The Great Inflation of the 1970s*

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PRELIMINARY AND INCOMPLETE!

October, 1999

Abstract

We explore two models of the take-off in inflation in the early 1970s: a sticky price model and a limited participation model. The latter has the virtue that it also accounts for the weak economic conditions (i.e., stagflation) of the early 1970s.

Our limited participation model incorporates the monetary policy rule estimated for the 1970s by Clarida, Gali and Gertler. The model has an equilibrium in which a bad technology shock drives up expected inflation which the Fed accommodates with higher money growth. The Fed also raises the interest rate, which has the effect of exacerbating the depressive effects of the bad technology shock. We argue that the model provides a useful stylized representation of the events of the early 1970s. We explore the implications of our analysis for the policy changes needed to ensure that a 1970s-style stagflation does not happen again.

* Christiano is greatful for a National Science Foundation grant to the National Bureau of Economic Research for financial support. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve System.

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1. Introduction

Considerable research has been devoted to understanding the causes of the high inflation experienced by many countries during the 1970s. The motivation for this research is to design policy rules and institutions that will reduce the likelihood that that experience will be repeated. One class of explanations is that the inflation take-off reflected an increase in inflation expectations that became self-fulfilling because of the nature of monetary policy.[1] Clarida, Gali and Gertler (1999) (CGG) present a sticky price model which they conjecture can explain the 1970s inflation in this way. To evaluate this conjecture, we use the model to generate artificial data for the 1970s. We do the same experiment using the limited participation model of money studied in Christiano, Eichenbaum and Evans (1998). We show that the two models have sharply different predictions for the 1970s. The CGG model predicts a strong economy, while the limited participation model has the implication that output, employment, consumption and investment should have been weak. We then ask which model best accounts for the experience of the 1970s. Our tentative conclusion is that the limited participation model does best, because its implications conform better with the simultaneous low output and high inflation (i.e., stagflation) of the 1973-1975 period.

In both models, the monetary authority is modeled in the same way. Following CGG, we model it as implementing a Taylor rule, in which the nominal rate of interest is set as an increasing function of the expected rate of inflation and the output gap. The parameters of the policy rule are the ones estimated by CGG using US data from the 1970s. The CGG model is a rational expectations IS-LM model, which can be derived from an optimization framework. The models both have the property that a self-fulfilling take-off in inflation is possible.

We now briefly describe the mechanisms in these models which allow them to have this property. A key feature of the estimated monetary policy rule is that the coefficient on expected

[1] An example of this, which builds on the work of Kydland and Prescott (1977) and Barro and Gordon (xx), is due to Chari, Christiano and Eichenbaum (1998). They describe a model environment in which private agents who expect high inflation take actions which place a benevolent, optimizing monetary authority in a dilemma. Either it accommodates the expectations, in which case it produces the very take-off in inflation that was expected. Or, it fails to accommodate the expectations, in which case it generates a welfare-reducing fall in output and employment. According to this view, the Fed chose the path of accommodation as the least bad of two bad options. Our work in this paper is very much in the spirit of the Chari, Christiano and Eichenbaum analysis. The difference is that we do not model the policy authority at the level of objectives and constraints. We instead follow Clarida, Gali and Gertler (xx) in modeling the monetary authority at the level of its decision rule, which is estimated directly from the data of the 1970s.

inflation is less than one. As a result, when there is a rise in expected inflation, households expect this to result in a fall in the real rate of interest. In the CGG model, this stimulates spending which, via a standard sticky-price mechanism, results in a rise in output. Over time, the rise in output gives way to an increase in the price level, thus fulfilling the original rise in expected inflation. Evidently, the CGG model implies that a self-fulfilling outburst of inflation will produce a rise in employment and output and - in a version of the model with physical capital - investment. Our limited participation model also has the implication that inflation expectations can be self-fulfilling, although it happens by a very different mechanism. Instead of operating through the demand side of the economy, this mechanism operates through the supply side. In the limited participation model, the fall in the real rate of interest associated with a rise in expected inflation leads households to reduce their deposits with the financial intermediary. This reduction places upward pressure on the interest rate because firms need to borrow funds to finance productive inputs. In pursuing its policy of not letting the interest rate rise too much, the monetary authority must inject liquidity into the banking system. This injection then produces a rise in prices, thus validating the original rise in inflation expectations. Since the monetary authority does permit some rise in the nominal rate of interest, this has the effect of depressing output, employment, consumption and investment. Thus, the limited participation model contains pure stagflation equilibria. We consider two versions of our limited participation model. In the baseline model, investment is a cash good. In the alternative model, investment is a credit good. Investment falls during a self-fulfilling inflation episode in both versions of these model. Not surprisingly, it falls more in the version of the model in which investment is a cash good.

Although each of the models considered has equilibria in which inflation is triggered by sunspot variables, these are not the equilibria we study in this paper. Instead, we study equilibria in which inflation expectations are triggered by bad technology shocks.

According to these models, what should we do to prevent a recurrence of the high inflation of the 1970s? The CGG model and the benchmark limited participation model both imply that if the coefficient on expected inflation in the Taylor rule is larger than unity, then self-fulfilling inflation bursts are not possible. However, the limited participation model in which investment is a credit good implies self-fulfilling inflation outbursts are possible even if the coefficient on expected inflation is high. More basic changes to policy are required in that model.

The following section describes the monetary policy rule used in the analysis. The following two sections discuss the limited participation and the CGG models. After that, we discuss our simulation of the 1970s using these models. Finally, we briefly discuss the data from the 1970s. We end with a brief conclusion.

2. Monetary Policy

The specification of monetary policy that we adopt is the one estimated for the 1970s by Clarida, Gali and Gertler (1998). Their estimation procedure is consistent from the point of view of all the models considered in this paper. The policy rule has the following partial adjustment form:

$$R_t = \rho R_{t-1} + (1-\rho) R_t^*. \tag{2.1}$$

In words, the (gross) nominal rate of interest, R_t, is a weighted average of its value in the previous period and the current target value, R_t^*. The target interest rate is determined according to the following rule:

$$R_t^* = \text{constant} + \alpha E_t \log(\pi_{t+1}) + \gamma y_t, \;\; \pi_{t+1} = \frac{P_{t+1}}{P_t}, \tag{2.2}$$

where P_t is the price level, E_t is the date t conditional expectation and y_t is the percent deviation between actual output and trend output. The estimated values of ρ, α and γ are 0.75, 0.8 and 0.44, respectively. We use these values in our analysis.[2]

3. The Limited Participation Model

This section describes the two versions of the limited participation model considered in our analysis. They are differentiated according to whether investment is a cash or a credit good. In

[2] Clarida, Gali and Gertler (1998) use revised data to estimate the policy rule for the 1970s. Orphanides (1997) argues that constructing y_t using final revised data may give a very different view of y_t than actual policy makers in the 1970s had. He argues that the productivity slowdown that is thought to have occured beginning in the early 1970s was not recognized by policymakers until much later in that decade. As a result, according to Orphanides, real-time policymakers in the 1970s thought that output was further below potential than current estimates suggest. In private communication, Orphanides has informed us that when real-time data on y_t and the other variables are used to redo the Clarida, Gali and Gertler estimation procedure, he finds that the point estimates for ρ, α, β for the 1970s change. They move into the region where equilibrium indeterminacy does not occur. The standard errors on the point estimates are large, however, and do not exclude the Clarida, Gali and Gertler (1998) point estimates.

our baseline specification, we follow Christiano, Eichenbaum and Evans (1998) and Christiano and Gust (1999) in specifying investment to be a cash good. We first describe this version of the model. We then indicate the modifications to this model that are implied by dropping the cash in advance constraint on investment. Finally, we review the indeterminacy properties of these two models.

3.1. The Benchmark Model

We now briefly describe the model, which - apart from the specification of monetary policy - corresponds to the model analyzed in Christiano, Eichenbaum and Evans (1998). The model is composed of a representative household, a financial intermediary, a representative firm, and a monetary authority. We now describe each of these in turn.

The representative household begins period t with the economy's stock of money, M_t, and then proceeds to divide it between Q_t dollars allocated to the purchase of goods, and $M_t - Q_t$ dollars allocated to the financial intermediary. In the baseline specification, the household faces the following cash constraint on consumption and investment goods:

$$Q_t + W_t L_t \geq P_t \left(C_t + I_t \right),$$

where I_t denotes investment, C_t denotes consumption, L_t denotes hours worked, and W_t and P_t denote the wage rate and price level. For purposes of the calculations, we will assume that this constraint always holds as a strict equality. The household owns the stock of capital, and it has the standard capital accumulation technology:

$$K_{t+1} = I_t + (1 - \delta) K_t.$$

The household's monetary assets accumulate according to the following expression:

$$M_{t+1} = Q_t + W_t L_t - P_t \left(C_t + I_t \right) + R_t (M_t - Q_t + X_t) + D_t + r_t K_t,$$

where X_t is a date t monetary injection by the monetary authority and R_t denotes the gross rate of return on household deposits with the financial intermediary. Also, D_t denotes household profits, treated as lump sum transfers, and r_t is the rental rate on capital. An implication of this setup is that the household's date t earnings of rent on capital cannot be spent until the following period, while its date t wage earnings can be spent in the same period. As a result, inflation acts like a tax on investment income. The household's date t decision about Q_t must be made before the date t realization of the shocks, while all other decisions are made afterward. This assumption is what guarantees that when a surprise monetary injection occurs, the equilibrium rate of interest falls, and output and employment rise. To assure that these effects are persistent, we introduce an adjustment cost in changing Q_t, $H_t = H\left(\frac{Q_t}{Q_{t-1}}\right)$, where H_t is in units of time, and H is an increasing function.[3] The household's problem at time 0 is to choose contingency plans for C_t, I_t, Q_t, M_{t+1}, L_t, K_{t+1}, $t = 0, ..., \infty$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, L_t, H_t\right),\ U(C, L, H) = log\left[C - \psi_0 \frac{(L+H)^{(1+\psi)}}{1+\psi}\right],$$

subject to the information, cash, asset accumulation and other constraints.

The household's Euler equation for choosing labor is:

$$U_{L,t} + U_{C,t}\frac{W_t}{P_t} = 0. \tag{3.1}$$

The household's Euler equation for setting Q_t is:

$$E_{t-1}\left\{\frac{\Lambda_t}{P_t} - \beta\frac{\Lambda_{t+1}}{P_{t+1}}R_t\right\} = 0, \tag{3.2}$$

where

$$\Lambda_t = U_{C,t} + U_{H,t}H_t'\frac{P_{t-1}}{Q_{t-1}}\frac{1}{\pi_t} - \beta U_{H,t+1}H_{t+1}'\frac{Q_{t+1}/P_{t+1}}{\left(Q_t/P_t\right)^2}\pi_{t+1}. \tag{3.3}$$

Here, Λ_t is the marginal utility of an extra unit of consumption, financed by sending extra currency to the goods market in period t. The expression captures the fact that such an increase in consumption requires increasing Q_t, and this entails adjustment costs. The dating on the conditional expectation in (3.3) reflects that the Q_t decision is taken before the realization of

[3] Our adjustment cost function has the following form:

$$H\left(\frac{Q_t}{Q_{t-1}}\right) = d\left\{\exp\left[c\left(\frac{Q_t}{Q_{t-1}} - 1 - x\right)\right] + \exp\left[-c\left(\frac{Q_t}{Q_{t-1}} - 1 - x\right)\right] - 2\right\}$$

where x denotes the average rate of money growth.

the date t shocks.

The household's Euler equation for choosing K_{t+1} is given by the following expression:

$$E_t \left\{ U_{C,t} - \beta \left[\beta \Lambda_{t+2} \frac{r_{t+1}}{P_{t+1}} \frac{1}{\pi_{t+2}} + U_{C,t+1} (1 - \delta) \right] \right\} = 0. \tag{3.4}$$

To understand this expression, recall that - in the benchmark specification - the investment good, like the consumption good, is a cash good. As a result, the consumption cost of a unit increase in K_{t+1} is just one consumption good which, in utility terms, has value $U_{C,t}$. The gain is composed of the two terms in square brackets, discounted by β. The first term is the date $t+1$ value of the rental rate of capital, which is divided by π_{t+2} and converted into utility terms using $\beta\Lambda_{t+2}$ because the household cannot spend its date $t+1$ rental earnings until date $t+2$. The second term is the date $t+1$ value of the reduction in date $t+1$ investment made possible by the extra capital available at the end of $t+1$. This is converted into utility units with $U_{C,t+1}$ because the reduction in investment can be converted into an immediate increase in consumption purchases, without incurring any portfolio adjustment costs.

Now consider the firms. We suppose that a competitive, final good firm converts a continuum of intermediate goods using a linear homogeneous, Dixit-Stiglitz aggregator, into final output. Each intermediate good is produced by a monopolist using capital and labor. The monopolist behaves competitively in factor markets. The wage bill must be financed at the beginning of the period by borrowing cash from the financial intermediary, while rental payments on capital can be financed out of current period receipts. This setup leads, in a symmetric equilibrium, to the following efficiency conditions for labor and capital, respectively:

$$\frac{W_t R_t}{P_t} = \frac{f_{L,t}}{\mu}, \ \frac{r_t}{P_t} = \frac{f_{K,t}}{\mu}, \tag{3.5}$$

where μ is the fixed markup of price over marginal cost. Note the presence of R_t in the marginal condition for labor. This reflects our assumption that (intermediate) good producers must borrow the wage bill in advance, so that the end of period dollar cost of a unit of labor is $W_t R_t$.

The economy-wide resource constraint is:

$$C_t + K_{t+1} - (1-\delta)K_t \leq exp(z_t) K_t^{\theta} L_t^{1-\theta},$$

where the technology shock, z_t, has the following time series representation.

$$z_t = \rho_z z_{t-1} + \varepsilon_{z,t},$$

and $\varepsilon_{v,t}$ has mean zero and standard deviation σ_z.

The date t increment to money, X_t, is selected by the monetary authority. The monetary authority is assumed to do this in such a way that (2.1)-(2.2) is satisfied in equilibrium. We adopt a conventional sequence of markets equilibrium concept. An equilibrium is a state contingent sequence of prices, rates of return and quantities having the property that households and firms maximize and (2.1)-(2.2) are satisfied. Our strategy for solving the model, based on linearizing its first order conditions, is described in the Appendix.

3.2. The Alternative Model

In the alternative model, investment is a credit good, so that the household's cash constraint becomes:

$$Q_t + W_t L_t \geq P_t C_t.$$

While the other household Euler equations remain unchanged, the equation for K_{t+1}, equation (3.4), is replaced by:

$$E_t \left\{ \frac{\Lambda_{t+1}}{\pi_{t+1}} - \beta \frac{\Lambda_{t+2}}{\pi_{t+2}} \left[\frac{r_{t+1}}{P_{t+1}} + (1-\delta) \right] \right\} = 0. \tag{3.6}$$

To understand this equation, note that to pay for a unit increase in K_{t+1}, the household reduces *next* period's consumption, at a utility cost of $\beta\Lambda_{t+1}$. In units of next period's consumption good, the gain from this increase in K_{t+1} is the object in square brackets. But, that cannot be consumed until period $t+2$, after being deflated by π_{t+2}. The marginal value of the extra consumption is $\beta^2\Lambda_{t+2}$.

3.3. Indeterminacy in the Models

Self-fulfilling inflation outbursts are possible in versions of our model in which the nonstochastic steady state equilibrium is indeterminate. We identify such a situation using the eigenvaluecounting rules suggested by the analysis of Blanchard and Kahn (1980). See the appendix for more details. Here, we briefly summarize conditions under which the two versions of the limited participation model have indeterminate nonstochastic steady states.

As reported in Christiano and Gust (1999), for the benchmark model the nonstochastic steady state is determinate for values of α between, roughly, 1 and 3.5 and γ positive, but small. These findings were obtained by numerical analysis of the model, and were obtained for values of ρ between 0 and 1. In the case of the alternative model, we found that the nonstochastic steady state is indeterminate for all values of $\alpha \geq 0$, holding $\gamma = 0$.[4] [Add discussion of relation to Carlstrom and Fuerst.]

These differences between the models are important from a policy perspective. For example, the benchmark model implies that inflation outbursts like that in the 1970s can be prevented by increasing the value of α in the policy rule (for further discussion, see Christiano and Gust (1999).) However, this option does not work in the alternative model. In that model, a more fundamental change in monetary policy is required to rule out self-fulfilling bursts of inflation. Because of these policy implications, it is important to understand the reason why the steady state goes from being determinate in the benchmark model when $\alpha > 1$ to indeterminate when investment is a credit good.

Here is some progress towards developing intuition. Consider the case $\rho = \gamma = 0$ and suppose that $\varepsilon_{z,t} \equiv 0$ for all t. Let the initial date be date 0, when the initial conditions are K_0 and Q_{-1}.[5] We assume that these lie on a steady state growth path. Thus, one equilibrium involves staying on that growth path. But, are there other equilibria, which date 0 consumption and other variables are different from their steady state values, and then return to steady state asymptotically? If so, and if there are many such equilibria, then we say the steady state equilibrium is indeterminate. Moreover, in this case it is possible to construct stochastic equilibria in which variables respond to sunspots, or simply 'overreact' to fundamental shocks, such as the technology shock. The latter type of equilibria are the ones that we consider in this paper.

To answer the question whether there are other equilibria, we determine whether there are

[4] These findings are based on $\rho = 0$. We intend to explore other values of ρ.

[5] In future drafts, we will explore the implications for indeterminacy of changing the date zero state variables from K_0, Q_{-1} to K_0, Q_0, as in Carlstrom and Fuerst.

other paths which satisfy the two intertemporal Euler equations, the static Euler equation, and the policy rule. We write the policy rule as follows:

$$R_t = \pi_{t+1}^{\alpha}\kappa, \ \ \alpha > 1,$$

where κ is a constant. The labor and Q_t Euler equations are the same in the benchmark and alternative models. We reproduce them here in compact form. Combining (3.1) and (3.5), and making use of the parametric form of the production and utility functions:

$$(L_t + H_t)^{\psi} L_t^{\theta} = (1-\theta)\frac{K_t^{\theta}}{R_t \mu}.$$

Equation (3.2), in a nonstochastic economy, is:

$$\frac{\Lambda_t}{\beta \Lambda_{t+1}} = \frac{R_t}{\pi_{t+1}} = \kappa \pi_{t+1}^{\alpha - 1}.$$

Is there an equilibrium in which π_{t+1} rises above its steady state value for a while? If so, then according to the policy rule, this means that R_t must be high along this path. According to the labor Euler equation, this means that L_t must be low. What about the intertemporal Euler equation? With $\alpha > 1$, the policy rule implies that the real rate of interest is high along a high inflation path. Ignoring the adjustment costs in Q_t, this implies that the consumption profile must slope upward. But, if consumption is to asymptote back to the steady state path, then C_0 must drop. So, it appears that there may be many paths, in addition to the steady state path, which satisfy the labor and Q_t Euler equations, and the policy rule. Along these paths, the nominal interest rate is high, consumption is low but trending back up, and employment is low. But, do these paths *also* satisfy the Euler equation for capital? It turns out that they do when capital is a credit good, and they do not when capital is a cash good.

This argument will be developed further in the next draft. We will do this by studying the Euler equations for capital. For example, consider the case where investment is a credit good. Combining (3.6) with the firm's first order condition for capital and the Euler equation for Q_t, we obtain:

$$1 - \delta + \frac{f_{K,t+1}}{\mu} = \frac{R_{t+1}}{\pi_{t+1}} = \frac{\pi_{t+2}^{\alpha}}{\pi_{t+1}}.$$

[to be continued]

4. The Sticky Price Model

In this section, we briefly describe the sticky price model used by Clarida, Gali, and Gertler (1998). For a formal derivation of the model, see Woodford (1996). Like the limited participation model, the economy consists of a representative household and monopolistically competitive firms. However, households do not invest in capital so that, in equilibrium, $C_t = Y_t$. Also, firms set prices according to Calvo-style contracts so that price setting is staggered as in King and Wolman (1996) and Yun (1996). Thus, the model exhibits nominal price inertia and changes in monetary policy influence real activity.

After log-linearizing the equilibrium first order conditions of the representative household and firms, the model can be summarized by two equations:

$$y_t = E_t y_{t+1} - \frac{1}{\sigma}\left(i_t - E_t \pi_{t+1}\right) \tag{4.1}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t - \kappa z_t. \tag{4.2}$$

Here, i_t is the deviation of the (net) nominal interest rate from its steady state value, σ is the coefficient of relative risk aversion in a utility function separable in consumption, hours worked, and money balances, and β is the discount factor. Also, κ is a reduced form parameter that depends on the probability that a firm is able to reset its contract price, the discount factor, the economy's markup, and the labor supply elasticity. Since the real interest rate is negatively related to output in (4.1), it is often interpreted as the model's IS curve. Similarly, equation (4.2) resembles an aggregate supply curve since it posits a positive relationship between inflation and the deviation of output from trend. These two equations in addition to the monetary policy rule, (**??**)-(**??**), determine the equilibrium responses of prices and quantities in the CGG model. In simulating the CGG model, we used a value of $\kappa = 0.3$, which is the value used by Clarida, Gali, and Gertler (1998). We also choose $\beta = (1.03)^{-0.25}$ and $\sigma = 1$.

5. Simulation Results

This section constructs a simulation of the 1970s based on our models. We specify that the fundamental exogenous shock in this period is a bad shock to technology. For each model - the two limited participation models and the CCG model - we identify an equilibrium in which inflation 'overreacts' to this bad shock.

Figure 1 exhibits the dynamic response of the CCG and benchmark limited participation models to a 1% drop in technology. In each model there is a one dimensional indeterminacy, so that the impulse responses have one free parameter (for further details, see the appendix). We pinned down that free parameter by requiring that the price response in the period of the shock be the same between the two models.

Note from the figure that in the CGG model, employment and output rise in response to the shock. After four quarters, output is down, but the employment response remains up for several years. This dynamic response pattern reflects two things. First, it is well known that in sticky price models, a bad technology shock has at most a very small negative impact on output, since output is demand determined. As a result, a bad technology shock actually has a positive effect on employment in these models (see Gali (1999) and Basu and Fernald (1999)). Second, as explained in the introduction, a self-fulfilling rise in inflation by itself produces a rise in output and employment, as the fall in the real rate of interest stimulates the interest-sensitive components of aggregate demand. The simulation results in effect present the combined effects of both a self-fulfilling rise in inflation and a bad technology shock. The idea is that the bad technology shock actually triggered the rise in expected inflation, which ultimately became self-fulfilling because of the nature of the monetary policy rule. The key thing to note, however, is the overall degree of strength in the economy after the bad technology.

The figure also exhibits the response of the variables in the benchmark limited participation model to a bad technology shock. More variables are exhibited for that model because it also includes money and physical capital. The shock occurs in period 2, after that period's Q_t is set. The shock drives output and employment down and inflation up. The monetary authority reacts immediately to the increase in inflation expectations by reducing the money supply to push up the rate of interest (recall, the coefficient on expected inflation in the Taylor rule is positive). In period 3, when private agents set Q_3, they do so with higher inflation expectations.

They understand that the monetary authority's policy rule implies that the nominal rate of interest will go up, but that it will go up by less than the increase in inflation expectations (i.e., $0 < \alpha < 1$). That is, they expect the real rate to go down. This leads them to increase the funds allocated to the goods market by raising Q_3, that is, to drain funds from the financial intermediary (this is not reflected in the Figure, but will be reported in the next draft). To guarantee that the rate of interest only rises by a small amount (α is small), the monetary authority must inject funds into the financial intermediary, to make up for the loss of funds due to the rise in Q_3. The rise in the interest rate that occurs with all this produces a fall in output and employment. The stagflation persists for long time. Money growth, inflation, and the nominal interest rate remain high for years. Output, employment, consumption and investment are down for years. Investment is low, despite the low real rate of interest, because inflation acts like a tax on investment in this model.[6] Note that the effects are quite large. Output and employment remain 2 percent below trend for a long time, and money growth, inflation and interest rates are more than 6 percentage points above their steady state. The fall in investment is over 6 percent.

What is the reason for these persistent, and large effects following a technology shock? Fundamentally, it is bad monetary policy. With a less accommodating monetary policy (i.e., in which $\alpha > 1$ or in which the authorities follow a constant money growth rule), it would not be an equilibrium for inflation expectations to jump so much, and so the nominal interest rate would not rise so much. With a smaller interest rate rise, the negative output and employment response to a bad technology shock would be reduced. [experiments to document these conclusions will be added later]. There is irony here. One reason a monetary authority might assign a small value to α in its policy rule is that it is concerned with the real economy. It fears the negative output and employment effects of a sharp interest rate response after a rise in inflation expectations. The paradox is that this fear creates the risk that inflation expectations will take off, and when they do (as, perhaps, after a bad technology shock), this leads the policy authority to do greater damage to the economy then if they were non-accommodating.

Figure 2 compares the response to the bad technology shock in the alternative version of the limited participation model. The results are qualitatively similar.

[6] Feldstein (1997) has argued that high inflation hurts investment, though he emphasizes a mechanism that operates through the explicit tax system.

6. What Happened in the 1970s?

In this section, we begin with a brief review of the basic economic events in the 1970s. We then consider the implications for the models studied in the previous section. We argue that the limited participation model is a useful stylized representation of the stagflation in the early 1970s.

6.1. Policy and Inflation

Figure 3a displays quarterly data on inflation and the federal funds rate for the period 1960 to 1984.[7] Note how inflation begins to pick up in 1965 and hits three peaks, one in the early 1970s, one in early 1975 and the final one in late 1980. The early pickup in inflation was noted with alarm by policymakers, who responded with a sharp rise in the Federal Funds rate in 1969. This policy tightening is often credited with producing the 1970 recession (NBER peak and trough dates are indicated by the vertical lines in the figures). To the dismay of policymakers, the inflation rate continued to rise, despite the recession (see Figure 3a).[8] Frustrated by the difficulty of getting inflation under control by restrictive monetary policy, in August 1971 policymakers turned to wage and price controls. They were convinced that the underlying driving force of inflation was inflation expectations, and that these were all but impervious to recession.[9] They

[7] We used fyff from the Citibase database, which is the quarterly average Federal Funds rate. Inflation is the annual average of the GDP deflator, which has Citibase mnemonic gd.

[8] Arthur Burns, the chairman of the Federal Reserve at this time, said in a speech given at Pepperdine College, Los Angeles, in December 7, 1970 (see Burns (1978)):

> "The rules of economics are not working in quite the way they used to. Despite extensive unemployment in our country, wage rate increases have not moderated. Despite much idle industrial capacity, commodity prices continue to rise rapidly."(p.118)

[9] In a statement before the Joint Economic Committee of the US. Congress in 1971, Arthur Burns explained the role of expectations in inflation as follows:

> 'Consumer prices have been rising steadily since 1965 - much of the time at an accelerating rate. Continued substantial increases are now widely anticipated over the months and years ahead...in this environment, workers naturally seek wage increases sufficiently large...to get some protection against future price advances...thoughtful employers...reckon, as they now generally do, that cost increases probably can be passed on to buyers grown accustomed to inflation.' (Burns (1978, p.126).)

understood that, in principle, inflation could be stopped with a sufficiently restrictive monetary policy, but they were concerned that the short-run costs, in terms of lost output, would be intolerable.[10]

When price controls began to be removed in 1973, policymakers were once again surprised by the strength with which inflation took off. They had anticipated some inflationary pressure, and they raised rates very sharply in this period (see Figure 3a). But, they were surprised at just how strong the rise in inflation was.[11] Still, they raised rates by even more. Figures 3b and 3c show that the Fed responded very strongly to the rise in inflation. The increase in the Federal Funds rate was much greater than the rise in inflation or in expected inflation.[12]

Policymakers' resolve began to fade when output and investment started to show weakness in the middle of 1973 and hours worked began to soften in late 1973. They had indicated repeatedly that they were unwilling to countenance a severe recession in the fight against inflation. Their pronouncements to this effect were made more credible since their fears appeared to be confirmed by experience. Moreover, the 1960s and 1970s was a time when governments were expected to do good things for their citizens, and hurting a subset of them for the sake of curing a social problem

[10] In an appearance before the Committee on Banking and Currency, House of Representatives, July 30, 1974, Burns said (Burns (1978)):

> 'One may therefore argue that relatively high rates of monetary expansion have been a permissive factor in the accelerated pace of inflation. I have no quarrel with this view. But an effort to use harsh policies of monetary restraint to offset the exceptionally powerful inflationary forces of recent years would have caused serious financial disorder and economic dislocation. That would not have been a sensible course for monetary policy.'

In remarks before the Seventeenth Annual Monetary Conference of the American Bankers Association, Hot Springs, Virginia, May 18, 1970, Burns said (Burns (1978)):

> "An effort to offset, through monetary and fiscal restraints, all of the upward push that rising costs are now exerting on prices would be most unwise. Such an effort would restrict aggregate demand so severely as to increase greatly the risks of a very serious business recession. If that happened, the outcries of an enraged citizenry would probably soon force the government to move rapidly and aggressively toward fiscal and monetary ease, and our hopes for getting the inflationary problem under control would then be shattered."

[11] To some extent, the rise in inflation was due to the oil shock in late 1973. However, about 3/4 of the price increases of that year occurred before the Yom Kippur war and the October oil embargo.

[12] We calculated expected inflation for Figure 3 based on a one-month-ahead forecast of monthly inflation using five months' lags in monthly inflation, four months' lags in the Federal Funds rate, four months' lags in the monthly growth rate in M2, and four months' lags in the premium in the return to ten year Treasury bonds over the Federal Funds rate.

seemed unfair and wrong.[13] So, towards late 1974, policymakers reversed course and adopted a loose monetary policy, driving interest rates down sharply, to turn the economy around. Note from Figures 3b and 3c that real interest rates were negative or close to zero. Of course, as the economy entered the deep 1975 recession, inflation came down substantially anyway. But, the turnaround in monetary policy then had the implication that inflation would take off again as soon as the economy entered the expansion. Only later, in 1978 and 1979, did the Fed turn 'tough' and consciously tightened money until inflation came down. This can be see in Figure 3d, which shows the difference between the actual Federal Funds rate and the Federal Funds rate implied by (2.1)-(2.2), evaluated at the CGG parameter values. Note how these differences fluctuate around zero in the pre-1980 period, and are persistently positive thereafter. This is consistent with the CCG argument that in the late 1970s and early 1980s the Fed became persistently more aggressive on inflation than it had been in the previous period.

This picture of policy at the time, is one of policymakers impressed by the difficulty of breaking inflation expectations. Of course, the apparent intransigence of inflation expectations may well have been due in part to policymakers' very public expressions of concern about the costs of stopping inflation through monetary restraint.[14] Through these utterances, policy makers

[13] In an address before the joint meeting of the American Economic Association and the American Finance Association, on December 29, 1972, Burns expressed the general sense of the time (Burns (1978)):

> "Let me note, however, that there is no way to turn back the clock and restore the environment of a bygone era. We can no longer cope with inflation by letting recessions run their course; or by accepting a higher average level of unemployment; or by neglecting programs whose aim it is to halt the decay of our central cities, or to provide better medical care for the aged, or to create larger opportunities for the poor...."

Burns went on to explicitly defend the price controls that were then in place:

> "..as the incomes policy initiated in August of last year has demonstrated, efforts to influence wages and prices directly can play a constructive role when cost-push inflation reaches serious proportions...There are those who believe that the time is at hand to abandon the experiment with controls and to rely entirely on monetary and fiscal restraint to restore a stable price level. This prescription has great intellectual appeal; unfortunately, it is impractical. ...If monetary and fiscal policies became sufficiently restrictive to deal with the situation by choking off growth in aggregate demand, the cost in terms of rising unemployment, lost output, and shattered confidence would be enormous. As a practical matter, I see no alternative but to pursue for a while longer the experiment with direct controls."

[14] The notion that public expressions of concern for the real economy by a central banker might indavertently spark an inflation outburst is well understood today. For an elabortation, based on an episode in which the then

may have inadvertently reinforced the public's conviction that higher inflation was a realistic possibility. Although early on, policymakers did respond aggressively to inflation, eventually they backed off when the economy weakened. Overall, relative to the rise in inflation, interest rates did not rise by much during this period. The essence of this reaction is captured by the low value of α estimated by CCG for the 1970s.

6.2. The Real Economy

We now consider the developments with output, investment and employment over this period. To see the developments in the real economy, consider Figures 4a-4c, which display the logarithm of real GDP, total hours worked in nonagricultural business and business fixed investment. In addition, we display linear trends, computed using the data from the beginning of the sample to 1970Q1, and extrapolated through the end of the sample. These trend lines draw attention to trend change that occurred in these variables in the early 1970s. In addition, in each case we also fit a quadratic trend to the entire sample of data. Consider the GDP data in Figure 4a first. In this case, we have also included a linear trend fit to the data for the 1970s and extrapolated to the end of the sample. What is clear, by comparing the raw data with the two linear trends, is that the growth slowdown that started in the early 1970s became even more severe in the 1980s and 1990s. We infer from the fact that the slowdown persisted - even accelerated - in the last two decades, that the inflation of the 1970s must have had little to do with it. Now consider hours worked in Figure 4b. Note how that takes off beginning in the early 1970s, and how the growth rate seems to just increase continuously throughout the following decades. Again, we infer from the fact that the growth rate continued to rise after the inflation stopped that the inflation was not an important determinant of this development. Finally, note that investment shows very little trend change in the 1970s. After a pause during the 1974-1975 recession, investment returns to its former growth path. Investment does display weakness in the late 1980s and the 1990 recession. But, after that it grows again, returning to the pre-1970s trend line by 1997.

These changes in trend in hours worked and output complicate our attempts to discriminate between the CGG and the limited participation stories about inflation of the 1970s. Ideally,

vice-chairman of the Federal Reserve, Alan Blinder, spoke in public of the existence of a short-term trade-off between inflation and unemployment, see Barro (1996, pp. 58-60).

we would like to remove the effect on the data coming from the factors that account for the persistent change in trend, and study the remainder. We have not found a clean way to do this. We have taken an alternative, second best, route instead. We remove a quadratic trend from each variable and assume that the result reflects whatever impact there might have been from the Great Inflation of the 1970s. What we see there is weak output, employment and investment during the 1974-1975 recession (see Figures 5a - 5b).

6.3. Evaluating the Models

None of our models captures the events at the level of detail just discussed, nor would we want them to. What we want of a model is that it capture the broad outlines of what happened. We interpret the essence of what happened as follows. A rise in expected inflation occurred, perhaps in conjunction with a bad technology shock (e.g., the harvest failures and oil embargo). The Fed responded by raising interest rates. However, they did not raise rates much in relation to the actual rise in inflation. They clearly understood that higher rates would have stopped the inflation, but they did not resort to them because they feared what that would do to the real economy. At an informal level, this feature of policy is consistent with the low value of α in the policy rule used in our model. Moreover, CCG show that the policy rule fits the data well in a conventional econometric sense.

The real economy responded to these events by falling into a severe recession. Hours was down 6 percent from trend, investment was down 11 percent and output was down 3 percent, at the end of the 1975 recession (see Figure 5). At the same time, inflation rose from 4 percent in 1972 to 10 percent at the end of the recession. The Federal Funds rate went from around 4 percent in 1972 to a peak of around 12 percent near the end of the recession.

The responses in the limited participation model are of a similar order of magnitude, though somewhat weaker. Investment fell about 7 percent, and output and employment, 2 percent. Inflation rose from 4 to about 10 percent and the interest rate rose from about 7.2 to 10 percent. These results are tentative, however, since the technology shock, a 1 percent drop in z, was not calibrated. Still, they are suggestive of what this model is capable of. Note, for example, that the drop in output is double the drop in the technology shock.

The sticky price model does very poorly, by contrast. In the data, the drop in employment is much greater than the drop in output. In the model, employment is predicted to rise, while output only falls after a while. Initially, output rises too.

7. Conclusion

We have done a preliminary analysis of the stagflation of the early 1970s. We have attempted to describe it as reflecting the effects of a bad technology shock whose economic effects were amplified by the nature of monetary policy. We pursued this idea in the context of two models, a limited participation model and the CCG model. We found that the former was better able to account for the slowdown in output that occurred in 1973-1975.

Our findings are similar in spirit to those reported in Chari, Christiano and Eichenbaum (1998). There, a model with sticky prices was presented, and the monetary authority is modeled as an optimizing, benevolent agent. In that model too, a rise in inflation expectations, associated with a bad technology shock, triggers a prolonged episode of high inflation and low output.

8. Appendix: Solving and Simulating the Limited Participation Models

To solve our two versions of the limited participation model, we find it convenient to begin by adopting the following scaling of variables:

$$\lambda_t = \Lambda_t \frac{M_t}{P_t},\ q_t = Q_t/M_t,\ p_t = P_t/M_t,\ w_t = W_t/M_t, 1 + x_t = M_{t+1}/M_t,\ r_t^k = r_t/P_t, \tag{8.1}$$

so that:

$$\lambda_t = \frac{U_{C,t}}{p_t} + U_{H,t} H_t' \frac{1 + x_{t-1}}{q_{t-1}} - \beta U_{H,t+1} H_{t+1}' \frac{q_{t+1}}{q_t^2}(1 + x_t). \tag{8.2}$$

Using this notation, the Euler equations can be rewritten as follows:

$$E_t \left\{ U_{C,t} - \beta \left[\beta \lambda_{t+2} \frac{f_{K,t+1}}{\mu(1 + x_{t+1})} p_{t+1} + U_{C,t+1} (1 - \delta) \right] \right\} = 0, \tag{8.3}$$

$$\psi_0 (L_t + H_t)^{\psi} = \frac{w_t}{p_t},$$

$$E_{t-1} \left\{ \lambda_t - \beta \lambda_{t+1} \frac{R_t}{1 + x_t} \right\} = 0, \tag{8.4}$$

$$\frac{w_t R_t}{p_t} = \frac{f_{L,t}}{\mu},\ r_t^k = \frac{f_{K,t}}{\mu}. \tag{8.5}$$

The resource constraint is:

$$C_t + K_{t+1} - (1 - \delta) K_t = \exp(z_t) K_t^{\alpha} L_t^{1-\alpha} - \phi. \tag{8.6}$$

The household cash constraint, combined with the loan market clearing condition, and taking scaling into account, is:

$$p_t (C_t + K_{t+1} - (1 - \delta) K_t) = 1 + x_t, \tag{8.7}$$

and the loan market clearing condition is:

$$w_t L_t = 1 - q_t + x_t. \tag{8.8}$$

[to be continued...]

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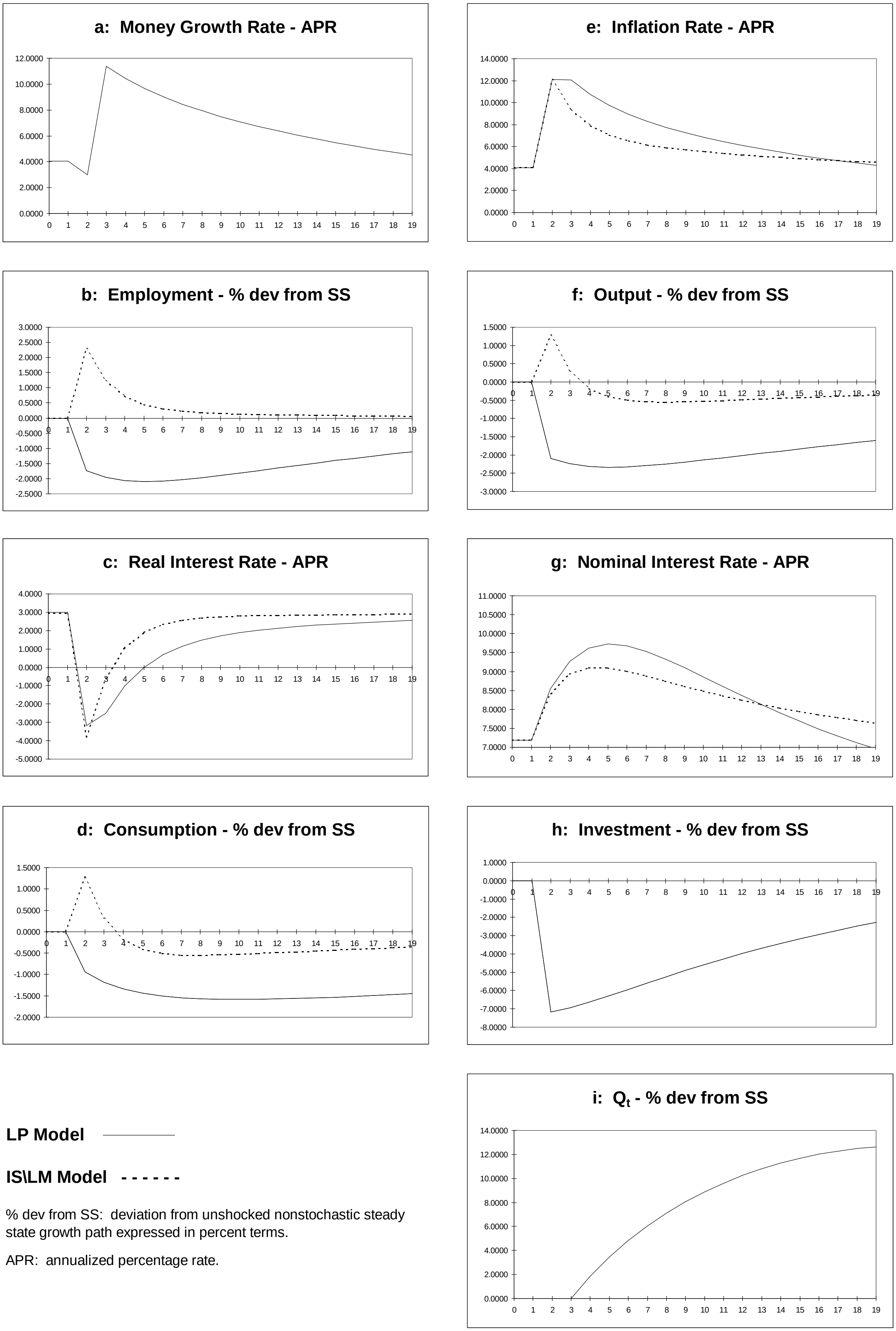
Figure 1
Response to a Technology Shock In Two Different Models



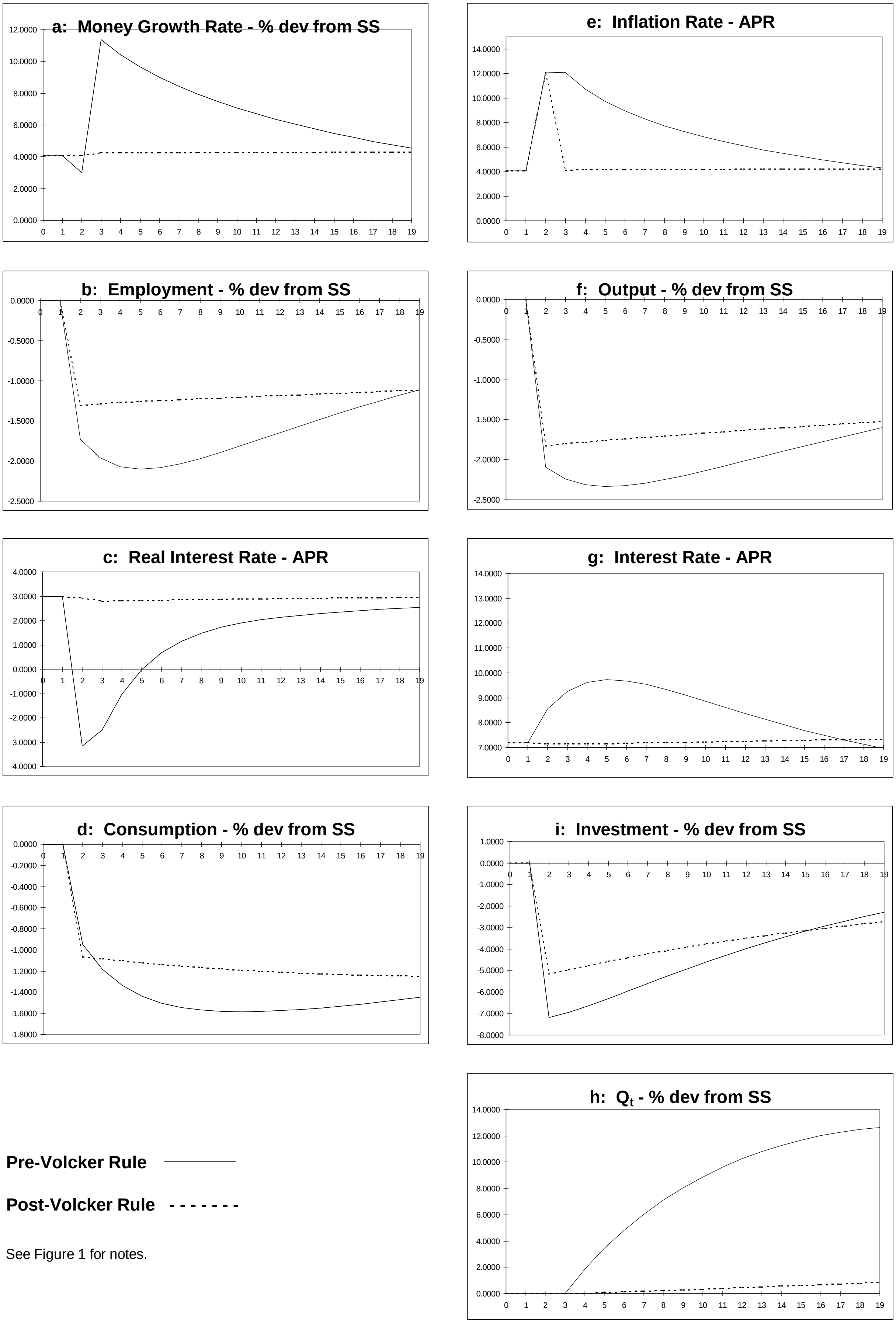
LP Model ————

IS\LM Model - - - - - -

% dev from SS: deviation from unshocked nonstochastic steady state growth path expressed in percent terms.

APR: annualized percentage rate.

Figure 2
Response to a Negative Technology Shock Under Two Different Taylor Rules



See Figure 1 for notes.

Fig 3a: Inflation and Federal Funds Rate

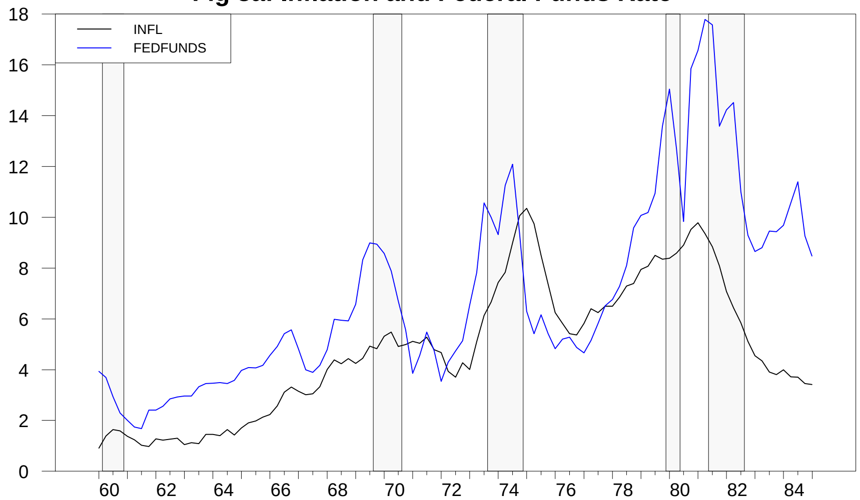


Fig 3c: ex ante real rate

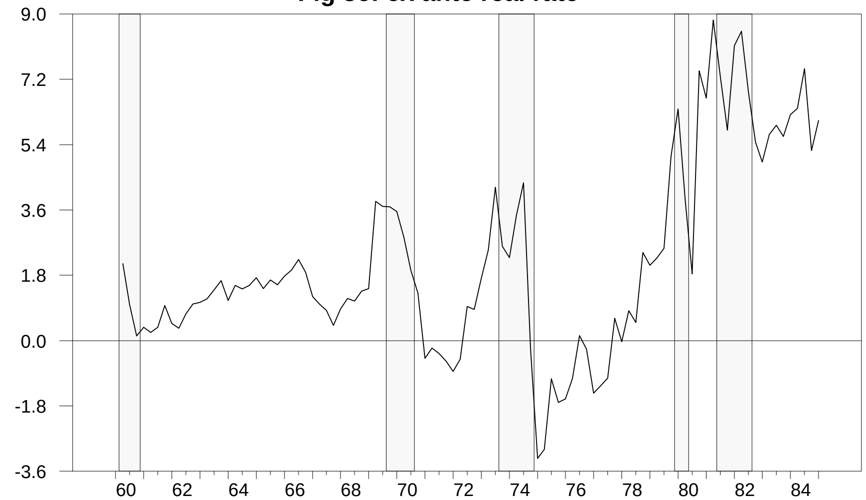


Fig 3b: ex post real rate

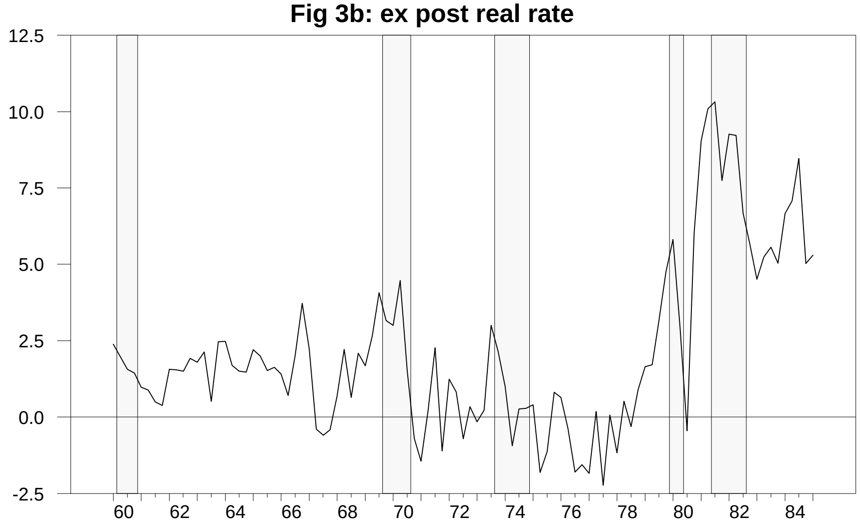


Fig 3d: Actual Fed Funds rate Minus Value Predicted by 1970s Rule

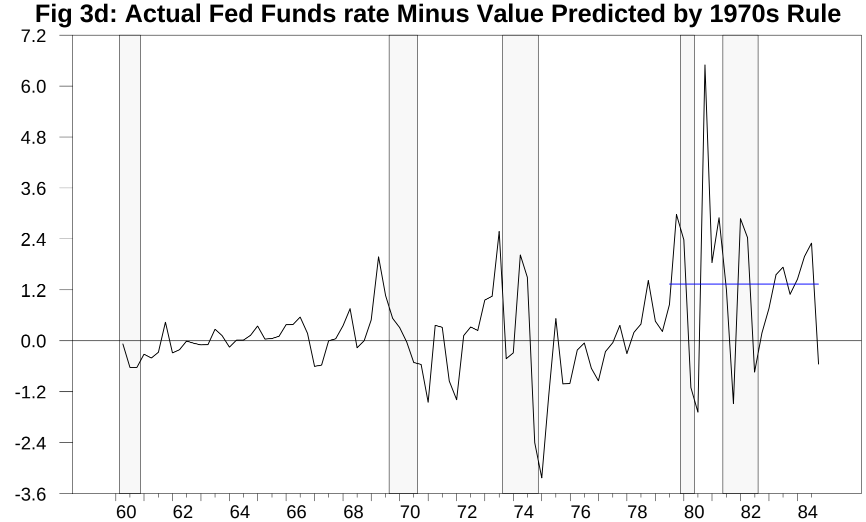


Fig 4a: Gross Domestic Product and trends

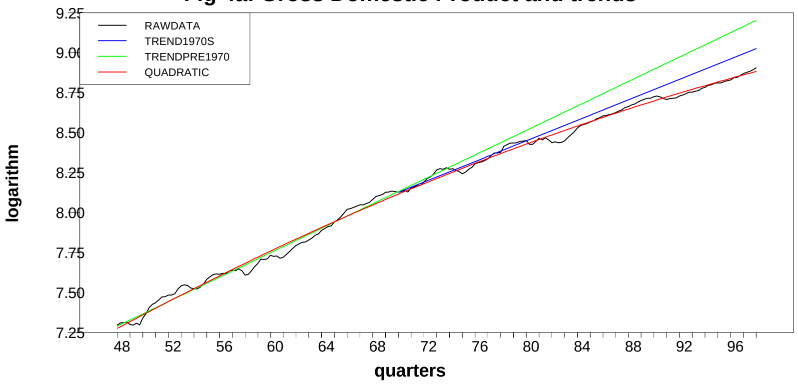


Fig 4c: Business fixed investment and trends

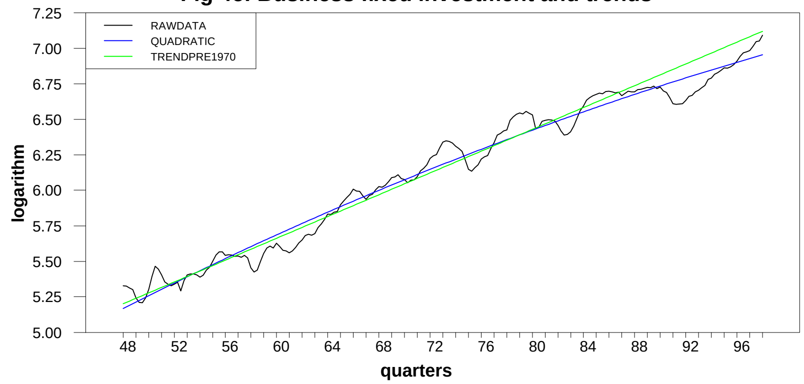
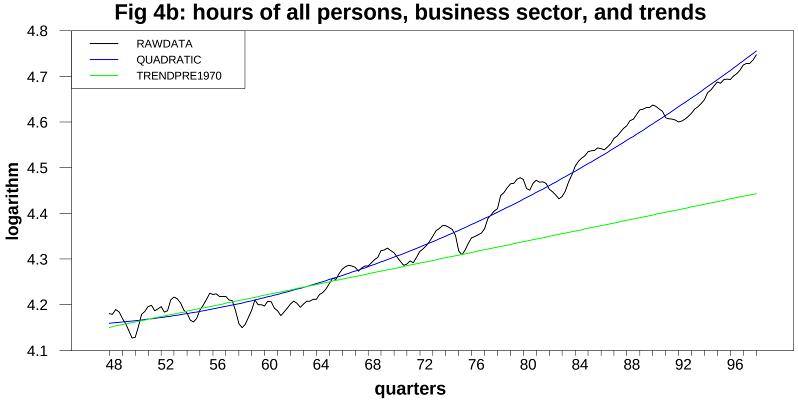


Fig 4b: hours of all persons, business sector, and trends



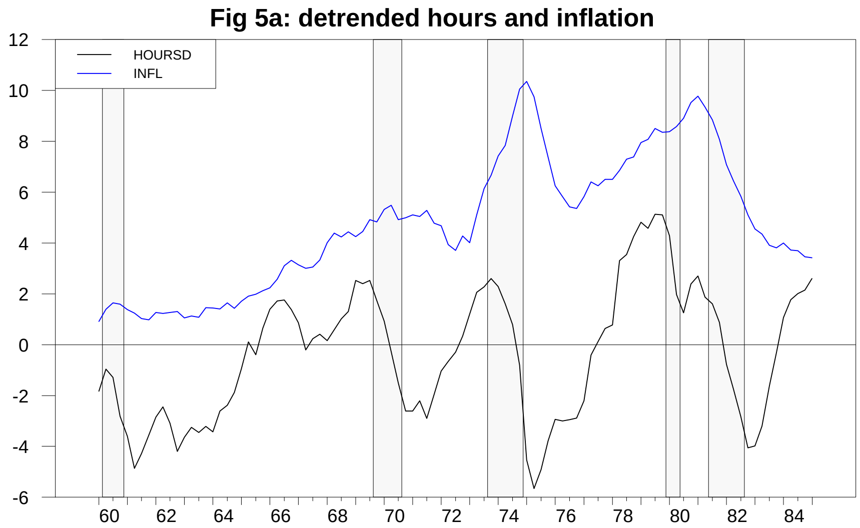


Fig 5a: detrended hours and inflation
HOURSD
INFL
12
10
8
6
4
2
0
-2
-4
-6
60
62
64
66
68
70
72
74
76
78
80
82
84

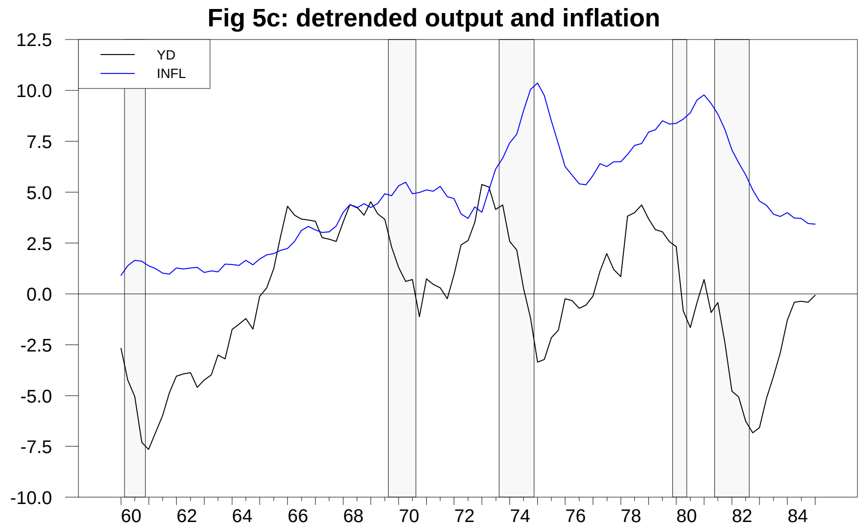


Fig 5c: detrended output and inflation
YD
INFL
12.5
10.0
7.5
5.0
2.5
0.0
-2.5
-5.0
-7.5
-10.0
60
62
64
66
68
70
72
74
76
78
80
82
84

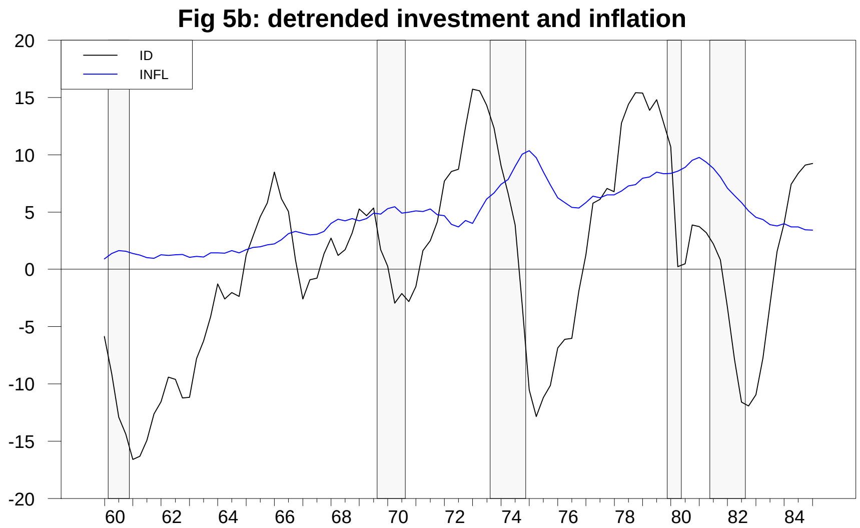


Fig 5b: detrended investment and inflation
ID
INFL
20
15
10
5
0
-5
-10
-15
-20
60
62
64
66
68
70
72
74
76
78
80
82
84