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Three essays on the neutrality of anticipated money growth

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THREE ESSAYS ON THE NEUTRALITY OF ANTICIPATED MONEY GROWTH

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Three essays on the neutrality of

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GENERAL INTRODUCTION

In recent years, a new focus has emerged for theories of the monetary impacts on real economic activity. Attention has moved from distinguishing between the short-run versus long-run real impacts of money growth to one of distinguishing the real short-run impacts of the currently predictable versus the unpredicted portions of money growth. In particular, one class of models of the new classical macroeconomics asserts that the predictable portion of money growth will not have real economic impacts. According to the hypothesis, anticipated money growth is "neutral" with respect to real economic activity; only the unanticipated money growth matters.

If one considers the implications of the neutrality hypothesis, clearly they are not trivial. Anticipated money growth will be the major portion of actual total money growth. If the neutrality hypothesis is correct that this portion of money growth has no real impacts, it implies that the dominant portion of money supply ceases to be a tool for affecting real economic activity. While unanticipated money growth has real impacts under the hypothesis, it cannot be used in a systematic way to affect the real economy, since the public would eventually come to anticipate it. If the neutrality hypothesis is correct, it essentially eliminates money stock growth as a tool to affect the real economy. Therefore, the hypothesis of neutrality of anticipated money growth is of interest from theoretical and policy perspectives.

The neutrality hypothesis has received support in several empirical tests using aggregate level data. Examining the theoretical bases of the neutrality, it is evident that neutrality in the sense implied by the theoretical models requires neutrality to hold at a disaggregated, as well as aggregate, level. Given the aggregate empirical test results supportive of neutrality, this increases the need to now examine the issue at disaggregated levels. Previous assessments of neutrality, however, primarily confine themselves to the aggregate level. Disaggregated research has not received much attention. The purpose of the present research is to fill this gap. The research here, presented in three essays, examines empirically and theoretically the neutrality of anticipated money growth from a disaggregated perspective.

Organization of Dissertation

This research on the neutrality hypothesis is organized as follows. Part One, "Neutrality of Anticipated Money Growth: Disaggregated Empirical Evidence," presents disaggregated testing of the real impacts of anticipated and unanticipated money growth across twelve U.S. manufacturing industries. The coverage of the theoretical background and econometric testing procedures is applicable to the research in both essays one and two. Therefore, the sections of essay one describing theoretical issues and the econometric test procedures are presented in greater detail than in essay two. The reader of essay two may refer back to this initial coverage.

Part Two presents the second essay, "Neutrality of Anticipated Money

Growth: Aggregate Impressions Versus Disaggregated Impacts." This focuses on aggregate level versus disaggregate level testing of the neutrality hypothesis and the potentially conflicting conclusions they may produce. The research here finds testing with aggregate level data may suggest neutrality of anticipated money holds, while disaggregated testing indicates that real impacts from anticipated money do exist.

Part Three, "Anticipated Money and Production with Rigidities in Output Price or Purchased Input Costs," switches from testing the actual impacts of anticipated money to an examination of a theoretical model of anticipated money impacts. The focus here is to move beyond the all-nominal-values-freely-flexible assumptions common in previous theoretical models. The paper here assesses results where production decisions are based not only on the producer's output price but also purchased input costs, and one of the nominal values is temporarily rigid. A series of three cases examines the real impacts from currently anticipated money under various combinations of output price and purchased input cost behavior. A final, fourth case addresses the anomaly revealed in the aggregate level versus disaggregated tests of neutrality in essay two. This final case presents an example in which real impacts from anticipated money exist at the disaggregated level, but when output is aggregated across differing market types, the impacts net out to reduce the apparent anticipated money impact. The aggregate level impression may, therefore, suggest anticipated money is neutral, despite the real impacts at disaggregated levels.

Each essay contains its own conclusion section; however, overall conclusions are briefly summarized following Part Three. The appendices to the individual essays are grouped together at the end. Appendix A presents background on the Lucas supply function -- an example of one theoretical model underlying the propositions of anticipated money neutrality. This serves as the theoretical background for the neutrality testing in essays one and two and is also pertinent to the analysis in essay three.

Appendix B discusses the econometric testing procedure in greater detail. The discussion in Appendix B is based around the industry data and tests for essay one's research. However, the basic methods are applicable to the second essay as well. Appendix C gives the supplementary information on data and test models specifically used in essay two's aggregate versus disaggregated testing.

Appendix D pertains strictly to the model in essay three. It presents the derivations and model manipulations for the four separate cases examined in this final essay.

PART ONE

NEUTRALITY OF ANTICIPATED MONEY GROWTH: DISAGGREGATED EMPIRICAL EVIDENCE

ABSTRACT

This paper presents disaggregated empirical evidence on the proposition of some of the new classical macro models that "anticipated money is neutral; only unanticipated money affects real economic variables." (This class of the new classical models is referred to here as the new classical macro neutrality models.) Previous tests of the proposition confine themselves to aggregate level examinations. There are a number of reasons why disaggregation is desirable in testing of the neutrality proposition, particularly in light of aggregate test results supportive of the neutrality hypothesis. This research assesses neutrality of anticipated money with respect to real output in twelve U.S. manufacturing industries.

Section I presents theoretical background on the neutrality proposition. It includes a brief description of the Lucas model -- an example of a new classical macroeconomic model which implies neutrality of anticipated money.

Section II discusses previous empirical testing of neutrality and the previous tests' conclusions. A brief description of the two primary estimation approaches (two-step and joint estimation) is also given. Section III lays out the basis of the disaggregation and the model estimated.

Results are presented in Section IV. Two phases of the test results are discussed: first, an interpretation of the broad overall pattern of F-test results; next, brief comments on some "items to note" concerning

particular impacts across the twelve industries. Section V summarizes conclusions from the disaggregated tests of neutrality.

Two appendices are included to provide greater detail for interested readers. Appendix A provides a fuller explanation of the Lucas supply mechanism (for readers unfamiliar with the model briefly described below in Section I's theoretical background of the neutrality issue.) Appendix B discusses more thoroughly the data and testing procedures in the twelve industries.

SECTION I. THEORETICAL BACKGROUND ON NEUTRALITY

The models set forth by the "new classical macroeconomics" (as it is referred to in the literature) have a clean, parsimonious elegance and appeal. Their streamlined frameworks offer remarkable versatility in addressing diverse issues and generate some powerful theoretical implications. The microeconomic base of these models injects a degree of analytical rigor that macroeconomic models have at times lacked.

However, there are theoretical and practical reasons to believe that a major subset of these new classical macro models does not apply to the U.S. industrial economy, and therefore the theoretical assertions of this set of models are of limited relevance for the actual U.S. economy.

In particular, a proposition emerging from some new classical macroeconomic models is that anticipated money growth will not affect real economic activity (anticipated money is said to be "neutral" with respect to real variables). (This subset of the classical macromodels shall be referred to as the "new classical macro neutrality models.") Frequently, a more restrictive proposition is set out -- that only unanticipated money matters. While this conclusion flows neatly from the assumed economic environment and information sets, that environment is deficient if the models are to provide useful input about actual economic interrelationships. Abstraction in theoretical models is recognized as necessary, but it seems probable that some crucial features of modern economic relationships have been abstracted completely out of these models. The degree of relevance of these models and their conclusions (here, the "only unanticipated money matters" conclusion) is an important issue. This concern about the relevance of the models is partly general -- arising from our general need to refine macroeconomic models such that they provide clearer insights into economic interactions and outcomes. More narrowly, the models' degree of relevance is a concern due to their strong implications for monetary policy. If anticipated money growth is in fact neutral with respect to real variables, this implies a change in money growth for the purposes of affecting real economic activity will not affect the economy to the extent expected. A large portion of policy-oriented money growth (the anticipated portion) is ineffective;[1] only a small residual -- the unanticipated portion of money growth -- has real impacts. If, however, anticipated money is found to be nonneutral, this implies greater room for monetary policy impacts. Therefore, evaluating the degree of relevance of these macro neutrality models is of interest from both the general ("refine the theories") and specific ("monetary policy implications") points of view.

An example of a macro model which implies neutrality of anticipated money is the often cited Lucas supply mechanism (1973). The Lucas model is briefly described below (with further detail for interested readers in Appendix A). The Lucas model is presented primarily to give readers unfamiliar with the new classical macro neutrality models a sense of the theoretical framework and linkages through which anticipated money is found to be neutral in this general class of models.

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[1]The "neutrality of anticipated money" proposition is also referred to by many authors as the "policy ineffectiveness proposition."

The Lucas (1973) supply model is based on producers' information extraction problems as they try to interpret observed price signals. Producers intend to respond to movements in perceived relative prices but not to movements in the aggregate price level (Δp_t). As producers observe changes in their own-market price, they must try to determine what portion is due to a relative price change (meriting output response) and what portion is due to an aggregate price level change. Producers' expectations of the aggregate price level, $E(p_t)$, are formed rationally. Once the expectations about the aggregate price level are formed, deviations of the observed market price from $E(p_t)$ are perceived as a relative price change to which output responds. Thus, Lucas's supply function for producers in market z is as follows:

(1) $y_t(z) = \gamma_1[p_t(z) - E(p_t)] + \lambda y_{t-1}(z) \qquad \gamma_1 > 0 \quad , \quad |\lambda| < 1$

where markets are indexed by z. $y_t(z)$ is actual output in market z, $p_t(z)$ is the observed market z price, p_t is the overall price level and $E(p_t)$ is the expectation of the overall price. All variables are in log form. Aggregate supply is obtained by summing market supplies (1) across all markets.

(2) $y_t = \gamma_2[p_t - E(p_t)] + \lambda y_{t-1}$

where y_t is current aggregate output, p_t is the current aggregate price level, and $E(p_t)$ is the expectation of the current aggregate price level. Thus, aggregate supply depends on the deviation of the current aggregate price level from the expected price level.

Consider again the aggregate price level term (p_t). Movements in the aggregate price level will be recognized as often being due to active demand management policies, such as monetary policy measures. This aspect, plus the assumption of rational expectations, is the link by which the anticipated and unanticipated monetary policy impacts become the relevant issue. The anticipated portion of monetary demand management policies will be recognized by producers as inducing aggregate price level changes (therefore captured in both p_t and $E(p_t)$) -- to which producers do not respond. Price movements induced by the unanticipated portion of monetary policy will be interpreted as a relative price change. Individual market supplies, and thus aggregate supply, will respond. The overall result: anticipated money growth does not affect real output; only unanticipated money growth affects real output.

As stated earlier, the Lucas supply mechanism is not the only model which implies the neutrality result. A number of other models -- typically sharing the Lucas model assumptions of flexible prices, and market clearing, equilibrium environments -- use slightly different mechanisms but produce the same message: anticipated money growth has no effect on real output.

With such extreme implications for monetary policy effectiveness, the importance of testing the relevance of the Lucas-type neutrality models for actual economies was quickly recognized. From a theoretical perspective, there are a number of reasons to believe that models of this type will not apply to the U.S. economy. The Lucas-type neutrality models assume freely flexible prices and output. They do not incorporate contracts, sticky prices, multi-period production processes, inventories, etc. Theoretical models addressing these issues have been developed elsewhere[1] and will not be repeated here. The main point is that before getting overly troubled by the monetary policy implications of the new macro neutrality models, or before dismissing the neutrality models as irrelevant, a number of macroeconomists recognized that these propositions need to be tested. The next section describes the previous major empirical tests of the neutrality propositions.

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[1]See, for example, treatment of contracts in Fischer (1977); or Gray (1978); inventories in Blinder (1982), Blinder and Fischer (1981) and Flood and Hodrick (1982); sticky prices in Blinder (1982), as well as several others.

SECTION II. PREVIOUS EMPIRICAL TESTING OF NEUTRALITY

Because of the difficulties associated with modelling and testing within a structural macroeconomic model, the testing efforts of many macroeconomists have focused on developing meaningful tests within the context of reduced-form output or unemployment models.[1, 2]

Robert Barro initiated much of the empirical work on the neutrality hypothesis with a series of papers testing the impact of unanticipated money impacts on aggregate U.S. output and unemployment. His early tests use annual aggregate data, while the most recent (Barro and Rush, 1980) extends the assessment to quarterly aggregate data.

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[1] In fact, the reduced-form approach predominates the testing. See, for example, Barro (1977, 1978), Barro and Rush (1980), Mishkin (1982, 1983), Hoffman and Schlagenhauf (1982), Gordon (1982), Enders and Falk (1983), and many others.

Progress is being made in developing econometric tests using the structural model approach. Hansen and Sargent have contributed heavily to making the approach somewhat more tractable. Hansen and Sargent (1980) provide an example of the structural modelling approach.

[2] Mishkin (1983) discusses his choice of the reduced-form model approach to the testing, rather than choosing to "look at the deep structure of economic relationships by (trying to) estimate parameters describing tastes and technology" (the Hansen and Sargent approach):

"There are advantages to the econometric approach here.... Fewer identifying assumptions are required to implement the econometric models analyzed here because the models are less structural. Because economists disagree about what is the appropriate structure of the economy (see Sims, 1980), empirical results obtained with fewer identifying assumptions are worth studying. The main conclusion to be drawn from these remarks is not that one set of econometric methodology is preferable to another; rather, all these techniques are needed for us to obtain a better understanding of how the economy works" (Mishkin, 1983, p. 2).

Very generally, the basic format of tests on the new classical macro neutrality proposition ("anticipated money does not affect real output; only unanticipated money matters") is to specify a model of real economic activity as a function of anticipated and unanticipated money growth. A reduced-form linear model such as the following is common:

$$(3) \quad y_t = \sum_{i=0}^{p} \alpha_i m^a_{t-i} + \sum_{i=o}^{p} \beta_i m^u_{t-i} + x_t \Phi + u_t$$

where y_t is real output or unemployment; m^a_t and m^u_t are anticipated and unanticipated money growth, respectively; x_t is a vector of other explanatory variables; u_t is the disturbance term.

Since anticipated and unanticipated components of money growth are unobservable variables, in order to implement the tests, actual money growth (m_t) must be decomposed to its anticipated and unanticipated components: ($m_t = m^a_t + m^u_t$). Barro's tests (also Barro and Rush) addressed this problem by first specifying a forecasting model of U.S. money supply growth. For example, in general notation:

$$(4) \quad m_t = z_t \psi + v_t$$

where z_t is a vector of variables relevant to forecasting money growth. v_t is the forecast error. Predicted values from the money supply model (as in (4)) represent anticipated money (m^a_t); unanticipated money (m^u_t) is the money forecast error. The anticipated and unanticipated money components generated by this forecasting model are then used (in 3) to estimate the output or unemployment responses. (This general estimation procedure used by Barro and Barro and Rush has been referred to in the literature as a two-step procedure.")[1] Specifically, the money forecasting equation used by Barro and Rush (i.e., their specific version of (4)) is as follows:

$$(5) \quad m_t = a_0 + \sum_{i=1}^{6} b_i m_{t-i} + \sum_{i=1}^{3} c_i U_{t-i} + d_o FedV_t + v_t$$

where m_t is the actual money growth rate (seasonally adjusted quarterly M1), U_t is an unemployment rate measure, and $FedV_t$ measures the size of the federal budget deficit relative to "normal" levels. (More detailed description and discussion of this money forecasting specification is available in the original sources. Interested readers should, in particular, consult Barro (1977) and Barro and Rush (1980)). This forecasting model was estimated by OLS to generate the anticipated and unanticipated

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[1] Summarizing concisely, the basic approach of the two-step procedure is as follows:

i) Estimate a money growth model via OLS, as eq. (4):

$$(4) \quad m_t = z_t \psi + v_t$$

Predicted values from the model serve as anticipated money; residuals serve as unanticipated money

ii) Substitute these estimated m_t^a, m_t^u values in to the output equation (eq. (3), repeated here for convenience) to estimate the output response:

$$(3) \quad y_t = \Sigma\alpha_i m_{t-i}^a + \Sigma\beta_i m_{t-i}^u + x_t\Phi + u_t$$

Substitution of (4) into (3) yields:

$$(3)' \quad y_t = \Sigma\alpha_i[z_{t-i}\gamma^*] + \Sigma\beta_i[m_{t-i} - z_{t-i}\gamma^*] + x_t\Phi + u_t$$

where * denotes estimated values from the stage 1 estimation of (4).

money series needed for estimation of the output (or unemployment) responses to monetary shocks.

Examining the specification of the output equation in the Barro-Rush tests, a typical example of an estimated equation is as follows:

$$(6) \quad y_t = a_1 + \sum_{i=0}^{8} \beta_i m^u_{t-i} + d_1 \log(G_t) + d_2 T + u_t$$

where y_t is the log of aggregate GNP in 1972 dollars; m^u_t is unanticipated money, (generated by (5)); G_t is real federal government expenditures; T is trend growth over time.

As is evident in (6), Barro and Rush's quarterly tests regressed real output (and unemployment) on current and lagged unanticipated money, plus other explanatory variables. They found that unanticipated money had a statistically significant positive impact on output and negative impact on unemployment. The annual tests (Barro, 1977) also include total actual money (m_t) in some models. Tests of the contribution of total actual money growth to explaining output (above and beyond that of unanticipated money) concluded that total money was not statistically significant. It appeared that the majority of money impacts arose from unanticipated money growth. The Barro and Barro-Rush results were widely interpreted as apparent confirmation of the new classical macroeconomic proposition. In particular, the results were taken to indicate that unanticipated money growth significantly affects real variables, but anticipated money growth has no significant effect on real aggregate output.

This aggregate empirical evidence supportive of the neutrality hypothesis spurred both controversy and further empirical testing. Some of the controversy surrounds Barro and Rush's two-stage estimation method. In particular, Abel and Mishkin (1981) address the problems that may arise when the parameters of the reduced-form output (or unemployment) equation (3) are estimated subject to the anticipated and unanticipated money estimates obtained in stage one (4). Examine again the equations involved in testing neutrality (Equations (3) and (4), repeated here for convenience):

(4) $m_t = z_t\psi + v_t$

(3) $y_t = \Sigma\alpha_i m^a_{t-i} + \Sigma\beta_i m^u_{t-i} + x_t\Phi + u_t$

Under the two-step procedure, the output equation becomes:

(3)' $y_t = \Sigma\alpha_i [z_{t-i}\psi^*] + \Sigma\beta_i [m_{t-i} - z_{t-i}\psi^*] + x_t\Phi + u_t$

In the two-stage procedure, the ψ parameters in (3)' are assumed to be the same as the OLS estimates in stage one. The two-step procedure ignores possible covariance of the parameter estimates across equations (i.e., the covariance of the $\hat{\psi}_i$'s with the $\hat{\alpha}_i$'s and $\hat{\beta}_i$'s). If the population covariances between the parameter estimates across the money and output equations are nonzero, then the two-stage estimates are not efficient. Also, calculations of standard errors, t-statistics, etc. which do not account for the covariance will not be theoretically appropriate if such covariance does exist. Note, however, that the parameter estimates in the two-step procedure are consistent estimates. [In general, if the parameter estimates in stage one (the ψ's in (4)) are consistent, then one can still get consistent α_i and β_i estimates in stage two.] Thus, the efficiency, but not the consistency, of estimates is called into question in the two-step procedure.[1]

Mishkin (1982) applies the joint estimation procedure[2] to test neutrality of anticipated money growth, again using aggregate level U.S. output data. Mishkin's tests present mixed results. In particular, tests using long lags on money variables (twenty quarters each of m^a and m^u), reject neutrality of anticipated money growth. However, shorter lag length models (eleven quarters of m^a and m^u) fail to reject neutrality. Hoffman and Schlagenhauf (1982) test neutrality of anticipated money on aggregate real output for seven nations and also obtain mixed results.[3] Yet, other aggregate tests support the neutrality proposition (Attfield, Demery and Duck, 1981; Wogin, 1980).

Thus, there is no clear empirical confirmation or overturning of the theoretical propositions that anticipated money growth is neutral. Note,

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[1]As a point of information, Barro estimated some of his earlier models using the joint estimation procedure suggested by Abel and Mishkin (see Barro and Rush, 1980). He found that anticipated money and ouput specifications were similar to those in the two-step estimation. His conclusions regarding the neutrality of anticipated money were not altered.

[2]The joint estimation procedure is described in Abel and Mishkin (1983). Summarizing briefly, in the joint estimation procedure the money and output equations [(3) and (4)] are estimated as a simultaneous system. Since this procedure allows for "information crossovers" between equations (3) and (4) as the parameters are estimated (thus allowing for possible covariance), the joint procedure yields more efficient estimates of the α_i, β_i and γ_i.

[3]In particular, longer lag models in the Hoffman and Schlagenhauf tests reject neutrality for four nations, fail to reject neutrality for three nations. The shorter lag models fail to reject the neutrality hypothesis for five of the seven nations.

however, that all of these previous tests of neutrality confine attention to use of aggregate level data only.

For a number of reasons, aggregate testing alone is not sufficient in testing the neutrality proposition. In particular, as one examines again the notion of neutrality as implied by the theoretical models (Lucas, 1972; Lucas, 1973; Barro, 1976), it is evident that true "neutrality" in the sense held by these models requires that anticipated money growth have no real impact -- not only at the aggregate output level, but also across the individual markets. Stating this more formally, let y^a denote aggregate real output and $y(z)$ denote real output of individual markets. By definition, $y^a = \sum_{i=1}^{N} y(z)$. A necessary condition for neutrality is that anticipated money growth have no real impact at the aggregate level (y^a). Furthermore, neutrality as implied by the models also requires no anticipated money growth impacts across the $y(z)$ (neutrality across all $y(z)$ is a necessary and sufficient condition).

Testing is needed at both the aggregate and disaggregated levels. Particularly in light of the aggregate results supportive of neutrality, it is important to dig behind this aggregate picture with a disaggregated neutrality examination. In addition, given that the theory is cast in the context of signal extraction problems of market producers, testing the disaggregate level real output responses to anticipated and unanticipated money growth is valuable. The research here aims at filling these gaps in present neutrality research. It examines the "only unanticipated money growth matters; anticipated money growth is neutral" proposition across twelve U.S. manufacturing industries.

Beyond these primary motivations for disaggregated testing of the neutrality hypothesis, additional benefits accompany. Given that the answer to a question of "whether" neutrality holds at a disaggregated level is not a pure "yes" or "no", one is able to assess the extent to which neutrality holds. This can be evaluated in terms of number of industries and in terms of the strength of anticipated and unanticipated money growth impacts relative to those hypothesized. Finally, disaggregated testing allows one to glean further information concerning monetary impacts upon various industries. Clearly, impacts will not be uniform across all industries.

As is discussed below, results of the disaggregated tests here indicate real impacts from anticipated money growth do exist in the majority of industries tested. Anticipated money is not neutral in the majority of industries tested. In addition to this broad overall conclusion, the disaggregated tests produce some interesting insights. The next section describes the procedure for the disaggregated testing. Section IV presents the test results, along with discussion of some interesting patterns uncovered in the testing.

SECTION III. DISAGGREGATED TESTING OF NEUTRALITY OF ANTICIPATED MONEY GROWTH

Section II reviewed previous empirical tests of the anticipated-unanticipated money propositions, including a brief discussion of estimation procedures, as well as the test results. Recall that a reduced form linear model, such as (3) is common. In pursuing the disaggregated examination of the neutrality hypothesis, equation (3) requires modification to allow different market responses to the respective money growth variables. A model of disaggregated real output for the z^{th} market can be represented as follows:

$$(7) \quad y_t(z) = \sum_{i=0}^{p} \alpha_i(z) m^a_{t-i} + \sum_{i=0}^{p} \beta(z) m^u_{t-i} + x_t(z)\phi(z) + u_t(z)$$

where terms are as previously defined,[1] but, as indicated by the index z, terms are now made market specific.

With respect to the $y_t(z)$ series, several levels of disaggregation are possible for a study such as this. The main constraint is the availability of quality time series data of sufficient length covering a cross section of sectors. The measures of disaggregated real output used here are subcomponent series of the Industrial Production (IP) index (Federal Reserve Board of Governors) for twelve U.S. manufacturing

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[1]Recall, all variables are in logarithms. $y_t(z)$ is the log of real output in industry (z); m^a and m^u are the anticipated and unanticipated portion of money growth (M1), respectively; $x_t(z)$ is a matrix of other factors important to determining real output in industry z; $a_i(z)$, $\beta_i(z)$, $\phi(z)$ are coefficient vectors; $u_t(z)$ is a serially uncorrelated random disturbance term which is independent of other right-hand-side variables and has zero mean and constant variance.

industries. The sample includes both durable and nondurable goods industries and covers over half of total industrial production.[1] Data are quarterly, seasonally unadjusted industry output for 1955 to 1978. This time frame avoids the sharp breaks in monetary policy procedures of the 1951 Federal Reserve-Treasury Accord and the October, 1979, switch to closer monetary aggregate targeting.

One additional comment concerning the disaggregated output measures -- while finer levels of disaggregation (beyond the two- and three-digit level) are not always possible or desirable,[2] a broader breakdown on the disaggregation is possible and useful. At this broader level, real Gross National Product data are available disaggregated to its "goods", "services" and "structures" components. Tests on the GNP

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[1]The sample consists primarily of two-digit SIC (standard industrial code) industries. The two-digit level was chosen to correspond to price and unemployment data available elsewhere at the two-digit level and, thus, preserve options for future research on price and unemployment responses.

Some three-digit-level industries were included in order to target the neutrality analysis toward a particular industry within a broader two-digit classification (i.e., autos within "transportation equipment"; steel within "primary metals").

Specifically, the twelve industries are primary metals, iron and steel (referred to hereafter as "steel"), fabricated metal products, electrical equipment, motor vehicles and parts ("autos"), aircraft and parts, apparel, textile mill products, chemicals and products, printing and publishing, utilities, and electric utility (nonresidential) sales.

Appendix B more fully describes the specific series selected and the Industrial Production Index more generally. Appendix B is presented, along with other appendices, at the end of the dissertation.

[2]Data problems arise with finer disaggregation efforts. The data are often unavailable or are so full of "noise" that it obscures real economic responses which may, in fact, occur.

subcomponents plus total GNP were conducted. This broader disaggregation establishes a link between previous aggregate tests of neutrality and the industry disaggregation here. In addition, these tests reveal an anomaly across results of aggregate level and disaggregated neutrality tests. The pattern of results suggests that use of aggregate level data alone masks real anticipated money impacts which are evident at the disaggregated level. Part Two of this dissertation presents this research.

Returning to coverage of the variables in the real output model (7), as before, m^a is the predictable portion of money growth, based on the money forecasting equation (4), and m^u is the random, unpredictable portion of money growth. The money forecasting equation consists of three lags of the unemployment rate, a measure of the federal budget deficit relative to normal levels and lags of actual money growth.[1] Tests for serial correlation of the unanticipated money growth (m^u) series indicate it is a white noise series with no significant serial correlation, thus indicating no "systematic prediction errors" emerge from this money forecasting equation.

The $x_t(z)\phi(z)$ component captures "other economic influences" relevant to determining industry output. A separate and unique real output model

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[1]This is the specification used in the Barro-Rush (1980) quarterly tests of neutrality. The specification here compares well with that used elsewhere. (For example, Attfield, Demery and Duck (1981) use real federal borrowing, lagged current account balance of payment surplus, and lagged actual money growth.) While particular money forecasting equation specifications differ across studies, impacts of variables omitted are very likely captured by the lagged money growth terms in the forecasting equation here. Furthermore, Mishkin (1982) and Hoffman, Low, and Schlagenhauf (1982) find that test results are robust across reasonable variations in the money forecasting equation.

was estimated for each industry, with the $x_t(z)$ vector being the vehicle to address special characteristics or events in the individual industries. For each industry, the $x_t(z)$ vector included a constant, trend growth rate, and three seasonal variables to capture the regular (not money-induced) impacts important to each industry. The trend growth term was adapted to handle cases of nonlinear industry growth over the time period.[1] Where relevant, the $x_t(z)$ vector also included treatment of special real shocks to the industry, i.e., real relative demand or input supply shifts (not money-induced) to which the industry would properly respond. For example, $x_t(z)$ captured such real shocks as the impacts of a severe steel industry strike, possible impacts from the 1970's oil supply shocks, and impacts of the Vietnam War military escalation upon the aircraft industry. Finally, as should be expected in many manufacturing processes, current output activity is often related to a portion of previous output levels. (This may occur for various reasons. For example, it may be due to high costs of altering production rates in the industry, to multi-period production processes, etc.) The degree of "persistence"

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[1]Alternative trends were examined (in series where it appeared relevant) to ensure that low Durbin-Watson values were not caused by inappropriate use of a linear trend where nonlinear was required. It was found that 1) a cubic trend (T, T^2, T^3) for textiles and 2) a "piecewise linear trend" for electric utilites (flatter linear trend for 1974:I to 1978:I) improved the fit of the model and made a statistically significant contribution. However, in both cases, the nonlinear trend did not greatly alter the significance conclusions on money variables from those yielded by the linear trend models (at 5% significance level). Other than these two cases of nonlinear trends, the linear trend was found to be as appropriate or superior to the variety of nonlinear trends examined for all other industries.

differs across manufacturing industries. For each industry, the $x_t(z)$ vector included lagged output variables to capture the degree of "persistence" indicated as relevant to the industry.

A comment concerning the lag length on the anticipated and unanticipated money growth variables in the industry real output model (7) is useful. Aggregate neutrality studies elsewhere include up to twenty lags of the respective money growth variables.[1] In the disaggregated research here, tests were conducted for the appropriate lag length on money variables in the real output model (3). Tests for each industry series identified at most four quarters of the respective money variables as relevant.[2] (In some cases, only current money variables had significant impacts.)[3] To establish some uniformity of treatment across series and

[1]For example, Mishkin (1982) tests aggregate neutrality in models using twenty quarterly lags and eleven quarterly lags of the money variables. Barro and Rush's (1980) aggregate tests use eleven quarterly lags. Hoffman and Schlagenhauf (1982) use eleven and seven quarterly lags of money.

[2]Concerning this issue of long money growth lags in aggregate models versus the shorter money lags found to be relevant in disaggregated tests here -- one interpretation is that monetary impacts (either anticipated or unanticipated) move through the industry level more rapidly than through the aggregate economy. The result is more likely due to a technical factor in the estimation. The lagged output variable in (7) may cause the shortened lag length on money growth impacts.

[3]Estimations using only current anticipated and unanticipated money as the money growth variables were also conducted. The significance test conclusions correspond to those reported below for the "four quarters of money variables" models.

strengthen comparability of results, estimations here used four quarterly lags of money growth variables. The estimations did not carry the long money lags (i.e., 20 quarters of m^a and m^u), since the extraneous lags cause substantial and unnecessary loss in degrees of freedom and reduce the power of significance tests.[1]

As indicated, estimation of the real output responses utilizes the predicted values obtained from the OLS estimate of the money forecasting equation as anticipated money growth (m^a) and the residuals as unanticipated money growth (m^u). Recall from Section II's discussion that this procedure is referred to in the literature as a "two-step procedure," and the alternative procedure used in some neutrality tests (Mishkin, 1982; and Abel and Mishkin, 1983) is joint estimation of the money forecasting (4) and real output equations (7). Evaluating the two procedures, both the joint and two-step procedures generate consistent parameter estimates. The joint estimation procedure produces more efficient estimates in those cases where nonzero covariance exists across the parameters of the money forecasting and real output models. An econometric evaluation of the two

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[1]Mishkin (1982) argues for long lags of money variables on the basis that omission of relevant variables results in biased estimates, while inclusion of irrelevant variables merely reduces the power of the test. However, as indicated here, tests determined the long lags (4th through 20th lags) were <u>not</u> relevant variables in model (7), thus eliminating the "biased estimates" issue. Furthermore, the impact of losing 34 degrees of freedom due to extraneous lag variables is not inconsequential.

procedures (Hoffman, Low, and Schlagenhauf, 1982), however, indicates that the joint estimation procedure is not necessarily superior to the two-step procedure in detecting the existence or violation of neutrality of anticipated money variables. The study indicates that the incremental gains from the joint versus the two-step procedure are small in many cases, whereas cost and tractability differences are substantial. Another consideration which makes the two-step procedure more appropriate for the disaggregated testing is that it maintains greater uniformity of procedure across the twelve industry estimations and maintains better comparability of results.[1]

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[1]In light of Mishkin's work testing neutrality, the choice of estimation approach was carefully considered. The Hoffman, Low and Schlagenhauf (1982) study provides thorough comparison of the two procedures and indicates no clear advantage to the joint procedure. The two-step approach has been selected in several current neutrality studies (Gordon, 1982; Enders and Falk, 1984; Skaggs, 1983). It was selected as the most reasonable approach to a multi-industry study of neutrality for several additional reasons. Joint estimation in a multi-industry study implies re-estimation of the money forecasting equation for each industry. Time and cost considerations face one with a trade-off between two-stage estimation across a variety of industries versus joint estimation on a much smaller set. Joint estimation forces one to sacrifice breadth. Perhaps more importantly, the variation of the money specifications implicit in the joint estimation procedure undercuts comparability of results across industries.

As should be evident from the above considerations, the two-step procedure is preferable for the purpose of this study -- that of moving the neutrality assessment from the aggregate to a disaggregated level.

Given that serially correlated residuals has serious implications for test of significance conclusions,[1] each real output model (7) was tested for serial correlation of the residuals.[2] In no case did statistically significant serial correlation prevail (using a 1% significance level), thus indicating the conclusions produced by the F-tests of significance are free from serial correlation distortions.

With this background on the disaggregated test procedures, attention turns now to the test results. Section IV presents the disaggregated evidence on anticipated money growth impacts.

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[1]Granger and Newbold (1974) studied the impact failing to correct for serial correlation upon significance test conclusions. They found that conclusions about the significance of variables changed substantially between testing models with and without serial correlation corrections. In particular, when serial correlation was present, there was a tendency to conclude that a statistically significant relationship existed, when in fact no relationship existed.

For reference, in the disaggregated testing here, models were estimated and tested which did and did not correct for serial correlation. Results were similar to Granger and Newbold's findings -- the magnitude of F statistics often changed drastically between the uncorrected and corrected models. For example, in the electrical equipment series, F statistics in the uncorrected estimation were 7.55 and 2.53 for anticipated and unanticipated money respectively. After correction for serial correlation, corresponding F statistics were 2.88 and 3.19.

[2]Concerning the test for serial correlation, the Durbin-Watson test is not valid in models with stochastic regressors, as applies here. An alternative test, Durbin's h test, breaks down in some situations where the number of observations is large (the formula for h involves the quantity: $\sqrt{1-T\ \mathrm{var}(\hat{\rho})}$. When T is large, this can produce situations where one needs the square root of a negative number). When T is sufficiently large, asymptotic distribution theory applies, and thus it is valid to use OLS residual estimates $[u_{t,OLS} = \hat{\rho}u_{t-1,OLS}+\varepsilon_t]$, conducting a t-test on $\hat{\rho}$. This is the procedure used here to test for first-order and higher-order serial correlation.

SECTION IV. DISAGGREGATED TEST RESULTS

The Overall Summary

The general summary of the disaggregated test results produces a dismal picture with respect to the "anticipated money growth has no real impacts; only unanticipated money growth matters" hypothesis. Even if results are examined from a less restrictive perspective, focusing separately on the anticipated money growth impacts and the unanticipated money growth impacts, one still finds anticipated money growth is not neutral in the majority of cases; real impacts at the disaggregated level do appear to exist. In addition, these disaggregated tests across twelve manufacturing industries indicate that unanticipated money growth does not have the major impact on real output which the theoretical models propose. Tests here indicate anticipated money growth has real impacts in more cases and at finer significance levels than does the unanticipated money growth. Given this very general summary of the results, attention below turns to specific details in the test results.

The Specifics

Table 1 presents the results for tests of significance on anticipated and unanticipated money growth variables in the twelve industries studied. The major interest is in the significance of groups of variables, rather than in the particular point estimates and their lag patterns.

Therefore, the statistics presented in Table 1 are F tests on four quarters of the respective money variables.[1]

"Only Unanticipated Money Growth Matters" Results

Examine first the test results with respect to the hypothesis that only unanticipated money matters. Column 1 presents F-tests on the α_i, or anticipated money growth impacts (Ho: all $\alpha_i=0$, i=0...3). Column 2 presents F-tests on the β_i, or unanticipated money growth impacts (Ho: all $\beta_i=0$, i=0...3). Column 3 provides reference information for more precise interpretation of column 1's test on m^a impacts. In each industry, total actual money growth was tested for statistically significant impacts on real output. This test (column 3) serves primarily as a check on findings of "no anticipated money impacts" to determine whether actual total money growth has impacts. It seems irrelevant to argue that anticipated money does not matter in an industry when, in fact, total money growth does not affect the industry's real output.

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[1]Several issues concerning the use of t statistics and attention to point estimates of the m^a_{t-i}, m^u_{t-i} impacts need to be considered. Due to multicollinearity within the m^a series, and across the m^a and m^u series, a t-test is not the appropriate statistic. Multicollinearity causes large standard errors of individiual coefficient estimates and, therefore, low t-statistics, suggesting no statistical impact from that variable. An F test on the group of collinear variables, however, would detect the significant impact. In addition, as is common when distributed lags of a particular variable enter the model (here, lags of m^a and m^u), unconstrained point estimates of the distributed lag may display an uninterpretable, oscillating positive, negative, positive pattern. For these reasons, in models such as are typicaly used for neutrality testing, the F statistic rather than the t statistic is the appropriate test statistic. If the model includes both m^a and m^u, the interpretability of the point estimates is reduced. Given the above, test results reported here present F statistics for the respective hypothesis tests and actual point estimates for the twelve industries are not presented.

Table 1. F tests on anticipated, unanticipated money growth impacts

Model: $y_t = x_t\phi + \sum_{i=0}^{3} \alpha_i m^a_{t-i} + \sum_{i=0}^{3} \beta_i m^u_{t-i}$ where $x_t\phi = a_0 + b_1 T + \sum_{i=1}^{3} c_i S_i + \sum_{i=1}^{k} d_i y_{t-i}$

Hypothesis→ / Series↓	(1) All $\alpha_i = 0$ "No anticipated money impacts"	(2) All $\beta_i = 0$ "No unanticipated money impacts"	(3) "No total money impacts[a]"
Primary Metals	4.61**(.002)[b]	0.54 (.70)	6.65**(.0001)
Steel	3.11* (.02)	0.40 (.81)	5.08**(.001)
Fabricated Metal Products	3.56**(.01)	1.54 (.20)	5.14**(.001)
Elec. Equipment	2.88* (.03)	3.19* (.02)	6.23**(.0002)
Autos and Parts	2.57* (.04)	1.51 (.21)	3.92**(.006)
Aircraft and Parts	1.03 (.40)	2.67* (.04)	1.66 (.169)
Apparel	1.41 (.24)	1.73 (.15)	2.83* (.031)
Textiles	5.67**(.0005)	3.35**(.01)	3.11* (.021)
Chemicals and Products	2.82* (.03)	2.42* (.05)	4.02**(.005)
Printing and Publishing	1.77 (.14)	2.14 (.08)	1.47 (.228)
Utilities	0.37 (.83)	1.03 (.40)	3.03* (.023)
Electric Utilities	1.01 (.36)	0.14 (.97)	4.13**(.005)

[a]Model for "total money impact" tests (column 3):

$$y_t = x_t(z)\phi(z) + \sum_{i=0}^{3} \gamma_i m_{t-i}$$ where m_t is actual total money growth.

[b]Values in parentheses give probability level of significance.

*Significant at 5% level.

**Significant at 1% level.

Neutrality of anticipated money implies the F-tests in column 1 should fail to reject the hypothesis of "no significant m^a impacts, all $\alpha_i=0$." Simultaneously, if unanticipated money growth is a major impact on real output, the F-tests in column 2 should reject the hypothesis of "no significant m^u impacts, all $\beta_i=0$." Note that support for the "only unanticipated money growth has real economic impacts" hypothesis requires a finding of a not statistically significant F value in column 1, plus a statistically significant F value in column 2. Examination of columns 1 and 2 together indicates that the "only unanticipated money matters" proposition appears to not hold in this disaggregated testing. In only one of the twelve series (aircraft and parts) does only the unanticipated money growth affect real output. If one considers the nature of the aircraft industry, this finding in support of the only unanticipated money matters proposition seems implausible. Typically, bursts in aircraft production occur when a major manufacturer introduces a new model or when military orders for aircraft increase. Drawing upon column 3's reference information, note that total money growth does not have significant impact in the aircraft industry.

The aircraft industry's result supportive of the "only m^u matters" hypothesis, therefore, seems to be a false impression: anticipated money appears to be neutral because total money growth in fact was not significant; the unanticipated money growth result may be due to incomplete treatment of the Vietnam War stimulus to the aircraft industry.

Recall, the "only unanticipated money growth matters" hypothesis does appear to receive support in several aggregate level tests. The implication drawn from the aggregate results is that anticipated money growth is not affecting real economic activity. This probe behind the aggregate results using a disaggregated real output sample covering over 50% of U.S. industrial production indicates it is not the case that only unanticipated money affects real economic activity. Eleven of the twelve cases fail to support the hypothesis.

Anticipated Money Growth Impacts

A less restrictive view may be taken in assessing the significance test results relative to the theory's hypothesized impacts for anticipated and unanticipated money growth. Rather than assess the joint proposition that "all α_i0, and some β_i=0" (anticipated money growth does not affect real output, and unanticipated money growth does affect real output), one can instead focus the examination on the individual hypotheses. Assessing first the anticipated money growth impacts, the theoretical model asserts "all α_i=0; no significant real impacts occur from the predictable portion of money growth." As indicated by the F statistics on the α_i's in column 1, significant anticipated money growth impacts do exist in the majority of industries tested (seven of the twelve). Note also from the reference tests on total money growth impacts (column 3), that two of the five industries in which "all α_i=0" is not rejected (anticipated money growth appears neutral) are also industries in which total money growth does not have significant impact. At best, three of twelve cases support neutrality of anticipated money. In most cases, the tests indicate real impacts exist from anticipated money growth.

Unanticipated Money Growth Impacts

Turning to the unanticipated money growth impacts, the theoretical model asserts "real impacts exist from unanticipated money; some $\beta_i \neq 0$." As examination of column 2 indicates, in only one-third of the cases is the hypothesis supported. Rather than m^u being the major source of real output impacts (as the theoretical models imply), disaggregated test results here indicate unanticipated money growth does not matter (eight of twelve series) more often that it does affect real output (four of twelve series).

In addition to examining the anticipated money growth and unanticipated money growth impacts (relative to the theoretically hypothesized impacts) in terms of number of industries, one can also get a sense of the strength of m^a and m^u impacts relative to the hypotheses (i.e., when unanticipated money growth is found to be significant, is it just barely significant at the 5% level, or is it also significant at smaller significance levels?). While it is not valid to directly compare the magnitude of the F statistics on m^a and m^u variables, note that if the significance level is set at the 1% level rather than the 5% level, the conclusion now is that unanticipated money growth impacts are significant in only one case, whereas anticipated money growth impacts are significant in several cases at the 1% level or smaller.

The main point is that aggregate test results are widely interpreted as indicating no real impacts exist from the predictable portion of money growth; only the random, unpredictable portion of money growth has real impacts. This probe behind the aggregate test indicates the aggregate picture may be misleading. Tests here indicate the restrictive hypothesis ("only unanticipated money matters") does not hold if examined at a disaggregated level. The less restrictive assessment of the individual hypotheses also indicates that real impacts from anticipated money growth exist at the disaggregated level which are not detected when one aggregates all U.S. production and tests solely at the aggregate level. Contrary to the hypothesis supported by tests with aggregate data, the disaggregated examination here finds anticipated money growth matters more often than unanticipated money growth and, in many cases, at a finer significance level.[1]

Patterns Across Industries

Beyond examining the disaggregated results from the perspective of support or lack of support for the "only unanticipated money growth matters" hypothesis, notice also a few patterns of impacts reflected in Table 1's disaggregated test results. Column 3 indicates actual money growth has particularly strong impacts in the durable goods industries (five of the six durable goods industries have F values significant at or below the 0.6% significance level). Columns 1 and 2 indicate that the

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[1] Ideally, tests would also allow statements concerning the sign and magnitude of respective current and lagged m^a and m^u impacts. Econometric methods as developed at this point do not allow comparisons of this sort. As mentioned before, multicollinearity interferes with valid interpretation of the point estimates. The F test, which always yields a positive value, indicates whether variables have a <u>significant</u> impact, but does not establish the sign of the impact. Test information concerning <u>sign</u> as well as significance of impacts would be useful in resolving the aggregate versus disaggregated test results and is an issue for further research.

impacts of money growth in the durable goods industries primarily come from the anticipated portion of money growth rather than the unanticipated money growth. Assessing the five durable good industries where "actual money growth matters," four of the five have impacts from m^a only; both anticipated and unanticipated money growth are significant in the fifth industry.

The impacts of anticipated money growth in the durable good industries are strong, relative to m^a impacts in utilities and nondurable good industries (as indicated by the probability level of statistical significance given in parentheses). Furthermore, notice that anticipated money growth has its strongest impact in the basic industry of primary metals ($F = 4.61$), with m^a impacts diminishing a bit as one moves through the fabricated metals ($F = 3.56$), electrical equipment ($F = 2.88$) and autos and parts ($F = 2.57$) industries. Unanticipated money growth has some of the weakest impacts in the same basic durable good industries in which the strongest anticipated money impacts exist (primary metals: F on $m^u = .54$; steel: F on $m^u = .40$). Impacts of unanticipated money in durable good industries are, in general, weak relative to those in nondurable good industries (utilities excluded).

Also useful in examining impacts across the industries are the results of estimations and tests of real output models with only the current values of the anticipated and unanticipated money growth variables.[1] Table 2 presents the coefficient estimates and F tests for the impacts of the current anticipated and unanticipated portions of money growth in the twelve industries.[2,3]

Impacts from current anticipated money growth are highly significant in the majority of durable goods industries (four of the five durable good industries in which actual money growth mattered). Across all industries, point coefficient estimates indicate current anticipated money impacts are, on average, over two and a half times as large as current

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[1]Model: $y_t(z) = \alpha_o(z)m_t^a + \beta_o(z)m_t^u + x_t(z)\phi(z)$ where $x_t(z)\phi(z)$ is as previously defined. Some theoretical models of anticipated money neutrality (Lucas, 1973) express real output (y_t) as a function of the current shock only. There are a number of reasons to expect impacts may be spread over several periods when considering modern industrial production activity (for example, multi-period production processes, multi-period contracts, and inventory holdings may distribute responses over several periods). "Current money only" models do provide useful information and are thus included here. However, the focus of interpretation is based on the model with four quarters of the respective money growth variables in which lagged m^a, m^u impacts can be expressed.

[2]Due to the nature of the construction of the m^a, m^u series (where current m^u is orthogonal to current m^a), models which include only the current money variables do not suffer from the multicollinearity problems mentioned earlier. Thus, the point estimates for current anticipated and unanticipated money growth impacts can be validly interpreted in this model.

[3]Notice that, consistent with the conclusions of the F tests in the "four quarters of m^a, m^u" models (Table 1), tests in the "current m^a, m^u" models indicate (i) the hypothesis that "only unanticipated money growth matters" is supported in only one of the twelve series, (ii) current anticipated money growth is significant more often (seven of twelve cases) than is unanticipated money growth (three of twelve cases); (iii) anticipated money impacts typically are significant at a smaller probability level than are unanticipated money impacts.

Table 2. Current anticipated, unanticipated money growth impacts

Model: $y_t(z) = x_t(z)\phi(z) + \alpha_o(z)m_t^a + \beta_o(z)m_t^u$

where $x_t(z)\phi(z)$ is as previously defined

	Anticipated Money		Unanticipated Money	
Series↓	α_o	F statistic H_o: $\alpha_o = 0$	β_o	F statistic H_o: $\beta_o = 0$
Primary Metals	8.11**	7.71**(.007)[a]	1.69	.734 (.394)
Steel	8.24*	4.66* (.034)	1.16	.201 (.655)
Fabricated Metals	3.51**	8.15**(.005)	1.23	2.36 (.128)
Elec. Equipment	3.50**	8.29**(.005)	2.26**	9.11**(.003)
Autos and Parts	6.80	3.08 (.083)	4.41	3.02 (.086)
Aircraft and Parts	.47	.184 (.669)	1.66*	5.70* (.019)
Apparel	1.63	2.20 (.142)	1.41*	4.45* (.038)
Textiles	3.61**	13.30**(.0005)	.692	1.25 (.267)
Chemicals and Products	3.53**	11.35**(.001)	1.09	2.77 (.100)
Printing and Publishing	2.37	3.03 (.085)	.53	.351 (.555)
Utilities	1.38*	4.34* (.040)	-.232	.280 (.598)
Electric Utilities	.91	2.48 (.119)	-.370	.987 (.323)

[a]Values in parentheses give probability level of significance.

*Significant at 5% level.

**Significant at 1% level.

unanticipated money impacts (average of all $\alpha_o = 3.6$; average of all $\beta_o = 1.4$). Some of the largest magnitude anticipated money growth impacts occur in the durable goods category (primary metals: $\alpha_o = 8.11$; steel: $\alpha_o = 8.24$; autos: $\alpha_o = 6.8$).

Tests for the relevant anticipated and unanticipated money lag length (within the four quarters) in each industry support the indication that durable good industries are particularly affected by lagged money impacts -- with anticipated money being the component that matters. The full four quarters of anticipated money were found to be significant in the primary metals and steel series, with three quarters of m^a significant in the fabricated metals series. The later lags of anticipated (or unanticipated) money were generally not as significant in nondurable goods industries as in these durable goods industries.

Another particular industry result of interest is the negative coefficient on current unanticipated money in the utilities and electric utilities industries. (Table 2, column 3). Though the coefficient is not statistically significant, it is a definite aberration. The negative coefficient did not occur in any of the models for any other industry[1] but

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[1]Note that, due to the nature of the anticipated and unanticipated money series, the current unanticipated money variable is not colinear with other money variables, even within the "four quarters of money" model. Thus, the point estimate on current unanticipated money can be interpreted.

Across the estimations required to test appropriate trend, treatment of particular industry shocks, money lag length tests, etc., the negative m_t^u coefficient never occurred in other industries. In utilities and electric utilities, however, the negative coefficient consistently occurred.

consistently occurred in the utilities and electric utilities industries. The negative coefficient, therefore, appears to not be a "spurious event" induced by a particular model specification and deserves further consideration.

The explanation of this unusual result may relate to the unique characteristic of the utilities industries as the only tightly regulated industries in the set of twelve. In particular, given that rates received by utilities are regulated, in the short term the price of output is fixed (due to time requirements in form filing, hearings before regulatory commissions, etc.). Costs of production in the utility industry have greater short-run flexibility. A producer facing fixed average or marginal revenue who is hit by an unexpected increase in marginal costs will optimally reduce quantity produced. Regulatory requirements that utilities meet demand at current rates may damp the magnitude of producers' response but not completely wipe out their quantity reduction response.[1] This would lead to a small negative coefficient on current price shock variables (such as the unanticipated money growth shocks). This is not claimed to be the <u>only</u> explanation. It is, however, consistent with the fact that only in these tightly regulated industries did the negative coefficients on current unanticipated money occur.

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[1]The utilities series is comprised of utilities <u>generation</u> as well as actual sales. For example, the hydroelectric generation component includes pumped storage. Thus, utility producers do preserve a degree of output response flexibility, despite regulations to meet demand at the regulated rates.

Summarizing the impacts across industries results, several pieces of evidence indicate durable goods industries are particularly affected by the anticipated portion of money growth. F statistics on the respective money variables (F statistics on m^a, m^u using either four quarters or current money variables) indicate anticipated money has highly significant impacts in the majority of durable goods industries tested. Estimates of point coefficients for current anticipated money impacts are of larger magnitude in the primary metals, steel and auto series than in any other series. In addition, not only current, but lagged anticipated money appears to have significant impacts in several of these industries. The disaggregated tests also indicate the heavily regulated industries (utilities and electric utilities) respond differently to current unanticipated money growth shocks than do other industries. Their fixed price, flexible costs nature may be the explanation for the negative response to monetary surprises. Information on patterns such as these should be useful in identifying the particular transmission mechanism for anticipated and unanticipated money growth impacts, and perhaps differentiating between different mechanisms in different types of industries. Testing on a larger number of industries at the three-digit and four-digit level will be useful in pursuit of this issue.

SECTION V. CONCLUSIONS

Current attention in monetary theory and policy is focusing on the impacts of anticipated money growth versus unanticipated money growth. Several theoretical models assert the predictable portion of money growth has no real impacts; only the unpredictable portion of money growth matters. Support for the "only unanticipated money matters" proposition is provided by a variety of aggregate level tests. As is discussed above, given these aggregate results and the nature of the theoretical models, a disaggregated probe behind the aggregate picture is an important next step.

The disaggregated evidence from tests on twelve U.S. manufacturing industries indicate that at this level: (i) the "only unanticipated money growth has real impacts" hypothesis is not supported; (ii) anticipated money appears to have impacts more often than unanticipated money growth and at finer significance levels; (iii) impacts of current anticipated money growth are typically of larger magnitude than current unanticipated money growth impacts. Econometric procedures, as currently developed, do not allow assessment of the sign of impacts from groups of anticipated or unanticipated money variables, only the significance. Such information would be useful in resolving the issue of the aggregate results supportive of neutrality versus the disaggregate evidence failing to support neutrality. Conceivably, anticipated money growth may cause a positive stimulus in some industries, with negative impacts elsewhere. These may net out to produce aggregate test results which appear to support neutrality when, in fact, at the disaggregated level, real impacts from anticipated money do exist.

An additional line of evidence from the disaggregated test results concerns impacts across various industries. Results here indicate anticipated money growth has strong significant impacts, currently and from lagged m^a values, in the durable goods industries. This result is consistent with alternative theoretical models which point to contracts, inventory holdings, etc. as reasons that anticipated money growth should be expected to have real impacts. Results also indicate the heavily regulated utility industries respond negatively to current monetary surprises. The fixed price, flexible cost nature of this industry seems a likely explanation for this unusual result. Further testing on a larger number of industries may provide the additional information needed to identify the transmission mechanisms for anticipated and unanticipated money growth impacts in a modern industrial economy.

PART TWO

NEUTRALITY OF ANTICIPATED MONEY GROWTH: AGGREGATE IMPRESSIONS VERSUS DISAGGREGATED IMPACTS

ABSTRACT

The "neutrality" models in new classical macroeconomic theory assert the anticipated portion of money growth does not have real economic impacts, only the unanticipated portion of money growth affects real economic activity. Results from a variety of empirical tests using aggregate level data support the neutrality proposition. As is explained below, these aggregate level results increase the need for disaggregated testing to achieve a more precise examination of the neutrality proposition. This research examines the conclusions from aggregate level versus disaggregated tests of the neutrality hypothesis, controlling for differences in the econometric test procedures. The research here finds that testing with aggregate level data does produce an appearance of support for the "only unanticipated money growth matters" hypothesis. However, disaggregated examination -- even at an intermediate level of disaggregation -- reveals that anticipated money growth is having significant real economic impacts on producers' output. "Neutrality" in the sense implied by the theoretical models does not hold. Therefore, as the research here shows, solely aggregate level testing can produce misleading impressions with respect to anticipated money growth neutrality.

SECTION I. INTRODUCTION

Spurred by the contributions of (Lucas, 1972, 1973, 1975; Barro, 1976), recent attention in macro and monetary theory has focused on the differing impacts of the predictable portion of money growth and the unpredicted portion of money growth. In particular, recent theoretical models assert the predictable (or "anticipated") portion of money growth will not affect real economic activity. (Anticipated money is said to be "neutral".) Only the unanticipated portion of money growth has real economic impacts. By now, Barro's empirical tests of the neutrality hypothesis are well-known. His series of studies (1977, 1978, 1979, 1980) for the U.S. aggregate economy presented results which were widely interpreted as supporting the neutrality of anticipated money growth hypothesis. Subsequent tests (conducted on aggregate U.S. and international economic activity, with some application of different estimation procedures; see, for example, Mishkin, 1982; Hoffman and Schlagenhauf, 1982; Wogin, 1980) produce mixed results. However, a number again lend support to the neutrality hypothesis.

These previous tests of neutrality confine themselves to aggregate level assessment of the hypothesis. Given the aggregate results supportive of neutrality, coupled with the nature of the underlying theory, a disaggregated assessment is a valuable "next step". This research examines the conclusions from aggregate level versus disaggregated testing of the neutrality hypothesis, controlling for differences in econometric procedures. Results from this examination indicate that testing with aggregate level real GNP data again produces an appearance of support for the "only unanticipated money matters" hypothesis. However, breaking the aggregate data to subdivisions -- even to the level of broad subcomponents of GNP -- indicates real impacts from anticipated money growth exist. Neutrality of the sense implied by Lucas (1973) does not hold.

Section II briefly presents the theoretical context of the neutrality proposition and covers standard test procedures. Section III addresses the disaggregated tests specifically, with the test results and discussion of results presented in Section IV. Concluding comments are made in Section V.

SECTION II. THE MODEL

The typical theoretical context for anticipated money neutrality propositions (Barro, 1976; Lucas 1972; Lucas, 1973) focuses on producers in individual markets facing an information extraction problem. Each producer's market demand consists of an overall aggregate demand component and a market-specific (relative demand) component, with aggregate demand shifts typically caused by changes in money growth. Producers aim to respond to shifts in relative demand but not to the aggregate demand shifts. Their problem is to disentangle movements in observed economic signals (such as market price) to identify the aggregate demand shift and relative demand shift components. They are aware of a general relationship between money growth, movements in economic signals and aggregate demand movements. Therefore, producers recognize that those changes in money growth which they are able to forecast correspond to an aggregate demand shift rather than relative demand shift, and do not respond with higher production. Producers are assumed to be rational and to exploit systematic relationships between money growth and other economic variables in forming perceptions of current money growth. The difficulty arises in distinguishing actual shifts in relative demand from movements caused by the random, unpredicted portion of money growth. The random, unanticipated portion of money growth "garbles the market signal" and is initially misinterpreted as a favorable relative demand shift, and the producer responds with increased output to this unanticipated portion of money growth. As this misperception of a favorable relative demand shift occurs in each individual market, the unanticipated portion of money growth leads to an aggregate real output response. Thus, according to the theoretical models, the anticipated portion of money growth has no real impact (i.e., is "neutral") upon real economic activity in the short run and in the long run; only the unanticipated portion of money growth has real economic impact.

The above framework can be expressed as follows:

(1) $y_t = \Sigma\alpha_i m^a_{t-i} + \Sigma\beta_i m^u_{t-i} + x_t\phi + u_t$

(2) $m_t = z_t\psi + v_t$

where y is the natural log of real output, m is the rate of growth of the money supply; z is a vector of observable economic variables relevant to predicting money growth in t; m^a and m^u are the predictable portion ("anticipated") and unpredictable portion ("unanticipated") of money growth, respectively. A money forecasting equation (2) identifies the predictable and random components of money growth utilized in the output equation (1), with $m^a_t \equiv z_t\psi$ and $m^u_t = m_t - m^a_t = v_t$. ϕ, α_i, and β_i are coefficients (ϕ is a coefficient vector), with α_i and β_i representing the real responses to anticipated and unanticipated money growth. u_t and v_t are serially uncorrelated and independently distributed random disturbance terms with zero mean and variances σ^2_u and σ^2_v, respectively.

The reduced form model of real economic activity (1) expresses real output as a function of anticipated and unanticipated money growth, plus other factors ($x_t\phi$) relevant in determining real output. Based on the assumption of rational agents exploiting systematic relationships between money growth and other economic variables, equation (1) utilizes the money forecasting equation's (2) decomposition of actual money growth into its anticipated and unanticipated components. The hypothesis that only unanticipated money growth affects real economic activity implies all the $\alpha_i = 0$ and some of the $\beta_i \neq 0$ in the real output model (1).

Note that the above theoretical framework implies individual disaggregated models of the market economic activity which underlie the aggregate output model (1). As constructed, the theory asserts that anticipated money growth will have no impact at the disaggregated level, and thus no impact at the aggregate level.

Previous econometric tests of neutrality focus attention on testing the aggregate version of the hypothesis. Using the aggregate version, a number of these previous tests have found support for the "only unanticipated money matters" proposition (Barro, 1977, 1978; Barro and Rush, 1980; Attfield, Demery and Duck, 1981; Wogin, 1980). Other aggregate tests present mixed results (Mishkin, 1982; Hoffman and Schlagenhauf, 1982).[1]

Examining again the notion of neutrality as implied by the theoretical models (Barro, 1976; Lucas, 1972, 1973), it is evident that

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[1]Clarifying the issue of "mixed results", Mishkin's tests in models using long lags (20 quarters) of anticipated and unanticipated money growth reject the neutrality hypothesis and find unanticipated money variables not statistically significant. In shorter lag-length models, however, he fails to reject neutrality. The Hoffman and Schlagenhauf study tests neutrality of anticipated money on aggregate real output in seven nations. In their longer lag models, they reject neutrality in four nations, fail to reject in three nations. The shorter lag models fail to reject neutrality in five of the seven nations. Neither of these studies, therefore, provide clear support or overturning of previous aggregate test results supportive of anticipated money neutrality.

true neutrality (in the sense held by these models) requires that anticipated money growth have no impact across economic subdivisions as well as at the aggregate level. Stating this more formally, if "z" subscripts denote the individual market models underlying (1), one should find: "all $\alpha_i(z) = 0$ and some $\beta_i(z) \neq 0$" across subcomponents of aggregate output, in addition to all $\alpha_i = 0$ and some $\beta_i \neq 0$ for aggregate output in (1). If anticipated money growth, in fact, does not have any real impact, one should find neutrality at the market level, across intermediate output levels, and at the aggregate real output level.

Given that absence of aggregate impacts from anticipated money growth is a necessary but not <u>sufficient</u> condition for neutrality, (in the sense implied by the theoretical models), testing is needed at both the aggregate and some disaggregated level of output. Particularly in light of the aggregate results supporting the "only unanticipated money matters" hypothesis, it becomes important to dig behind this aggregate picture with a disaggregated examination of the hypothesis. As stated earlier, such a probe behind the aggregate picture is the focus of the present research. Section III discusses the testing procedures used in the examination of aggregate level versus disaggregated testing of the neutrality hypothesis.

SECTION III. TESTING

The Aggregate Level Testing

Among the aggregate tests lending support to the neutrality of anticipated money growth hypothesis, the strongest and most widely familiar set of results in a quarterly test is the Barro and Rush (1980) test of the neutrality hypothesis. This test, however, may suffer from problems caused by serially correlated disturbances.[1] Granger and Newbold (1974) point out the serious consequences for significance test conclusions of failing to correct significant serial correlation of disturbances. In particular, Granger and Newbold find that when significant serial correlation is left uncorrected, there is a tendency to conclude that a significant relationship exists between variables when, in fact, no relationship exists. Test conclusions are thus subject to question when serial correlation is left uncorrected.[2] Question also arises concerning the full model used to test anticipated money growth

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[1] Due to the lengthy observation interval in studies using annual data, tests with quarterly output (or unemployment) data are preferable. The Barro and Rush quarterly output and unemployment study is widely familiar, with strong results giving apparent support to the hypothesis that anticipated money growth is neutral; only unanticipated money growth matters. The models and results which are the basis for the majority of discussion in the study display a Durbin-Watson statistic of 0.3.

[2] Examination of the serial correlation issue here (specifically in the anticipated money neutrality testing) found the same pattern as Granger and Newbold. F statistics changed substantially between tests in models with serially correlated disturbances and those displaying no significant serial correlation.

impacts in some of the previous aggregate level tests of the neutrality hypothesis.[1]

Therefore, a first step in this probe behind the aggregate appearance of support for neutrality was to examine the impact of these issues upon the significance test conclusions for anticipated and unanticipated money growth variables. Conceivably, the supportive aggregate level results would not hold up after the corrections for serial correlation and to the test model. Using a model which included both anticipated money growth and unanticipated money growth variables and which displayed no significant serial correlation, the neutrality hypothesis was retested using aggregate real U.S. Gross National Product (the same output measure used in most of the previous aggregate level U.S. neutrality tests). Applying test methods which correspond to those described in detail below (in the discussion of the disaggregated testing), this aggregate level retesting found that impacts of anticipated money growth upon real aggregate GNP do not appear significant (at the 5% significance level); unanticipated money growth does appear significant at the aggregate level. Furthermore, this pattern in the aggregate level results was robust across minor changes in the test period.

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[1]Tests here also examined the impact of omitting the anticipated money variable from the model, as is done in several studies (Barro and Rush, 1980; Attfield, Demery, and Duck, 1981). Tests indicate that a model which does not allow anticipated money impacts to be registered (i.e., used unanticipated money only) led to a substantially larger F statistic on unanticipated money than when for both anticipated and unanticipated money impacts are considered in the model. Just recently, Sheehey (1984) has also noticed and commented on this omission from test models used in several previous neutrality studies.

Thus, the aggregate level tests here appear to support the neutrality hypothesis. These results from the aggregate level retesting are valuable because they provide a stronger basis for the present evaluation of aggregate level versus disaggregated neutrality test conclusions. Rather than drawing upon the conclusions of other aggregate neutrality tests, it is useful to have a set of results from the application of comparable procedures to the aggregate and disaggregated output levels. This ensures that differences in aggregate versus disaggregated test conclusions are not due to differences in the econometric methods. In addition, these results from the aggregate level retesting are useful because they indicate that the neutrality pattern in the aggregate tests elsewhere remains even after one corrects problems in these tests. These aggregate test findings under the methods here therefore establishe a link with the present disaggregated tests and with aggregate level tests elsewhere.

The Disaggregated Testing

In moving the neutrality assessment to some level below the aggregate output level, there is in principle a spectrum of potential disaggregation levels. From a practical perspective, the main constraints are the availability of a sufficiently long and high-quality time series of data and coverage of a sufficiently large proportion of total real GNP to provide meaningful insights to the aggregate results elsewhere. The real output measures used here are broad subcomponents of the real aggregate GNP quarterly data from 1955 to 1978. While this level of disaggregation is not as fine as would be needed for a microeconomic testing of neutrality, it still provides useful insights behind the aggregate test results. As indicated previously, if anticipated money growth is in fact neutral at the market level, then neutrality will also hold across intermediate and aggregated output levels. A finding of nonneutrality across intermediate levels is a strong indication that market level nonneutralities must exist. Furthermore, the Gross National Product subcomponent measures have the advantage that together they totally encompass total aggregate real GNP. This attribute strengthens the link between these disaggregated GNP subcomponent tests to the aggregate level tests here and elsewhere.[1]

Disaggregated assessment of the neutrality hypothesis requires modification of the real output model (1) to allow varying responses across the different sectors to the respective money variables and also to capture differing basic characteristics of the various sectors. A model of real output for sector "z" can be represented as follows:

$$(3) \quad y_t(z) = \Sigma\alpha_i(z)m^a_{t-i} + \Sigma\beta_i(z)m^u_{t-i} + x_t(z)\phi(z) + u_t(z)$$

where terms are as previously defined, but as indicated by the z index, are now individualized to sectors.

With respect to the various entries in the output model, the $x_t(z)\phi(z)$ component captures "other economic influences" relevant to each sector and is the vehicle to address special characteristics or events in

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[1]A multi-industry neutrality test, disaggregated to a finer level and covering over half of U.S. industrial production (Gauger, 1984a) supports the general conclusions of the broad GNP subcomponent (goods, services, structures) tests here. See Part One of this dissertation.

the individual sectors. For each GNP subcomponent series, the $x_t(z)$ vector included a constant and a trend growth rate term, which was adapted (when applicable) to handle cases of nonlinear growth over the time period. Unusual economic shocks, such as impacts of the wage and price control era or the oil supply shocks, were examined and included when relevant in a subcomponent's $x_t(z)$ vector. As should be expected in modern industrial production, current output activity is often related to previous output levels, causing a degree of "persistence" in output activity across time periods. (This occurs for various reasons. For example, high costs of adjusting industrial production rates, multi-period production processes, etc. may cause this persistence in output levels across periods.) The degree of output persistence should be expected to differ between production of goods and production of physical structures, for example. For each GNP subcomponent series, the $x_t(z)$ vector included lagged output variables to capture the degree of persistence relevant to that subcomponent.

As indicated earlier, m^a is the predictable portion of money growth, based on the money forecasting equation, and m^u is the random, unpredictable portion of money growth. The money forecasting equation specification includes three lags of the unemployment rate, a measure of the federal budget deficit relative to previous deficit levels, and lags of actual money growth.[1] Tests for serial correlation of the unanticipated money growth series (m^u) confirm that it is a random (white noise) series with no significant serial correlation, implying no "systematic prediction errors" emerge from this money foreasting model.

Estimation of the real output responses utilizes the predicted values obtained from an OLS estimate of the money foreasting equation as anticipated money growth (m^a) and the residuals as unanticipated money growth (m^u). An alternative to this "two-step estimation" procedure which is used in some neutrality tests (Mishkin, 1982; Hoffman and Schlagenhauf, 1982) is joint estimation of the money forecasting (1) and real output equations (3). In cases where nonzero covariance exists across the parameter estimates for the money forecasting and real output equations (covariance across $\hat{\psi}$ and the $\hat{\alpha}_i$, $\hat{\beta}_i$), then a joint estimation procedure will be more efficient than a two-step procedure. Both procedures produce consistent estimates, however. An econometric evaluation of the two procedures (Hoffman, Low and Schlagenhauf, 1982) indicates joint estimation is not clearly superior to the two-step procedure in detecting

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[1]This is the money forecasting equation specification used in the Barro-Rush (1980) quarterly tests of neutrality. This specification compares well with these used in more recent neutrality tests (for example, Attfield, Demery and Duck, 1981). Criticism of the particular money forecasting equation followed the Barro and Barro-Rush studies. However, subsequent examinations by Mishkin (1982) and Hoffman, Low, and Schlagenhauf find that neutrality test results are robust across reasonable variations in the money forecasting equation specification. An advantage to adopting the specification used in the Barro-Rush quarterly tests is that it maintains stronger comparability between the disaggregated test results here and their original strong aggregate level results which supported the "only unanticipated money growth matters" hypothesis.

violations of anticipated money neutrality. The study indicates that the incremental gains of the joint procedure with respect to significance test conclusions are small in many cases. Cost and tractability differences between procedures are substantial. Another consideration which makes the two-step procedure preferable for the multi-sector testing here is that it maintains greater uniformity of procedures across GNP subcomponents and thus gives better comparability of results.[1]

The appropriate lag length on the anticipated and unanticipated money growth variables in the respective real output models (3) was tested for each GNP subcomponent. Aggregate level neutrality studies elsewhere (Mishkin, 1982, for example) include up to twenty quarters of the money growth variables. Money lag length tests here identified at most four quarters of the respective money variables (m^a, m^u) as relevant.[2] (In some cases, only current money variables had significant impacts.)[3] To

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[1]In light of Mishkin's econometric work in testing neutrality, the choice of estimation procedure was not made lightly. The Hoffman, Low, and Schlagenhauf (1982) study, which provides a thorough and useful comparison of the two procedures, indicates no clear advantage to the joint estimation procedure. Furthermore, several current neutrality studies (Gordon, 1982; Enders and Falk, 1984; Skaggs, 1983) apply the two-step procedure.

[2]Concerning this issue of long money growth lags in aggregate models versus the shorter money lags found to be relevant in the disaggregated tests here -- one interpretation is that monetary impacts (either anticipated or unanticipated) move through economic subsectors more rapidly than through the agggregate economy. The result is more likely due to a technical issue in the estimation. The lagged output variable in (3) may cause the shortened money growth lag length.

[3]Estimation and tests were also conducted using only current anticipated and unanticipated money as the money growth variables. The pattern of significance test results across the subcomponent series correspond to those reported below (Table 1) for the "four quarters of m^a, m^u" models.

establish general uniformity of treatment across series and strengthen comparability of results, all output model (3) estimations included four quarters of anticipated and unanticipated money growth variables. It was decided to not carry the long money lags (i.e., twenty quarters each of m^a and m^u), because the extraneous money lags cause substantial and unnecessary loss in degrees of freedom and reduce the power of significance tests.[1]

Given the serious consequences of serially correlated residuals upon significance test conclusions, each real output model was tested for significant serial correlation. In no case did significant serial correlation exist (using 1% significance level).[2]

Section IV presents the tests of significance for the anticipated money and unanticipated money growth impacts and discusses the results as

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[1]Mishkin (1982) argues for long lags of money variables on the basis that omission of relevant variables results in biased estimates, while inclusion of irrelevant variables merely reduces the power of the test. However, as indicated here, tests determined that the long lags (4th through 20th lags) were not relevant variables in model (3), and therefore omitting them will not be biasing the estimates. Furthermore, the impact of losing 34 degrees of freedom due to extraneous money lag variables is not inconsequential.

[2]The Durbin-Watson test for serial correlation is not valid for models with stochastic regressors, as applies here. The typical alternative -- Durbin's h statistic -- breaks down in some cases with a large number of observations. (The formula for the h statistic involves the quantity: $\sqrt{1-T\ \mathrm{Var}(\hat{\rho})}$. When T is large, one can encounter a negative value inside the radical sign.) This is the situation encountered in testing here. When T is sufficiently large, asymptotic distribution theory applies, thus making it valid to use OLS residual estimates (u_{OLS}) to test serial correlation of the true disturbances (u) via the following approach: regress $u_{t,OLS} = \hat{\rho}\, u_{t-1,OLS} + \varepsilon_t$; conduct a t-test on $\hat{\rho}$. This procedure was applied to test for first-order and higher-order serial correlation.

they relate to the neutrality hypothesis itself and to the aggregate level neutrality test results.

SECTION IV. RESULTS

The Overall Summary

In considering neutrality test results here and elsewhere, the aggregate level results versus disaggregate results present quite a contrast. While tests with aggregate level data present a picture of "no anticipated money impacts exist; only unanticipated money matters," in fact, tests disaggregated even to an intermediate level (broad GNP subcomponents) indicate anticipated money growth does have real output impacts. A major message emerging from tests here is that conclusions drawn from aggregate level testing need to be made cautiously. Potentially, there are no significant <u>net</u> impacts from anticipated money growth when one aggregates across offsetting disaggregate level impacts. However, this is not the notion of "neutrality" of anticipated money growth implied by the theoretical models. Neutrality there implies no real impacts existing across the market level or intermediate levels and, therefore, neutrality of anticipated money at the macro level. Results here indicate neutrality in this sense does not hold, despite the aggregate level impression given in some neutrality testing. Discussion below presents specific comments on the aggregate real GNP and GNP subcomponent test results.

Specific Results

Table 1 presents the results for tests of significance on anticipated and unanticipated money growth impacts on the GNP subcomponents and total real GNP. The interest here is in whether significant impacts exist from groups of anticipated or unanticipated money variables, rather than in particular point estimates and their lag patterns. Therefore, the statistics in Table 1 are F statistics on four quarters of the respective money variables. Due to multicollinearity among variables in the real output models of neutrality tests (multicollinearity within the m^a series and across the m^a and m^u series), the point estimates of an unconstrained distributed lag cannot be interpreted as showing the true pattern of economic impacts. In addition, individual t statistics will not be the appropriate test for significant impacts. Attention here, therefore, focuses on the F tests; individual point coefficients are not presented.[1]

Column 1's F statistics test anticipated money growth impacts. Neutrality of anticipated money growth implies the F tests should <u>fail to reject</u> the hypothesis "all $\alpha_i = 0$." Column 2 tests unanticipated money growth impacts. If unanticipated money growth is a major impact on real economic activity, F tests here should <u>reject</u> the hypothesis "all $\beta_i = 0$." Column 3 is a "reference information column," testing impacts from actual "total money growth," m_t. The purpose of the test is to assure that findings of "no significant impact" from m^a or m^u are not, in fact, stemming from "no impacts from actual money growth" in some subcomponent series. As column 3's tests confirm, actual money growth appears to have highly

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[1]Table 2 does present point estimates for impacts of current anticipated money and unanticipated money growth impacts. The "current m^a and m^u only" models do not tell the whole story in cases with significant lagged money impacts. They are, however, free of multicollinearity impacts (due to the nature of construction of the m^a and m^u series), and since the most significant impacts appear to occur in the current quarter, the "current m^a, m^u only models" do provide some useful information.

Table 1. F tests on anticipated, unanticipated money growth impacts; Aggregate real GNP and GNP subcomponents

Model: $y_t(z) = \sum_{i=0}^{3} \alpha_i(z)m^a_{t-i} + \sum_{i=0}^{3} \beta_i(z)m^u_{t-i} + x_t(z)\phi(z)$

where $X_t(z)\phi(z)$ is as previously defined.

Hypothesis→ Series↓	(1) All $\alpha_i = 0$ "No anticipated money impacts	(2) All $\beta_i = 0$ "No unanticipated money impacts"	(3) All $\gamma_i = 0$ "No impacts from actual money growth"[a]
Total GNP	1.19 (.318)	3.41**(.010)	3.21**(.003)
Goods	3.83**(.007)	3.02* (.023)	4.13**(.0004)
Structures	2.51* (.048)	1.85 (.128)	3.31**(.003)
Services	1.41 (.238)	1.37 (.251)	2.03* (.054)

[a]Model for "total money impact" tests:

$y_t(z) = \sum_{i=0}^{3} \gamma_i(z)m_{t-i} + x_t(z)\phi(z)$ where m_t is actual money growth.

[b]Values in parentheses give probability level of statistical significance.

*Significant at 5% level.

**Significant at 1% level.

significant impacts across all the subcomponent series (significant at the 1% level for all series except "services"; impacts for services significant at the 5.4% level).

Results of columns 1 and 2 together address the "only unanticipated money matters hypothesis" for the GNP subcomponents and aggregate real GNP. (One should find a small insignificant F in column 1 simultaneously with a significant F in column 2.) Evaluating the aggregate level GNP results in the first row, F tests here indicate the anticipated money growth impacts appear to not be significant (at the 5% significance level); unanticipated money impacts do appear to be significant at the 1% significance level. Attention focused only on results of an aggregate level test would lead to the conclusion that anticipated money growth does not have real impacts. Results would appear to support the theoretical propositions that only unanticipated money affects real economic activity. However, the additional information from the disaggregated tests on the GNP subcomponents challenges the aggregate level appearance of support for anticipated money neutrality.

Results for neutrality tests on the GNP subcomponents appear in the second through fourth rows of Table 1. As is evident by simultaneously examining results in columns 1 and 2, in no case does "only unanticipated money growth matter" across the GNP subcomponent series. Table 1's F statistics indicate significant impacts on the real output of goods from both the anticipated and unanticipated portions of money growth, with anticipated money impacts significant at the 1% significance level, and unanticipated money impacts significant at the 5% level. In the structures subcomponent, only the anticipated portion of money growth has impacts which are significant at the 5% level. Neither anticipated nor unanticipated money growth impacts appear to be significant in the services series.[1] In general, anticipated money impacts are significant at smaller probability levels than unanticipated money impacts across all subcomponent series. The goods production responses show stronger F statistics (on both anticipated and unanticipated money impacts) than in the structures or services subcomponents. Tests conducted on the current versus lagged money growth impacts indicate that the majority of the significant impact underlying the four-quarter F statistics in Table 1 appears to come from the current (anticipated or unanticipated) money growth variables. The lagged impact tests indicate that, to the extent that significant lagged impacts exist, they are lagged anticipated money growth impacts, particularly in the structures series. In no case did lags of unanticipated money have significant impacts at the 5% level.

Given that lagged anticipated money impacts do appear to matter in some subcomponent series, a model which uses only the current values of anticipated and unanticipated money growth does not tell the whole story on respective money growth impacts. However, the "current money variables only" models [i.e., $y_t(z) = \alpha_o(z)m_t^a + \beta_o(z)m_t^u + x_t(z)\phi(z)$] do provide some

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[1] The data plot for the "services" subcomponent series indicates it very likely is a quarterly imputation based on annual data, with quarterly values primarily following a "stepwise trend growth" pattern. The seeming lack of response to either m^a or m^u could be caused by this sort of imputation.

Table 2. "Current money variables only" model estimations and F tests

Model: $y_t(z) = \alpha_o(z)m_t^a + \beta_o(z)m_t^u + x_t(z)\phi(z)$

where $X_t(z)\phi(z)$ is as previously defined

Series	α_o	F on H_o: $\alpha_o = 0$	β_o	F on H_o: $\beta_o = 0$
Total GNP	3.51**	9.13**(.003)[a]	2.23**	11.59**(.001)
Goods	2.13**	15.05**(.0002)	.84*	5.58* (.020)
Structures	2.31**	8.36**(.005)	1.22**	6.64**(.010)
Services	.163	1.05 (.309)	.153	2.13 (.148)

[a]Values in parentheses give probability level of statistical significance.

*Significant at 5% level.

*Significant at 1% level.

useful information, particularly because multicollinearity problems will not prevail in such a model. Results of tests on m_t^a and m_t^u in the "current variables only" model (Table 2) confirm the indication from F tests in Table 1 that real anticipated money growth impacts do exist at the disaggregated level.

As the results in Table 2 indicate, now at the aggregate as well as disaggregated level, current anticipated money has significant impact. The finding of a significant aggregate level impact from current anticipated money, but no significant impact in the four-quarter F test potentially may be explained by lagged anticipated money impacts which may offset the impact of the current variable. (As this suggests, the aggregate test results may capture offsetting impacts across subcomponents andl across time, all intertwined, and thus masking an accurate picture of the real economic impacts.)[1]

Examining results for the subcomponents series in the "current money" models of Table 2, tests here indicate that both of the money growth variables appear to have significant current impacts in the goods and structures series. Again, the services subcomponent shows no significant response to either anticipated or unanticipated money growth (supporting

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[1]Alternatively, this difference in the current versus four-quarter F test conclusions may be due to a "power of the F-test" issue. In particular, when only one variable within a group of variables tested has a significant impact, the F statistic may not be powerful enough to detect the single variable's impact. Thus, an F test on a variable group which includes lagged money impacts may not detect the impact from current anticipated money growth, whereas a test targeted to the specific variable would detect the impact of the single variable.

earlier indications that this series may be a quarterly imputation). As in the earlier four-quarter F tests, here again anticipated money growth impacts are significant at a smaller probability level than the unanticipated money impacts in the goods and structures real output series. Also interesting to note is that, across all series, the current money impact point estimates (α_o in column 1; β_o in column 3) are larger in magnitude for the current anticipated money growth than for current unanticipated money growth. Rather than anticipated money being neutral, tests here indicate anticipated money growth impacts which are significant at smaller probability levels than unanticipated money growth impacts, and current anticipated money impacts of larger magnitude than unanticipated money impacts. Again, it is recognized that these "current variable only tests" (Table 2) will not reflect all of the anticipated money and unanticipated money growth impacts. In particular, the impacts of the lagged money growth variables (which tests indicated to be relevant in some series) are not being captured in these "current variable only models". These models and test results do support the basic indication, however, that aggregate level test results which suggest that "only unanticipated money matters" do not fully reflect the real impacts from anticipated money growth which exist and are evident in a disaggregated testing of neutrality.

SECTION V. CONCLUDING COMMENTS

The results from aggregate level versus disaggregated neutrality tests present quite a contrast. Aggregate level tests give an impression that only unanticipated money growth has significant impacts, anticipated money growth is neutral. In the examination here, however, several pieces of disaggregated evidence indicate that significant real impacts from anticipated money growth do exist.

In considering the potential explanation for the aggregate versus disaggregated results, it is important to keep in mind that current econometric procedures in the neutrality testing do not indicate the sign of the anticipated money or unanticipated money impacts, only the significance. First, multicollinearity across variables in the neutrality model interferes with valid interpretation of the point estimates in the distributed lag estimates. In addition, the F statistics used to test anticipated and unanticipated money growth impacts will always have a positive value, regardless of whether the impact from the variable is positive or negative. Thus, tests here are subject to this limitation in the current econometric procedures for testing neutrality. This is an issue warranting further research.

In resolving the contrasting aggregate level versus disaggregated neutrality test results, one plausible explanation is that disaggregate level impacts of anticipated money growth may offset each other, particularly in those cases where anticipated money growth has significant lagged, as well as current, impacts. As one sums across the offsetting

positive and negative anticipated money impacts, the apparent aggregate level impact from anticipated money growth will be reduced. This may lead to the anomalous result that anticipated money appears to be neutral in an aggregate level test despite the real impacts from anticipated money which exist at the disaggregated level. Considering more closely the results for unanticipated money growth, the aggregate level tests found significant impacts exist, while in the disaggregated tests, unanticipated money growth had significant impacts in some (but not all) series. Potentially, the explanation underlying this aggregate versus disaggregate level result involves the aggregation across a series of small but "same-signed" impacts from unanticipated money growth at the disaggregated level. The impacts with individual subcomponents may appear to be not significant when tested in a four-quarter F test. (Recall, for example, the finding that the disaggregated current unanticipated money growth impacts are smaller in magnitude than those from current anticipated money growth, i.e.:
$\beta_o < \alpha_o$ in Table 2.) However, if these are generally positive impacts (as suggested by the β_o estimates in Table 2), then the summation across the small "same-signed" impacts could lead to the net result of significant impact from unanticipated money growth when tested at the aggregate level.

Thus, the anomaly of the aggregate versus disaggregated results can be resolved with a reasonable explanation. Even after resolving the anomaly, however, the main message of this research needs to be kept in mind. The disaggregated tests indicate that the notion of neutrality of anticipated money growth, as implied by the theoretical models does not hold. Results here indicate real disaggregated impacts exist. Aggregate level tests do not "tell the whole story," and, accordingly, assertions of neutrality based on aggregate level tests alone should be viewed cautiously.

PART THREE

ANTICIPATED MONEY AND PRODUCTION WITH RIGIDITIES IN OUTPUT PRICE OR PURCHASED INPUT COSTS

ABSTRACT

Previous theoretical analyses of the real impacts from curently anticipated and unanticipated money primarily focus on production in an environment where a freely flexible relative output price is the key entry to producer supply decisions. Models which do consider purchased input costs typically assume that they are is freely flexible as well.

The analysis here moves beyond the "output price only" or "freely flexible nominal values" assumption sets. Real impacts of currently anticipated and unanticipated money are examined in a model where the producer's supply decision is based both on the relative price of market output and the real cost of purchased inputs. Furthermore, production occurs with one nominal value temporarily rigid. A series of three cases assess impacts when production occurs in the various combinations of output price and input cost behavior. The analysis indicates that when assumptions allow something other than the "all freely flexible nominal values" assumption typical in previous work, now currently anticipated money does have real impacts in those cases where either output price or purchased input costs are rigid. Beyond the issue of <u>existence</u> of anticipated money impacts -- which has been the prime focus in previous neutrality examinations -- this paper looks also at the implied <u>sign</u> of the impact. It finds that when purchased input costs are the rigid nominal value, currently anticipated money has positive real output impacts; when output price is the relatively more rigid value, anticipated money has a negative impact.

In addition, the analysis below highlights the importance of a disaggregated examination of anticipated money neutrality to accompany the existing aggregate-level examinations. In particular, a final case presented in Section IV of the paper illustrates the contrasting conclusions that may be drawn in disaggregated versus aggregate examinations of neutrality. Because the positive and negative anticipated money impacts at the disaggregated level can offset each other when output is summed across markets, the apparent impacts of anticipated money at the aggregate level may be reduced. Potentially, this can lead to false conclusions of anticipated money being neutral when analysis is confined to the aggregate level alone.

SECTION I. INTRODUCTION

The controversy concerning the real economic impacts of anticipated money growth versus unanticipated money growth has remained strong for a number of years. The theoretical debates over the "neutrality" of anticipated money growth (the proposition that the predictable portion of money growth has no real economic impact) have approached the issue from a variety of angles. Whether the theoretical finding is one of neutrality or nonneutrality of anticipated money often turns on the specific production environment assumed. In particular, differences in the assumptions on which nominal values enter the production decision (for example, output price versus a purchased input cost) and differences in the assumed flexibility of nominal values are important elements affecting the final theoretical result.

Lucas (1973) examines production in an environment where relative output price, but no explicit input costs enter, and price is assumed freely flexible. Only unanticipated money growth has real economic impacts in Lucas's environment. Anticipated money growth is neutral.

Bull and Frydman (1983) incorporate costs of a purchased input as they derive the Lucas supply function from a labor market base. Once again, however, prices and wages are assumed freely flexible, and their model produces the basic Lucas result -- only unanticipated changes in nominal values matter; the anticipated portion has no real economic impact.

Fischer (1977) examines the potential for real monetary policy impacts when production is based on the expected real wage (wage relative to expected aggregate price level), and nominal wages are set by contracts and therefore rigid. In this environment, the currently predictable portion of the money supply, as well as the unanticipated monetary policy, have real short-run impacts.[1]

Each of the "pure cases" dealt with in the previous assessments (i.e., production based upon only a freely flexible price of output relative to aggregate price; upon both output price and purchased input cost, but both freely flexible; or upon wages that are nominally rigid temporarily) provide a useful reference point for assessing anticipated money and unanticipated money impacts. However, interest turns next to examining real output impacts as one moves away from the "pure" environ-

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[1]It is useful to clarify the concept of "anticipated money" used in this and a number of other papers on neutrality.

From a current monetary policy perspective, the issues of interest are: of total money supply (i) what is the portion which the public can currently predict or "anticipate"? and (ii) to what extent is this currently predictable portion of money "neutral" or have no real economic impact?

For example, in Fischer's setting, wages for period t are set in t-2 based on the expectation in t-2 of the money supply in t, $(E_{t-2}m_t)$. The total money forecast error can be divided into two parts:

$$(m_t-E_{t-2}m_t) = (m_t-E_tm_t) + (E_tm_t-E_{t-2}m_t)$$

The first component cannot be predicted based on information at the start of period t, i.e., currently unanticipated money. The second component, while not predicted at wage setting time, can be predicted based on current economic information. The focus here is on this portion of money: $(E_tm_t-E_{t-2}m_t)$. To the extent this portion affects output, this predictable portion of money will not be neutral from a current policy perspective.

ments assumed previously. What are the production decisions and real impacts from the currently predictable and unpredictable portions of money supply when producers consider both price of market output relative to expected aggregate price and real costs of purchased inputs. Furthermore, what is the impact of anticipated money when one nominal value is freely flexible and the other rigid? For example, suppose the producer's output price moves freely but the wage to purchased factors is rigid. Alternatively, the producer's price may be rigid or sticky within the period but wages to purchased factors relatively flexible.

While such situations are common throughout the economy, these cases have not previously been examined. The model here and the four cases of output price and purchased input cost behavior address these issues. As is discussed below, the implications for impacts from anticipated money are quite different from those in the "relative price (or wage) only," or the "all prices and costs freely flexible" environments. In particular, the research here indicates that attention should not be confined to existence or significance of real anticipated money impacts, but should focus also on the sign of that impact.

In addition, the approach here is useful in resolving the anomaly indicated by aggregate-level versus disaggregated empirical testing of anticipated money neutrality. In particular, a number of aggregate-level tests (Barro, 1977; Barro and Rush, 1980; Hoffman and Schlagenhauf, 1982; Wogin, 1980; Gauger, 1984b) appear to support the proposition that only unanticipated money matters, whereas a disaggregated examination indicates real anticipated money impacts exist (Bean, 1983; Gauger, 1984a; Gauger, 1984b). The analysis below addresses three separate cases of output price and input cost[1] behavior: price and cost both freely flexible; flexible prices, rigid cost; rigid price, flexible cost. The analysis in these three cases does not look at long-run general equilibrium impacts or anticipated or unanticipated money.[2] The primary focus is on the nature of short-run anticipated money impacts in the respective production environments. In addition to considering these as three unrelated production analyses, however, one can also view these first cases as three general categories by which the various disaggregated markets in the economy can be characterized. An aggregate economy is comprised of a mixture of the "flexible price and cost," "flexible price with rigid costs," and "rigid price with flexible costs" markets. Given that anticipated money has differing impacts across markets of the different natures, the aggregate impression of anticipated money impacts is likely to obscure the disaggregated impacts that exist. The analysis here finds that when one examines the neutrality issue within the separate "flexible price with rigid costs" and "rigid price with flexible costs" environments (as

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[1]For convenience, the terms "cost" and "price" will often be used below. "Cost" is understood to refer to the cost of purchased inputs, as opposed to self-owned inputs.

[2]For example, in the rigid factor wage case (case 2), essentially the firms temporarily face an infinitely elastic labor supply at the contracted wage. As general equilibrium analysis makes clear, this situation cannot prevail throughout the aggregate economy for a long period. However (as relates to the cases here), the situation may apply temporarily to a sector of the economy. A general equilibrium analysis would more rigorously formalize the interactions that occur throughout the economy.

individual markets might be characterized), here anticipated money does have real impacts, though of differing natures. When one assesses a combination of the production environments (i.e., an aggregation across markets of differing price and cost natures), the result is an aggregate appearance of anticipated money impacts which is much smaller than those found at the disaggregated level. In addition, in the aggregate examination, unanticipated money impacts may now seem to dominate the anticipated money impacts even if this pattern does not prevail at the disaggregated level. Thus, the analysis here can resolve the anomaly in the contradicting results from aggregate-level versus disaggregated empirical testing of anticipated money neutrality.

Section II introduces the basic model used throughout the paper and, to aide subsequent analysis, examines the anticipated and unanticipated money impacts in the situation where the producer's market output price and purchased input costs are both assumed freely flexible.

Section III alters the price, cost environment: first to the case of temporarily rigid factor wages but flexible output price; next to the rigid output price with flexible wages case. For each case, the implied real output results are generated. Results from the three cases are briefly compared with respect to anticipated and unanticipated money impacts.

Section IV considers the issue: what do the impacts appear to be for anticipated and unanticipated money when one assesses an aggregation across the individual environments? This section examines how the apparent aggregate results on anticipated and unanticipated money impacts differ from those indicated when one examines impacts within the individual "market" environment itself. Concluding comments are made in Section V.

SECTION II. THE MODEL

Case 1: Production with Both Price and Cost Flexible

The model used in this paper to analyze anticipated and unanticipated money impacts parallels the basic spirit of the Lucas (1973) supply function, with modifications to address the particular issues of interest here. The setting is one of a large number of producers operating in "z" separate markets. Production occurs with two basic factors (which may also represent categories of the two-factor types): an externally purchased factor, such as hired labor, and a self-owned factor, such as entrepreneurial skill or self-owned capital. For purposes of exposition, hired labor is assumed to be the key purchased input, and the wage to labor ($w_t(z)$) is the key purchased input cost. The analysis is not confined to the labor input, however, and could easily be cast in the context of some other non-storeable purchased input without altering the basic results. The entrepreneur (or other self-owned factor) receives the price of market output ($P_t(z)$). In making this input decision, the entrepreneur considers the market price and the aggregate price level (P_t). (P_t captures the price of the entrepreneur's aggregate consumption bundle. In the case of self-owned capital, $P_t(z)$ and P_t capture the reward for production in this use versus alternative uses.) Producers observe their market price and nominal wage in period t. They do not know the true aggregate price level in t and must form an expectation of P_t. Producers are assumed to be rational and exploit the available information on macroeconomic variables and any systematic relationships between macroeconomic variables in forming their price expectations.

More formally, the above can be represented as follows:

Output supply is a function of the price of market output, market wage, and the expectation of the aggregate price level.[1]

$$Y_t(z) = F(P_t(z), W_t(z), E_t(z)P_t)$$

where $Y_t(z)$ is real output in market z.

Output is homogeneous of degree zero in these nominal values. Thus, one can divide through by any one price to convert the function to one in relative prices. Using the aggregate price, output is given by:

$$Y_t(z) = F\left(\frac{P_t(z)}{E_t(z)P_t}, \frac{W_t(z)}{E_t(z)P_t}, 1\right)$$

Assume that after taking logarithms, output can properly be represented by a linear model such as:[2,3]

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[1]Each producer will form expectations based on the information available in his market, which can be denoted $E_t(z)P_t$. Given that information on many macroeconomic variables is available throughout the economy, there will be a common component to price expectations across markets, i.e., $E_t(z)P_t = \overline{E_tP_t} + x_t(z)$ where E_tP_t is the component of price expectations that is common across markets. $x_t(z)$ is the component of producers' price expectations which differs across markets. When one sums across markets (as in aggregate supply, equation 6 below), these differences in producers' expectations will on average net out to zero $(E\Sigma X_t(z) = 0)$, leaving the common component (E_tP_t) of aggregate price expectations equation 6).

To simplify notation, the market output equations for the remaining cases will be presented in terms of the E_tP_t expectation term.

[2]For convenience, the $P_t(z)$ and P_t notation are maintained but now understood to refer to the logarithm (rather than the level) of the market price and aggregate price level, respectively.

[3]The model could include a $y_{t-1}(z)$ term to represent the persistence of output across periods which occurs in actual production. However, this issue is not the focus for the analysis here. Therefore, the $y_{t-1}(z)$ term is not carried in the model. As the reader can prove, this does not alter the basic results obtained.

$$(1)\quad y_t(z) = \alpha_1(P_t(z)-E_t(z)P_t) + \alpha_2(w_t(z)-E_t(z)P_t) + u_t(z)$$

$$(2)\quad P_t(z) = P_t + z$$

$$(3)\quad w_t(z) = \gamma + P_t + c$$

$$(4)\quad u_t(z) = u_t + \varepsilon_t(z) \qquad E(u_t) = \bar{u}, \quad E(\varepsilon_t(z)) = 0$$

$$E(c) = E(z) = 0$$

$$E(u_t(z), z) = E(u_t(z), c) = 0$$

where $\alpha_1 > 0$, $\alpha_2 < 0$; $y_t(z)$ is the logarithm of real output in market z (expressed as the deviation from the natural rate of output in z); $P_t(z)$, $w_t(z)$, and $E_t(z)P_t$ are the logarithms of market price, the wage for purchased inputs, and the market expectation of the aggregate price level, respectively. $u_t(z)$ is the random supply shock in market z, representing market supply impacts not already captured in the price and wage variables. As indicated by (4), the total market shock term consists of an aggregate supply shock term, u_t, and a market-specific shock term, $\varepsilon_t(z)$. For example, the aggregate disturbance term (u_t) represents shocks affecting the entire economy, such as the oil supply shocks of the 1970s. The expected value of u_t is $\bar{u}$ (which may or may not be assumed equal to zero; for generality, derivations below allow $\bar{u} \neq 0$). The market-specific supply shock, $\varepsilon_t(z)$ represents impacts particular to the z^{th} market, such as a drought affecting an agricultural crop market. The expected value of $\varepsilon_t(z)$ is zero.

In this first case (intended primarily to introduce the model), both the producers' output price and wage to purchased factors are assumed to be freely flexible across periods. Market price and wage behavior for this case are given by equations (2) and (3). Market price ($P_t(z)$) consists of an aggregate price level term (P_t), plus a market-specific term (z), representing relative demand shifts in the market. In the present case, it is assumed the nominal wage for purchased factors (3) adjusts with the aggregate price movements to maintain a constant real wage, along with a component (γ) to capture productivity changes, plus the market-specific cost shock term (c). For purposes here, γ is assumed to be zero, in order to focus attention on the major issues of interest. Firms are assumed to operate on their factor demand curve for the purchased input.

The market-specific price and cost terms have expected values of zero. $u_t(z)$, z and c are assumed to be mutually and serially uncorrelated. E(cz) may equal zero, but the analysis is not confined to this assumption (i.e., shifts affecting market price may or may not affect market wage).

Substituting the price and wage relationships (2) and (3) into (1), and incorporating the γ=0 assumption, the market real output supply can be represented as:

$$(5) \quad y_t(z) = \alpha_1[P_t+z-E_t(z)P_t] + \alpha_2[P_t+c-E_t(z)P_t] + u_t(z)$$

To further examine real output given by equation 5, the solution for the current aggregate price level of the system, P_t, and its expected value need to be determined. Aggregate supply is based upon the above market supply functions.[1,2]

(6) $y_t = \alpha_1(P_t - E_tP_t) + \alpha_2(w_t - E_tP_t) + u_t$

where y_t is the logarithm of current aggregate output, and, as indicated earlier, u_t is the random aggregate supply disturbance, with $E(u_t) = \bar{u}$ and is uncorrelated with z and c. Summing market prices ($P_t(z)$) (or wages, $w_t(z)$) across all markets and taking averages yields the aggregate price level (P_t) (or wage, w_t) term in equation 6.[3]

In order to close the model and solve for the equilibrium aggregate price level of the system (P_t), aggregate demand must be specified. A straightforward aggregate demand function based on the equation of exchange is assumed.

(7) $y_t = \beta(m_t - P_t) + v_t$

where m_t is the logarithm of the exogenously determined money stock in t. v_t is the random component of aggregate demand which has an expected value of zero and is uncorrelated with the disturbance terms to market prices, wages, and output supply [E(vz) = E(vc) = E(vu) = 0]. The coefficient β may reasonably take the value of one; however, for generality, β is

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[1]Note that the α_i for the aggregate function will differ from the disaggregated level coefficients. For convenience in notation, the original symbols are retained.

[2]See footnote 1 on page 82 concerning the price expectation terms.

[3]With respect to summation across markets, notice that

$\overset{z}{\Sigma}P_t(z) = \sum_{1}^{z}(P_t+z)$ and $\Sigma z = 0$; $\overset{z}{\Sigma}w_t(z) = \sum_{1}^{z}(P_t+c)$ and $\Sigma c = 0$

Taking averages yields P_t and $w_t = P_t$ in equation 6.

assumed to be positive but allowed to differ from one. The analysis here is not aimed at examining a particular money supply process; thus, a specific form on m_t is not specified at this point.

Equating aggregate supply and demand (6 and 7) yields:

$$\beta(m_t - P_t) + v_t = \alpha_1 P_t - \alpha_1 E_t P_t + \alpha_2 P_t - \alpha_2 E_t P_t + u_t$$

$$(\beta+\alpha_1+\alpha_2)P_t = \beta m_t + (\alpha_1+\alpha_2)\ E_t P_t + (v_t - u_t)$$

which may be solved for the equilibrium aggregate price level:

$$P_t^* = \frac{\beta}{\beta+\alpha_1+\alpha_2}\ m_t + \frac{\alpha_1}{\beta+\alpha_1+\alpha_2}\ E_t P_t + \frac{\alpha_2}{\beta+\alpha_1+\alpha_2}\ E_t P_t + \frac{1}{\beta+\alpha_1+\alpha_2}\ (v_t - u_t)$$

which will be denoted:

$$(8) \quad P_t^* = \delta_1 m_t + \delta_2 E_t P_t + \delta_3 E_t P_t + \delta_4 (v_t - u_t)$$

where $\delta_1 = \frac{\beta}{\beta+\alpha_1+\alpha_2}$, $\delta_2 = \frac{\alpha_1}{\beta+\alpha_1+\alpha_2}$, $\delta_3 = \frac{\alpha_2}{\beta+\alpha_1+\alpha_2}$, $\delta_4 = \frac{1}{\beta+\alpha_1+\alpha_2}$;

$\delta_1, \delta_2, \delta_4 > 0$; $\delta_3 < 0$.[1]

Equation (8) merely states the straightforward result when all nominal values are flexible, equilibrium price is a function of the current money stock, the expectation of the aggregate price level, and the aggregate demand shock relative to the aggregate supply shock.

Taking the expectation of the aggregate price level (8) produces:

$$E_t P_t = \delta_1 E_t m_t + \delta_2 E_t P_t + \delta_3 E_t P_t + \delta_4 E_t (v_t - u_t)$$

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[1]Evaluating the sign of the denominator, recall that β is positive and may be greater than one. α_1 and $|\alpha_2|$ are less than one and of opposite signs. With respect to α_1 magnitudes, if labor were the only input to production, then α_1 and $|\alpha_2|$ could have the same value (although not required to be equal). Since α_1 also captures some self-owned input, $\alpha_1 \geq |\alpha_2|$ and thus $\beta + \alpha_1 > |\alpha_2|$. The denominator is therefore positive.

$$(9)\quad E_tP_t = \frac{\delta_1}{1-\delta_2-\delta_3} E_tm_t + \frac{\delta_4}{1-\delta_2-\delta_3} (-\bar{u})$$

Given that the public recognizes that the money stock in t strongly affects price level behavior, their expectation of the price level in t is based upon the expected money stock in t and the structural parameters. This price expectation (9) can be substituted into equation (8) to express aggregate price in terms of the money supply in t and the exogenous shock terms:

$$P_t^* = \delta_1 m_t + \left(\frac{\delta_1\delta_2}{1-\delta_2-\delta_3} - \frac{\delta_1\delta_3}{1-\delta_2-\delta_3}\right) E_tm_t + \frac{\delta_2\delta_4+\delta_3\delta_4}{1-\delta_2-\delta_3} (-\bar{u}) + \delta_4(v_t-u_t)$$

Output supply (5 or 6) is expressed in terms of the price forecast error, $P_t-E_tP_t$; therefore, it is useful to assess the difference between the aggregate price level and the expected price level:

$$P_t^*-E_tP_t = \delta_1 m_t + \left[\frac{-\delta_1}{1-\delta_2-\delta_3} + \frac{\delta_1-\delta_2}{1-\delta_2-\delta_3} + \frac{\delta_1\delta_3}{1-\delta_2-\delta_3}\right] E_tm_t$$

$$+ \frac{-\delta_4+\delta_2\delta_4+\delta_3\delta_4}{1-\delta_2-\delta_3} (-\bar{u}) + \delta_4(v_t-u_t)$$

The bracketed term simplifies to

$$\frac{-\delta_1(1-\delta_2-\delta_3)}{(1-\delta_2-\delta_3)} = -\delta_1,$$

thus, the price forecast error reduces to:

$$(10)\quad P_t^*-E_tP_t = \delta_1(m_t-E_tm_t) + \delta_4(v_t-\underbrace{(u_t-\bar{u}_t)}_{\substack{\text{(let } e_t \text{ denote this unpredicted}\\ \text{portion of the supply shock)}}})$$

As (10) indicates, in a case where all nominal values are flexible, only the currently unpredicted portion of money supply and the unpredicted demand shocks relative to supply shocks enter the price forecast error. While current anticipated money growth does affect P_t^*, it is also captured in the current aggregate price expectation, and thus current anticipated money does not enter the price forecast error.

Given the above, real output supply (repeated here for convenience) can be examined in terms of anticipated or unanticipated money impacts.

$$(1) \quad y_t(z) = \alpha_1[P_t(z)-E_tP_t] + \alpha_2[w_t(z)-E_tP_t] + u_t(z)$$

Recall: $P_t(z) = P_t+z$

$w_t(z) = P_t+c$

Substituting for the price and wage terms and then $P_t^*-E_tP_t$ produces:

$$y_t(z) = \alpha_1[\delta_1(m_t-E_tm_t)+\delta_4(v_t-e_t+z]+\alpha_2[\delta_1(m_t-E_tm_t)+\delta_4(v_t-e_t)+c]+u_t(z)$$

or

$$(11) \quad y_t(z) = \underbrace{\overset{(+)\ (-)}{\delta_1(\alpha_1+\alpha_2)}(m_t-E_tm_t)}_{A}+\underbrace{\delta_4(\alpha_1+\alpha_2)(v_t-e_t)+\alpha_1z+\alpha_2c+u_t(z)}_{\beta}$$

As shown in equation (11), real output is affected by the unpredicted portion of money growth (term A) and the true shock terms (term B). Unanticipated money growth is not captured in price expectations and, thus, causes movements in nominal values which are misinterpreted as relative changes in the producer's output price or the purchased input cost, to which the producer responds. As term B indicates, real output also properly responds to true relative price changes (α_1z), true relative cost changes (α_2c) and the unpredicted aggregate demand shifts relative to aggregate supply shifts ($(\alpha_1+\alpha_2)(v_t-e_t)$).

These are not surprising results for this introductory case with all freely flexible nominal values. In fact, given that the context is similar to Lucas (1973), one would question a result that differed drastically from those implied by the Lucas supply function.

Attention turns now from the benchmark case (freely flexible output price and purchased input cost) to examine results when one of the nominal values is temporarily rigid or sticky. Section III first examines the case with rigid wages for purchased inputs and flexible output prices. The rigid price, flexible wage case follows. A brief comparison of results concludes Section III.

SECTION III. PRODUCTION UNDER RIGID NOMINAL WAGE OR PRICE

Case 2: Rigid Wage to Purchased Inputs

The basic model is as in the previous case: output is a function of market output price, the expected aggregate price level, and the wage to purchased factors. Producers respond positively to their market price relative to the expected aggregate price level and negatively to their expected real cost of purchased inputs $(w_t(z)-E_tP_t)$. In this second case, however, assumptions on the flexibility of nominal values are altered a bit. Here, the producer's market price $(P_t(z))$ remains freely flexible across periods. However, the nominal wage for purchased inputs is sticky or rigid in the sense that the wage prevailing in the current period is established in a previous period. (Note that while the length of a period is not strictly specified, it is considered to be less than a year.) While the market price, the aggregate price level and real output may adjust across periods to economic impacts, the nominal wage does not adjust. Wages may be rigid for reasons of formal wage contracts for the purchased input, or, given the short length of the period, due to less formal wage agreements prior to employment, or otherwise "sticky" wages.[1] Firms operate on their demand curve for hired labor. It is assumed they can hire the amount of labor wanted at the predetermined wage during the

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[1]The purpose here is not to establish <u>why</u> contracts or otherwise predetermined wages exist. Instead, it is to acknowledge that they do exist in many sectors of the economy, and then assess the impact with respect to the neutrality of anticipated money.

term of the labor agreement (via changes in number of workers and/or in number of hours worked).[1,2]

The nominal wage in case two is again set with an intent to maintain a constant real wage in period t. However, because the nominal wage is set in a previous period (in t-2, for example), it is based upon the expectation in t-i (here, t-2) for the aggregate price prevailing in t. Nominal wages for the purchased inputs in this second case are given by:

$$(12) \quad {}_{t-i}w_t(z) = {}_{t-i}w_t = \gamma + {}_{t-i}P_t$$

where, under Fischer's (1977) notation, ${}_{t-i}w_t$ is the logarithm of the wage set in t-i to prevail in period t; ${}_{t-i}P_t$ is the expectation formed in t-i of the aggregate price level for period t, more commonly denoted $E_{t-i}P_t$;[3] the γ term is again set at zero. The flexible price terms (market price and aggregate price) are related as before: $P_t(z) = P_t+z$, $E(z) = 0$.

If the wage to all producers is predetermined, aggregate supply is now given by:

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[1]For example, it may be a case of contract where the risk-averse workers trade certainty of the wage for uncertainty in hours worked.

[2]Essentially, the firm temporarily faces an infinitely elastic labor supply at the predetermined wage. As stated earlier, this cannot prevail throughout the whole economy for the long run. It can occur for a short period or in sectors of the economy.

The intent here is to assess impacts of anticipated and unanticipated money when production is in a rigid wage environment. The environment may apply to a sector of the economy -- it need not be the only environment in the economy. Case four, the combination of production environments case, illustrates this.

[3]$E_{t-i}P_t$ is the notation which is hereafter used to denote the expectation in t-i of price in period t.

(13) $y_t = \alpha_1[P_t - E_tP_t] + \alpha_2[{}_{t-i}w_t - E_tP_t] + u_t$

or substituting for ${}_{t-i}w_t$:

(14) $y_t = \alpha_1[P_t - E_tP_t] + \alpha_2[E_{t-i}P_t - E_tP_t] + u_t$

Following the procedures of before, (7) and (14) are used to determine the aggregate price level in this system where production is based on a rigid nominal wage to hired labor. Let P_t' denote the aggregate price level which equates aggregate supply and demand in case two. Now, arbitrarily setting t-i at t-2 and solving for P_t', the aggregate price level for this system is given by:[1]

$$P_t' = \frac{\beta}{\beta+\alpha_1} m_t + \frac{\alpha_1}{\beta+\alpha_1} E_tP_t + \frac{\alpha_2}{\beta+\alpha_1} E_tP_t - \frac{\alpha_2}{\beta+\alpha_1} E_{t-2}P_t + \frac{1}{\beta+\alpha_1}(v_t-u_t)$$

which will be denoted:

$$(15)\quad P_t' = \overset{(+)}{\psi_1 m_t} + \overset{(+)}{\psi_2 E_tP_t} - \overset{(-)}{\psi_3[E_{t-2}P_t - E_tP_t]} + \overset{(+)}{\psi_4(v_t-u_t)}$$

where $\psi_1 = \frac{\beta}{\beta+\alpha_1}$, $\psi_2 = \frac{\alpha_1}{\beta+\alpha_1}$, $\psi_3 = \frac{\alpha_2}{\beta+\alpha_1}$, $\psi_4 = \frac{1}{\beta+\alpha_1}$;

Notice that $\psi_3[E_{t-2}P_t - E_tP_t]$ carries the impact of the predetermined nominal wage relative to current expectations of the aggregate price level. When expectations at the time of wage setting fall short of current expectations ($E_{t-2}P_t < E_tP_t$), equation (15) implies that the impact is to reduce the aggregate price level. As the purchased input's real cost to producers falls, output is increased, which leads to the

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[1]For the present and subsequent cases, only key results will be stated in the main body of the paper. Full derivations of results for all cases are presented in Appendix D.

reduction in the aggregate price level (relative to the previous flexible wage case).

To evaluate the aggregate price level, P_t', in terms of exogenous variables requires substitution for the two price expectation terms, $E_{t-2}P_t$ and E_tP_t.

The expectation as of t-2 for the aggregate price level in t is given by [noting that $E_{t-2}(E_tP_t) = E_{t-2}P_t$]:

$$(16) \quad E_{t-2}P_t = \frac{\psi_1}{1-\psi_2} E_{t-2}m_t + \frac{\psi_4}{1-\psi_2}(-\bar{u})$$

Taking the expectation as of t [noting that $E_t(E_{t-2}P_t)$ is already established in period t, thus $E_t(E_{t-2}P_t) = E_{t-2}P_t$] produces:

$$E_tP_t = \frac{\psi_1}{1-\psi_2-\psi_3} E_tm_t - \frac{\psi_3}{1-\psi_2-\psi_3} E_{t-2}P_t + \frac{\psi_4}{1-\psi_2-\psi_3}(-\bar{u})$$

into which (16) is substituted for the $E_{t-2}P_t$ term.

$$(17) \quad E_tP_t = \frac{\psi_1}{1-\psi_2-\psi_3} E_tm_t - \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}m_t + \left(\frac{\psi_4}{1-\psi_2-\psi_3} + \frac{-\psi_3\psi_4}{(1-\psi_2)(1-\psi_2-\psi_3)}\right)(-\bar{u})$$

Before substituting terms into the aggregate price expression (15), it is again useful to specifically evaluate the difference between the expectation on aggregate price at wage setting time versus the current expectation, i.e., (16)-(17). This quantity, which is essentially the revision in the price forecast, will be used in the real output equation as well as the price equation.

$$(18)\quad E_{t-2}P_t - E_tP_t = \frac{\psi_1}{1-\psi_2-\psi_3}[E_{t-2}m_t - E_tm_t] + \underbrace{\left[\frac{\psi_4}{1-\psi_2} - \frac{\psi_4+\psi_2\psi_4+\psi_3\psi_4}{(1-\psi_2)(1-\psi_2-\psi_3)}\right]}_{=0}(-\bar{u})$$

$[E_{t-2}P_t - E_tP_t]$, which carries the impact of the rigid nominal wage, will be based on the revision in money growth expectations. Where there is an upward revision in the money forecast, this will be a negative term.

Using the E_tP_t and $E_{t-2}P_t$ expressions, the aggregate price level for the system can now be examined in terms of exogenous impacts. Substituting equations (17) and (18) into the aggregate price equation (15, repeated here for convenience):

$$(15)\quad P_t' = \psi_1m_t + \psi_2E_tP_t - \psi_3[E_{t-2}P_t - E_tP_t] + \psi_4(v_t - u_t)$$

$$P_t' = \psi_1m_t + \psi_2\left[\frac{\psi_1}{1-\psi_2-\psi_3}E_tm_t - \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)}E_{t-2}m_t + \frac{\psi_4}{1-\psi_2}(-\bar{u})\right]$$
$$- \psi_3\left[\frac{\psi_1}{1-\psi_2-\psi_3}E_{t-2}m_t - \frac{\psi_1}{1-\psi_2-\psi_3}E_tm_t\right] + \psi_4(v_t - u_t)$$

which simplifies to:

$$(19)\quad P_t' = \psi_1m_t + \frac{\psi_1\psi_2+\psi_1\psi_3}{1-\psi_2-\psi_3}E_tm_t - \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)}E_{t-2}m_t$$
$$+ \frac{\psi_2\psi_4}{1-\psi_2}(-\bar{u}) + \psi_4(v_t - u_t)$$

As equation (19) indicates, the current aggregate price level in case two depends not only on the current actual money supply and the current expected money supply, but also on previous periods' expectations of m_t.

Recall that in the output supply function there are two components to the real output impacts: (i) the impact of the producer's (flexible) output price relative to the expected aggregate price level (carried by the $\alpha_1[P_t(z)-E_tP_t]$ term), and (ii) the impact of the temporarily rigid wage for purchased inputs (the $\alpha_2[E_{t-2}P_t-E_tP_t]$ term). Equation (18) presents this latter term. The flexible wage impact will be primarily given by equations (19)-(17), or:

$$P_t'-E_tP_t = \psi_1 m_t + \frac{-\psi_1+\psi_1\psi_2+\psi_1\psi_3}{1-\psi_2-\psi_3} E_tm_t + \frac{\psi_1\psi_3-\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}m_t$$

$$+ \frac{\psi_2\psi_4-\psi_2\psi_4}{1-\psi_2}(-\bar{u}) + \psi_4(v_t-u_t)$$

which reduces to:

$$(20) \quad P_t' - E_tP_t = \psi_1(m_t-E_tm_t) + \psi_4(v_t-u_t)$$

Assembling these price and expected price results, real output for this second case can now be examined. Recall, market output is given by:

$$y_t(z) = \alpha_1[z+P_t-E_tP_t] + \alpha_2[E_{t-2}P_t-E_tP_t] + u_t(z)$$

Substitution of equations (18) and (20) for the bracketed terms states real market output in terms of the exogenous money supply variable. Here, the relationship is stated in terms of the anticipated and unanticipated money impacts affecting output in case two. (Recall that "anticipated money" refers to the portion of the current money supply which can be currently anticipated based on the information available at the start of period t.)[1] Real output for case two is given by:

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[1]See footnote 1, page 76 for further clarification.

$$(21)\quad y_t(z) = \underbrace{\alpha_1[\psi_1(m_t - E_t m_t)]}_{A} + \underbrace{\alpha_2\left[\frac{\psi_1}{1-\psi_2-\psi_3}(E_{t-2}m_t - E_t m_t)\right]}_{\beta}$$

$$+ \alpha_1 z + u_t(z) + \alpha_1\psi_4(v_t - u_t)$$

Evaluating real output for the environment assumed in case two indicates the following:

1. The relative price term (A) (in which the nominal value is freely flexible) depends only on the unanticipated portion of money supply. While previous expectations of money supply ($E_{t-2}m_t$) do affect the actual aggregate price level (as shown by equation (19)), they do not enter the perceived relative price $[P_t - E_t P_t]$. People recognize that the rigid wage will affect output and the aggregate price level and, therefore, include this impact in their price expectations. The result: in the $[P_t - E_t P_t]$ term (term A), only the currently unanticipated money has real impacts, and it enters with a positive coefficient (α_1).
2. Assessing the second term (B), which carries the impact of temporarily rigid costs for purchased inputs, here currently anticipated money matters. Rearranging the term to state it in terms of the forecast revision and considering an upward revision in money expectations ($E_t m_t > E_{t-2}m_t$), term B becomes

   $$\left[\overset{(-)}{\alpha_2}\left(\overset{(-)}{\frac{-\psi_1}{1-\psi_2-\psi_3}}\ \overset{(+)}{(E_t m_t - E_{t-2}m_t)}\right)\right].$$

   As this indicates, the rigidities in purchased input costs lead to a positive impact from this portion of money supply even though it can currently be anticipated. Considering more closely the events underlying this, recall that the nominal wage to purchased inputs set in t-2 is based on the money supply expectations for period t formed in t-2. As more information becomes available through time, the money expectations are revised and enter current perceptions of the aggregate price level. As money supply expectations are revised upward, producers realize an advantage in lowered real costs of purchased inputs and increase production. Therefore, the rigidities in the nominal wage lead to positive impacts from the currently predictable portion of money supply.

Further comments on (21) are made below in the comparison of real output results across cases. The case where purchased input costs are flexible but the producer's market output price is temporarily rigid is briefly presented next. The end of Section III focuses on comparing output results and the implied impacts of anticipated and unanticipated money in three cases.

Case 3: Rigid Output Price

Again, the basic model is the same as that introduced in case one. However, now attention is on production in an environment where the price of market output, $P_t(z)$, is sticky or temporarily "rigid" relative to movements in costs of purchased inputs. Output price rigidities exist in the economy for a number of reasons. It may be due to formal contracts on price. In a case of intermediate goods production, the output here is someone else's produced input, and corresponding to this, the rigid output price here is someone else's rigid input cost (seen in case two). Given the time frame (where the "period" length is less than a year), "temporary rigidity across periods" includes situations of infrequent or slow output price adjustments (as opposed to formally contracted price rigidity). While in some markets of the economy the output price does adjust easily and frequently to the current market clearing level, there are a number of markets in a modern industrial economy in which the output price is not constantly remarked to the current equilibrium level. For purposes of establishing customer goodwill, reducing customers' search incentive, costs of remarking prices, and so on, output prices are adjusted infrequently. With prices temporarily rigid, output quantity does more of the adjusting. Thus, situations such as that assumed in case three are not uncommon throughout the economy. As before, the purpose here is not to explain the reasons for or assess the optimality of price stickiness. Instead, it is to acknowledge that temporarily rigid output prices occur in a number of markets, and then assess the impact with respect to anticipated money neutrality.

Following the basic model of case one, the nominal wage to purchased inputs is assumed to be flexible across periods. The wage is again given by

$$w_t(z) = \gamma + P_t + c$$

where γ is set to zero; $E(c) = 0$, and terms are as previously defined. The producer's price of market output in case three is assumed to be determined in a previous period (t-i) and based upon expectations in t-i of the aggregate price level to prevail in period t:

$$P_t(z) = {}_{t-i}P_t = E_{t-i}P_t$$

Market supply under these price and wage assumptions is given by:

$$y_t(z) = \alpha_1[{}_{t-i}P_t - E_tP_t] + \alpha_2[w_t(z) - E_tP_t] + u_t(z)$$

or, substituting for the rigid output price and flexible wage terms (and setting t-i at t-2):

$$y_t(z) = \alpha_1[E_{t-2}P_t - E_tP_t] + \alpha_2[c + P_t - E_tP_t] + u_t(z)$$

The solution procedure follows that of the previous rigid wage case: solve the system for the price which equates supply and demand (denoted $\tilde{P}_t$ for case three)[1]; take expectations of price as of period t and t-2; substitute these expectation terms into the $\tilde{P}_t$ expression to state price in terms of exogenous impacts; evaluate real output in terms of anticipated and unanticipated money impacts under these conditions. Rather than repeat all steps of the solution, major results for this third

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[1] As stated, $\tilde{P}_t$ denotes the price which equates aggregate supply and demand in case three. While not all output prices adjust every period, supply and demand forces do establish a direction of pressure on output prices. $\tilde{P}_t$ indicates the level toward which prices will move when market price is readjusted. Given of the structure assumed on the flexible wage (with $w_t(z)$ adjusting each period in response to aggregate price level pressure), the $\tilde{P}_t$ term appears in the supply function via the wage term even when the market output price is sticky.

case are collected below, and discussion moves quickly to evaluation of the real output results.[1]

The implied price expression for the system ($\tilde{P}_t$), before substituting for expectations is given by:

$$\tilde{P}_t = \frac{\beta}{\beta+\alpha_2} m_t - \frac{\alpha_1}{\beta+\alpha_2} E_{t-2}P_t + \frac{\alpha_1}{\beta+\alpha_2} E_tP_t + \frac{\alpha_2}{\beta+\alpha_2} E_tP_t + \frac{1}{\beta+\alpha_2} (v_t-u_t)$$

which will be denoted:

$$(22) \quad \tilde{P}_t = \overset{(+)}{\gamma_1} m_t - \overset{(+)}{\gamma_2}[E_{t-2}P_t - E_tP_t] + \overset{(-)}{\gamma_3} E_tP_t + \overset{(+)}{\gamma_4}(v_t-u_t)$$

where $|\alpha_2| < \beta$, such that $\beta+\alpha_2 > 0$.

Expectations in periods t-2 and t are given by:

$$(23) \quad E_{t-2}P_t = \frac{\gamma_1}{1-\gamma_3} E_{t-2}m_t + \frac{\gamma_4}{1-\gamma_3}(-\bar{u})$$

$$(24) \quad E_tP_t = \frac{\gamma_1}{1-\gamma_2-\gamma_3} E_tm_t + \frac{-\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} E_{t-2}m_t + \left(\frac{\gamma_4}{1-\gamma_2-\gamma_3} + \frac{-\gamma_2\gamma_4}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right)(-\bar{u})$$

Substituting the price expectations (equations 23 and 24) into equation 22 and condensing terms produces a statement of price in terms of only exogenous impacts:

[1]Recall, full derivations for all four cases are presented in Appendix D.

$$(25)\quad \tilde{P}_t = \gamma_1 m_t + \frac{\gamma_1\gamma_2+\gamma_1\gamma_3}{1-\gamma_2-\gamma_3} E_t m_t + \left[\frac{-\gamma_1\gamma_2}{1-\gamma_2-\gamma_3} + \frac{-\gamma_1\gamma_2\gamma_3}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] E_{t-2}m_t$$

$$+ \left[\frac{\gamma_2\gamma_4-\gamma_2\gamma_4+\gamma_3\gamma_4}{1-\gamma_2-\gamma_3} + \frac{-\gamma_2\gamma_3\gamma_4}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right](-\bar{u}) + \gamma_4(v_t-u_t)$$

The price and expected price expressions are substituted into the supply function to produce a statement of output in terms of the currently anticipated and unanticipated portions of money supply (and the random shock terms):

$$(26)\quad y_t(z) = \underbrace{\alpha_1\left[\frac{\gamma_1}{1-\gamma_2-\gamma_3}(E_{t-2}m_t-E_t m_t)\right]}_{A} + \underbrace{\alpha_2[\gamma_2(m_t-E_t m_t)]}_{B}$$

$$+ \alpha_2 c + u_t(z) + \alpha_2\gamma_4(v_t-e_t)$$

Evaluating the real output result in this "rigid market output price, flexible cost of purchased inputs" environment indicates:

1. In term B, which represents impacts via the freely flexible wage for purchased inputs, only the unanticipated portion of money supply has impacts on real output.
2. In the term representing the nominal rigidity (term A, which carries the impact of the producer's temporarily rigid market output price), currently predictable money growth $(E_t m_t - E_{t-2}m_t)$,

has real impacts. Examining this impact more closely, consider, for example, an upward revision in the money forecast (such that $E_{t-2}m_t < E_t m_t$). If the output price were freely flexible across periods, it would adjust upward. Given the temporarily rigid market output price, however, the producer's price relative to the current expectation of the aggregate price has fallen. The impact is to reduce output. Thus, due to the rigid output price component, an impact from currently anticipated money not only exists, but is a negative real impact.

Summarizing results of the three cases, the analysis here finds that in an environment where producer's output price and costs of purchased inputs are both freely flexible (case one), anticipated money does not have real impacts; only the unanticipated portion of money supply matters. In case two, with the nominal wage for purchased inputs temporarily rigid and the producer's output price flexible, anticipated money "matters" and has a positive impact on real output. In case three, the producer's output price is temporarily rigid and costs of purchased inputs flexible across periods. Here, anticipated money again matters, but has a negative real output impact. Comparing magnitudes of the anticipated and unanticipated money response coefficients for the three cases, it is interesting to note that responses to anticipated and unanticipated money movements are largest in the rigid output price case.[1] This makes sense when one

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[1]Presenting the money coefficients in terms of the original parameters (column at right), the three output functions are as follows: e

Using m^u to denote currently unanticipated money, $(m_t - E_t m_t)$
m^a to denote currently anticipated money, $(E_t m_t - E_{t-2} m_t)$
$\omega_t(z)$ to denote the random disturbance terms

<u>Flexible output price and input wage</u>

$$y_t(z) = (\alpha_1 + \alpha_2)\pi_f^u\, m^u + \omega_t(z) \qquad \pi_f^u = \frac{\beta}{\beta + \alpha_1 + \alpha_2}$$

<u>Rigid wage for purchased inputs</u>

$$y_t(z) = \overset{(-)}{\alpha_1}\, \pi_{\bar{w}}^u\, m^u - \overset{(+)}{\alpha_2}\, \pi_{\bar{w}}^a\, m^a + \omega_t(z) \qquad \pi_{\bar{w}}^u = \frac{\beta}{\beta + \alpha_1}, \quad \pi_{\bar{w}}^a = \frac{\beta}{\beta - \alpha_2}$$

<u>Rigid output price</u>

$$y_t(z) = - \overset{(+)}{\alpha_1}\, \pi_{\bar{p}}^a\, m^a + \overset{(+)}{\alpha_2}\, \pi_{\bar{p}}^u\, m^u + \omega_t(z) \qquad \pi_{\bar{p}}^u = \frac{\beta}{\beta + \alpha_2}, \quad \pi_{\bar{p}}^a = \frac{\beta}{\beta - \alpha_1}$$

where $\alpha_1 > 0$, $\alpha_2 < 0$, $\alpha_1 \geq |\alpha_2|$.

Across a variety of reasonable values for the α_i and β, one finds:

$$\pi_{\bar{p}}^a > \pi_{\bar{w}}^a > 0, \quad \pi_f^a = 0 \qquad \pi_{\bar{p}}^u > \pi_{\bar{w}}^u > \pi_f^u > 0$$

Focusing on the anticipated money coefficients, the relative magnitudes of $\pi_{\bar{p}}^a$, $\pi_{\bar{w}}^a$ may be explained as follows:

In case 2, where output price is flexible, a positive anticipated money value does not change $P_t(z)$ relative to $E_t P_t$. The only m^a impact which occurs is via the rigid wage advantage.

In case 3, with output price rigid, a positive m^a value hits the producer with a double impact, as relative output price falls and relative costs rise, thus leading to larger response to m^a.

In case 1, producers do not experience an advantage or detriment from anticipated money since all nominal values adjust. Only the unanticipated money growth matters here.

considers that when price is temporarily rigid and a money shock (for example, a positive shock) occurs, both the producer's relative output price and purchased input costs "move against" the producer, i.e., the relative output price falls due to the temporary rigidity, but the flexible input costs move upward.

The main point of the above is to focus on the altered anticipated money neutrality conclusions when one considers environments with price or cost rigidities. If anticipated money impacts are examined in a setting with all nominal values freely flexible, neutrality of anticipated money holds, as seen in case one. However, if one considers settings with some nominal values temporarily rigid or "sticky", the real impacts of anticipated money are now evident. Furthermore, conclusions on sign of the impact as well as its existence are of interest. Depending on whether it is the wage for purchased inputs or market output price that is rigid, impacts of anticipated money will be positive or negative, respectively.

The analysis here has proceeded as if production occurs in one of three separate environments. In fact, the total economy consists of a mixture of the previous cases, with the different markets of the economy falling generally into one of the three categories based on the flexibility of price relative to the flexibility of purchased input costs. If one considers the aggregate versus disaggregate impressions on neutrality, it is feasible that significant positive and negative anticipated money impacts (as in cases two and three) exist within the respective disaggregated markets of the economy. If one aggregates across all market types, however, potentially these positive and negative anticipated money impacts net out against each other, reducing the apparent impact of anticipated money. Thus, an analysis conducted only at the aggregate level may not detect major anticipated money impacts and conclude anticipated money is "neutral" -- even though significant impacts exist at the disaggregated level. Such a pattern has emerged in econometric testing of neutrality across aggregate and disaggregated levels (Gauger, 1984b). The next section briefly considers an example of this situation using the present model. Output consists of an aggregation across a mixture of the previous market types. Impacts of anticipated and unanticipated money are examined at the aggregate and disaggregated level. Implied magnitudes of the impacts from anticipated and unanticipated money make some interesting shifts across the disaggregate and aggregate level assessments.

SECTION IV. AGGREGATION OF MIXED MARKET TYPES

The previous section gives insight to production in various specific environments of output price and input cost behavior and to the consequences for the neutrality of anticipated money in the respective situations. In fact, the aggregate economy consists of different market types. One can approach this situation with the fourth case here, which assesses anticipated money and unanticipated money impacts when output consists of an aggregation of the three previous market types.

Suppose, for example, one considers a collection of markets which consists of one-third of markets which have freely flexible output price and purchased input costs; one-third which operate with a contracted or temporarily rigid wage for purchased inputs; and one-third which have temporarily rigid output price and flexible input costs. For the sake of example, let the sum across these markets comprise total output for the aggregate economy. The previous three cases, therefore, can categorize broad subsectors of the aggregate economy. Output models are repeated here for convenience.

Both prices, costs flexible:

$$y_t(z) = \alpha_1[P_t(z)-E_tP_t] + \alpha_2[w_t(z)-E_tP_t] + u_t(z)$$

Flexible price, rigid cost:

$$y_t(z) = \alpha_1[P_t(z)-E_tP_t] + \alpha_2[{}_{t-i}w_t-E_tP_t] + u_t(z)$$

Rigid price, flexible cost:

$$y_t(z) = \alpha_1[{}_{t-i}P_t-E_tP_t] + \alpha_2[w_t(z)-E_tP_t] + u_t(z)$$

As one sums across the markets of mixed types, total output is given by:[1]

$$(27)\quad y_t = \frac{\alpha_1}{3}[P_t - E_tP_t] + \frac{\alpha_2}{3}[w_t - E_tP_t] + \frac{\alpha_1}{3}[P_t - E_tP_t]$$
$$+ \frac{\alpha_2}{3}[{}_{t-i}w_t - E_tP_t] + \frac{\alpha_1}{3}[{}_{t-i}P_t - E_tP_t] + \frac{\alpha_2}{3}[w_t - E_tP_t] + u_t$$

Substituting for the sticky output price and purchased input wage terms and rearranging produces the aggregate supply statement for this example:

$$(28)\quad y_t = \frac{2\alpha_1}{3}[P_t - E_tP_t]\,\frac{2\alpha_2}{3}[P_t - E_tP_t] + \frac{\alpha_1}{3}[E_{t-2}P_t - E_tP_t]$$
$$+ \frac{\alpha_2}{3}[E_{t-2}P_t - E_tP_t] + u_t$$

Aggregate demand is as before:

$$(7)\quad y_t = \beta(m_t - P_t) + v_t$$

Applying the solution procedures of before (not fully presented here, see Appendix D), key results produced in this "mixed markets" analysis are as follows.

The aggregate price level for the system (denoted P_t^{**}), prior to substitution for price expectation terms is given by:

$$(29)\quad P_t^{**} = \frac{3\beta}{D}m_t - \frac{\alpha_1}{D}[E_{t-2}P_t - E_tP_t] - \frac{\alpha_2}{D}[E_{t-2}P_t - E_tP_t] + \frac{2\alpha_1}{D}E_tP_t$$
$$+ \frac{2\alpha_2}{D}E_tP_t + \frac{3}{D}(v_t - u_t)$$

where the denominator is $D = 3\beta + 2(\alpha_1 + \alpha_2) > 0$.[2]

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[1]For tractability, the α_1 and the α_2 are assumed to be uniform across the three categories. Different α_{ij} and α_{2j} are admissible but primarily complicate notation. The major results still hold.

[2]See footnote 1, page 86 for the argument which establishes the positive denominator.

This will be denoted as follows, where θ_i values are evident from the above:

$$(30)\quad P_t^{**} = \theta_1 m_t - \theta_2[E_{t-2}P_t - E_tP_t] - \theta_3[E_{t-2}P_t - E_tP_t] + \theta_4 E_tP_t + \theta_5 E_tP_t + \theta_6(v_t - u_t)$$

$$\theta_1,\ \theta_2,\ \theta_4,\ \theta_6 > 0; \qquad \theta_3,\ \theta_5 < 0$$

Taking expectations as of t and t-2 of the aggregate price level, and defining $\theta_{2\to5} = \theta_2 + \theta_3 + \theta_4 + \theta_5$:

$$(31)\quad E_{t-2}P_t^{**} = \frac{\theta_1}{1-\theta_4-\theta_5} E_{t-2}m_t + \frac{\theta_6}{1-\theta_4-\theta_5}(-\bar{u})$$

$$(32)\quad E_tP_t^{**} = \frac{\theta_1}{1-\theta_{2\to5}} E_tm_t + \left[\frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right]E_{t-2}m_t + \left[\frac{\theta_6}{(1-\theta_{2\to5})} + \frac{-\theta_2\theta_6-\theta_3\theta_6}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right](-\bar{u})$$

Substituting price expectations into (30) produces a statement of aggregate price level in terms of exogenous impacts:

$$P_t^{**} = \theta_1 m_t + \left[\frac{\theta_1\theta_2+\theta_1\theta_3+\theta_1\theta_4+\theta_1\theta_5}{(1-\theta_{2\to5})}\right]E_tm_t + \left[\frac{-\theta_1\theta_1-\theta_1\theta_3}{(1-\theta_{2\to5})}\right]E_{t-2}m_t + \left[\frac{-\theta_1\theta_2\theta_4-\theta_1\theta_3\theta_4-\theta_1\theta_2\theta_5-\theta_1\theta_3\theta_5}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right]E_{t-2}m_t + \theta_6(v_t-u_t) + \frac{\theta_6(\theta_4+\theta_5)}{(1-\theta_4-\theta_5)}(-\bar{u})$$

which condenses to the more tractable expression for price as a function of current actual money supply, current and previous expectations of the money supply, and the stochastic disturbances:

$$(33)\quad P_t^{**} = \theta_1 m_t + \frac{\theta_1(\theta_2+\theta_3+\theta_4+\theta_5)}{(1-\theta_{2\to5})} E_t m_t + \left[\frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right] E_{t-2}m_t$$
$$+ \frac{\theta_6(\theta_4+\theta_5)}{1-\theta_4-\theta_5}(-\bar{u}) + \theta_6(v_t-u_t)$$

Given these price and expectation terms, aggregate supply in this mixed-market-types example will be:

$$(34)\quad y_t = \frac{2(\alpha_1+\alpha_2)}{3}[\theta_1(m_t-E_t m_t)] + \frac{(\alpha_1+\alpha_2)}{3}\left[\frac{\theta_1}{(1-\theta_{2\to5})}(E_{t-2}m_t-E_t m_t)\right]$$
$$+ \frac{2\theta_6(\alpha_1+\alpha_1)}{3}(v_t-u_t) - \frac{2\theta_6(\alpha_1+\alpha_2)}{3}(-\bar{u}) + u_t$$

As shown by (34), aggregate supply is a function of an anticipated and unanticipated money term (plus the disturbance terms). Evaluation of these aggregate impacts is given below, after presentation of the implied disaggregated supply functions implied in this system.

Real output in the respective market categories will be given by the following:

For flexible output price and input wage markets -

$$(35i)\quad y_t(f) = (\alpha_1+\alpha_2)\theta_1(m_t-E_t m_t) + \alpha_1 z + \alpha_2 c + \theta_6(\alpha_1+\alpha_2)(v_t-e_t)$$
$$+ u_t(z)$$

For flexible output price, rigid input wage markets -

$$(ii)\quad y_t(\bar{w}) = \alpha_1\theta_1(m_t-E_t m_t) + \alpha_2\frac{\theta_1}{(1-\theta_{2\to5})}(E_{t-2}m_t-E_t m_t)$$
$$+ \alpha_1 z\alpha_1\theta_6(v_t-e_t) + u_t(z)$$

For rigid output price, flexible input wage markets -

$$\text{(iii)} \quad y_t(\bar{p}) = \alpha_1 \frac{\theta_1}{(1-\theta_{2+5})} (E_{t-2}m_t - E_t m_t) + \alpha_2 \theta_1 (m_t - E_t m_t)$$

$$+ \alpha_2 \theta_6 (v_t - e_t) + \alpha_2 c + u_t(z)$$

Briefly examining these market output results for this "mixed economy" example, again one finds that when all nominal values are flexible (35i), only the currently unanticipated portion of money supply affects real output. When either output price or the cost of purchased inputs is temporarily rigid, there are real impacts from currently predictable money supply $[E_{t-2}m_t - E_t m_t]$, as well as the unpredicted portion. When input cost is rigid, anticipated money supply has a positive real output impact in that market (35ii). When output price is rigid, the real market impact is negative (35iii). These results on existence and sign of anticipated money impacts in the various market categories are consistent with those in the previous individual case assessments.

Of greater interest than the above results on existence of anticipated money impacts in this "mixed economy" example are the implied pattern on coefficient magnitudes across the aggregate output and market output results (34 through 35iii). The results for the models here fall very much in line with the patterns of impacts found in econometric examination of the neutrality hypothesis across the aggregate and disaggregated testing levels (Gauger, 1984b).

To assist the comparison of relative coefficient magnitudes, the respective coefficients in (34) through (35iii) will be more simply denoted: θ_j^a, θ_j^u, where the superscript denotes a coefficient on anticipated (a) or unanticipated (u) money, and the "j" subscript denotes either the aggregate output (θ_A) or one of the disaggregated supply relationships: flexible wages and output prices (θ_f); rigid wages ($\theta_{\bar{w}}$) or rigid output price ($\theta_{\bar{p}}$). "$\omega_t(j)$" summarizes the various disturbance terms.

Under this notation, (34) and (35i, ii, iii) become:

Aggregate output

(34') $y_t = \theta^u_A[m_t - E_t m_t] + \theta^a_A[E_{t-2}m_t - E_t m_t] + \omega_t(A)$

Market-type outputs

35i') $y_t(f) = \theta^u_f[m_t - E_t m_t] + \omega_t(f)$

(ii') $y_t(\bar{w}) = \theta^u_{\bar{w}}[m_t - E_t m_t] + \theta^a_{\bar{w}}[E_{t-2}m_t - E_t m_t] + \omega_t(\bar{w})$

(iii') $y_t(\bar{p}) = \theta^a_{\bar{p}}[E_{t-2}m_t - E_t m_t] + \theta^u_{\bar{p}}[m_t - E_t m_t] + \omega_t(\bar{p})$

Anticipated and unanticipated money coefficients, with their values in terms of the original α_i's and β, are given in Table 1.

Evaluation of coefficient magnitudes indicates the following patterns (comparisons are based on absolute values of the coefficients):

1. At the disaggregated level (for market types with nonzero θ^a_j), the coefficient on anticipated money exceeds the coefficient on unanticipated money. Thus, in the rigid wage and rigid output price cases, anticipated money impacts are larger than unanticipated money impacts across reasonable values of α_i's and β.

   $\theta^a_{\bar{w}} > \theta^u_{\bar{w}}$; $\theta^a_{\bar{p}} > \theta^u_{\bar{p}}$

2. Furthermore, the implied anticipated money impacts at the disaggregated level exceed the aggregate-level coefficient.

   $\theta^a_{\bar{w}}$ and $\theta^a_{\bar{p}} > \theta^a_A$.

3. When one assesses aggregate-level impacts, now the pattern switches from that in (1). At the aggregate level, the unanticipated money coefficient exceeds the anticipated money coefficient. An evaluation at the aggregate level alone would suggest unanticipated money impacts dominate anticipated money impacts.

   $\theta^a_A < \theta^u_A$.

Thus, a disaggregate-level examination of major real output impacts indicates that at this output level, the anticipated money impacts dominate unanticipated money impacts. Furthermore, impacts of anticipated money at the disaggregated level exceed the values on anticipated money indicated in an aggregated assessment. In other words, neutrality of anticipated money does not hold when one moves the examination to a disaggregated level. Evaluating the aggregate level results, unanticipated money here has the appearance of being the major impact on output. This occurs, however, not necessarily because anticipated money is neutral and unanticipated money is actually the major output influence across all output levels. Instead, the appearance of anticipated money neutrality may occur because of an offsetting of the disaggregate levels' positive and negative anticipated money impacts. When one sums across market types, the apparent impacts from anticipated money are reduced. As the analysis here shows, an examination confined to the aggregate level alone

Table 1. Anticipated and unanticipated money coefficients for aggregate vs. disaggregated output functions [equations (34') through (35iii')]

Coefficient→ ↓Case	Unanticipated Money θ^u_j	Anticipated Money θ^a_j	In terms of original parameters[a,b] θ^u_j	 θ^a_j
Aggregate	$\theta^u_A = \dfrac{2(\alpha_1+\alpha_2)\theta_1}{3}$	$\theta^a_A = \dfrac{(\alpha_1+\alpha_2)\theta_1}{3(1-\theta_{2\to5})}$	$\theta^u_A = \dfrac{\beta(\alpha_1+\alpha_2)}{3/2\beta+\alpha_1+\alpha_2}$	$\theta^a_A = \dfrac{\beta(\alpha_1+\alpha_2)}{3\beta-\alpha_1-\alpha_2}$
Flexible p, w	$\theta^u_f = (\alpha_1+\alpha_2)\theta_1$	$\theta^a_f = 0$	$\theta^u_f = \dfrac{\beta(\alpha_1+\alpha_2)}{\beta + 2/3(\alpha_1+\alpha_2)}$	$\theta^a_f = 0$
Rigid wage	$\theta^u_{\underline{w}} = \alpha_1\theta_1$	$\theta^a_{\underline{w}} = \dfrac{\alpha_2\theta_1}{(1-\theta_{2\to5})}$	$\theta^u_{\underline{w}} = \dfrac{\beta\alpha_1}{\beta + 2/3(\alpha_1+\alpha_2)}$	$\theta^a_{\underline{w}} = \dfrac{\beta\alpha_2}{\beta - 1/3(\alpha_1+\alpha_2)}$
Rigid price	$\theta^u_{\underline{p}} = \alpha_2\theta_1$	$\theta^a_{\underline{p}} = \dfrac{\alpha_1\theta_1}{(1-\theta_{2\to5})}$	$\theta^u_{\underline{p}} = \dfrac{\beta\alpha_2}{\beta - 1/3(\alpha_1+\alpha_2)}$	$\theta^a_{\underline{p}} = \dfrac{\beta\alpha_1}{\beta + 2/3(\alpha_1+\alpha_2)}$

[a]Recall: $\beta > 0$; $\alpha_1 > 0$; $\alpha_2 < 0$; $\alpha_1 \geq |\alpha_2|$.

[b]Summary of Magnitude Relationships:

1. $\theta^a_{\underline{w}} > \theta^u_{\underline{w}}$ $\qquad \theta^a_{\underline{p}} > \theta^u_{\underline{p}}$.

2. $\theta^a_{\underline{w}}, \theta^a_{\underline{p}} > \theta^a_A$.

3. $\theta^a_A < \theta^a_A$.

might suggest that anticipated money does not have significant output impacts (i.e., "neutrality holds"). In fact, real impacts from anticipated money exist within the disaggregated markets, and, in fact, the anticipated money impacts can exceed those of unanticipated money at this output level. Thus, if one's examination of money impacts <u>includes</u> attention to the disaggregated level, one sees that neutrality of anticipated money does not hold.

The pattern implied by the model here for the impacts of anticipated and unanticipated money is consistent with empirical results found in econometric tests of the neutrality hypothesis across both aggregate level and disaggregated real output measures (Gauger, 1984a; Gauger, 1984b). These tests apply similar procedures across the aggregate and disaggregated testing levels, yet detect an anomalous result. They find that in an aggregate level test, only the unanticipated portion of money supply appears to have real impacts -- a result consistent with conclusions of several other tests of neutrality which confine attention to aggregate-level data (for example, Barro, 1978; Barro and Rush, 1980; Hoffman and Schlagenhauf, 1982; Attfield, Demery and Duck, 1981). However, when one tests at the disaggregated level (using two different levels of disaggregation), the tests hit the anomaly: significant anticipated money impacts are found to exist at the disaggregated level. Furthermore, these impacts are often more highly significant than the impacts from unanticipated money.

The model here resolves the anomalous results as it indicates the events which may underlie it. The example here in case four shows how significant but opposite signed anticipated money impacts within different-natured markets may offset in aggregation to produce a small net impact from anticipated money. As the analysis here indicates, testing at the aggregate level only may conceal significant anticipated money impacts which exist at lower levels. Thus, a note of precaution emerges from case four and the econometric tests: conclusions of anticipated money neutrality based only on aggregate level testing may be false images. Attention to disaggregate level impacts is also important.

SECTION V. SUMMARY

Previous theoretical models examining anticipated and unanticipated money impacts primarily consider production in settings where a flexible relative price of output is the only key entry to producer supply decisions. Models which do consider purchased input costs typically assume this nominal value is freely flexible also. The analysis in this paper moves beyond the "price only, freely flexible nominal values" assumption sets. The model here assesses anticipated and unanticipated money impacts in an environment in which (i) producers are assumed to base production decisions on both the relative price of market output (the price received by the self-owned factors) and the real cost of purchased inputs. Also, (ii) production occurs with temporary rigidities in either output price or purchased input costs (due to contracts or to less formal sources of temporary price stickiness).

The analysis initially assesses production impacts from anticipated and unanticipated money under three separate sets of assumed output price and input cost behavior: (i) both output price and purchased input cost flexible (case one), (ii) flexible price of market output and temporarily rigid purchased input costs (case two); (iii) temporarily rigid output price and freely flexible input costs (case three). Results of these first three cases indicate: (1) Only unanticipated money has real impacts in the model when both output price and input costs are freely flexible. As should be expected, this result corresponds to those of models elsewhere which assume freely flexible nominal values. (2) Anticipated money does have real impacts if output price or purchased input costs are temporarily rigid. (3) Furthermore, anticipated money impacts are of opposite signs across cases two and three; i.e., impacts of anticipated money are positive or negative according to whether the purchased input costs or market output price is relatively more rigid.

In Section IV, the analysis turns to the issue of disaggregated versus aggregate examination of the anticipated money impacts and potential differences in conclusions drawn for neutrality according to the perspective level used in the examination. The analysis in case four ties into empirical tests of neutrality -- and the anomaly in the aggregate versus disaggregated test results. Section IV considers an example where total output is an aggregation across differing market types. The implied results for anticipated and unanticipated money impacts are compared across the disaggregated and aggregate levels. The aggregate versus disaggregated results implied by the model and case four are consistent with patterns of impacts in the empirical tests of neutrality. Anticipated money appears to not have significant impacts if one assesses aggregate-level output; unanticipated money appears to be the dominant impact on aggregate real output. However, significant anticipated money impacts are evident when one examines real output responses at disaggregated levels. Here, the anticipated money impacts can exceed the unanticipated money impacts -- quite opposite to the patterns at the aggregate level, which could suggest neutrality of anticipated money holds. Because the disaggregate levels' positive and negative anticipated money impacts may offset each other when one aggregates across market types, the apparent impacts of anticipated money are reduced. Therefore, the aggregate examination can produce a false picture of neutrality. Both the empirical studies and the analysis here present the same clear message: investigations of anticipated money neutrality should not be confined to the aggregate-level assessments; disaggregated examination is also needed. The impacts detected at the finer output levels can yield quite different conclusions for anticipated money neutrality.

GENERAL SUMMARY

The three preceding essays examine from a disaggregated perspective the hypothesis that anticipated money growth is "neutral"; only unanticipated money growth has real economic impacts. While the particular emphasis differs across essays, all point to a common conclusion: solely aggregate level assessment of neutrality is not sufficient; a disaggregated examination can reveal impacts missed in aggregate level research.

Specific conclusions are stated in the individual essays; however, the very general results are briefly summarized here. Part One presents the first essay, which is a disaggregated examination of the neutrality hypothesis using real output measures from twelve U.S. manufacturing industries. Test results indicate that at this output level, anticipated money growth is not neutral. Results indicate that anticipated money does have real impacts, and, in fact, anticipated money growth "matters" in more cases than unanticipated money growth.

Part Two presents the second essay, which examines more specifically the issue of aggregate versus disaggregated testing of neutrality. The research here controls for differences in econometric procedures and tests the neutrality hypothesis using aggregate level real GNP (Gross National Product) and the disaggregated GNP subcomponent data. The tests here hit upon an anomaly. The aggregate results suggest neutrality holds: anticipated money growth does not have significant impacts; unanticipated money impacts are significant. This result is consistent with findings in several previous aggregate tests cited in support of the neutrality proposition. However, tests here indicate that when one disaggregates to the level of the GNP subcomponents, the results present a different message. Real impacts from anticipated money growth are evident on the subcomponents of real GNP.

Essay three examines neutrality of anticipated money in a theoretical model that moves beyond the freely flexible nominal values assumptions common in previous theoretical neutrality research. The research here analyzes anticipated money impacts in environments with different combinations of producer output price and purchased input cost behavior. The analysis indicates anticipated money does have real impacts if either output price or purchased input costs are temporarily rigid. Furthermore, these anticipated money impacts are of opposite signs. A final case in essay three illustrates how the conflicting conclusions of the aggregate versus disaggregated test results can occur. The positive and negative impacts of anticipated money which exist in disaggregated markets (of differing price and cost behavior) may offset one another when output is aggregated across markets. The apparent anticipated money impacts are reduced and may cause a false appearance at the aggregate level of anticipated money being neutral, despite the real impacts at the disaggregated level.

As is stated in the introduction, the implications of the neutrality hypothesis are not trivial. Thus, it continues to be of interest from both a theoretical and policy perspective. There are many facets of the neutrality issue that have not yet been examined. The clear message of the research here is that as future research examines neutrality, either theoretically or empirically, one cannot confine attention to the aggregate level. In each case here, the research indicates that real impacts may be obscured in the aggregation. Disaggregate level examination is also important to evaluate the impacts of anticipated money growth on real economic activity.

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APPENDIX A. THE LUCAS MODEL

The Lucas model is an example of a new classical macroeconomic model which implies to the neutrality of anticipated money implication. The context for the Lucas model focuses on producers' information extraction problems in a world of uncertainty. Producers' supply decisions are based on the observed own-market price relative to the perceived overall price level. Supply responds positively to perceived changes in relative price only. Given the lack of perfect foresight, producers must use available information to form perceptions of the current overall price level. For example, when the observed market price ($p_t(z)$) rises, producers must determine what portion of the change [$\Delta p_t(z)$] is due to an overall price change (Δp_t), and what portion is due to a relative price change [$\Delta p_t(z) - \Delta p_t$].

The general format of the Lucas supply function is as follows:[1] Written in logs --

(1) $y_t = \gamma[p_t(z) - E(p_t | I_t(z))] + \lambda y_{t-1}(z) \qquad |\lambda| < 1,\ \gamma > 0$

(2) $p_t(z) = p_t + z$

where: $p_t \sim N(\bar{p}, \sigma^2)$

$z \sim N(0, \tau^2)$

---

[1] Lucas uses cyclical and secular components in his 1973 model. There, total market supply is given by:

$$y_t(z) = y_{nt} + y_{ct}(z)$$

where $y_{nt} = \alpha + \beta t$ represents normal trend growth.

$y_{ct}(z)$ is the cyclical component, as in equation 1, which varies with perceived relative price.

Market-specific components are indexed by z. $y_t(z)$ is the log of real output in market z at time t. It depends upon current observed market price ($p_t(z)$) relative to expectations of the general price level, given information available in market z at time t, ($[E(p_t|I_t(z)]$), and a cyclical lagged output term.

With respect to the information set, producers know their observed market price in t. They also know the past history of overall prices, (p_t), and thus are aware of the distribution of p_t, its means ($\bar{p}_t$), and variance (σ^2). Producers also know the basic relationship between their market price and the overall price level (eq. 2). In Lucas' specification, market price consists of an aggregate price-level component and a market-specific component. The market-specific component (z in eq. 2), has zero mean and variance τ^2. Though producers do not know current p_t, they make inferences about it using observations on $p_t(z)$ and knowledge on the distribution of p_t plus relationship (2).

Substituting the information set in to (2), taking expectations, and manipulating,[1] yields the conditional expectation on overall price:

$$(3) \quad E[p_t|I_t(z)] = (1-\theta)p_t(z)+\theta p_t$$

$$\theta = \frac{Var(z)}{Var(z) + Var(P_t)} = \frac{\tau^2}{\tau^2 + \sigma^2}$$

θ represents the variability of the market-specific price component relative to the sum of the market component and general price variability.

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[1] Derivations shown on pages 129-130.

Expected overall price is a weighted average of the producer's two pieces of information, with the weight θ being the relative variance of local and aggregate prices.

Combining the price level expectation specification (3) with the basic supply function (1) yields the final market supply specification:

(4) $y_t(z) = \theta\gamma[p_t(z) - \bar{p}_t] + \lambda y_{t-1}(z)$

Aggregate supply is the average of market supplies across all markets:[1]

(5) $y_t = \theta\gamma[p_t - \bar{p}_t] + \gamma y_{t-1}$

where (in logs): y_t = log of aggregate output at time t

p_t = log of current overall price level

$\bar{p}_t$ = log of the mean of overall price distribution

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[1]To move from market supply (eq. 4) to aggregate supply (eq. 5), integrate across z (across all markets). Assume γ, θ, λ are constants. Recall, market price is given by: $p_t(z) = p_t + z$, where the market specific component of price has zero mean ($\bar{z} = 0$). Thus, market specific price shocks cancel out. Overall price level (p_t) is the sum of market prices across all markets: $p_t = \int p_t(z)\, dz$. Aggregate output (y_t) is the sum of market output across all markets: $y_t = \int y_t(z)\, dz$ and also $\lambda y_{t-1} = \lambda \int y_{t-1}(z)\, dz$.

Note also, that Lucas' 1973 model included the normal trend growth (y_{nt}) term. Incorporating this into the aggregate supply function, equation 5 becomes:

$$y_t = y_{nt} + \theta\gamma[p_t - \bar{p}_t] + \lambda[y_{t-1} - y_{nt-1}].$$

With respect to: The price expectation specification $[E[p_t|I_t(z)]]$ and the market supply specification (eq. 4)

Consider $E[p_t|I_t(z)]$.

Denote the expectation: p_t.

Suppose firms' forecasts are a linear function of available information, $p_t(z)$, $\bar{p}_t$.

$$p_t = \pi_1 p_t(z) + \pi_2 \bar{p}_t \qquad \text{where } \pi_1 + \pi_2 = 1$$

Firms want to pick π_1, π_2 such that they minimize the variance of the forecast error:

$$\underset{\pi_1,\pi_2}{\text{Min}}\ E[E(p_t-p_t)^2] \rightarrow \underset{\pi_1,\pi_2}{\text{Min}}\ \underbrace{E[(p_t-\pi_1 p_t(z)-\pi_2\bar{p}_t)^2]}_{V}$$

First Order Conditions:

$$\text{i)}\quad \frac{\partial V}{\partial \pi_1}:\ E[2(p_t-\pi_1 p_t(z)-\pi_2\bar{p}_t)(-p_t(z))] = 0$$

$$\text{ii)}\quad \frac{\partial V}{\partial \pi_2}:\ E[2(p_t-\pi_1 p_t(z)-\pi_2\bar{p}_t)(-\bar{p}_t)] = 0$$

Recall, $p_t(z)$ and p_t are related via relationship (2): $p_t(z) = p_t + z$.

Substitute for $p_t(z)$ in the F.O.C.; divide by -2 to simplify.

$$\text{i')}\quad E[(p_t-\pi_1(p_t+z)-\pi_2\bar{p}_t)(p_t+z)] = 0$$

$$\text{ii')}\quad E[(p_t-\pi_1(p_t+z)-\pi_2\bar{p}_t)(\bar{p}_t)] = 0$$

Multiply through in i'):

$$E[(p_t^2 + p_t z - \pi_1 p_t^2 - 2\pi_1 p_t z - \pi_1 z^2 - \pi_2\bar{p}_t p_t - \pi_2\bar{p}_t z)] = 0$$

p_t and market shocks are independent, thus $p_t z = 0$, $\bar{p}_t z = 0$,

$\bar{p}_t p_t = 0$

Thus, i') becomes:

$$\text{i''})\quad E[p_t^2(1-\pi_1) - \pi_1 z^2] = 0$$

$$= \underbrace{E[p_t^2(1-\pi_1)]}_{\substack{\text{variance of} \\ \text{overall price} \\ \text{level, } \sigma^2}} - \pi_1 \underbrace{E(z^2)}_{\substack{\text{variance of} \\ \text{market shock, } \tau^2}} = 0$$

$$= \mathrm{Var}(p_t)(1-\pi_1) - \pi_1 \mathrm{Var}(z) = 0$$

Solve for π_1:

$$\mathrm{Var}(p_t) = \pi_1[\mathrm{Var}(z) + \mathrm{Var}(p_t)]$$

$$\pi_1 = \frac{\mathrm{Var}(p_t)}{\mathrm{Var}(p_t) + \mathrm{Var}(z)} = \frac{\sigma^2}{\sigma^2 + \tau^2}$$

$$\pi_2 = 1-\pi_1 = \frac{\tau^2 + \sigma^2 - \sigma^2}{\tau^2 + \sigma^2}$$

$$\pi_2 = \frac{\tau^2}{\tau^2 + \sigma^2}$$

Returning to the forecast equation, denote the coefficient on $\bar{p}_t$ (π_2) as θ. Denote the coefficient on $p_t(z)$ (π_1) as $1-\theta$, to yield the forecast equation re-expressed:

$$p_t = (1-\theta)p_t(z) + \theta\bar{p}_t \qquad \text{i.e., equation (3) in the model.}$$

Substitute this $E[p_t | I_t(z)]$ expression into the supply equation:

$$y_t(z) = \gamma[p_t(z) - E(p_t | I_t(z))] + \lambda y_{t-1}(z)$$

$$= \gamma[p_t(z) - [(1-\theta)p_t(z) + \theta p_t]] + \lambda y_{t-1}(z)$$

$$= \gamma[p_t(z) - p_t(z) + \theta p_t(z) - \theta p_t] + \lambda y_{t-1}(z)$$

$$= \theta\gamma[p_t(z) - \bar{p}_t] + \lambda y_{t-1}(z)$$

i.e., equation (4) in the model.

APPENDIX B. DETAIL ON ESTIMATION AND TESTING

Specific details on the estimation and testing procedures are given in this appendix. Detail of this sort can be distracting and bothersome to the general reader -- interested primarily in final results and analysis. However, from experience in the research here, specific detail and documentation is valuable to persons considering (or involved in) similar research. This appendix is provided for people with such interests.

Output Data

The output measures used come from the Federal Reserve Board of Governors' Industrial Production (IP) index. Advantages of the IP series include the following: i) IP captures real output, as opposed to a value (the form of much of the disaggregated output data) which must somehow be appropriately deflated. ii) Subcomponents of the overall IP series provide a disaggregated measure which is linked to SIC (Standard Industrial Code) industry breakdowns. Subcomponents are available at levels of the two-digit, three-digit and some four-digit SIC code industries. The two-digit level is a useful disaggregation, since "auxiliary" industry information is often published at the two-digit level (i.e., unemployment, price data; worker contract information, etc). iii) IP subcomponents are available on a quarterly, seasonally unadjusted basis. When available, seasonally unadjusted data is preferable to adjusted data. Elaborate seasonal adjustment procedures (such as Census X-11) may "smooth away" the economic responses which one is trying to detect. iv) There is excellent continuity of measurement over time and over industries with IP disaggregated data. This strengthens the comparability of final results across industries. v) IP is carefully constructed, and the performance is monitored over time. (For example, performance relative to GNP data is monitored.) When major revisions are made, revised series extending back in time are recalculated and published. This type of "quality control" increases the confidence one places in test results from this measure as opposed to other output measures.

The Industrial Production index was selected over disaggregated GNP data because GNP subcomponents are available on an income basis only, rather than output basis. There is a substantial amount of imputation in deriving the quarterly income series. Accounting conventions can distort the picture of the underlying behavior of real output. Seasonally unadjusted subcomponent series do not exist (partly because the imputations to the quarterly series automatically incorporate the seasonal adjustments).[1]

Questions may arise as to whether the use of an index (rather than a raw output tally) affects the pattern of empirical results. Since this research was started, some unpublished work by Neil Skaggs has come to attention. Skaggs uses unemployment data disaggregated to the one-digit level to test some neutrality issues. While the focus of his research differs from that here, similar empirical test procedures establish some comparability. There are similarities between patterns of test results under the unemployment and IP output mésures. This comparability of

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[1]Based on conversations with Ken Petrick and Leo Bernstein with the National Income and Products Division of the U.S. Department of Commerce.

results improves the case for IP as an appropriate (and perhaps the best available) output measure for this disaggregated research.

One final consideration is that the IP index (as its name suggests) covers primarily the manufacturing sector. It omits, for example, services which have matched or exceeded the goods component of real GNP since about 1971:4. In order to assess the importance of this -- and also to establish a link to previous aggregate GNP work -- tests were also conducted using the real GNP broad breakdowns of goods, service and structures (as well as the sum of goods, services, structures). Examination of these GNP subcomponents showed that services primarily followed a trend growth pattern. Thus, the omission of services primarily alters trend, but not movements about trend, which is the research interest here. As noted in the documentation on the IP index, the IP series captures most of the cyclical movements of the aggregate economy.[1] Thus, one can regard IP an an excellent output measure for these tests, validly reflecting production responses in the U.S. economy.

The specific series selected, corresponding SIC code and the proportion in total Industrial Production for each series are listed in Table B1 below. As a general guide on how series were selected, a first group was selected based on "importance" (in the sense of being a large proportion) to total U.S. production activity. The primary metals, steel, and fabricated metal products series were specifically selected as a set to examine impacts across stages in goods production (from primary

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[1]Further detail provided in summary of Industrial Production, Federal Reserve Board of Governors, 1971.

Table B1. Industry series used

Series	SIC Code	Proportion of series in Total IP[a]
Primary Metals	33	6.57
Steel	331,332	4.21
Fabricated Metal Products	34	5.93
Electrical Machinery & Equipment	36	8.05
Autos (Motor Vehicles & Parts)	371	4.50
Aircraft & Parts with 1.06 due to military aircraft; 1.67 due to noncommercial aerospace eqpt. parts	372	3.73
Apparel	23	3.31
Textile Mill Products	22	2.68
Chemicals Products	28	7.74
Printing & Publishing	27	4.72
Utilities	---	5.69
Electrical Utilities (Sales, nonresidential kwh)	---	1.15

[a]Over half (53%) of total IP represented by the sample.

industry to finished goods). The above criterion (industries having a large proportion in total industrial production) produced mostly durable-good type industries. Thus, another group of industries was selected which represented more of the nondurable good industries. The utility series were selected to examine responses in a tightly regulated industry.

Estimation Procedure

As is mentioned in Essay One of Part One, the anticipated (m^a) and unanticipated (m^u) money growth specifications are those used in the Barro-Rush (1980) tests of neutrality. With respect to this m^a, m^u data, recall that alternative money forecasting specification did not seem clearly superior to that used by Barro and Rush. Furthermore, work by Mishkin (1982) and Hoffman and Schlagenhauf (1982) indicate that results are robust across money specifications. The estimation followed the two-step procedure. Recall that the major alternative is a joint estimation of the money and output equations. The gains of joint estimation are in efficiency, not in consistency of estimates. Research by Hoffman, Low and Schlagenhauf (1982) indicates that the joint procedure is not clearly superior to the two-stage procedure for detecting violations of neutralilty. Thus, the incremental benefits of the joint procedure (efficiency only) do not seem to warrant the additional costs of the joint estimation (in particular, for the twelve industry estimations).

The time frame for the output estimations runs from 1955:I to 1978:I. This avoids the sharp breaks in monetary policy procedure of the 1951

Federal Reserve -- Treasury Accord and the October, 1979 Federal Reserve switch to closer monetary aggregate targeting. (With time series analysis, it is important to avoid sharp breaks in the processes generating the data, unless assessing those breaks is one's testing purpose.) Using this time span, ninety-three quarterly observations entered each of the estimations. The dependent variable was the natural log of the Industrial Production index subcomponent series for twelve industries (primarily two digit level SIC industries). Evaluation indicated that the log transformation was not too severe (i.e., did not distort the patterns in the data). Also, for the series containing a multiplicative seasonal pattern (a seasonal swing which increases over time), the use of the natural log corrected the multiplicative seasonal pattern.

The model estimated for the majority of testing is as follows. Using the general notation of the text:

$$(1)\quad y_t(z) = X_t(z)\phi + \sum_{i=0}^{3} \alpha_i(z)m^a_{t-i} + \sum_{i=0}^{3} \beta_i(z)m^u_{t-i}$$

or substituting in the $x_t\phi$ terms:

$$(1')\quad y_t(z) = a_0 + b_1T + \sum_{i=1}^{3} c_iS_i + \sum_{i=1}^{k} d_iy_{t-i} + \sum_{i=0}^{3} \alpha_i m^a_{t-1} + \sum_{i=0}^{3} \beta_i m^u_{t-i}$$

$$(k=1 \text{ or } 2)$$

With respect to the $x_t\phi$ entries, the a_0, b_1, and c_i terms capture the constant, trend growth and seasonal production components, respectively. The d_i terms capture the degree of persistence in output relevant to the industry. These were the terms that appeared in the $x_t\phi$ component across all series. For some series, (primary metals, steel, aircraft), $x_t\phi$ also included terms to capture abnormal market shocks (severe strikes, Vietnam War military escalation, etc.).

Testing here is based on a full model which includes both anticipated and unanticipated money variables (as in (1) or (1')). Note that in some other tests of neutrality (for example, Barro and Rush, 1980, Skaggs, 1982), output is regressed only on the unanticipated money growth variable. While this does allow testing of whether unanticipated money has real impacts, it does not get at issues of whether anticipated money is neutral or what is the impact of unanticipated relative to anticipated money. Barro's earlier annual tests included some models with both unanticipated money and total money growth variables. The empirical results for these were not reported, nor was the analysis of these models very extensive. None of the "unanticipated money", plus "total money growth", models were estimated for the quarterly work. Thus, the bulk of the Barro, and Barro-Rush conclusions, seem to be extracted from their "truncated" full models -- models which use unanticipated money as the only money variable. This is not a balanced treatment of the two sources of money impacts and not an appropriate full model for establishing the conclusions on money impacts which Barro (1977) and Barro and Rush (1980) imply in their results analyses. Comments at the end of this appendix (concerning alternative specifications tested) describe the specific pattern of results produced by estimating the "unanticipated money only" model. While the resulting pattern has some appeal (due to the nice economic responses it suggests), the model is not appropriate for balanced testing of the hypotheses on unanticipated and anticipated money impacts.

The full model used in this disaggregated research (1 or 1') allows for both types of money impacts to be tested and to assess the impact of each in the presence of the other type of money variable.

Addressing now the serial correlation issue and the correction procedures used -- Granger and Newbold (1974) discuss the erroneous test conclusions that can be drawn when tests fail to correct serial correlation of the residuals. Therefore, tests here do include serial correlation corrections. As an initial check for the presence of serial correlation, Model 1', without serial correlation correction, was estimated for each series and the Durbin-Watson (DW) statistic examined. Durbin-Watson statistics indicated significant serial correlation for every series (which is not unusual for quarterly economic time series). Serially correlated residuals are often caused by the omission of a relevant variable from the model. Relating this to the present context, it frequently occurs in manufacturing production that current output is related to previous output levels (due to costs of adjusting production rates, multi-period production processes, etc.) i.e., there is a "persistence" in output activity which calls for a lagged output term in the model. This is the situation encountered with the industries here. Not all industries exhibit the same degree of output persistence; therefore, the appropriate number of lagged output terms needed had to be determined for each industry. Model 1' was estimated for each series using one lagged output term initially, and these residuals were then tested for serial correlation. Note that when right-hand-side regressor variables include a lagged dependent variable, the Durbin-Watson statistic is no longer a valid indicator of serial correlation. The Durbin h statistic is frequently a good alternative means to test for serial correlation -- unless one has a large number of observations. (When N is large, the Durbin h formula may require taking the square root of a negative number.) This is the situation encountered in tests here (with N = 93). Therefore, the method used to test for serial correlation was to obtain for each series the residuals from estimation of Model 1' (with a single right-hand-side lagged output term). Each series' residual was regressed on a lagged residual, i.e.,

$$u_t = \hat{\rho} u_{t-1} + \varepsilon_t$$

A t-test on $\hat{\rho}$ indicated whether statistically significant serial correlation remained in that series. For series in which serial correlation remained, Model 1' was estimated with two lagged output terms; the new residuals obtained and regressed on a lagged residual; t-statistic on the new $\hat{\rho}$ evaluated. The procedure was repeated for each series until the t on $\hat{\rho}$ values indicated that no significant serial correlation remained. Table B2 reports the lagged output specification and other treatments (i.e., dummy variable for strike, etc.), required for the respective industries.

The above-described method could fail to detect possible higher-order serial correlation in a series. Therefore, as a double check, the model was estimated using a Cochrane-Orcutt procedure (in the SAS computer package) to detect whether higher-order serial correlation existed. Estimations allowed for up to six autoregressive terms. For quarterly time-series data, an AR(6) scheme generally captures any seasonal and

Table B2. Industry specifications used in test models

Series	Lags of Y	Special Treatment for Series
Primary Metals	1 lag	delete T = 19, 20 or dummy var. for strike
Steel	1 lag	delete T = 19, 20 or dummy var. for strike
Fabricated Metals	1 lag	————
Electrical Eqpt.	2 lags	————
Autos	1 lag for lnY 2 lags for diff. of logs	————
Aircraft	2 lags	dummy var for T = 45 to 62 due to Vietnam War escalation (2.73 of the 3.73 aircraft series proportion in total IP is due to military aircraft and non-commercial aerospace equipment); omission of dummy does not alter money conclusions greatly.
Apparel	2 lags	————
Textiles	2 lags or 1 lag	cubic trend (T, T^2, T^3); delete T = 80→82, cubic trend
Chemical Products	2 lags	a 3rd lag is statistically signif.; reduces serial correlation problem only slightly;
Printing & Publishing	1 lag	————
Utilities	2 lags	————
Electric Utilities	2 lags	piecewise linear T (flatter after T = 77) improves fit and serial correlation problems; does not alter money conclusions greatly.

annual autoregressive patterns. This evaluation did not detect any significant serial correlation beyond that already corrected for in the previously described procedure.

One final consideration in determining a proper specification for each series (i.e., determining the appropriate Model 1' for each industry) concerns the trend term. A low D.W. value (thus indicating serial correlation) can be caused by improper use of a linear trend when some nonlinear treatment is needed. Alternative trends were examined in series where data plots suggested a nonlinear trend might apply. In the textiles and electric utilities series, a nonlinear trend is indicated as statistically significant. Therefore, test models here use a cubic trend in the textiles series and a "piecewise linear" trend for electric utilities. In a few series, the nonlinear trend variable was statistically significant, but only slightly lowered the mean square error, did not indicate improvement of serial correlation problems, and did not alter the conclusions concerning money impacts. For these series the linear trend was kept. In general, for all series except textiles and electric utilities, the linear trend was determined to be as appropriate or superior to a variety of nonlinear trends examined.

Previous aggregate empirical tests have found long lags of the money variables to be important. Thus, in the testing here, examination of possible money impacts was not confined to the four quarters each of anticipated and unanticipated money indicated in Model 1'. The relevant lag length for money variables was explicitly tested. Starting with a model with sixteen quarters (four years) of anticipated and unanticipated money, the contribution of the first four quarters of anticipated and unanticipated money, respectively, was tested with an F statistic. Successive tests on four quarter increments indicated that, at most, one year of the money variables was the relevant lag length in virtually all industries. Therefore, tests here are conducted with a model using one year of money variables. However, this was done only after identifying four quarters as the relevant lag length on money impacts at the industry level.

Alternative Specifications Examined

Differencing

As noted in the text, Granger and Newbold suggest using first differences of the data ($w_t = y_t - y_{t-1}$) as a means to treat serial correlation or, better yet, estimating the model using both levels and differences. Models here were estimated in both the log and difference of log form. Conclusions concerning anticipated and unanticipated money impacts are in most cases very similar. However, in a few series, differencing was found to induce negative serial correlation. Therefore, for the main analysis, the research here uses the lagged dependent variable treatment discussed by Granger and Newbold.

"Truncated" test models

Earlier in this appendix, comment was made on Barro and Rush's model for testing -- which used unanticipated money only. For the sake of comparison, models for each industry were estimated which used "unanticipated only" or "anticipated only" money variables. The models were as follows:

$$\text{(2i)}\quad y_t(z) = x_t(z)\phi + \sum_{i=0}^{3} \alpha_i(z) m^a_{t-i}$$

$$\text{(2ii)}\quad y_t(z) = x_t(z)\phi + \sum_{i=0}^{3} \beta_i(z) m^u_{t-i}$$

where $x_t(z)\phi$ is as described earlier. (Note that these are not regarded as appropriate alternatives to the full model used in tests here. They were estimated for comparison --primarily to investigate possible impacts from use of the "unanticipated-only" specification.)

Briefly summarizing the effect of using (2i) and (2ii) as the test models: F statistics were higher when unanticipated or anticipated money alone entered the model than when tested in the presence of the other money variable. Looking only at the test results for the "unanticipated-only" model (2ii), unanticipated money was statistically significant in nine of the twelve industries at the 10% significance level (five of twelve using the 5% level), compared to five of twelve (four of twelve using 5% level) when tested in the appropriate full model. If attention is confined to these test results from the (2ii) "truncated model", an interpretation that "unanticipated money has signficant impacts on real disaggregated output" (similar to Barro and Rush's) could be extracted. Turning attention to include the "anticipated-only" model test results (2i), however, anticipated money impacts still dominate the unanticipated money impacts. (Note the much higher F statistics on anticipated money.) Neutrality of anticipated money can no longer be inferred if one gives balanced assessment to both the (2i) and (2ii) tests.

In addition, some other interesting patterns emerge if test conclusions are based on the "unanticipated-only" model (2ii). Briefly summarized, the impacts were as follows:

1. F statistics were always higher in the "unanticipated-only" model (the above-mentioned issue).
2. Money variables had consistently positive point coefficients across the lagged values. This contrasts with the mixture of positive, negative coefficients induced when the full model (with anticipated and unanticipated money together) is estimated. This result applied to both the "anticipated-only" and "unanticipated-only" models.
3. The pattern of point coefficients followed an inverted V pattern, similar to that found by Barro, Barro and Rush, and Hoffman and Schlagenhauf. (i.e.: impacts in the second or third quarter were generally larger than current impacts; impacts tapered off at the end of the lag structure.)
4. Standard errors on the unanticipated money variables are smaller than in the full model specification (multicollinearity problems do not exist in the unanticipated money series). Therefore, t statistics on the unanticipated money point estimates are stronger.

The four items combined produce results to which it is tempting to attach an economic interpretation. Perhaps these "unanticipated-only" and "anticipated-only" models have some use in reflecting patterns of money impacts. For example, they are not hampered with the distributed lag,

Table B3. Comparison: test results from "one lagged output", "two lagged output" model specifications.

Model (general notation): $y_t = X_t\phi + \sum_{i=0}^{3} m^a_{t-i} + \sum_{i=0}^{3} \beta_i m^u_{t-i}$

Hypothesis→			All $\alpha_i = 0$	All $\beta_i = 0$
↓Series	Lags of y	t stat. on $\hat{\rho}$[a]	No anticipated money impacts"[c]	No unanticipated money impacts"[c]
Primary Metals	1 lag[b]†	.99	4.39**(.003)	0.66(.62)
	2 lags		4.61**(.002)	.54(.71)
Steel	1 lag†	.27	3.11* (.02)	0.40(.81)
	2 lags		3.12* (.02)	.34(.85)
Fabricated Metal Prod.	1 lag†	1.21	3.56**(.01)	1.54(.20)
	2 lags		2.57* (.09)	1.80(.14)
Elec. Eqpt.	1 lag†	3.13*	7.55**(.0001)	2.53*(.05)
	2 lags		2.88* (.03)	3.19*(.02)
Autos	1 lag†	.178	2.57* (.045)	1.51(.21)
	2 lags		2.52* (.048)	1.47(.22)
Aircraft	1 lag	5.88*	0.916 (.46)	0.87(.49)
	2 lags†		1.03 (.40)	2.67*(.04)
Apparel	1 lag	1.97*	2.49* (.05)	1.48(.22)
	2 lags†		1.41 (.24)	1.73(.15)
Textiles	1 lag	2.78*	5.49**(.0006)	2.29 (.07)
	2 lags†		5.67**(.0005)	3.35**(.01)
	$T \to T^3$			

Chemicals & Products	1 lag	2.32*	3.35**(.01)	1.66 (.17)
	2 lags†		2.82* (.03)	2.42* (.05)
Printing & Publishing	1 lag†	.63	1.77 (.14)	2.14 (.08)
	2 lags		2.05 (.09)	2.49* (.05)
Utilities	1 lag	2.49*	0.170 (.95)	1.07 (.38)
	2 lags†		.37 (.83)	1.03 (.40)
Electric Utilities	1 lag	2.63*	0.965 (.43)	0.18 (.95)
	2 lags† piece-wise T		1.01 (.36)	.137 (.97)

[a]From t test on residuals: $u_t = \hat{\rho}\, u_{t-1} + \varepsilon_t$.

[b]†denotes specification selected for the industry's main testing model.

[c]Differences in conclusions across 1 lag, 2 lag models occur for:

Aircraft, Textiles, Printing & Publishing - "unanticipated money" F stat. rises when correct for remaining serial correlation.

Apparel - "anticipated" F stat. falls when correct for remaining serial correlation.

Chemicals & Products - "unanticipated" F stat. falls when correct for remaining serial correlation.

Results are otherwise very similar between one lag and two lag specifications. Therefore, differences in number of y_{t-i} terms used in main test results does not weaken comparability across industries.

*Significant at 5% level.

**Significant at 1% level.

multicollinearity problems present in the full model. These models (2i and 2ii), however, are not appropriate for testing and drawing conclusions on the strength and significance of the unanticipated and anticipated money impacts.

Uniformity of lagged y terms

Some readers may question the extent to which differences in the number of lagged output terms across industries affect the pattern of results on the tests of anticipated and unanticipated money impacts. Thus, to examine the extent of this impact, models were estimated using one lag of y and two lags of y across all industry series. Table B3 of this appendix presents the test results for these "uniform lagged y" treatments. As Table B3 indicates, once the bulk of the persistence of output behavior was captured via the first lagged output term, conclusions about the significance of anticipated and unanticipated money impacts often were not greatly altered by the addition of a second lagged output term. This indicates that differences in the number of lagged output terms in main test models does not weaken comparability of test results across industries.

GNP Subcomponent assessments

To establish a link between previous aggregate real GNP tests of neutrality and this disaggregated research, tests of the neutrality hypothesis were also conducted using the broad real GNP breakdowns of: goods, services and structures. Also, tests on the summed subcomponents (logically, total real GNP, Barro and Rush's output measure) were conducted. Procedures for testing were consistent with those described in this appendix for the IP industry disaggregations. Part Two's essay discusses this research.

Data Series:

Industry Output and Money Data

PRIMARY METALS

QUARTERLY DATA FROM 1955:1 TO 1978:1

PM = PRIMARY METALS

55	1	79.010	85.699	78.270	86.988	90.415
56	2	88.578	63.521	85.343	87.509	83.205
57	3	73.527	69.689	59.354	59.025	59.217
58	4	71.416	86.193	98.530	43.837	62.342
60	1	91.319	77.585	61.355	59.518	61.547
61	2	73.198	72.294	77.365	86.906	78.763
62	3	66.399	73.006	80.436	93.047	75.693
63	4	79.887	89.126	94.829	89.894	97.351
65	1	106.590	109.413	98.776	93.458	107.632
66	2	114.074	105.466	106.370	105.167	102.200
67	3	92.733	99.867	107.833	114.367	94.867
68	4	100.200	114.700	117.533	108.433	114.400
70	1	112.033	113.833	101.633	98.833	110.300
71	2	114.900	85.067	90.467	107.600	116.867
72	3	106.967	116.900	126.267	131.100	121.900
73	4	127.500	129.433	131.633	117.467	113.800
75	1	106.200	97.633	89.500	92.400	106.734
76	2	119.399	109.564	103.134	108.453	122.620
77	3	104.929	108.398	111.294		

STEEL

QUARTERLY DATA FROM 1955:1 TO 1978:1

ST = STEEL

55	1	87.461	97.541	90.072	97.822	101.500
56	2	100.517	66.094	97.934	99.899	93.694
57	3	82.379	76.792	62.585	62.697	63.230
58	4	77.297	95.828	112.197	33.693	64.297
60	1	104.532	83.755	62.809	59.833	61.967
61	2	76.258	77.016	81.649	93.385	78.701
62	3	64.803	72.440	82.155	98.945	76.427
63	4	79.487	90.100	97.260	93.835	102.286
65	1	112.282	115.342	103.128	89.988	106.245
66	2	114.612	106.807	105.768	102.800	98.967
67	3	94.000	104.200	112.300	116.100	91.267
68	4	93.233	111.367	116.067	108.500	114.300
70	1	109.233	112.500	100.467	96.567	109.667
71	2	114.633	77.800	82.200	102.067	111.633
72	3	102.500	112.033	120.567	126.067	119.267
73	4	123.233	123.700	126.000	116.600	112.833
75	1	111.000	98.067	85.167	89.100	102.255
76	2	116.081	105.262	95.618	97.731	115.509
77	3	101.462	100.557	101.290		

FABRICATED METALS
QUARTERLY DATA FROM 1955:1 TO 1978:1

FM = FABRICATED METALS

55	1	63.023	67.045	69.821	71.482	67.875
56	2	67.149	68.290	72.053	70.288	70.340
57	3	71.793	69.951	61.441	59.131	65.073
58	4	67.564	68.005	73.116	73.791	69.173
60	1	72.001	71.378	72.182	68.757	63.075
61	2	68.161	71.897	74.310	71.404	76.022
62	3	77.605	76.438	76.463	77.579	76.360
63	4	80.926	81.575	82.639	80.797	85.337
65	1	88.918	91.071	88.606	94.626	96.442
66	2	96.468	95.352	100.645	100.500	100.200
67	3	98.000	101.233	104.400	104.800	104.833
68	4	108.333	108.467	107.933	106.567	108.533
70	1	104.967	103.767	101.033	100.000	102.333
71	2	103.433	102.367	105.833	108.167	110.667
72	3	111.067	118.367	121.567	125.000	123.433
73	4	128.833	125.333	126.633	124.800	120.167
75	1	104.833	106.900	111.033	116.800	119.954
76	2	123.819	124.557	127.383	126.863	129.726
77	3	131.581	135.708	136.771		

ELECTRICAL EQUIPMENT
QUARTERLY DATA FROM 1955:1 TO 1978:1

EL = ELECTRICAL EQUIPMENT

55	1	38.728	39.354	38.253	43.175	42.096
56	2	43.024	41.664	45.636	43.823	41.880
57	3	42.161	43.305	38.383	36.051	38.491
58	4	43.693	44.600	45.831	47.968	52.113
60	1	52.739	51.163	50.515	52.026	51.810
61	2	53.041	54.358	60.014	60.985	62.885
62	3	62.561	65.303	63.792	64.115	63.684
63	4	67.397	66.620	66.447	66.857	73.852
65	1	75.838	78.881	80.911	91.100	93.345
66	2	98.634	97.598	102.196	100.267	97.067
67	3	97.400	105.333	104.933	103.500	104.367
68	4	109.100	111.133	112.333	112.067	111.933
70	1	109.167	108.533	107.533	107.133	105.133
71	2	106.400	106.433	112.767	115.467	119.700
72	3	121.633	132.200	136.467	141.967	143.600
73	4	150.233	147.333	147.533	143.333	136.900
75	1	113.800	112.700	116.600	122.767	127.911
76	2	134.236	135.842	141.191	139.499	144.716
77	3	145.711	151.617	150.468		

AUTOMOBILES AND PARTS
QUARTERLY DATA FROM 1955:1 TO 1978:1

AUTO = AUTOMOBILES AND PARTS

55	1	80.673	85.886	75.489	82.617	74.046
56	2	64.592	53.988	70.747	76.726	70.541
57	3	61.941	66.889	56.050	47.656	39.939
58	4	60.350	70.747	74.576	58.848	60.763
60	1	86.770	79.112	59.908	73.133	58.436
61	2	69.216	55.756	78.759	78.081	82.941
62	3	68.185	89.922	88.213	92.690	74.135
63	4	98.345	95.047	98.846	78.081	90.805
65	1	117.313	123.027	97.049	126.120	124.147
66	2	121.466	88.920	121.172	102.733	108.333
67	3	80.500	108.333	120.200	128.867	99.267
68	4	132.700	124.900	119.800	101.400	119.933
70	1	102.033	107.033	81.267	78.967	120.467
71	2	123.100	105.300	125.667	134.167	144.500
72	3	116.500	148.100	158.533	157.867	132.467
73	4	146.500	129.400	136.033	122.033	125.400
75	1	93.700	112.667	111.900	126.067	140.197
76	2	154.863	129.517	143.413	157.977	171.479
77	3	148.898	165.898	162.099		

AIRCRAFT AND PARTS
QUARTERLY DATA FROM 1955:1 TO 1978:1

AIR = AIRCRAFT AND PARTS

55	1	61.501	60.172	60.607	63.885	65.421
56	2	65.719	69.043	74.613	77.501	75.301
57	3	71.220	65.719	62.166	59.576	60.011
58	4	62.487	62.120	61.134	60.836	60.332
60	1	58.750	54.716	54.235	56.091	57.329
61	2	56.573	57.375	61.822	63.106	61.868
62	3	63.725	67.209	70.051	67.415	67.644
63	4	69.937	68.974	67.301	66.177	68.172
65	1	68.011	69.478	72.137	77.937	82.980
66	2	85.020	89.627	95.908	97.200	98.633
67	3	99.467	104.733	104.700	101.967	103.133
68	4	102.300	99.233	97.467	96.867	95.833
70	1	89.233	81.633	77.467	76.233	71.533
71	2	66.867	65.767	66.633	65.533	65.367
72	3	65.667	71.433	72.333	73.867	75.233
73	4	78.933	77.767	77.900	77.767	79.867
75	1	71.600	71.633	74.533	75.333	72.486
76	2	68.528	66.637	71.106	71.336	72.365
77	3	73.093	70.875	76.848		

APPAREL

QUARTERLY DATA FROM 1955:1 TO 1978:1

CL = APPAREL

55	1	74.754	72.379	70.776	75.259	80.128
56	2	74.071	72.914	73.032	79.682	75.200
57	3	74.339	70.212	73.418	70.301	72.676
58	4	74.695	81.434	80.128	79.059	79.772
60	1	85.650	83.542	80.187	77.307	80.989
61	2	81.434	83.215	83.097	87.312	86.451
62	3	84.819	83.572	90.637	91.172	88.144
63	4	86.303	92.775	93.784	90.964	91.201
65	1	98.445	98.030	95.744	97.228	101.533
66	2	102.008	98.148	98.000	100.733	100.067
67	3	99.733	99.433	103.933	104.400	102.500
68	4	100.833	107.467	107.867	107.833	103.633
70	1	104.267	103.767	100.433	97.000	102.533
71	2	105.733	105.500	105.233	108.467	110.433
72	3	109.800	108.967	115.433	122.667	120.033
73	4	111.233	118.300	117.800	114.500	106.433
75	1	99.900	105.433	111.267	113.700	126.623
76	2	130.393	122.641	123.295	136.492	137.957
77	3	133.179	129.027	131.031		

TEXTILES

QUARTERLY DATA FROM 1955:1 TO 1978:1

TEX = TEXTILES

55	1	63.825	63.930	62.825	68.008	69.165
56	2	65.956	63.667	66.798	65.982	63.825
57	3	62.062	61.378	59.905	59.852	63.114
58	4	66.850	69.534	72.796	70.244	69.849
60	1	72.664	72.191	66.666	65.693	66.745
61	2	71.928	71.402	75.374	76.795	78.321
62	3	74.453	75.190	77.347	81.425	78.031
63	4	78.873	82.609	86.608	85.030	86.582
65	1	91.896	95.106	90.449	93.580	98.815
66	2	102.446	96.711	95.763	98.033	101.933
67	3	96.667	103.300	107.233	110.733	105.467
68	4	108.167	113.167	115.667	109.800	111.633
70	1	113.167	114.333	109.067	110.700	111.467
71	2	118.100	115.800	120.767	125.500	136.100
72	3	132.333	137.033	141.233	147.133	140.733
73	4	142.367	141.633	145.200	131.733	112.500
75	1	100.733	121.333	130.133	136.967	136.146
76	2	141.674	132.121	128.452	129.681	137.282
77	3	133.486	137.059	133.280		

CHEMICALS AND PRODUCTS

QUARTERLY DATA FROM 1955:1 TO 1978:1

CH = CHEMICALS AND PRODUCTS

55	1	38.313	39.942	38.936	42.001	42.695
56	2	43.102	41.402	43.725	45.186	45.042
57	3	44.324	46.143	44.874	45.042	46.431
58	4	50.071	52.298	55.698	54.141	55.123
60	1	56.656	58.068	55.410	55.339	55.770
61	2	59.936	58.715	62.498	63.815	67.120
62	3	65.228	66.737	67.910	72.484	73.035
63	4	73.921	74.400	79.548	80.170	80.937
65	1	83.571	88.527	89.581	89.533	91.018
66	2	96.238	97.483	97.866	95.733	99.200
67	3	101.033	104.067	102.667	109.400	112.233
68	4	113.733	112.900	119.600	121.433	119.500
70	1	115.800	122.300	123.033	120.567	116.633
71	2	125.267	129.767	131.867	134.133	144.267
72	3	147.800	148.233	147.967	155.933	157.967
73	4	155.967	153.733	163.633	167.667	152.633
75	1	133.267	142.167	153.767	159.800	162.392
76	2	172.083	174.743	174.176	175.207	189.946
77	3	190.788	186.876	185.308		

PRINTING AND PUBLISHING
QUARTERLY DATA FROM 1955:1 TO 1978:1

PUB = PRINTING AND PUBLISHING

55	1	56.641	59.441	58.767	63.018	61.152
56	2	63.096	62.137	66.595	64.522	66.103
57	3	64.522	66.466	62.551	63.251	62.914
58	4	66.803	65.558	68.229	67.555	71.495
60	1	69.317	71.780	69.810	72.921	69.214
61	2	71.002	70.250	74.709	72.117	74.009
62	3	73.102	76.472	69.032	77.950	82.019
63	4	82.045	76.576	83.004	86.063	84.612
65	1	80.931	87.748	92.077	90.807	86.634
66	2	93.348	100.606	97.858	91.900	99.533
67	3	106.667	101.867	94.833	101.933	109.933
68	4	106.100	98.867	107.033	114.700	108.933
70	1	99.300	107.633	114.367	106.733	98.600
71	2	104.900	114.233	110.733	102.800	110.533
72	3	120.400	117.033	107.833	117.967	128.267
73	4	118.867	108.633	119.933	128.833	115.567
75	1	102.400	110.433	124.133	116.433	111.849
76	2	121.611	133.177	123.237	116.551	126.051
77	3	138.236	129.610	120.649		

UTILITIES

QUARTERLY DATA FROM 1955:1 TO 1978:1

UT = UTILITIES

55	1	43.083	42.134	44.726	45.726	48.472
56	2	47.138	48.549	48.600	51.577	49.678
57	3	52.629	51.936	54.271	51.423	54.913
58	4	54.836	58.890	57.299	60.917	59.993
60	1	64.304	61.328	64.946	63.047	66.203
61	2	64.510	69.206	67.999	72.233	69.231
62	3	74.158	72.336	77.186	73.850	80.137
63	4	76.750	82.292	80.445	88.168	83.421
65	1	87.937	85.397	92.736	88.784	94.070
66	2	90.914	101.897	95.122	100.567	96.333
67	3	101.000	102.133	108.733	103.767	111.600
68	4	109.667	117.667	111.333	122.200	118.033
70	1	124.967	119.400	130.367	123.100	131.733
71	2	125.500	135.233	129.400	138.200	133.033
72	3	144.933	141.400	146.467	139.467	154.133
73	4	141.600	144.033	139.067	149.667	141.900
75	1	148.133	140.033	152.767	143.100	154.660
76	2	143.316	156.756	152.189	162.162	147.342
77	3	164.159	152.289	167.331		

ELECTRIC UTILITIES
QUARTERLY DATA FROM 1955:1 TO 1978:1

UTE = ELECTRIC UTILITIES

55	1	41.407	43.451	47.589	46.791	46.891
56	2	47.465	50.132	49.459	49.434	50.207
57	3	53.921	50.556	49.384	49.359	54.918
58	4	53.398	54.345	56.913	61.400	58.084
60	1	59.356	59.929	65.039	60.901	60.103
61	2	63.220	69.876	66.510	66.435	67.881
62	3	73.440	70.000	70.648	72.718	80.022
63	4	75.784	76.232	79.448	86.752	81.368
65	1	82.041	85.257	92.810	87.799	88.198
66	2	91.389	101.909	94.580	95.333	97.067
67	3	106.467	101.233	103.467	105.200	116.200
68	4	109.600	111.367	114.300	127.133	118.900
70	1	119.100	122.533	135.267	124.467	126.000
71	2	127.733	140.500	132.333	135.133	138.933
72	3	151.767	144.800	147.567	149.500	166.833
73	4	154.000	146.267	149.600	165.567	152.600
75	1	151.167	149.967	167.600	154.233	161.737
76	2	160.466	177.428	164.848	166.566	166.796
77	3	185.495	169.760	171.365		

INDUSTRIAL PRODUCTION (TOTAL)
QUARTERLY DATA FROM 1955:1 TO 1978:1

IP = TOTAL INDUSTRIAL PRODUCTION

55	1	56.115	58.462	58.156	61.191	60.962
56	2	61.089	59.380	62.798	63.028	62.416
57	3	61.727	60.248	56.396	55.784	58.079
58	4	61.421	63.640	67.364	63.563	64.686
60	1	68.002	67.441	65.196	64.354	62.722
61	2	66.420	67.313	70.323	70.654	72.720
62	3	72.108	73.460	74.302	77.363	75.934
63	4	78.485	79.174	82.184	81.418	83.944
65	1	86.877	90.014	89.479	92.973	95.116
66	2	98.304	97.564	100.089	98.733	99.733
67	3	98.867	102.633	103.967	106.900	105.867
68	4	108.633	109.767	111.700	111.333	111.800
70	1	108.333	109.400	107.633	105.733	107.467
71	2	110.267	109.233	111.333	114.633	119.633
72	3	120.067	124.600	126.533	130.400	130.500
73	4	131.633	128.967	132.300	131.400	124.500
75	1	112.200	115.333	120.600	123.000	126.729
76	2	131.198	131.636	132.276	133.732	139.316
77	3	139.493	140.016	139.528		

ANTICIPATED MONEY GROWTH
QUARTERLY DATA FROM 1955:1 TO 1978:1

DMA = ANTICIPATED MONEY GROWTH

55	1	0.010	0.008	0.005	0.005	0.003
56	2	0.006	0.003	0.003	0.005	0.003
57	3	0.001	0.003	-0.002	0.003	0.012
58	4	0.011	0.011	0.010	0.008	0.007
60	1	0.002	0.004	0.003	0.007	0.004
61	2	0.006	0.009	0.008	0.011	0.008
62	3	0.006	0.004	0.008	0.009	0.010
63	4	0.010	0.009	0.008	0.010	0.013
65	1	0.010	0.008	0.009	0.010	0.014
66	2	0.012	0.010	0.003	0.006	0.010
67	3	0.012	0.015	0.010	0.011	0.015
68	4	0.015	0.015	0.014	0.010	0.009
70	1	0.009	0.010	0.012	0.012	0.012
71	2	0.015	0.021	0.013	0.011	0.016
72	3	0.019	0.017	0.019	0.014	0.017
73	4	0.013	0.014	0.013	0.016	0.012
75	1	0.011	0.008	0.021	0.018	0.010
76	2	0.013	0.017	0.013	0.017	0.017
77	3	0.017	0.018	0.016		

UNANTICIPATED MONEY GROWTH
QUARTERLY DATA FROM 1955:1 TO 1978:1

DMR = UNANTICIPATED MONEY GROWTH

55	1	0.002	-0.002	-0.001	-0.003	0.001
56	2	-0.003	-0.003	0.001	-0.002	-0.003
57	3	-0.000	-0.009	0.000	0.008	-0.002
58	4	0.002	0.002	-0.002	-0.003	-0.013
60	1	-0.006	-0.006	0.004	-0.005	-0.000
61	2	0.002	-0.003	0.002	-0.005	-0.004
62	3	-0.008	0.002	0.001	0.001	0.000
63	4	0.001	-0.003	0.002	0.006	-0.001
65	1	-0.003	-0.000	0.002	0.006	0.002
66	2	0.000	-0.012	-0.002	0.004	0.004
67	3	0.010	-0.001	0.003	0.008	0.006
68	4	0.004	0.003	-0.004	-0.004	-0.003
70	1	0.000	0.003	0.001	0.001	0.005
71	2	0.010	-0.004	-0.007	0.007	0.004
72	3	0.002	0.005	-0.001	0.002	-0.003
73	4	-0.001	0.001	0.001	-0.005	-0.002
75	1	-0.010	0.010	-0.003	-0.012	-0.003
76	2	0.008	-0.006	0.004	0.001	0.002
77	3	0.003	-0.001	-0.004		

APPENDIX C. GNP SUBCOMPONENT ANALYSIS

Data Source

GNP in 1972 dollars disaggregated to subcomponents of goods, services, structures. Tests also conducted on the sum of goods, services, and structures (i.e.: total real GNP).

Source: Table 1.4 "GNP by Major Product Type in Constant Dollars", from National Income & Product Accounts of the United States: Statistical Tables 1929-1976, and Survey of Current Business, July 1981, for data updating.

Estimation and Test Procedure

Estimation and test procedure are as described for the twelve industry tests. (See Appendix B for Part One's essay.) i.e., two-step estimation procedure, F tests on 4 quarters of anticipated, unanticipated money growth. Information on $x_t(z)\phi$ entries (i.e.: lagged output terms, other treatments) used in the specific test models is given in the roster below.

GNP: Specifications of models

Series	Lags of Y	Other Treatments
Total GNP	2 lags	--
Goods	1 lag	--
Services	1 lag	--
Structures	2 lags	piecewise linear trend SS, but does not alter test conclusions greatly

Results for Alternative Specifications Examined

Results of major interest are reported in Table 1 of the main text of the essay in Part Two. Table 1 reports F statistics for tests on four quarter of anticipated money growth (col. 1), unanticipated money growth (col. 2), and total actual money growth (col. 3). Paralleling the supplementary tests run in the twelve-industry study (discussed in Appendix B for Essay One), the GNP subcomponent analysis examined (i) the effect of testing anticipated and unanticipated money growth impacts within a model which included only the money variables subject to test (i.e., the "truncated models" discussed in Appendix B for Essay One), and (ii) the impact on test conclusions of uniform lagged y treatment across all the subcomponent and total GNP series.

Table C1 presents test results from the "truncated models". As indicated, use of the truncated model is generally more favorable to finding significant impacts than is the appropriate full model (one which includes both m^a and m^u regressors). Table C2 presents results from models which uniformly include two lagged output terms in all series. As indicated, conclusions as to significance of anticipated and unanticipated money growth impacts are not altered from those in the major testing models (i.e., results in Table 1 of main text in Part Two's essay). These patterns (indicated by both series of tests) correspond to those found in the twelve-industry study.

Table C1. GNP Subcomponents in "unanticipated money only", "anticipated money only" models

	"Unanticipated money only" model	"Anticipated money only" model
	Model: $y_t(z) = x_t\phi + \sum_{i=0}^{3} \beta_i m^u_{t-i}$	Model: $y_t(z) = x_t\phi + \sum_{i=0}^{3} \alpha_i m^a_{t-i}$
Hypothesis→	All $\beta_i = 0$	All $\alpha_i = 0$
↓Series	"No unanticipated money impacts	"No anticipated money impacts
Total GNP	5.21**(.0009)[a]	2.75*(.034)
Goods	4.12**(.004)	4.46**(.002)
Services	2.89*(.027)	2.79*(.031)
Structures	4.17**(.004)	4.47**(.002)

[a]Values in parentheses give probability level of statistical significance.

*Significant at 5% level.

**Significant at 1% level.

Table C2. GNP Subcomponents: F tests on anticipated, unanticipated money growth impacts; two lagged output terms for all series

$$\text{Model:}\quad y_t(z) = x_t(z)\phi + \sum_{i=0}^{3} \alpha_i(z)m^a_{t-1} + \sum_{i=0}^{3} \beta_i(z)m^u_{t-1}$$

Hypothesis→ ↓Series	(1) All $\alpha_i = 0$ "No anticipated money impacts"	(2) All $\beta_i = 0$ "No unanticipated money impacts"	(3) All $\gamma_i = 0$ "No money impacts"[a]
Total GNP	1.19 (.318)[b]	3.41*(.01)	3.21**(.003)
Goods	2.74*(.034)	3.06*(.021)	3.28**(.003)
Services	1.14 (.342)	1.16 (.335)	1.98 (.059)
Structures	2.51*(.098)	1.85 (.128)	3.31**(.003)

[a]Model for total money impact tests (column 3):

$y_t(z) = x_t(z)\phi + \sum_{i=0}^{3}\gamma_i(z)m_{t-i}$ where m_t is actual total money growth.

[b]Values in parentheses give probability level of significance.

*Significant at 5% level.

**Significant at 1% level.

GNP Data Series

GOODS SUBCOMPONENT
QUARTERLY DATA FROM 1955:1 TO 1978:1

GD = GOODS

55	1	304.400	315.100	321.600	325.900	321.800
56	2	321.000	319.400	321.400	324.600	322.800
57	3	325.000	314.400	302.900	303.600	314.800
58	4	325.100	327.100	337.500	330.000	335.500
60	1	342.900	338.300	336.500	325.600	325.300
61	2	335.100	341.000	350.500	358.500	360.100
62	3	363.400	363.300	366.500	369.400	374.000
63	4	378.900	387.200	392.600	396.500	398.800
65	1	412.800	415.500	423.900	438.200	451.600
66	2	453.300	456.800	464.000	459.500	461.600
67	3	464.500	468.000	471.400	482.900	489.700
68	4	488.300	495.600	496.800	498.300	493.200
70	1	487.200	489.200	492.700	478.400	497.300
71	2	494.100	497.200	500.300	508.400	526.300
72	3	536.000	547.800	570.700	568.700	568.400
73	4	581.400	566.200	567.800	564.400	551.600
75	1	530.000	540.200	558.600	560.900	581.300
76	2	587.000	589.000	591.200	612.900	625.200
77	3	636.900	637.200	636.900		

STRUCTURES SUBCOMPONENT

QUARTERLY DATA FROM 1955:1 TO 1978:1

STR = STRUCTURES

55	1	80.600	81.700	80.900	79.500	79.600
56	2	81.000	80.900	80.400	80.300	79.400
57	3	79.200	79.800	80.200	79.200	81.400
58	4	86.000	89.700	91.400	90.500	87.700
60	1	90.300	87.700	88.100	89.700	91.400
61	2	89.500	91.200	94.800	94.700	97.700
62	3	98.800	98.500	99.200	103.800	106.500
63	4	107.000	108.700	108.900	108.500	108.300
65	1	111.400	116.400	116.900	119.300	120.600
66	2	116.900	115.400	110.500	110.700	112.500
67	3	114.500	117.800	120.400	121.800	121.900
68	4	124.100	125.200	124.800	122.700	117.300
70	1	115.900	113.400	116.400	119.400	122.100
71	2	126.600	129.600	131.100	136.300	136.200
72	3	136.300	140.500	143.100	140.400	138.600
73	4	134.400	128.800	125.400	118.100	111.600
75	1	106.000	104.500	109.500	113.200	117.000
76	2	115.700	113.900	117.500	119.600	125.600
77	3	127.000	125.200	125.700		

SERVICES SUBCOMPONENT

QUARTERLY DATA FROM 1955:1 TO 1978:1

SER = SERVICES

55	1	259.100	256.500	260.800	264.000	265.500
56	2	268.200	270.400	276.600	278.600	281.900
57	3	284.300	284.900	282.400	287.100	289.700
58	4	291.400	294.700	297.400	300.700	304.700
60	1	307.500	312.400	313.200	316.800	321.000
61	2	325.500	327.500	333.700	336.000	340.700
62	3	343.200	346.200	349.300	353.500	359.300
63	4	362.800	368.200	372.200	375.800	379.700
65	1	382.400	387.800	393.300	399.200	403.300
66	2	409.100	415.800	422.100	427.500	430.200
67	3	437.300	441.500	444.800	451.100	456.600
68	4	459.500	463.400	467.300	470.900	475.100
70	1	478.300	480.300	484.100	486.800	492.100
71	2	496.200	499.000	504.000	512.600	516.100
72	3	520.700	526.500	532.900	539.300	548.900
73	4	550.200	558.200	561.500	564.300	567.100
75	1	568.300	574.100	578.000	583.200	586.700
76	2	590.900	598.200	604.400	608.800	612.400
77	3	621.900	626.100	637.500		

TOTAL GROSS NATIONAL PRODUCT
QUARTERLY DATA FROM 1955:1 TO 1978:1

TOT = TOTAL GNP (GOODS + SERVICES + STRUCTURES)

55	1	644.100	653.300	663.300	669.400	666.900
56	2	670.200	670.700	678.400	683.500	684.100
57	3	688.500	679.100	665.500	669.900	685.900
58	4	702.500	711.500	726.300	721.200	727.900
60	1	740.700	738.400	737.800	732.100	737.700
61	2	750.100	759.700	779.000	789.200	798.500
62	3	805.400	808.000	815.000	826.700	839.800
63	4	848.700	864.100	873.700	880.800	886.800
65	1	906.600	919.700	934.100	956.700	975.500
66	2	979.300	988.000	996.600	997.700	1004.300
67	3	1016.300	1027.300	1036.600	1055.800	1068.200
68	4	1071.900	1084.200	1088.900	1091.900	1085.600
70	1	1081.400	1082.900	1093.200	1084.600	1111.500
71	2	1116.900	1125.800	1135.400	1157.300	1178.600
72	3	1193.000	1214.800	1246.700	1248.400	1255.900
73	4	1266.000	1253.200	1254.700	1246.800	1230.300
75	1	1204.300	1218.800	1246.100	1257.300	1285.000
76	2	1293.600	1301.100	1313.100	1341.300	1363.200
77	3	1385.800	1388.500	1400.100		

APPENDIX D. DERIVATIONS FOR PART THREE

Case 1: Flexible Output Price and Purchased Input Costs

Market Supply (in logarithms)

(1) $y_t(z) = \alpha_1[P_t(z) - E_t(z)P_t] + \alpha_2[w_t(z) - E_t(z)P_t] + u_t(z)$

$\alpha_1 > 0 \qquad \alpha_1 \geq |\alpha_2|$

$\alpha_2 < 0$

$u_t(z) = u_t+\varepsilon_t(z) \qquad E(u_t) = \bar{u} \qquad E(\varepsilon_t(z)) = 0 \qquad E(\varepsilon_t(z)^2) = \sigma_\varepsilon^2$

P_t is not known; producers must form expectation based on available information at start of period t; for purposes of the analysis below, attention is focused on the common component to the producers' aggregate price expectations, E_tP_t. (See text of paper for further explanation.)

Each producer observes $P_t(z)$, $w_t(z)$; knows the relationship between the aggregate price level and $P_t(z)$, $w_t(z)$.

(2) $P_t(z) = P_t+z$

(3) $w_t(z) = \gamma+P_t+c \qquad$ assume $\gamma = 0$; therefore, have $w_t(z) = P_t+c$

$E(z) = E(c) = 0; \; E(P_tz) = E(P_tc) = 0; \quad E(z^2) = \sigma_z^2, \; E(c^2) = \sigma_c^2$

Aggregate Supply

Substitute for $P_t(z)$, $w_t(z)$; sum across all z markets; take averages.

(4) $y_t = \alpha_1[P_t-E_tP_t]+ \alpha_2[P_t-E_tP_t] + u_t$

where the α_1, α_2 aggregate parameters are weighted averages of the respective market parameters.

<u>Aggregate Demand</u>

(3) $y_t = \beta(m_t - P_t) + v_t$

$\beta > 0$

$E(v_t) = 0; \quad E(v_t^2) = \sigma_v^2$

$E(vu) = E(vc) = E(vz) = 0$

<u>Note</u>: The main body of the paper incorporates the specific assumptions on the disturbance terms [$E_{t-2}(v_t) = E_t(v_t) = 0$; $E_{t-2}(u_t) = E_t(u_t) = \bar{u}$] into the derivations. The derivations in the appendix here are kept more general by carrying the $E_{t-i}(v_t - u_t)$ terms. Thus, those preferring other structures on the disturbance terms can easily incorporate the alternative assumptions into the derivations presented here.

Equate AS to AD; solve for equilibrium aggregate price.

$$\beta(m_t - P_t) - v_t = \alpha_1 P_t - \alpha_1 E_t P_t + \alpha_2 P_t - \alpha_2 E_t P_t + u_t$$

$$(\beta + \alpha_1 + \alpha_2) P_t = \beta m_t + (\alpha_1 + \alpha_2) E_t P_t + (v_t - u_t)$$

$$P_t^* = \underbrace{\frac{\beta}{\beta + \alpha_1 + \alpha_2}}_{\delta_1} m_t + \underbrace{\frac{\alpha_1}{\beta + \alpha_1 + \alpha_2}}_{\delta_2} E_t P_t + \underbrace{\frac{\alpha_2}{\beta + \alpha_1 + \alpha_2}}_{\delta_3} E_t P_t + \underbrace{\frac{1}{\beta + \alpha_1 + \alpha_2}}_{\delta_4} (v_t - u_t)$$

$\therefore$ (6) $P_t^* = \delta_1 m_t + \delta_2 E_t P_t + \delta_3 E_t P_t + \delta_4 (v_t - u_t)$

Take expectation of price:

$$E_t P_t = \delta_1 E_t m_t + \delta_2 E_t P_t + \delta_3 E_t P_t + \delta_4 E_t (v_t - u_t)$$

$$(1 - \delta_2 - \delta_3) E_t P_t = \delta_1 E_t m_t + \delta_4 E_t (v_t - u_t)$$

(7) $E_t P_t = \dfrac{\delta_1}{1 - \delta_2 - \delta_3} E_t m_t + \dfrac{\delta_4}{1 - \delta_2 - \delta_3} E_t (v_t - u_t)$

Substitute this expectation into (6):

$$P_t^* = \delta_1 m_t + \delta_2\left[\frac{\delta_1}{1-\delta_2-\delta_3} E_t m_t + \frac{\delta_4}{1-\delta_2-\delta_3} E_t(v_t-u_t)\right]$$

$$+ \delta_3\left[\frac{\delta_1}{1-\delta_2-\delta_3} E_t m_t + \frac{\delta_4}{1-\delta_2-\delta_3} E_t(v_t-u_t)\right] + \delta_4(v_t-u_t)$$

$$(8) \quad P_t^* = \delta_1 m_t + \frac{\delta_1\delta_2+\delta_1\delta_3}{1-\delta_2-\delta_3} E_t m_t + \frac{\delta_2\delta_4+\delta_3\delta_4}{1-\delta_2-\delta_3} E_t(v_t-u_t) + \delta_4(v_t-u_t)$$

Assess $[P_t^*-E_tP_t]$:

$$P_t^*-E_tP_t = \delta_1 m_t + \frac{\delta_1\delta_2+\delta_1\delta_3-\delta_1}{1-\delta_2-\delta_3} E_t m_t + \frac{\delta_2\delta_4+\delta_3\delta_4-\delta_4}{1-\delta_2-\delta_3} E_t(v_t-u_t)$$

$$+ \delta_4(v_t-u_t)$$

$$= \delta_1 m_t - \frac{\delta_1(1-\delta_2-\delta_3)}{(1-\delta_2-\delta_3)} E_t m_t - \frac{-\delta_4(1-\delta_2-\delta_3)}{(1-\delta_2-\delta_3)} E_t(v_t-u_t)$$

$$+ \delta_4(v_t-u_t)$$

$$(9) \quad [P_t^*-E_tP_t] = \delta_1(m_t-E_tm_t) + \delta_4[(v_t-u_t)-E_t(v_t-u_t)]$$

Assess market supply, given P_t and E_tP_t:

$$(1) \quad y_t(z) = \alpha_1[P_t(z)-E_tP_t] + \alpha_2[w_t(z)-E_tP_t] + u_t(z)$$

$$y_t(z) = \alpha_1[P_t-E_tP_t+z] + \alpha_2[P_t-E_tP_t+c] + u_t(z)$$

$$y_t(z) = \alpha_1[\delta_1(m_t-E_tm_t) + \delta_4((v_t-u_t)-E_t(v_t-u_t)) + z]$$

$$+ \alpha_2[\delta_1(m_t-E_tm_t) + \delta_4((v_t-u_t)-E_t(v_t-u_t)) + c] + u_t(z)$$

$$(10) \quad y_t(z) = \delta_1(\alpha_1+\alpha_2)(m_t-E_tm_t) + \delta_4(\alpha_1-\alpha_2)((v_t-u_t)-E_t(v_t-u_t))$$

$$+ \alpha_1 z + \alpha_2 c + u_t(z)$$

Denote disturbance terms as "$\omega_t(z)$"

(11) $y_t(z) = \delta_1(\alpha_1+\alpha_2)(m_t-E_tm_t) + \omega_t(z)$

or

$$y_t(z) = \theta_f^u(m_t-E_tm_t) + \omega_t(z)$$

Only unanticipated money growth affects real output.

Case 2: Rigid Wages to Purchased Factors

Price is as before: $P_t(z) = P_t + z \qquad E(z) = 0$

Wages to prevail in t are set in t-i; intent is to maintain the expected real wage; therefore, wages are now given by:

$_{t-i}w_t(z) = E_{t-i}P_t + \gamma$; assume $\gamma = 0$, thus wages given by

(1) $_{t-i}w_t(z) = E_{t-i}P_t$

Market Supply

(2) $y_t(z) = \alpha_1[P_t(z) - E_tP_t] + \alpha_2[_{t-i}w_t(z) - E_tP_t] + u_t(z)$

Substitute for price and wage; set t-i at t-2 (for exposition):

(3) $y_t(z) = \alpha_1[P_t + z - E_tP_t] + \alpha_2[E_{t-2}P_t - E_tP_t] + u_t(z)$

Aggregate Supply

(4) $y_t = \alpha_1[P_t - E_tP_t] + \alpha_2[E_{t-2}P_t - E_tP_t] + u_t$

Aggregate Demand

(5) $y_t = \beta(m_t - p_t) + v_t$

Assumptions on c, z, v, u_t same as before.

Solve for price that equates AD and AS; denote as P_t'.

$$\beta(m_t - p_t) + v_t = \alpha_1P_t - \alpha_1E_tP_t + \alpha_2E_{t-2}P_t - \alpha_2E_tP_t + u_t$$

$$(\beta + \alpha_1)P_t = \beta m_t + \alpha_1E_tP_t + \alpha_2E_tP_t - \alpha_2E_{t-2}P_t + (v_t - u_t)$$

$$P_t' = \underbrace{\frac{\beta}{\beta+\alpha_1}}_{\psi_1} m_t + \underbrace{\frac{\alpha_1}{\beta+\alpha_1}}_{\psi_2} E_tP_t + \underbrace{\frac{\alpha_2}{\beta+\alpha_1}}_{\psi_3} E_tP_t - \underbrace{\frac{\alpha_2}{\beta+\alpha_1}}_{\psi_3} E_{t-2}P_t + \underbrace{\frac{1}{\beta+\alpha_1}}_{\psi_4} (v_t - u_t)$$

(6) $P_t' = \psi_1m_t + \psi_2E_tP_t - \psi_3[E_{t-2}P_t - E_tP_t] + \psi_4(v_t - u_t)$

Take expectation as of t-2 for P_t':

$$E_{t-2}P_t = \psi_1 E_{t-2}m_t + \psi_2 E_{t-2}(E_tP_t) - \psi_3[E_{t-2}(E_{t-2}P_t) - E_{t-2}(E_tP_t)] + \psi_4 E_{t-2}(v_t-u_t)$$

Note: $E_{t-2}(E_tP_t) = E_{t-2}P_t$ and $E_{t-2}(E_{t-2}P_t) = E_{t-2}P_t$

$$E_{t-2}P_t = \psi_1 E_{t-2}m_t + \psi_2 E_{t-2}P_t + \psi_4 E_{t-2}(v_t-u_t)$$

$$(1-\psi_2)E_{t-2}P_t = \psi_1 E_{t-2}m_t + \psi_4 E_{t-2}(v_t-u_t)$$

(7) $$E_{t-2}P_t = \frac{\psi_1}{1-\psi_2} E_{t-2}m_t + \frac{\psi_4}{1-\psi_2} E_{t-2}(v_t-u_t)$$

Assess expectation as of t for P_t':

$$E_tP_t = \psi_1 E_tm_t + \psi_2 E_tP_t - \psi_3[E_t(E_{t-2}P_t)-E_t(E_tP_t)] + \psi_4 E_t(v_t-u_t)$$

$E_{t-2}P_t$ already determined at t; therefore, $E_t(E_{t-2}P_t) = E_{t-2}P_t$

$$(1-\psi_2-\psi_3)E_tP_t = \psi_1 E_tm_t - \psi_3 E_{t-2}P_t + \psi_4 E_t(v_t-u_t)$$

$$E_tP_t = \frac{\psi_1}{1-\psi_2-\psi_3} E_tm_t - \frac{\psi_3}{1-\psi_2-\psi_3} E_{t-2}P_t + \frac{\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t)$$

Substitute for $E_{t-2}P_t$ (using equation (7)):

$$E_tP_t = \frac{\psi_1}{1-\psi_2-\psi_3} E_tm_t - \frac{\psi_3}{1-\psi_2-\psi_3}\left[\frac{\psi_1}{1-\psi_2} E_{t-2}m_t + \frac{\psi_4}{1-\psi_2} E_{t-2}(v_t-u_t)\right] + \frac{\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t)$$

(8) $$E_tP_t = \frac{\psi_1}{1-\psi_2-\psi_3} E_tm_t - \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}m_t - \frac{\psi_3\psi_4}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}(v_t-u_t) + \frac{\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t)$$

Assess $[E_{t-2}P_t - E_tP_t]$:

$$[E_{t-2}P_t - E_tP_t] = \frac{-\psi_1}{1-\psi_2-\psi_3} E_t m_t + \left[\frac{\psi_1}{1-\psi_2} + \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)}\right] E_{t-2}m_t$$

$$- \frac{\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t) + \left[\frac{\psi_4}{1-\psi_2} + \frac{\psi_3\psi_4}{(1-\psi_2-\psi_3)(1-\psi_2)}\right] E_{t-2}(v_t-u_t)$$

Examine the term on $E_{t-2}m_t$:

$$\left[\frac{\psi_1}{1-\psi_2} + \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)}\right] = \frac{\psi_1-\psi_1\psi_2-\psi_1\psi_3+\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} = \frac{\psi_1(1-\psi_2)}{(1-\psi_2-\psi_3)(1-\psi_2)}$$

$$= \frac{\psi_1}{1-\psi_2-\psi_3}$$

Similar procedures apply to coefficient on disturbance term.

Thus,

(9) $$[E_{t-2}P_t - E_tP_t] = \frac{\psi_1}{1-\psi_2-\psi_3} [E_{t-2}m_t - E_tm_t]$$

$$+ \frac{\psi_4}{1-\psi_2-\psi_3} [E_{t-2}(v_t-u_t) - E_t(v_t-u_t)]$$

Assess P'_t, given E_tP_t and $E_{t-2}P_t$:

Recall $P'_t = \psi_1 m_t + \psi_2 E_tP_t - \psi_3[E_{t-2}P_t - E_tP_t] + \psi_4(v_t-u_t)$.

Substitute for E_tP_t and $E_{t-2}P_t$ terms:

$$P'_t = \psi_1 m_t + \psi_2\left[\frac{\psi_1}{1-\psi_2-\psi_3} E_tm_t - \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}m_t\right.$$

$$\left. - \frac{\psi_3\psi_4}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}(v_t-u_t) + \frac{\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t)\right]$$

$$- \psi_3\left[\frac{\psi_1}{1-\psi_2-\psi_3} E_{t-2}m_t - \frac{\psi_1}{1-\psi_2-\psi_3} E_tm_t + \frac{\psi_4}{1-\psi_2-\psi_3} E_{t-2}(v_t-u_t)\right.$$

$$\left. - \frac{\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t)\right] + \psi_4(v_t-u_t)$$

$$P_t' = \psi_1 m_t + \frac{\psi_1\psi_2+\psi_1\psi_3}{1-\psi_2-\psi_3} E_t m_t + \left[\frac{-\psi_1\psi_2\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} + \frac{-\psi_1\psi_3}{1-\psi_2-\psi_3}\right] E_{t-2} m_t$$

$$+ \frac{\psi_2\psi_4+\psi_3\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t) + \left[\frac{-\psi_2\psi_3\psi_4}{(1-\psi_2-\psi_3)(1-\psi_2)} + \frac{-\psi_3\psi_4}{1-\psi_2-\psi_3}\right] E_{t-2}(v_t-u_t)$$

$$+ \psi_4(v_t-u_t)$$

Examine the term on $E_{t-2}m_t$:

$$\left[\frac{-\psi_1\psi_2\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} + \frac{-\psi_1\psi_3}{1-\psi_2-\psi_3}\right] = \frac{-\psi_1\psi_2\psi_3-\psi_1\psi_3+\psi_1\psi_2\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} = \frac{-\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)}$$

Similar procedures apply to the coefficient on disturbance term.

$$(10)\quad P_t' = \psi_1 m_t + \frac{\psi_1\psi_2+\psi_1\psi_3}{1-\psi_2-\psi_3} E_t m_t - \frac{\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2} m_t + \psi_4(v_t-u_t)$$

$$+ \frac{\psi_2\psi_4+\psi_3\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t) - \frac{\psi_3\psi_4}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}(v_t-u_t)$$

Assess $[P_t'-E_tP_t]$:

$$[P_t'-E_tP_t] = \psi_1 m_t + \left[\frac{-\psi_1+\psi_1\psi_2+\psi_1\psi_3}{1-\psi_2-\psi_3}\right] E_t m_t + \frac{-\psi_1\psi_3+\psi_1\psi_3}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2} m_t$$

$$+ \frac{-\psi_4+\psi_2\psi_4+\psi_3\psi_4}{1-\psi_2-\psi_3} E_t(v_t-u_t) + \frac{-\psi_3\psi_4+\psi_3\psi_4}{(1-\psi_2-\psi_3)(1-\psi_2)} E_{t-2}(v_t-u_t)$$

$$+ \psi_4(v_t-u_t)$$

Examine term on $E_t m_t$:

$$\left[\frac{-\psi_1+\psi_1\psi_2+\psi_1\psi_3}{(1-\psi_2-\psi_3)}\right] = \left[\frac{-\psi_1(1-\psi_2-\psi_3)}{(1-\psi_2-\psi_3)}\right] = -\psi_1$$

Thus,

$$(11)\quad [P_t'-E_tP_t] = \psi_1(m_t-E_tm_t) + \psi_4[(v_t-u_t)-E_t(v_t-u_t)]$$

Given these aggregate price and expected price terms, assess market supply.

$$(2)\quad y_t(z) = \alpha_1[P_t(z)-E_tP_t] + \alpha_2[{}_{t-i}w_t-E_tP_t] + u_t(z)$$

$$y_t(z) = \alpha_1[P_t'-E_tP_t+z] + \alpha_2[E_{t-2}P_t-E_tP_t] + u_t(z)$$

$$(12)\quad y_t(z) = \alpha_1\psi_1(m_t-E_tm_t) + \alpha_2\,\frac{\psi_1}{1-\psi_2-\psi_3}\,(E_{t-2}m_t-E_tm_t) + \alpha_1 z + u_t(z)$$

$$+ \alpha_1\psi_4[(v_t-u_t)-E_t(v_t-u_t)] + \frac{\alpha_2\;\psi_4}{1-\psi_2-\psi_3}\,[E_{t-2}(v_t-u_t)-E_t(v_t-u_t)]$$

Denote disturbance terms as "$\omega_t(z)$"

$$(13)\quad y_t(z) = \alpha_1\psi_1(m_t-E_tm_t) + \alpha_2\,\frac{\psi_1}{1-\psi_2-\psi_3}\,(E_{t-2}m_t-E_tm_t) + \omega_t(z)$$

or

$$(14)\quad y_t(z) = \underset{w}{\theta_-^u}(m_t-E_tm_t) + \underset{w}{\theta_-^a}(E_{t-2}m_t-E_tm_t) + \omega_t(z)$$

Real output is a function of anticipated and unanticipated money growth. Denoting $(E_tm_t-E_{t-2}m_t)$ as m^a,

$$\frac{\partial y_t(z)}{\partial m^a} > 0.$$

Case 3: Output Price Rigid

Wages are as in Case 1: $w_t(z) = P_t + z \qquad E(z) = 0$

Price to prevail in t set in t-i, based upon expectation in t-i of price level in t.

(1) $_{t-i}P_t(z) = E_{t-i}P_t$

Market Supply

(2) $y_t(z) = \alpha_1[_{t-i}P_t(z) - E_tP_t] + \alpha_2[w_t(z) - E_tP_t] + u_t(z)$

Substitute for price and wage; set t-i at t-2 (for sake of exposition):

(3) $y_t(z) = \alpha_1[E_{t-2}P_t - E_tP_t] + \alpha_2[P_t + c - E_tP_t] + u_t(z)$

Aggregate Supply

(4) $y_t = \alpha_1[E_{t-2}P_t - E_tP_t] + \alpha_2[P_t - E_tP_t] + u_t$

Aggregate Demand

(5) $y_t = \beta(m_t - p_t) + v_t$

Assumptions on c, z, v, u same as before.

Solve for the price that equates AD and AS; denote as $\tilde{P}_t$.

$$\beta(m_t - p_t) + v_t = \alpha_1E_{t-2}P_t - \alpha_1E_tP_t + \alpha_2P_t - \alpha_2E_tP_t + u_t$$

$$(\beta+\alpha_2)P_t = \beta m_t - \alpha_1E_{t-2}P_t + \alpha_1E_tP_t + \alpha_2E_tP_t + v_t - u_t$$

$$\tilde{P}_t = \underbrace{\frac{\beta}{\beta+\alpha_2}}_{\gamma_1} m_t - \underbrace{\frac{\alpha_1}{\beta+\alpha_2}}_{\gamma_2} E_{t-2}P_t + \underbrace{\frac{\alpha_1}{\beta+\alpha_2}}_{\gamma_2} E_tP_t + \underbrace{\frac{\alpha_2}{\beta+\alpha_2}}_{\gamma_3} E_tP_t + \underbrace{\frac{1}{\beta+\alpha_2}}_{\gamma_4} (v_t - u_t)$$

(6) $\tilde{P}_t = \gamma_1m_t - \gamma_2[E_{t-2}P_t - E_tP_t] + \gamma_3E_tP_t + \gamma_4(v_t - u_t)$

Take expectation as of t-2 of $\tilde{P}_t$:

$$E_{t-2}P_t = \gamma_1 E_{t-2}m_t - \gamma_2[E_{t-2}(E_{t-2}P_t) - E_{t-2}(E_tP_t)] + \gamma_3 E_{t-2}(E_tP_t) + \gamma_4 E_{t-2}(v_t - u_t)$$

Note: $E_{t-2}(E_{t-2}P_t) = E_{t-2}P_t$ and $E_{t-2}(E_tP_t) = E_{t-2}P_t$.

$$E_{t-2}P_t = \gamma_1 E_{t-2}m_t + \gamma_3 E_{t-2}P_t + \gamma_4 E_{t-2}(v_t - u_t)$$

$$(1-\gamma_3)E_{t-2}P_t = \gamma_1 E_{t-2}m_t + \gamma_4 E_{t-2}(v_t - u_t)$$

$$(7) \quad E_{t-2}P_t = \frac{\gamma_1}{1-\gamma_3} E_{t-2}m_t + \frac{\gamma_4}{1-\gamma_3} E_{t-2}(v_t - u_t)$$

Assess expectation as of t for $\tilde{P}_t$:

$$E_tP_t = \gamma_1 E_t m_t - \gamma_2[E_t(E_{t-2}P_t) - E_t(E_tP_t)] + \gamma_3 E_t(E_tP_t) + \gamma_4 E_t(v_t - u_t)$$

$E_{t-2}P_t$ already determined at t; therefore, $E_t(E_{t-2}P_t) = E_{t-2}P_t$.

$$(1-\gamma_2-\gamma_3)E_tP_t = \gamma_1 E_t m_t - \gamma_2 E_{t-2}P_t + \gamma_4 E_t(v_t - u_t)$$

$$E_tP_t = \frac{\gamma_1}{1-\gamma_2-\gamma_3} E_t m_t - \frac{\gamma_2}{1-\gamma_2-\gamma_3} E_{t-2}P_t + \frac{\gamma_4}{1-\gamma_2-\gamma_3} E_t(v_t - u_t)$$

Substitute for $E_{t-2}P_t$ (using equation (7)):

$$E_tP_t = \frac{\gamma_1}{1-\gamma_2-\gamma_3} E_t m_t - \frac{\gamma_2}{1-\gamma_2-\gamma_3}\left[\frac{\gamma_1}{1-\gamma_3} E_{t-2}m_t + \frac{\gamma_4}{1-\gamma_3} E_{t-2}(v_t - u_t)\right] + \frac{\gamma_4}{1-\gamma_2-\gamma_3} E_t(v_t - u_t)$$

$$(8) \quad E_tP_t = \frac{\gamma_1}{1-\gamma_2-\gamma_3} E_t m_t - \frac{\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} E_{t-2}m_t - \frac{\gamma_2\gamma_4}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} E_{t-2}(v_t - u_t) + \frac{\gamma_4}{1-\gamma_2-\gamma_3} E_t(v_t - u_t)$$

Assess $[E_{t-2}P_t - E_tP_t]$:

$$[E_{t-2}P_t - E_tP_t] = \frac{-\gamma_1}{1-\gamma_2-\gamma_3} E_tm_t + \left[\frac{\gamma_1}{1-\gamma_3} + \frac{\gamma_1\gamma_3}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] E_{t-2}m_t$$

$$- \frac{\gamma_4}{1-\gamma_2-\gamma_3} E_t(v_t-u_t) + \left[\frac{\gamma_4}{1-\gamma_3} + \frac{\gamma_2\gamma_4}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] E_{t-2}(v_t-u_t)$$

Examine the term on $E_{t-2}m_t$:

$$\left[\frac{\gamma_1}{1-\gamma_3} + \frac{\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] = \frac{\gamma_1-\gamma_1\gamma_2-\gamma_1\gamma_3+\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} = \frac{\gamma_1(1-\gamma_3)}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}$$

$$= \frac{\gamma_1}{1-\gamma_2-\gamma_3}$$

Similar procedures apply to coefficient on disturbance term.

$$(9) \quad [E_{t-2}P_t - E_tP_t] = \frac{\gamma_1}{1-\gamma_2-\gamma_3} [E_{t-2}m_t - E_tm_t] + \frac{\gamma_4}{1-\gamma_2-\gamma_3} [E_{t-2}(v_t-u_t) - E_t(v_t-u_t)]$$

Assess $\tilde{P}_t$, given $E_{t-2}P_t$ and E_tP_t:

Recall:

$$\tilde{P}_t = \gamma_1m_t - \gamma_2[E_{t-2}P_t - E_tP_t] + \gamma_3E_tP_t + \gamma_4(v_t-u_t)$$

Substitute for the E_tP_t and $E_{t-2}P_t$ terms:

$$\tilde{P}_t = \gamma_1m_t - \gamma_2\left[\frac{\gamma_1}{1-\gamma_2-\gamma_3} E_{t-2}m_t - \frac{\gamma_1}{1-\gamma_2-\gamma_3} E_tm_t + \frac{\gamma_4}{1-\gamma_2-\gamma_3} E_{t-2}(v_t-u_t)\right.$$

$$\left. - \frac{\gamma_4}{1-\gamma_2-\gamma_3} E_t(v_t-u_t)\right] + \gamma_3\left[\frac{\gamma_1}{1-\gamma_2-\gamma_3} E_tm_t - \frac{\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} E_{t-2}m_t\right.$$

$$\left. - \frac{\gamma_2\gamma_4}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} E_{t-2}(v_t-u_t) + \frac{\gamma_4}{1-\gamma_2-\gamma_3} E_t(v_t-u_t)\right] + \gamma_4(v_t-u_t)$$

$$\tilde{P}_t = \gamma_1 m_t + \left[\frac{\gamma_1\gamma_2+\gamma_1\gamma_3}{1-\gamma_2-\gamma_3}\right] E_t m_t + \left[\frac{-\gamma_1\gamma_2}{1-\gamma_2-\gamma_3} - \frac{\gamma_1\gamma_2\gamma_3}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] E_{t-2} m_t$$

$$+ \left[\frac{\gamma_2\gamma_4+\gamma_3\gamma_4}{1-\gamma_2-\gamma_3}\right] E_t(v_t-u_t) + \left[\frac{-\gamma_2\gamma_4}{1-\gamma_2-\gamma_3}\right.$$

$$\left. - \frac{\gamma_2\gamma_3\gamma_4}{(1-\gamma_1-\gamma_3)(1-\gamma_3)}\right] E_{t-2}(v_t-u_t) + \gamma_4(v_t-u_t)$$

Examine the $E_{t-2}m_t$ term:

$$\left[\frac{-\gamma_1\gamma_2}{1-\gamma_2-\gamma_3} + \frac{-\gamma_1\gamma_2\gamma_3}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] = \frac{-\gamma_1\gamma_2+\gamma_1\gamma_2\gamma_3-\gamma_1\gamma_2\gamma_3}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} = \frac{-\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}$$

Similar procedures apply to the coefficient on disturbance term.

$$\text{(10)} \quad \tilde{P}_t = \gamma_1 m_t + \frac{\gamma_1\gamma_2+\gamma_1\gamma_3}{1-\gamma_2-\gamma_3} E_t m_t - \frac{\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} E_{t-2} m_t + \gamma_4(v_t-u_t)$$

$$+ \frac{\gamma_2\gamma_4+\gamma_3\gamma_4}{1-\gamma_2-\gamma_3} E_t(v_t-u_t) - \frac{\gamma_2\gamma_4}{(1-\gamma_2-\gamma_3)(1-\gamma_3)} E_{t-2}(v_t-u_t)$$

Assess $[\tilde{P}_t-E_tP_t]$:

$$[\tilde{P}_t-E_tP_t] = \gamma_1 m_t + \left[\frac{-\gamma_1+\gamma_1\gamma_2+\gamma_1\gamma_3}{1-\gamma_2-\gamma_3}\right] E_t m_t + \left[\frac{-\gamma_1\gamma_2}{1-\gamma_2-\gamma_3}\right.$$

$$\left. + \frac{-\gamma_1\gamma_2\gamma_3+\gamma_1\gamma_2}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] E_{t-2} m_t + \left[\frac{\gamma_2\gamma_4+\gamma_3\gamma_4-\gamma_4}{1-\gamma_2-\gamma_3}\right] E_t(v_t-u_t)$$

$$+ \left[\frac{-\gamma_2\gamma_4}{1-\gamma_2-\gamma_3} + \frac{\gamma_2\gamma_4-\gamma_2\gamma_3\gamma_4}{(1-\gamma_2-\gamma_3)(1-\gamma_3)}\right] E_{t-2}(v_t-u_t) + \gamma_4(v_t u_t)$$

Examine term on $E_{t-2}m_t$:

$$\left[\frac{-\gamma_1+\gamma_1\gamma_2+\gamma_1\gamma_3}{(1-\gamma_2-\gamma_3)}\right] = \frac{-\gamma_1(1-\gamma_2-\gamma_3)}{(1-\gamma_2-\gamma_3)} = -\gamma_1$$

$$(11)\quad [\tilde{P}_t - E_tP_t] = \gamma_1(m_t - E_tm_t) + \gamma_4[(v_t - u_t) - E_t(v_t - u_t)]$$

Given these aggregate price and expected price terms, assess market supply.

$$(2)\quad y_t(z) = \alpha_1[E_{t-2}P_t - E_tP_t] + \alpha_2[w_t(z) - E_tP_t] + u_t(z)$$

$$y_t(z) = \alpha_1[E_{t-2}P_t - E_tP_t] + \alpha_2[P_t + c - E_tP_t] + u_t(z)$$

$$(12)\quad y_t(z) = \alpha_1\left[\frac{\gamma_1}{1-\gamma_2-\gamma_3}(E_{t-2}m_t - E_tm_t) + \frac{\gamma_4}{1-\gamma_2-\gamma_3}(E_{t-2}(v_t-u_t) - E_t(v_t-u_t))\right] + \alpha_2[\gamma_1(m_t - E_tm_t) + \gamma_4((v_t-u_t) - E_t(v_t-u_t))] + \alpha_2c + u_t(z)$$

Denote disturbance terms as "$\omega_t(z)$"

$$(13)\quad y_t(z) = \alpha_1\frac{\gamma_1}{1-\gamma_2-\gamma_3}(E_{t-2}m_t - E_tm_t) + \alpha_2\gamma_1(m_t - E_tm_t) + \omega_t(z)$$

or

$$(14)\quad y_t(z) = \theta^a_{\bar{p}}(E_{t-2}m_t - E_tm_t) + \theta^u_{\bar{p}}(m_t - E_tm_t) + \omega_t(z)$$

Real output is a function of anticipated and unanticipated money growth. Denoting $(E_tm_t - E_{t-2}m_t)$ as m^a,

$$\frac{\partial y_t(z)}{\partial m^a} < 0.$$

Case 4: Aggregation of Mixed Market Types

Market Supplies

Assume three different market types exist.

(i) Flexible price of market output and cost of purchased inputs

$$(1)\quad y_t(z) = \alpha_1[P_t(z)-E_tP_t] + \alpha_2[w_t(z)-E_tP_t] + u_t(z)$$
$$= \alpha_1[P_t+z-E_tP_t] + \alpha_2[P_t+c-E_tP_t] + u_t(z)$$

(ii) Flexible output price; wage to purchased inputs temporarily rigid

$$(2)\quad y_t(z) = \alpha_1[P_t(z)-E_tP_t] + \alpha_2[{}_{t-i}w_t(z)-E_tP_t] + u_t(z)$$
$$= \alpha_1[P_t+z-E_tP_t] + \alpha_2[E_{t-2}P_t-E_tP_t] + u_t(z)$$

(iii) Flexible wage to purchased inputs; output price temporarily rigid

$$(3)\quad y_t(z) = \alpha_1[{}_{t-i}P_t-E_tP_t] + \alpha_2[w_t(z)-E_tP_t] + u_t(z)$$
$$= \alpha_1[E_{t-i}P_t-E_tP_t] + \alpha_2[P_t+c-E_tP_t] + u_t(z)$$

Assume 1/3 of each market type exists in the economy. For tractability, assume α_1 same across market types, α_2 same across market types. Set t-i at t-2.

Aggregate Supply

$$(4)\quad y_t = 1/3\ \alpha_1[P_t-E_tP_t] + 1/3\ \alpha_2[P_t-E_tP_t] + 1/3\ \alpha_1[P_t-E_tP_t]$$
$$+ 1/3\ \alpha_2[E_{t-2}P_t-E_tP_t] + 1/3\ \alpha_1[E_{t-2}P_t-E_tP_t] + 1/3\ \alpha_2[P_t-P_t]_t] + u_t$$

Aggregate Demand

$$(6)\quad y_t = \beta(m_t-p_t)+ v_t$$

Assumptions on z, c, v, u are as before.

Equate AS and AD; solve for P_t^{**}

$$\beta(m_t-p_t) + v_t = \frac{2\alpha_1}{3} P_t + \frac{2\alpha_2}{3} P_t + \frac{\alpha_1}{3} E_{t-2}P_t - \frac{\alpha_1}{3} E_tP_t + \frac{\alpha_2}{3} E_{t-2}P_t$$
$$- \frac{\alpha_2}{3} E_tP_t - \frac{2\alpha_1}{3} E_tP_t - \frac{2\alpha_2}{3} E_tP_t + u_t$$

$$(\beta + 2/3\ (\alpha_1+\alpha_2))P_t = \beta m_t - \frac{\alpha_1}{3} E_{t-2}P_t + \frac{\alpha_1}{3} E_tP_t - \frac{\alpha_2}{3} E_{t-2}P_t$$
$$+ \frac{\alpha_2}{3} E_tP_t + \frac{2\alpha_1}{3} E_tP_t + \frac{2\alpha_2}{3} E_tP_t + (v_t-u_t)$$

$$P_t^{**} = \underbrace{\frac{3\beta}{D}}_{\theta_1} m_t - \underbrace{\frac{\alpha_1}{D}}_{\theta_2} [E_{t-2}P_t-E_tP_t] - \underbrace{\frac{\alpha_2}{D}}_{\theta_3} [E_{t-2}P_t-E_tP_t] + \underbrace{\frac{2\alpha_1}{D}}_{\theta_4} E_tP_t$$
$$+ \underbrace{\frac{2\alpha_2}{D}}_{\theta_5} E_tP_t + \underbrace{\frac{3}{D}}_{\theta_6} (v_t-u_t)$$

where $D = 3\beta + 2(\alpha_1+\alpha_2)$; $D > 0$ since $\beta > 0$, $\alpha_1 > 0$ and $\alpha_1 > |\alpha_2|$

(7) $$P_t^{**} = \theta_1 m_t - \theta_2[E_{t-2}P_t-E_tP_t] - \theta_3[E_{t-2}P_t-E_tP_t] + \theta_4 E_tP_t + \theta_5 E_tP_t + \theta_6(v_t-u_t)$$

Take expectation as of t-2 of aggregate price level, P_t^{**}:

$$E_{t-2}P_t = \theta_1 E_{t-2}m_t - \theta_2[E_{t-2}(E_{t-2}P_t) - E_{t-2}(E_tP_t)] - \theta_3[E_{t-2}(E_{t-2}P_t)$$
$$- E_{t-2}(E_tP_t)] + \theta_4 E_{t-2}(E_tP_t) + \theta_5 E_{t-2}(E_tP_t) + \theta_6 E_{t-2}(v_t-u_t)$$

Note: $E_{t-2}(E_{t-2}P_t) = E_{t-2}P_t$ and $E_{t-2}(E_tP_t) = E_{t-2}P_t$.

$$(1-\theta_4-\theta_5)E_{t-2}P_t = \theta_1 E_{t-2}m_t + \theta_6 E_{t-2}(v_t-u_t)$$

(8) $$E_{t-2}P_t = \frac{\theta_1}{1-\theta_4-\theta_5} E_{t-2}m_t + \frac{\theta_6}{1-\theta_4-\theta_5} E_{t-2}(v_t-u_t)$$

Take expectation as of t for P_t^{**}:

$$E_tP_t = \theta_1E_tm_t - \theta_2[E_t(E_{t-2}P_t) - E_t(E_tP_t)] - \theta_3[E_t(E_{t-2}P_t) - E_t(E_tP_t)]$$
$$+ \theta_4E_t(E_tP_t) + \theta_5E_t(E_tP_t) + \theta_6E_t(v_t-u_t)$$

$E_t(E_{t-2}P_t) = E_{t-2}P_t$ and $E_t(E_tP_t) = E_tP_t$.

$$(1-\theta_2-\theta_3-\theta_4-\theta_5)E_tP_t = \theta_1E_tm_t - \theta_2E_{t-2}P_t - \theta_3E_{t-2}P_t + \theta_6E_t(v_t-u_t)$$

$$E_tP_t = \frac{\theta_1}{1-\theta_{2\to5}}E_tm_t - \frac{\theta_2}{1-\theta_{2\to5}}E_{t-2}P_t - \frac{\theta_3}{1-\theta_{2\to5}}E_{t-2}P_t + \frac{\theta_6}{1-\theta_{2\to5}}E_t(v_t-u_t)$$

where $1-\theta_{2\to5} = 1-\theta_2-\theta_3-\theta_4-\theta_5$.

Substitute (8) in for $E_{t-2}P_t$:

$$E_tP_t = \frac{\theta_1}{1-\theta_{2\to5}}E_tm_t - \frac{\theta_2}{1-\theta_{2\to5}}\left[\frac{\theta_1}{1-\theta_4-\theta_5}E_{t-2}m_t + \frac{\theta_6}{1-\theta_4-\theta_5}E_{t-2}(v_t-u_t)\right]$$
$$- \frac{\theta_3}{1-\theta_{2\to5}}\left[\frac{\theta_1}{1-\theta_4-\theta_5}E_{t-2}m_t + \frac{\theta_6}{1-\theta_4-\theta_5}E_{t-2}(v_t-u_t)\right]$$
$$+ \frac{\theta_6}{1-\theta_{2\to5}}E_t(v_t-u_t)$$

(9) $$E_tP_t = \frac{\theta_1}{(1-\theta_{2\to5})}E_tm_t + \left[\frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right]E_{t-2}m_t$$
$$+ \left[\frac{-\theta_2\theta_6-\theta_3\theta_6}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right]E_{t-2}(v_t-u_t) + \frac{\theta_6}{(1-\theta_{2\to5})}E_t(v_t-u_t)$$

Assess $[E_{t-2}P_t - E_tP_t]$:

$$[E_{t-2}P_t - E_tP_t] = \frac{-\theta_1}{(1-\theta_{2+5})} E_t m_t + \left[\frac{\theta_1}{(1-\theta_4-\theta_5)} + \frac{\theta_1\theta_2+\theta_1\theta_3}{(1-\theta_{2+5})(1-\theta_4-\theta_5)}\right] E_{t-2}\, m_t + \left[\frac{\theta_6}{(1-\theta_4-\theta_5\ )} + \frac{\theta_2\theta_6+\theta_3\theta_6}{(1-\theta_4-\theta_5)(1-\theta_{2+5})}\right] E_{t-2}(v_t-u_t) - \frac{\theta_6}{(1-\theta_{2+5})} E_t(v_t-u_t)$$

Examine term on $E_{t-2}m_t$:

$$\left[\frac{\theta_1}{(1-\theta_4-\theta_5)} + \frac{\theta_1\theta_2+\theta_1\theta_3}{(1-\theta_{2+5})(1-\theta_4-\theta_5)}\right]$$

$$= \frac{\theta_1-\theta_1\theta_2-\theta_1\theta_3-\theta_1\theta_4-\theta_1\theta_5+\theta_1\theta_2+\theta_1\theta_3}{(1-\theta_4-\theta_5)(1-\theta_{2+5})} = \frac{\theta_1(1-\theta_4-\theta_5)}{(1-\theta_4-\theta_5)(1-\theta_{2+5})}$$

Similar procedures apply to coefficient on disturbance term.

$$(10)\quad [E_{t-2}P_t-E_tP_t] = \frac{\theta_1}{(1-\theta_{2+5})}[E_{t-2}m_t-E_tm_t] + \frac{\theta_6}{(1-\theta_{2+5})}[E_{t-2}(v_t-u_t) - E_t(v_t-u_t)]$$

Assess P^{**}_t, given E_tP_t and $E_{t-2}P_t$:

$$(7)\quad P^{**}_t = \theta_1m_t - \theta_2[E_{t-2}P_t-E_tP_t] - \theta_3[E_{t-2}P_t-E_tP_t] + \theta_4E_tP_t + \theta_5E_tP_t + \theta_6(v_t-u_t)$$

$$P_t^{**} = \theta_1 m_t - \theta_2\left[\frac{\theta_1}{(1-\theta_{2+5})} E_{t-2}m_t - \frac{\theta_1}{(1-\theta_{2+5})} E_t m_t\right] - \theta_3\left[\frac{\theta_1}{(1-\theta_{2+5})} E_{t-2}m_t\right.$$

$$\left. - \frac{\theta_1}{(1-\theta_{2+5})} E_t m_t\right] + (\theta_4+\theta_5)\left[\frac{\theta_1}{(1-\theta_{2+5})} E_t m_t\right.$$

$$+\left(\frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_{2+5})(1-\theta_4-\theta_5)}\right)E_{t-2}m_t + \left(\frac{-\theta_2\theta_6-\theta_3\theta_6}{(1-\theta_{2+5})(1-\theta_4-\theta_5)}\right)E_{t-2}(v_t-u_t)$$

$$\left. + \frac{\theta_6}{(1-\theta_{2+5})} E_t(v_t-u_t)\right] + \left(\frac{-\theta_2\theta_6-\theta_3\theta_6}{(1-\theta_{2+5})}\right)[E_{t-2}(v_t-u_t)-E_t(v_t-u_t)]$$

$$+ \theta_6(v_t-u_t)$$

$$P_t^{**} = \theta_1 m_t + \left[\frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_{2+5})} + \frac{(\theta_4+\theta_5)(-\theta_1\theta_2-\theta_1\theta_3)}{(1-\theta_{2+5})(1-\theta_4-\theta_5)}\right]E_{t-2}m_t$$

$$+\left[\frac{\theta_1\theta_2+\theta_1\theta_3+\theta_1\theta_4+\theta_1\theta_5}{(1-\theta_{2+5})}\right]E_t m_t + \left[\frac{(\theta_4+\theta_5)(-\theta_2\theta_6-\theta_3\theta_6)}{(1-\theta_{2+5})(1-\theta_4-\theta_5)}\right.$$

$$\left. + \frac{-\theta_2\theta_6-\theta_3\theta_6}{(1-\theta_{2+5})}\right]E_{t-2}(v_t-u_t) + \left[\frac{-\theta_2\theta_6-\theta_3\theta_6+\theta_4\theta_6+\theta_5\theta_6}{(1-\theta_{2+5})}\right]E_t(v_t-u_t)$$

$$+ \theta_6(v_t-u_t)$$

Examine term on $E_{t-2}m_t$:

$$\left[\frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_{2+5})} + \frac{(\theta_4+\theta_5)(-\theta_1\theta_2-\theta_1\theta_3)}{(1-\theta_{2+5})(1-\theta_4\theta_5)}\right] = \frac{(-\theta_1\theta_2-\theta_1\theta_3)(1-\theta_4-\theta_5+\theta_4+\theta_5)}{(1-\theta_4-\theta_5)(1-\theta_{2+5})}$$

$$= \frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_4-\theta_5)(1-\theta_{2+5})}$$

Similar procedures apply to coefficient on disturbance term.

$$(11)\quad P_t^{**} = \theta_1 m_t + \left[\frac{-\theta_1\theta_2-\theta_1\theta_3}{(1-\theta_4-\theta_5)(1-\theta_{2\to5})}\right]E_{t-2}m_t + \left[\frac{\theta_1(\theta_2+\theta_3+\theta_4+\theta_5)}{(1-\theta_{2\to5})}\right]E_t m_t$$

$$+\left[\frac{\theta_6(\theta_2+\theta_3+\theta_4+\theta_5)}{(1-\theta_{2\to5})}\right]E_t(v_t-u_t)$$

$$+\left[\frac{-\theta_2\theta_6-\theta_3\theta_6}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right]E_{t-2}(v_t-u_t) + \theta_6(v_t-u_t)$$

Assess $[P_t^{**}-E_tP_t]$:

$$[P_t^{**}-E_tP_t] = \theta_1 m_t + \left[\frac{-\theta_1+\theta_1(\theta_2+\theta_3+\theta_4+\theta_5)}{(1-\theta_{2\to5})}\right]E_t m_t$$

$$+\left[\frac{-\theta_1\theta_2-\theta_1\theta_3+\theta_1\theta_2+\theta_1\theta_3}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right]E_{t-2}m_t + \theta_6(v_t-u_t)$$

$$+\left[\frac{-\theta_6+\theta_6(\theta_2+\theta_3+\theta_4+\theta_5)}{(1-\theta_{2\to5})}\right]E_t(v_t-u_t)$$

$$+\left[\frac{\theta_6(-\theta_2-\theta_3+\theta_2+\theta_3)}{(1-\theta_{2\to5})(1-\theta_4-\theta_5)}\right]E_{t-2}(v_t-u_t)$$

Examine term on $E_t m_t$:

$$\left[\frac{-\theta_1+\theta_1(\theta_2+\theta_3+\theta_4+\theta_5)}{(1-\theta_{2\to5})}\right] = \frac{-\theta_1(1-\theta_2-\theta_3-\theta_4-\theta_5)}{(1-\theta_{2\to5})} = -\theta_1$$

$$(12)\quad [P_t^{**}-E_tP_t] = \theta_1(m_t-E_tm_t) + \theta_6(v_t-u_t) - \theta_6E_t(v_t-u_t)$$

Assess Aggregate Supply, given these P_t^{**} and $E_{t-i}P_t$ terms:

$$(5) \quad y_t = \frac{2\alpha_1}{3}[P_t - E_tP_t] + \frac{2\alpha_2}{3}[P_t - E_tP_t] + \frac{\alpha_1}{3}[E_{t-2}P_t - E_tP_t]$$

$$+ \frac{\alpha_2}{3}[E_{t-2}\,P_t - E_tP_t] + u_t$$

$$y_t = \frac{2\alpha_1+2\alpha_2}{3}[\theta_1(m_t - E_tm_t)] + \frac{\alpha_1+\alpha_2}{3}\left[\frac{\theta_1}{(1-\theta_{2+5})}(E_{t-2}m_t - E_tm_t)\right] + u_t$$

$$+ \frac{2\alpha_1+2\alpha_2}{3}\theta_6(v_t-u_t) - \left[\frac{2\alpha_1+2\alpha_2}{3}\theta_6 + \frac{(\alpha_1+\alpha_2)\theta_6}{3(1-\theta_{2+5})}\right]E_t(v_t-u_t)$$

$$+ \frac{(\alpha_1+\alpha_2)\theta_6}{3(1-\theta_{2+5})}E_{t-2}(v_t-u_t)$$

Stated in terms of the original parameters, and using ω_t to denote disturbance term, this is:

$$(13) \quad y_t = \frac{\beta(\alpha_1+\alpha_2)}{3/2\ \beta + \alpha_1+\alpha_2}(m_t - E_tm_t) + \frac{\beta(\alpha_1+\alpha_2)}{3\beta-\alpha_1-\alpha_2}(E_{t-2}m_t - E_tm_t) + \omega_t$$

or

$$(14) \quad y_t = \theta^u(m_t - E_tm_t) + \theta^a(E_{t-2}m_t - E_tm_t) + \omega_t$$

For reasonable values of β and α_i, we have $\theta^u > \theta^a$ in the aggregate output function.

Assess Market Output, given these P_t^{**} and $E_{t-i}P_t$ terms:

<u>Flexible P and W Market</u>

$$y_t(f) = \alpha_1[z+P_t-E_tP_t] + \alpha_2[c+P_t-E_tP_t] + u_t(z)$$

$$= (\alpha_1+\alpha_2)\theta_1(m_t-E_tm_t) + \theta_6(\alpha_1+\alpha_2)((v_t-u_t)-E_t(v_t-u_t)) + u_t(z)$$

$$(14) \qquad = \frac{(\alpha_1+\alpha_2)\beta}{\beta + 2/3\ (\alpha_1+\alpha_2)} (m_t - E_t m_t) + \omega_t(z)$$

$$= \theta_f^u\ (m_t - E_t m_t) + \omega_t(z)$$

<u>Rigid w and Flexible P Market</u>

$$y_t(\bar{w}) = \alpha_1[z+P_t-E_tP_t] + \alpha_2[E_{t-2}P_t - E_tP_t] + u_t(z)$$

$$= \alpha_1\theta_1(m_t-E_tm_t) + \alpha_2 \frac{\theta_1}{(1-\theta_{2+5})} (E_{t-2}m_t - E_tm_t) + \alpha_1 z + u_t(z)$$

$$+ \alpha_1\theta_6((v_t-u_t)-E_t(v_t-u_t)) + \alpha_2 \frac{\theta_6}{(1-\theta_{2+5})} [E_{t-2}(v_t-u_t)-E_t(v_t-u_t)]$$

$$(15) \quad y_t(\bar{w}) = \frac{\alpha_1\beta}{\beta + 2/3\ (\alpha_1+\alpha_2)} (m_t-E_tm_t) + \frac{\alpha_2\beta}{\beta - 1/3\ (\alpha_1+\alpha_2)} (E_{t-2}m_t-E_tm_t) + \omega_t(z)$$

$$y_t(\bar{w}) = \theta_{\bar{w}}^u\ (m_t-E_tm_t) + \theta_{\bar{w}}^a\ (E_{t-2}m_t-E_tm_t) + \omega_t(z)$$

<u>Flexible w and Rigid P Market</u>

$$y_t(\bar{p}) = \alpha_1[E_{t-2}P_t-E_tP_t] + \alpha_2[c+P_t-E_tP_t] + u_t(z)$$

$$= \frac{\alpha_1\theta_1}{(1-\theta_{2+5})} (E_{t-2}m_t-E_tm_t) + \alpha_2\theta_1(m_t-E_tm_t) + \alpha_2 c + u_t(z)$$

$$+ \alpha_2\theta_6((v_t-u_t)-E_t(v_t-u_t)) + \frac{\alpha_1\theta_6}{(1-\theta_{2+5})} (E_{t-2}(v_t-u_t)-E_t(v_t-u_t))$$

$$(16) \quad y_t(\bar{p}) = \frac{\alpha_1\beta}{\beta - 1/3\ (\alpha_1+\alpha_2)} (E_{t-2}m_t-E_tm_t) + \frac{\alpha_2\beta}{\beta + 2/3\ (\alpha_1+\alpha_2)} (m_t-E_tm_t) + \omega_t(z)$$

$$y_t(\bar{p}) = \theta_{\bar{p}}^a\ (E_{t-2}m_t-E_tm_t) + \theta_{\bar{p}}^u\ (m_t-E_tm_t) + \omega_t(z)$$

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