac{1}{\beta - \beta\lambda(1 - \theta) + e\delta_2(1 - \theta)} [(\beta\lambda - e\delta_2)\theta\overline{P}_t$$

$$+ e\delta_2 M_{t-1} + e\delta_{2\,t-1}M_t + e\delta_2\varepsilon_t - a_1N_{t-1}(z)]$$

The realization of the general price level is obtained by substitution of (A.20) into (A.13). Recognizing that the difference between P_t and $\overline{P}_t$ is due solely to unexpected money growth ε_t (since this is the only variable unknown in period t) we can write the aggregate price level as:

$$(A.21)\ P_t = \overline{P}_t + \frac{e\delta_2}{\beta - \beta\lambda(1 - \theta) + e\delta_2(1 - \theta)} \varepsilon_t$$

which implies $P_t \sim N(\overline{P}_t, \sigma^2)$ where:

$$(A.22)\ \sigma^2 = \left(\frac{e\delta_2}{\beta - \beta\lambda(1 - \theta) + e\delta_2(1 - \theta)}\right)^2 \sigma_m^2$$

This means that the variance of the general price level is a function of the variance of money growth and the degree of impact on the price level attributable to money growth. The latter is related to the expectations of agents as defined by θ. Note that the expected money term in included as part of $\overline{P}_t$.

Substitution of (A.22) into θ and the result into the coefficient of unexpected money, we obtain (for the coefficient):

$$\frac{\beta\tau^2\delta^2 - (\delta_1\delta_2 e)(X\sigma_m^2 + \tau^2)}{(\beta - e\delta_2)\tau^2 + e\delta_1(X\sigma_m^2 + \tau^2)}$$

where: $X = \left(\frac{e\delta_2}{\beta - \beta\lambda(1 - \theta) + e\delta_2(1 - \theta)}\right)^2$

This result reflects the Lucas proposition that an increase in the variance of money growth decreases the value of the coefficient and hence makes the output-money (inflation) "trade-off" less favorable.

The sectors examined in this paper are assumed to be subjected to the same variance of the money supply. It is impossible, therefore, to test the influence of the variance of money growth on the coefficients estimates across sectors. However, I suggest for future research a more direct test of the Lucas proposition that the greater θ, i.e., the greater the confusion of real versus monetary change, the more favorable the "trade-off".

In conclusion, the Lucas type model does not justify the inclusion of the expected money growth variable in the equations to be estimated. Rather the necessary condition is that $\lambda \neq 1$, i.e., prices do not fully adjust to expected monetary changes. There are, of course, other interesting implications of this model but for the most part, they extend far beyond the scope of this paper.

APPENDIX 2B

DERIVATIONS OF EQUATIONS (4.2), (4.3) AND (4.4)

Assume a long-linear production function for output Y in terms of labor, ℓ, only:

$$(B.1)^{1} \quad Y = A + \ell^{\alpha} + u$$

where A is a constant and u is a white noise error term, assumed to reflect aggregate productivity shifts. The term α is restricted to $0 < \alpha < 1$. The marginal product of labor is given by:

$$(B.2) \quad MP_t = \frac{\partial y}{\partial \ell} = \alpha\ell^{\alpha-1}.$$

The value of the marginal product (VMP) is given by:

$$(B.3) \quad VMP = MP_L P = \alpha\ell^{\alpha-1}P$$

or alternatively as,

$$(B.4) \quad \log P_t + \log MP_t = \log\alpha - (1 - \alpha)\log\ell + \log P.$$

Since contracts set in time t necessarily involve the prediction of the value of marginal product formed in t-2 we write:

$$(B.5) \quad {}_{t-2}\log VMP = {}_{t-1}\log P_t + {}_{t-2}MP_t$$

[1]The notation is Barro's 1977 Journal of Monetary Economics. I argue that in the short-run -- the emphasis of this study -- the degree of capital and other similar production components are constant and included in the term A.

Microeconomic theory tells us that nominal wages will be set equal to the VMP. From equation (B.5) this implies that wages will be set in time t-2 for time t according to the expected value of marginal product formed in t-2 for period t. Assuming the input labor function to remain constant implying ${}_{t-2}\log MP$ = constant, and assuming contracts are drawn up to maintain constancy of the real wage, we specify:

(B.6) $\log(MP = \text{CONSTANT}) = \log {}_{t-2}P_t + \log {}_{t-2}W_t$

or in terms of rates of change:

(B.6') = (4.2) ${}_{t-2}W_t(z) = {}_{t-2}P_t(z);$

in general,

$${}_{t-i}W_t(z) = {}_{t-i}P_t(z).$$

The supply function can be constructed as follows: From the above discussion we know that the value of marginal product equals the nominal wage (all variables in period t) thus, we can write (by substituting the right side of B.4 for VMP):

(B.7) $(1 - \alpha)\log \ell^N = \log\alpha + P_t - W_t$

where N denotes the absence of a wage contract. If wages are set two periods in the past, the real wage (${}_{t-2}W_t/P_t(z)$) will only equal the marginal product if ${}_{t-2}W_t = W_t$. If this equality does not hold, the marginal product of labor will equal the difference between current prices and contracted wages (${}_{t-2}W_t$) plus the difference between the actual wage in t, W_t minus the expected wage:

$$\text{(B.8)} \quad \log MP = {}_{t-2}W_t - P_t + (W_t - {}_{t-2}W_t).$$

The forecast error ($W_t - {}_{t-2}W_t$) will be denoted as e_t, thus:

$$\text{(B.9)} \quad \log MP = {}_{t-2}W_t - P_t + e_t.$$

This forecast error will lead to additional adjustments in the demand for labor. Substitution of $\log MP = -(1-\alpha)\log\ell + \log\alpha$, gives:

$$\text{(B.10)} \quad \log\ell = \frac{1}{1-\alpha}\log\alpha + \frac{1}{1+\alpha}\left[P_t - {}_{t-2}W_t\right] - \frac{1}{1+\alpha}e_t.$$

This is the demand for labor equation. Substitution of this equation into the log of (B.1) we have:

$$\text{(B.11)} \quad \log Y_t = \left(A + \frac{\alpha}{1+\alpha}\log\alpha\right) + \frac{\alpha}{1-\alpha}\left[P_t - {}_{t-2}W_t\right] + \left(U_t - \frac{1}{1-\alpha}e_t\right)$$

or alternatively:

$$\text{(B.12)} \quad \log Y_t = \beta\left[P_t - {}_{t-2}W_t\right] + U_t^1$$

where the constant has beet set to zero, $\beta = \frac{\alpha}{1-\alpha}$ and $U_t^1 = U_t - \frac{1}{1-\alpha}e_t$. This is equivalent to equation (2.2) in the text except that the text is specified according to sectors.

APPENDIX 2C

USE OF AGGREGATE MONEY

This Appendix examines briefly the use of aggregate money in the demand equation versus the use of money which first enters a given sector. Archibald and Lipsey have argued that Patinkin's neutrality of money can be extended to the case of money being unequally distributed. They conclude that in the short-run, local optimas are obtained which are not characterized by the neutrality of money. Subsequent readjustment of the price level and the flow of resources will result in the long-run the neutrality of money, hence a global optima. In this context, the use of aggregate money supply is appropriate, testing whether these short-run non-neutral situations actually arise. Using lagged dependent variables we can make use of the Koy transformation to study the long and short-run affects.

The assumption of Barro, mentioned in the text, is equilvanet to

$$(C.1) \quad M_t(z) = \frac{1}{n}M_t + e,$$

i.e., that the money which directly impacts upon a given sector is a constant fraction 1/n of the aggregate money supply. Without the error term one would expect to find the strict neutrality conditions, as discussed by Patinkin. The addition of the error term allows for this fraction to change, thus introducing the kind of non-neutrality described by Archibald and Lipsey. The key point of Archibald and Lipsey's argument is the separation of local and global optimum, and also the broadened interpretation of the neutrality of money.

It might be argued that the strong form of neutrality implies that $M_t(z)$ should be used in the equations, but by substituting the right side of (C.1) the aggregate money variable can be used and the error structure of the demand equation can be interpreted as including the distributional affect of money, i.e., e. The expanded definition of neturality seems more relevant to the type of policy implications that may be found to exist in this study.

APPENDIX 3A

STANDARD INDUSTRIAL CLASSIFICATIONS

The purpose of this Appendix is to summarize the description of industries used in this study. For a detailed description see Standard Industrial Classification Manual, 1972.[1] Table 3A.1 lists the industries by durable and non-durable commodity groups.

Manfacturing:

A. Division D

Includes establishments, plants, factories, or mills engaged in mechanical or chemical transformation of materials into new products. Component assembly of manufactured products is also included in this group. Both "finished" and "semifinished" are included; "finished" implies a consumption good, "semifinished" implies goods to be used in further production, i.e., investment good.[2]

B. Food and Kindred Products: Major Group 20 (Non-Durable)

Includes establishments manufacturing or processing foods and beverages for human consumption. Other related products include ice, chewing gum, animal and vegetable fats and oils, and prepared foods for animals and fowls. Examples of products include meat and poultry

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[1]Standard Industrial Classification Manual, 1972. Executive Office of the President: Office of Management and Budget, 1972. Table 3A.1 shows excerpts from this manual.

[2]Ibid., p. 56.

TABLE 3A.1

MAJOR GROUPS ACCORDING TO DURABLE/NON-DURABLE CLASSIFICATIONS**

Durable SIC Code***	Non-Durable SIC Code
33 Primary Metals	20 Food
36 Electrical Machinery	22 Textiles
35 Non-Electrical Machinery	26 Paper
37 Transportation Equipment	28 Chemical
32 Stone, Clay and Glass, etc.	29 Petroleum
34 Fabricated Metal	30 Rubber

**Department of Commerce, Bureau of Economic Analysis.

***The SIC Codes are defined in the _Standard Industrial Classification Manual, 1972_.

products, dairy products, canned and preserved fruits and vegetables, grain mill products, bakery products, liquor, malt, and soft beverages, and frozen seafood.[3]

C. Tobacco Manufacturers: Major Group 21 (Non-Durable)

Includes establishments manufacturing cigaretts, cigars, smoking and chewing tobacco, snuff, and in stemming and redrying tobacco. Pesticides from tobacco by-products are not included (see major group 28: chemicals and allied products).[4]

D. Textile Mill Products: Major Group 22 (Non-Durable)

Includes establishments engaged in the preparation of yarns and fiber, in dying and finishing fiber, yarn, fabric and knit apparel, in coating, waterproofing and other fabric treatment, and in manufacturing fabric, carpets and rugs from yarn and felt and lace goods. No distinction is made between integrate mill and contract mill products.[5]

E. Paper and Allied Products: Major Group 26 (Non-Durable)

This group includes establishments engaged in the manufacture of pulps from wood and other cellulose fibers, and from rags. Includes paperboard mill products and boxes, sanitary paper products and food containers, building paper such as asbestos paper, asphalt board, and wallboard.[6]

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[3]Ibid., p. 59.

[4]Ibid., p. 70.

5Ibid., p. 71.

[6]Ibid., p. 100.

F. Chemical and Allied Products: Major Group 18 (Non-Durable)

This group includes establishments producing basic chemicals, such as acids, alkalies, salts, and organic chemicals; chemical products for further manufacture, such as synthetic fibers, plastics, plants, fertilizer, explosives and pigments; and finished chemical products, such as drugs, cosmetics and soap.[7]

G. Petroleum Refining and Related Industries: Major Group 29

Includes establishments engaged in petroleum refining, manufacturing of paving and roofing materials, and lubricating oils and grease.[8]

H. Rubber and Miscellaneous Plastic Products: Major Group 30 (Non-Durable)

Includes establishments engaged in manufacturing products from natural, synthetic, or reclaimed rubber, gutta, percha, balata, or gutta siak. Included are tires, rubber footwear, mechanical rubber goods, heels and soles, and flooring. Recapping and retreading are classified under Services, 7534. This group also contains finished plastic products and primary plastics for the trade. Synthetic rubber is classified under Chemical and Allied Products, Group 28.[9]

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[7]Ibid., p. 111.

[8]Ibid., p. 127.

[9]Ibid., p. 129.

I. <u>Stone, Clay, Glass and Concrete Products</u>: Major Group 32 (Durable)

Includes establishments engaged in manufacturing flat glass and other glass products, cement, clay products, concrete and gypsum products, cut stone, asbestos products from materials taken principally from earth in the form of stone, clay and sand.[10]

J. <u>Primary Metal Industries</u>: Major Group 33 (Durable)

Includes establishments engaged in the smelting and refining of ferrous and nonferrous metals from ore, pig, or scrape; in rolling, drawing, and alloying of ferrous and nonferrous metals. Castings, nails, spikes, insulated wire and cable and the production of coke are also included.[11]

K. <u>Fabricated Metal Products</u>: Major Group 34 (Durable)

Includes establishments engaged in fabricating ferrous and nonferrous metal products such as metal cans, tinware, hand tools, cutlery, general hardware, nonelectric heating apparatus, fabricated structural metal products, metal forgings, metal stampings, and small firearms.[12]

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[10]bid., p. 136.

[11]Ibid., p. 145.

[12]Ibid., p. 153.

L. Non-Electrical Machinery: Major Group 35 (Durable)

Includes the manufacture of engines and turbines, farm and garden machinery and equipment, construction, mining and materials handling machinery, metalworking machinery, industrial machinery, office computing and accounting machines and refrigeration and service industry machinery.[13]

M. Electrical Machinery, Equipment and Supplies: Major Group 36 (Durable)

Includes establishments engaged in manufacturing machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and utilization of electrical supplies. Household appliances, electric lighting and wiring equipment, radio, television, phonograph records, pre-recorded magnetic tape, communication equipment, electronic components, batteries, and X-ray equipment are examples of products in this major group.[14]

N. Transportation Equipment: Major Group 37 (Durable)

Includes establishments engaged in manufacturing equipment for transportation of passengers and cargo by land, air, and water. Important products in this group include motor vehicles, trucks and buses, aircraft, guided missiles and space vehicles, ships, boats, railriad equipment, motorcycles, bicycles, and snowmobiles.[15]

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[13]Ibid., p. 167.

[14]Ibid., p. 184.

[15]Ibid., p. 196.

APPENDIX 3B

F-TEST

The test performed in this paper concerns the influence of additional variables on the mean of the dependent variable. The two theories in this paper are:

(1) $X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 \text{UNEXCEPT MONEY} + \alpha_3 N_{t-1} + \alpha_4 \text{TIME}$

(2) $X_t = \beta_0 + \beta_1 X_{t-1} + \beta_2 \text{UNEXPECTED} + \beta_3 N_{t-1} + \beta_4 \text{TIME}$
$+ \beta_5 \text{EXPECTED MONEY}.$

The test of the second theory is:

H_0: $\beta_5 = 0$ against the alernative hypothesis

H_A: $\beta_5 \neq 0$

Following Kmenta, let the subscript k denote the value pertaining to the first hypothesis and the subscript q denote the values pertaining to the second hypothesis. If the additional explanatory variables are not relevant in explaining the variation of Y_i (the dependent variable) then in the population the sum of squared errors[16] of equation (1) and (2)

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[16] $\sum_i (Y_i - \bar{Y})^2 = \sum_i (\hat{Y} - \bar{Y})^2 + \sum_i e_i^2$

where $\sum_i (Y_i - \bar{Y})^2$ is the sum of squares total;

$\sum_i (\hat{Y} - \bar{Y})^2$ is the sum of squares of the difference between the predicted value of Y and its mean value, i.e., ths sum of squares regression. This is the variation of Y_i explained by the set of independent variables; and

$\sum_i (e_i)^2$ is the sum of squares error which is the variation of Y_i not explained by the set of independent variables, $\sum_i (e_i)^2 = \sum_i (Y_i - \hat{Y})^2$.

would be identical. Observed differences are due to sampling error. If this is true, then:

$$\frac{(SSR_q - SSR_K)/(Q - K)}{(SSE_q/(N - Q))} \sim F_{Q-K,\ N-Q},$$

where SSR is the sum of squared regression and SSE is the sum of squared errors. Given a level of significance, this formula can be used to test the null hypothesis. The additional explanatory variable cannot decrease the sum of squared regression and hence $R_q^2 > R_K^2$. The F-test measures whether the SSE is significantly reduced by the addition of explanatory variables.

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DIFFERENTIAL IMPACTS OF MONETARY POLICY: A SECTORAL APPROACH

by

James Hartley Chessen

(ABSTRACT)

The proposition tested in the thesis is that actual money growth is not systematically related to output growth of selected manufacturing sectors. Given that money growth is found to be non-neutral, two further tests are undertaken.

First, I test the rational expectations hypothesis that only unexpected monetary changes affect output growth against the Phillips' type stabilization hypothesis that both expected and unexpected monetary growth affect output growth. Further, I examine the arguments that under different conditions the degree of association between output growth and money growth (given statistically by the magnitude of the coefficient on money growth) is not constant. The conditions tested relate to the level of capacity utilization and the phase of the business cycle.

Secondly, I test for differential sector to aggregate manufacturing output response. Non-neutrality does not imply differentiality since money growth can be significantly related to individual manufacturing sectors in an identical way. Differential effects might be argued to exist because the different structure of each sector imposes different restrictions on decisions and actions that can be undertaken. If differential effects are found to exist, a

test of specific sector characteristics, which may be functionally related to the differential association, will be undertaken.

Money growth was found to be significantly related to individual sector output growth in equations unadjusted for seasonal variation. No association was found in seasonally adjusted estimations indicating that money growth is related to the seasonal amplitude and not the underlying non-seasonal structure. This supports the neutrality proposition.

Expected and unexpected money growth, in the seasonally unadjusted estimations, were found to be statistically significant in nine of the twelve industries examined. Further, these associations are strongly related to the level of capacity utilization and the phase of the business cycle.

The test of differential impact did not support the hypothesis that the incidence of money growth was unequal across sectors. Therefore, no further investigation was necessary.