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The Effectiveness of Monetary Policy: An Assessment*

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Abstract

When monetary policies are endogenous, the conventional VAR approach for detecting the effect of monetary policies is powerless. This paper proposes to test the implication of monetary policies along a different dimension. That implication is to exploit the policy induced exogeneity of endogenous variables that are the source of monetary non-neutrality. We illustrate the idea by constructing a new Keynesian sticky wage model with capital accumulation and then testing the implications of optimal monetary policies for nominal wages under both complete and incomplete information. Econometric test using post war US data suggests that the nominal wage is exogenous with respect to lagged macro variables. Such exogeneity is consistent with new Keynesian models in which the monetary authority pursues active monetary policy based on information with a lag.

Keywords: Optimal monetary policy; Sticky wages; Sticky prices; Business Cycles.

JEL Classification: E52, E41, E32.

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1 Introduction

For decades, detecting the non-neutrality of money using VARs has been the major means to find out the real effects of monetary policy. The power of VARs for detecting the effects of money, however, relies largely on the identifying assumption that monetary policy changes be exogenous, so as to render meaningful the notion of “monetary policy shocks” in an impulse responses analysis. Unfortunately, it is hard to deny that the so called “monetary policy shocks” are often endogenous. The endogeneity of monetary policy implies that VAR’s can fail to identify the mechanisms through which monetary policy affects the real economy as well as the true magnitude of that effect, because money can fail to appear as a significant dependent variable in a VAR when it is endogenous.[1]

To illustrate, denote s_t as the vector of the state variables that all agents in the economy observe in period t, denote c_t as the vector of decision variables of the private sector, and assume that monetary policy follows the linear feedback rule $m_t = \alpha s_t$.[2] Suppose a rational-expectations general-equilibrium model has the reduced-form first-order conditions given by:

$$E_t \begin{bmatrix} s_{t+1} \\ c_{t+1} \end{bmatrix} = A \begin{bmatrix} s_t \\ c_t \end{bmatrix} + B_1 E_t m_{t+1} + B_2 m_t,$$

in which the monetary policy, m, is taken as parametric by the private sector of the economy. According to classical theory, $B_1 = B_2 = 0$, hence money does not influence the real economy. According to Keynesian theory, $B_1, B_2 \neq 0$ and money does have real consequences.

The fact that the matrices $B \neq 0$, however, does not at all imply that the effects of money can be detected by VARs. To see that, substitute out the monetary policy rule by αs in the equation, we get:

$$E_t \begin{bmatrix} s_{t+1} \\ c_{t+1} \end{bmatrix} = (I - \alpha B_1)^{-1} (A + \alpha B_2) \begin{bmatrix} s_t \\ c_t \end{bmatrix}.$$

[1] In a comprehensive econometric analysis, Leeper, Sims, and Zha (1996) showed that most VAR specifications imply that only a modest (or in some cases, essentially none) of the variance of output or prices in the US since 1960 is attributable to shifts in monetary policy, and on the other hand, that a large fraction of the variation in monetary policy instruments is attributable to systematic reaction by policy authors to the state of the economy. They conclude that “This is of course what we would expect of good monetary policy, but it is also the reason why using the historical behavior of aggregate time series to uncover the effects of monetary policy is difficult.”

[2] If α is time-dependent and is itself a function of the state, we can linearize the monetary feedback rule, $m_t = \alpha(s_t)s_t$, around a steady state to get a similar formula.

Solving for the system forward under tranversality conditions and rational expectations, the equilibrium decision rules obtained by the private sector then take the form:

$$c_t = c(\alpha, s_t),$$

which reflects the Lucas Critique that the forward looking private sector's decision rules are not invariant to the monetary policy α. It follows that the state variables in the economy evolve according to the equilibrium law of motion:

$$s_{t+1} = s(\alpha, s_t).$$

The control vector c can also be expressed in a VAR form:

$$c_{t+1} = \tilde{c}(\alpha, c_t),$$

where the mapping $\tilde{c}$ may be singular.

It is then clear that in a correctly specified VAR model for the economy, money fails to show up as a significant dependent variable when it is endogenous. That is, money fails to Granger cause endogenous variables such as s_{t+1} in a VAR even if it does have real influences on s_{t+1}.

In such a case, it is difficult not only to measure the effectiveness of monetary policy, but also to distinguish the classical theory from the Keynesian theory by VARs. In the classical case, money fails to show up in a VAR as a significant dependent variable because $B_1 = B_2 = 0$. In the Keynesian case, money also fails to show up as a significant dependent variable in a VAR simply due to the endogenouty of monetary policy. If the monetary authority should follow a passive money growth rule according to monetarism, VARs will also be incapable of fully identifying the real effects of money.

This paper proposes to assess the effectiveness of monetary policy by testing the implication of endogenous monetary policy along a different dimension. That implication is the policy-induced exogeneity of some endogenous variables that are the source of monetary non-neutrality.

According to the new Keynesian theory, short-run price or nominal wage stickiness are the culprit of monetary non-neutrality. If this is the case, then optimal monetary policies aiming at stabilizing the economy will render some of the price variables completely "sticky", so that they become completely independent of any endogenous variables in the economy.[3]

[3]On the other hand, if prices adjust instantaneously as in the neoclassical theory, then they ought to be determined by endogenous variables that influence supply and demand. Hence, they ought to be themselves endogenous.

To illustrate, suppose there are two nominal prices in an economy, p_1 and p_2, and that p_1 is temporarily sticky in the sense that it is influenced by two forces at any point of time: one pertaining to its own history, reflecting price inertia or stickiness, and the other pertaining to market clearing forces, indicating that supply and demand will rule in the long run. These assumptions suggest that the log of p_{1t} can be characterized by:

$$\log p_{1t} = \sum_{j=1}^{k} \theta_j \log p_{1t-j} + (1-\theta)\log p_{1t}^*, \quad \sum_{j=1}^{k} \theta_j = \theta \in [0,1], k \leq \infty; \tag{1}$$

where p_1^* is the equilibrium market-clearing price that adjust instantaneously to demand and supply. That is, p_1^* satisfies:

$$\log p_1^* = \log p_2 + f(x),$$

where x denotes equilibrium quantities in the economy.

In the neoclassical economy, the relative price, $(\log p_1^* - \log p_2)$, is completely determined by the market forces $f(x)$ and is independent of the influence of money.[4] In the new Keynesian economy, the relative price, $(\log p_1 - \log p_2)$, is not completely determined by market forces, and money is not neutral in the short run:

$$\begin{aligned} \log p_{1t} - \log p_2 &= \sum_{j=1}^{k} \theta_j \log p_{1t-j} + (1-\theta)\log p_{1t}^* - \log p_2 \\ &= \sum_{j=1}^{k} \theta_j \log p_{1t-j} + (1-\theta) f(x) - \theta \log p_2. \end{aligned} \tag{2}$$

The goal of an optimal monetary policy is then to choose money supply such that the relative price in the Keynesian economy behaves in the same way as it does in a classical economy:

$$\log p_1 - \log p_2 = f(x).$$

To achieve that, equation 2 suggests that the monetary authority should set the level of money supply such that

$$\log p_2 = \frac{1}{\theta}\sum_{j=1}^{k} \theta_j \log p_{1t-j} - f(x).$$

This implies

$$\log p_{1t} = \frac{1}{\theta}\sum_{j=1}^{k} \theta_j \log p_{1t-j}.$$

[4] Since $f(\cdot)$ is homogeneous of degree zero in money, it can be viewed as independent of money.

Then by equation 1, we have

$$\log p_{1t}^* = \log p_{1t} = \frac{1}{\theta} \sum_{j=1}^{k} \theta_j \log p_{1t-j}.$$

Therefore, the endogenous variables, p_1^*, is rendered completely exogenous under optimal monetary policy. This striking implication of optimal monetary policy on prices can be exploited to assess the effectiveness of monetary policy and the new Keynesian theory. The recent literature of the "new synthesis" is full of examples of that implication. For example, King and Wolman (1998) showed that the aggregate price is a constant under optimal monetary policy when the source of monetary non-neutrality is the sticky price.[5] We show, however, that the same implication holds in more general settings in which capital accumulation and incomplete information of the monetary authority are taken into consideration explicitly.

In what follows, we concretize our ideas by embedding a new Keynesian sticky wage model into a rational expectations, stochastic general equilibrium framework with capital accumulation in section 2. We show the quantitative business cycle effects of nominal wage stickiness in the new Keynesian model in section 3. Optimal monetary policies are discussed in sections 4 and 5 in the contexts of complete information and incomplete information. There we prove the complete exogeneity of nominal wages under these monetary policies. In section 6, the implications of optimal monetary policy for the dynamic behavior of nominal wages are exploited to assess the effectiveness of post-war US monetary policy. Section 7 concludes the paper.

2 The Model

We embed a textbook Keynesian model (Sargent, 1987, p50) into a rational expectations general equilibrium framework by assuming that the labor market does not clear instantaneously in the short run due to nominal wage stickiness, and that only the goods market and the asset market clear instantaneously.[6] As a result, the aggregate supply curve is upward sloping, and the levels of employment and output are in part determined by aggregate demand and monetary policies.

[5] For the case of sticky wages, see Erceg, Henderson, and Levin (2000). Also see Clarida, Gali, and Gertler (1997, 1998, 1999), Gali and Gertler (1999), Gali and Monacelli (2000), Obstfeld, M. and K. Rogoff (1999), and among others for that implication of price behavior under optimal monetary policies.

[6] The model shares similar features to that of Bordo, Erceg, and Evans (2000). Also see Taylor (1980), Calvo (1983), and the more recent work of Leeper and Sims (1994).

Specifically, a representative household chooses sequences of consumption $\{c_t\}_{t=0}^{\infty}$, real money balance $\left\{\frac{m_t}{p_t}\right\}_{t=0}^{\infty}$, capital stock $\{k_{t+1}\}_{t=0}^{\infty}$, and labor supply $\{n_t^s\}_{t=0}^{\infty}$, taking as given the real wages $\left\{\frac{w_t}{p_t}\right\}_{t=0}^{\infty}$ and real rental rates $\{r_t\}_{t=0}^{\infty}$ to solve

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log(c_t) + \phi \log\left(\frac{m_t}{p_t}\right) - a\frac{(n_t^s)^{1+\gamma}}{1+\gamma} \right\}$$

subject to:

$$c_t + \frac{m_t}{p_t} + k_{t+1} - (1-\delta)k_t = \frac{w_t}{p_t}n_t + r_t k_t + \frac{m_{t-1}x_t}{p_t},$$

where the gross growth rate of money supply, $x_t = m_t/m_{t-1}$, is also taken as exogenous by the private sector.

Assuming that the goods market clears instantaneously, the first-order necessary conditions for optimality are then given by:

$$a\left(n_t^s\right)^{\gamma} = \frac{1}{c_t}\frac{w_t}{p_t} \tag{3}$$

$$\frac{\phi}{\left(\frac{m_t}{p_t}\right)} = \frac{1}{c_t} - \beta E_t \frac{1}{c_{t+1}}\frac{p_t}{p_{t+1}}x_{t+1} \tag{4}$$

$$\frac{1}{c_t} = \beta E_t \frac{1}{c_{t+1}}\left(r_{t+1} + 1 - \delta\right) \tag{5}$$

$$c_t + k_{t+1} - (1-\delta)k_t = \frac{w_t}{p_t}n_t + r_t k_t \tag{6}$$

$$m_t = m_{t-1}x_t \tag{7}$$

where (3) relates optimal labor supply to the real wage, (4) gives the optimal demand for real money balance, (5) characterizes the optimal consumption demand, (6) relates aggregate demand for goods to aggregate real income (the goods market clearing condition), and (7) equates nominal money demand to supply. Notice that equation (4) can be written as:

$$\phi = \frac{m_t}{p_t c_t} - \beta E_t \frac{m_{t+1}}{p_{t+1}c_{t+1}},$$

which can be solved forward under a transversality condition to get:

$$\frac{m_t}{p_t c_t} = \frac{\phi}{1-\beta},$$

which reflects the quantity theory of money and where the right-hand side can be interpreted as the inverse velocity of money.

A representative firm produces output y according to a constant returns to scale production technology:

$$y_t = A_t k_t^{\alpha} n_t^{1-\alpha},$$

where A_t represents random shocks to productivity. In each period, the firm chooses the demand for labor n_t^d and capital k_t, taking the real wage and rental rate as given to solve

$$\max \left\{ A_t k_t^{\alpha} n_t^{1-\alpha} - \frac{w_t}{p_t} n_t - r_t k_t \right\}.$$

The firm's optimal demand for labor and capital inputs are then given by the first-order conditions:

$$(1-\alpha) A_t k_t \left(n_t^d\right)^{-\alpha} = \frac{w_t}{p_t}$$

$$\alpha A_t k_t^{\alpha-1} \left(n_t^d\right)^{1-\alpha} = r_t,$$

which also implies the zero profit condition:

$$\frac{w_t}{p_t} n_t^d + r_t k_t = A_t k_t^{\alpha} \left(n_t^d\right)^{1-\alpha}.$$

The optimal demand for labor is then given by:

$$n_t^d = (1-\alpha)^{\frac{1}{\alpha}} A_t^{\frac{1}{\alpha}} k_t \left(\frac{p_t}{w_t}\right)^{\frac{1}{\alpha}}.$$

Substituting this labor demand schedule into the production function gives the aggregate supply function:

$$y_t = (1-\alpha)^{\frac{1-\alpha}{\alpha}} A_t^{\frac{1}{\alpha}} k_t \left(\frac{p_t}{w_t}\right)^{\frac{1-\alpha}{\alpha}},$$

which is upward sloping with regard to the price level p_t.

The system of equations that solves the model can be grouped as the following:

$$n_t^s = \left(\frac{1}{ac_t}\frac{w_t}{p_t}\right)^{\frac{1}{\gamma}} \tag{8}$$

$$n_t^d = (1-\alpha)^{\frac{1}{\alpha}} A_t^{\frac{1}{\alpha}} k_t \left(\frac{w_t}{p_t}\right)^{-\frac{1}{\alpha}}, \tag{9}$$

$$p_t = \frac{1-\beta}{\phi}\frac{m_t}{c_t} \tag{10}$$

$$\frac{1}{c_t} = \beta E_t \frac{1}{c_{t+1}} \left(\alpha A_{t+1} k_{t+1}^{\alpha-1} \left(n_{t+1}^d\right)^{1-\alpha} + 1 - \delta\right) \tag{11}$$

$$c_t + k_{t+1} - (1-\delta)k_t = A_t k_t^{\alpha} \left(n_t^d\right)^{1-\alpha} \tag{12}$$

If the labor market clearing condition, $n^s = n^d$, holds, then equations (8) and (9) can be combined to solve for the equilibrium real wage and employment, which together with equations (11) and (12) determine the optimal paths of c_t, k_{t+1}, and n_t in terms of the state (A_t, k_t).

Equation (10) then determines the price level. This is the classical result in which money is a veil.[7]

Due to stickiness in the nominal wage w_t, however, the household's labor supply n^s does not always equal to the firm's labor demand, n^d. Hence we cannot use the labor market clearing condition to solve for employment. Instead, the level of employment (the effective labor demand n^d) has to be determined by equilibrium in the goods market. That is, the system of equations for solving the model becomes (after substituting out the effective labor demand n^d using equation 9):

$$p_t = \frac{1-\beta}{\phi}\frac{m_t}{c_t} \tag{13}$$

$$\frac{1}{c_t} = \beta E_t \frac{1}{c_{t+1}} \left(\alpha \left(1-\alpha\right)^{\frac{1-\alpha}{\alpha}} A_{t+1}^{\frac{1}{\alpha}} \left(\frac{w_{t+1}}{p_{t+1}}\right)^{-\frac{1-\alpha}{\alpha}} + 1 - \delta \right) \tag{14}$$

$$c_t + k_{t+1} - (1-\delta)k_t = (1-\alpha)^{\frac{1-\alpha}{\alpha}} A_t^{\frac{1}{\alpha}} k_t \left(\frac{w_t}{p_t}\right)^{-\frac{1-\alpha}{\alpha}} \tag{15}$$

Notice that money matters in such an economy because it affects the price level p, which in terns affects the aggregate demand and aggregate supply through its effect on the real wage w/p.

In a standard Keynesian model, in place of the labor market clearing condition is an equation that specifies exogenously the short-run behavior of the nominal wage. We assume that the nominal wage is influenced by two forces: one pertains to the history of nominal wages, reflecting wage inertia or stickiness due to institutional factors or staggered wage setting behavior; and the other pertains to market forces from demand and supply. We assume that in the long run nominal wages are determined solely by demand and supply of labor. Under these assumptions, the log of nominal wage can be characterized by:

$$\log w_t = \sum_{j=0}^{k} \theta_j \log w_{t-j} + (1-\theta)\log w_t^*, \tag{16}$$

where $\sum_{j=1}^{k} \theta_j = \theta \in [0,1], k \leq \infty$, and where w^* is the equilibrium nominal wage determined by the market clearing condition:

$$n^s = n^d.$$

Hence, w^* is given by (using equation 8 and the condition $n^s = n^d$):

$$w_t^* = a\left(n_t^d\right)^{\gamma} p_t c_t.$$

[7] In the classical model, the equilibrium nominal wage is a function of the state: $w_t = f(k_t, A_t)$. It is therefore not exogenous with respect to current macro conditions. In the case that the technology shocks are serially correlated, the nominal wage is also in part predictable by lagged variables such as lagged output.

Equation system (13) - (16) represents the textbook version of the Keynesian model in a dynamic, rational expectations setting. The Keynesian model has a simple form of analytical solution when the rate of capital depreciation $\delta = 1$. In such a case, the decision rule for k_{t+1} is given by:

$$k_{t+1} = \beta\alpha y_t = \beta\alpha \left[(1-\alpha)^{\frac{1-\alpha}{\alpha}} A_t^{\frac{1}{\alpha}} k_t \left(\frac{w_t}{p_t} \right)^{-\frac{1-\alpha}{\alpha}} \right].$$

If we define the net aggregate supply as $y_t - k_{t+1}$, then the net supply function is given by:

$$\begin{aligned} &\log(y_t - k_{t+1}) \\ = &\left\{ \log(1-\beta\alpha)(1-\alpha)^{\frac{1-\alpha}{\alpha}} + \frac{1}{\alpha}\log A_t + \log k_t - \frac{1-\alpha}{\alpha}\log w_t \right\} + \frac{1-\alpha}{\alpha}\log p_t. \end{aligned}$$

According to equation 13, the net aggregate demand function is given by:

$$\log c_t = \log \frac{1-\beta}{\phi} + \log m_t - \log p_t.$$

Using a standard price-quantity diagram, the above supply curve is upward sloping and the demand curve is downward sloping (see figure 1).

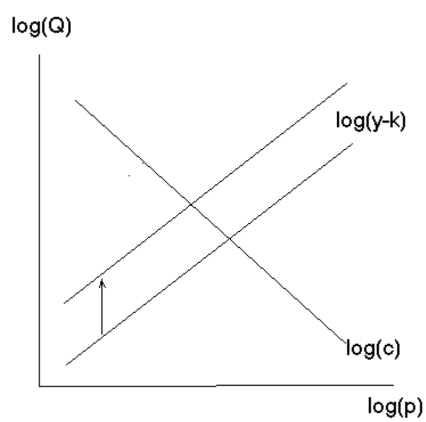

Figure 1. The "Keynesian" effect of a decrease in nominal wage.

Due to the stickiness in the nominal wage, a decrease in the money supply shifts the demand curve inward, causing a reduction in the equilibrium quantities of net output and consumption. On the other hand, a decrease in the nominal wage raises the aggregate supply, which shifts the supply curve upward, resulting in a drop in the equilibrium price level and an increase in the equilibrium quantities. This "Keynesian effect" of changes in the nominal wage on equilibrium quantity and price is shown in figure 1. It is also clear from the diagram that the central bank should conduct an expansionary monetary policy to shift the demand curve upward when facing an adverse supply shock (such as an oil price increase) which shifts the supply curve downward.

3 Business Cycles in the Keynesian Economy

To quantify the business cycles arising from the Keynesian economy, we calibrate the model's parameters, generate impulse responses of the model to monetary and technology shocks, and compare them to the classical model in which $\theta = 0$. Since analytical solutions for the Keynesian model do not exist when $\delta < 1$, the model is solved using the method of log-linearization around the long-run steady state where all markets are cleared. Because the model becomes a standard RBC model when $\theta = 0$, we will use the two terms, "classical" and "RBC", interchangeably in what follows.

Monetary growth and technology shocks are assumed to follow $AR(1)$ processes:

$$\log x_t = (1 - \rho_x) + \rho_x \log x_{t-1} + \varepsilon_{xt}, \quad \varepsilon_{xt} \sim i.i.d(0, 1),$$

$$\log A_t = (1 - \rho_a) + \rho_a \log A_{t-1} + \varepsilon_{at}, \quad \varepsilon_{at} \sim i.i.d(0, 1),$$

The structural parameters are calibrated according to quarterly time frequency as follows. The capital elasticity of output $\alpha = 0.3$, the time discounting factor $\beta = 0.99$, the inverse labor supply elasticity $\gamma = 1.5$, the rate of capital depreciation $\delta = 0.025$, and the distributed lag parameter, k, in the wage equation (16) is set to one, so that

$$\log w_t = \theta \log w_{t-1} + (1 - \theta) \log w_t^*.$$

The two autoregressive coefficients, ρ_x and ρ_a, are set to 0.9. The impulse responses of output, consumption, investment and labor demand to a negative one percent decrease in money supply are plotted in figure 2, where dashed lines represents the classical model ($\theta = 0$) and solid lines represent the Keynesian model ($\theta = 0.9$).

It is seen in figure 2 that a contractionary monetary shock has a hump-shaped effect on the sticky-wage economy, while leaving the RBC economy completely intact. At the impact of the shock, output in the Keynesian economy drops by about 0.5 percent, and the other variables drop by a similar amount. The full impact on the economy, however, does not arrive until 5 quarters later, exhibiting a very strong lagged multiplier effect. At the trough of the recession, output drops by 2.2 percent, consumption drops by one percent, investment drops by more than 7 percent, and employment drops by almost 3 percent.

The recovery from the business cycle trough is very slow. It takes about 60 quarters for output to reach its pre-shock level from the business cycle trough. Such persistent effects of monetary shocks on an sticky-wage economy is very typical and they will be discussed further below in comparison with the case of technology shocks.

The impulse responses to a negative one percent decrease in technology are shown in figure 3, where the dashed lines represent the RBC model and solid lines represent the Keynesian model. Sticky nominal wages render the economy more volatile than the RBC economy in response to technology shocks. For example, output in the sticky wage model drops by 2 percent at the impact of the technology shock, as oppose to 1.3 percent in the flexible wage model. Table 1 summarizes some selected second moments of the two economies. It shows that the variance of output in the sticky wage model is about (?) times that in the RBC model. Higher volatilities induced by the nominal wage stickiness reduce welfare because they hinder consumption smoothing and intertemporal substitutions.

The reason why output is more volatile in the presence of sticky nominal wages is obvious. Due to a decrease in productivity, the marginal product of labor also decreases. Since nominal wage is sticky, which results in stickiness in the marginal cost of labor, the marginal benefit of labor must be kept from decreasing in order to maximize profit. This compels firms to cut labor demand more than necessary in order to maintain the desired level of the marginal product of labor. Hence output falls more than necessary. Consequently, both consumption and investment also fall more than they do in the RBC model.

Another feature of the impulse responses to technology shocks in the sticky wage model is the fast recovery relative to the classical model after a technology shock. It takes output only 4 quarters and employment only 2 quarters respectively to recover half of their pre-shock levels, as oppose to 9 quarters and 6 quarters respectively in the flexible wage model. Such a speed of recovery is especially striking when being compared to the case under a monetary shock (figure 2), where the length of half-life recovery is at least 4-5 times longer starting from the business cycle trough.

A. Inspecting the Propagation Mechanism

Why do recoveries take so much longer under monetary shocks than under technology shocks? The answer lies in the different propagation mechanisms of the sticky wage economy with regard to the two different sources of shocks. Under technology shocks, the main mechanism for propagating the impact of the shock is through capital accumulation. The speed of labor market adjustment plays little role in magnifying that propagation. On the other hand, under monetary shocks, the main propagation mechanism is the sluggish labor market adjustment.

To see the differences in the propagation mechanisms, consider a simpler version of the sticky wage model where the rate of capital depreciation $\delta = 1$ and where the inverse elasticity of labor supply $\gamma = 0$. The log-linearized equilibrium output is given by the production function in (15):

$$\hat{y}_t = \frac{1}{\alpha}\hat{A}_t + \hat{k}_t + \frac{1-\alpha}{\alpha}\left(\hat{p}_t - \hat{w}_t\right).$$

Since $k_t = \beta\alpha y_{t-1}$ and $p_t = \frac{1-\beta}{\phi}\frac{m_t}{c_t}$, we have

$$\hat{y}_t = \frac{1}{\alpha}\hat{A}_t + \hat{y}_{t-1} + \frac{1-\alpha}{\alpha}\left(\hat{m}_t - \hat{c}_t - \hat{w}_t\right).$$

Substituting out consumption by the decision rule: $c_t = (1-\beta\alpha)y_t$, the above equation (after re-arrangement) can be further reduced to:

$$\hat{y}_t = \alpha\hat{y}_{t-1} + \hat{A}_t + (1-\alpha)\hat{m}_t - (1-\alpha)\hat{w}_t.$$

The nominal wage can be expressed as distributed lags in money supply:

$$\begin{aligned}
\hat{w}_t &= \theta\hat{w}_{t-1} + (1-\theta)\hat{w}_t^* \\
&= \theta\hat{w}_{t-1} + (1-\theta)\left(\gamma\hat{n}_t + \hat{p}_t + \hat{c}_t\right) \\
&= \theta\hat{w}_{t-1} + (1-\theta)\hat{m}_t \\
&= \frac{1-\theta}{1-\theta L}\hat{m}_t,
\end{aligned}$$

where L is the lag operator. Hence the nominal wage is constant without monetary shocks. Namely, $\hat{w}_t = \hat{m}_t = 0$. This implies that the law of motion for the output in the absence of monetary shocks follows:

$$y_t = \alpha y_{t-1} + A_t.$$

It is clear then that the impact of technology shocks is propagated in output over time purely through the technology parameter α, which also governs the speed of capital accumulation in the model.

On the other hand, under monetary shocks, the law of motion for output follows:

$$\hat{y}_t = \alpha\hat{y}_{t-1} + (1-\alpha)\hat{m}_t - (1-\alpha)\frac{1-\theta}{1-\theta L}\hat{m}_t,$$

which implies a second order difference equation,

$$\hat{y}_t = (\theta + \alpha)\hat{y}_{t-1} - \theta\alpha\hat{y}_{t-2} + (1 - \alpha)\theta\hat{x}_t,$$

where $\hat{x}_t = \hat{m}_t - \hat{m}_{t-1}$ is the money growth rate. The two roots of the second order difference equation are θ and α, which governs the speed of convergence to the steady state after a shock. Clearly, the propagation mechanism of monetary shocks is determined by the speed of labor market adjustment (θ) being compounded by the speed of capital accumulation (α).

This implies that while the impact of technology shocks is immediately absorbed by the economy, it takes a much longer time for the economy to fully absorb the total impact of a monetary shock, and it also takes a much longer time for the economy to recover from that shock. That is, recessions caused by monetary shocks are much harder to overcome than those caused by technology shocks. The contrast is shown in figure 4, where the solid lines represent impulse responses to a monetary shock and the dashed lines represent impulse responses to a technology shock.[8]

Figure 4 also reveals that under nominal wage stickiness the effect of monetary shocks on employment and consumption is much stronger comparing to that of technology shocks. For example, employment drops by nearly 3 percent at the business cycle trough under monetary shocks as oppose to 1.5 percent under technology shocks. This is so because for a similar drop in output, employment drops more when the total factor productivity remains constant than it does when the total factor productivity decreases (due to a negative technology shock). Consequently, the productivity of labor or the real wage will rise under adverse monetary shocks whereas they will decrease under adverse technology shocks. This is shown in figure 5. Economic history seems to confirm these predictions. For example, during the Great Depression, which is thought being caused by a severe monetary contraction, the average manufacturing real wage for all industries rose by more than 10% during the contraction phase of the business cycle (see Bordo, Erceg, and Evans, 2000). Whereas during the oil price crises in the early 70s, the average hourly real wage for total private sector dropped by about 4% at the business cycle trough.

The fact that money is not neutral in the Keynesian economy offers not only the room but also the desirability of an active monetary policy. The following two sections discuss the design

[8]Using a similar model to ours, Bordo, Erceg, and Evans (2000) study the impact of contractionary monetary policy during the Great Depression. Quantitative calibration exercises in their work showed that monetary contraction is responsible for the slow recovery of the US economy during that period.

and the implementation of optimal monetary policies that eliminate the inefficiency caused by sticky nominal wages, as well as the econometric implications for testing the effectiveness of these policies.

4 Optimal Monetary Policy under Complete Information

A first-best outcome is defined as the resource allocation in the RBC model ($\theta = 0$) in which the labor market clears instantaneously. As is seen earlier, output is less volatile in the RBC model in response to exogenous shocks. In comparison, a larger volatility of output arises in the Keynesian model due to the fact that the real wage fails to equate labor supply and labor demand because of nominal wage rigidity. Precisely due to that rigidity, however, monetary policy has real influence on the real wage.

Proposition 1 *In order to replicate the RBC allocation, an optimal monetary policy should seek to achieve:*

$$w_t^* = \bar{w}\left(w_{t-1}, w_{t-2,}, ..., w_{t-k}\right),$$

where

$$\log \bar{w}\left(w_{t-1}, w_{t-2,}, ..., w_{t-k}\right) \equiv \frac{1}{\theta}\sum_{j=1}^{k}\theta_j \log w_{t-j}.$$

Proof. To replicate the neoclassical allocation, an optimal monetary policy should seek to replicate the real wage that clears the labor market. Since the real wage in the sticky wage model follows (use equation 16):

$$\frac{w_t}{p_t} = \frac{w_{t-1}^{\theta_1}...w_{t-k}^{\theta_k}}{p_t^{\theta}}\left(\frac{w_t^*}{p_t}\right)^{1-\theta},$$

in order to have $\frac{w_t}{p_t} = \frac{w_t^*}{p_t}$,we must have $w_t^* = \left[w_{t-1}^{\theta_1}...w_{t-k}^{\theta_k}\right]^{\frac{1}{\theta}}$,or

$$\log w_t^* = \frac{1}{\theta}\sum_{j=0}^{k}\theta_j w_{t-j}.$$

■

Remark 1 *By equation (16), the above also implies:*

$$\log w_t = \log w_t^* = \frac{1}{\theta}\sum_{j=1}^{k}\theta_j \log w_{t-j}.$$

Hence, the real wage in the Keynesian model under the recommended policy becomes:

$$\frac{\bar{w}\left(w_{t-1}, w_{t-2,}, ..., w_{t-k}\right)}{p_t} = a n_t^{\gamma} c_t. \tag{4.1}$$

Substituting the real wage into the labor demand function (9) immediately yields the same condition that would obtain in the classical model where the labor market clears instantaneously.

Proposition 2 *To implement the optimal monetary policy, the monetary authority should set the money supply according to:*

$$m_t = \frac{\phi}{1-\beta} \frac{\bar{w}\left(w_{t-1}, w_{t-2,}, ..., w_{t-k}\right)}{a n_t^{\gamma}}. \tag{4.2}$$

Proof. Combining equations 13 and 17 gives:

$$\bar{w} = a n_t^{\gamma} p_t c_t = a n_t^{\gamma} \frac{1-\beta}{\phi} m_t,$$

which implies

$$m_t = \frac{\phi}{1-\beta} \frac{\bar{w}}{a n_t^{\gamma}}.$$

■

Remark 2 *Proposition 2 suggests that it is always possible to implement optimal monetary policy according to (18) such that the market clearing wage, w_t^*, behaves just like the sticky part of the nominal wage:*

$$\begin{aligned} w_t^* &= a n_t^{\gamma} \frac{1-\beta}{\phi} m_t \\ &= \bar{w}\left(w_{t-1}, w_{t-2,}, ..., w_{t-k}\right). \end{aligned}$$

Consequently, the real wage is ensured to follow

$$\frac{\bar{w}\left(w_{t-1}, w_{t-2,}, ..., w_{t-k}\right)}{p_t} = a n_t^{\gamma} c_t,$$

and the nominal wage is ensured to follow[9]

$$w_t = w_t^* = \bar{w}\left(w_{t-1}, w_{t-2,}, ..., w_{t-k}\right). \tag{4.3}$$

[9]Notice that the policy works regardless of the value of θ (i.e., even in the case $\theta = 1$ where nominal wage is perfectly sticky). This is so because for any type of nominal wage rigidity, we need only to choose money supply according to (18) so that the real wage is ensured to follow (17).

Corollary 3 *When the labor supply is infinitely elastic, the optimal monetary policy is to follow a passive rule by setting money growth rate to the wage inflation rate.*

Proof. When the labor supply is infinitely elastic, we have $\gamma = 0$. Equation (18) implies that money supply follows a passive rule.■

One of the most striking implications of optimal monetary policies in the new Keynesian model is the policy-induced complete exogeneity of nominal wage behavior given by equation (19). That implication can be exploited to test the effectiveness of the US monetary policy.

A. Decision Making under Endogenous Monetary Policy

To obtain a deeper understanding on the influence of monetary policy when agents are forward looking, it is instructive to see how the private sector actually derive optimal decision rules under rational expectations in the presence of endogenous monetary policy.

Log linearize the first order conditions (13)-(15) around the long-run steady state under the specified sticky wage process (16), we can arrive at the following reduced-form system of linear equations:

$$E_t \begin{bmatrix} \hat{c}_{t+1} \\ \hat{k}_{t+1} \\ \hat{A}_{t+1} \\ \hat{w}_t \\ \vdots \\ \hat{w}_{t-k+1} \end{bmatrix} = M \begin{bmatrix} \hat{c}_t \\ \hat{k}_t \\ \hat{A}_t \\ \hat{w}_{t-1} \\ \vdots \\ \hat{w}_{t-k} \end{bmatrix} + R_1 E_t \hat{m}_{t+1} + R_2 \hat{m}_t$$

$$\begin{bmatrix} \hat{n}_t^d \\ \hat{p}_t \end{bmatrix} = Z_1 \begin{bmatrix} \hat{k}_t \\ \hat{c}_t \\ \hat{A}_t \\ \hat{w}_{t-1} \\ \vdots \\ \hat{w}_{t-k} \end{bmatrix} + Z_2 \hat{m}_t,$$

where a hat variable $\hat{x}_t$ denotes percentage deviations from its steady state value $\bar{x}$: $\hat{x}_t \equiv \log x_t - \log \bar{x}$. The state variables include the initial capital stock, the level of technology, the history of nominal wages, and the monetary policy: $\{k_t, A_t, w_{t-1}, ...w_{t-k}, m_t\}$. The control variable is consumption c_t. Solving for the above system forward under transversality conditions, the linear decision rule of consumption takes the form:

$$\hat{c}_t = \pi_{ck}\hat{k}_t + \pi_{ca}\hat{A}_t + \sum_{j=1}^{k} \pi_{cwj}\hat{w}_{t-j} + \sum_{j=0}^{\infty} \lambda^j E_t \hat{m}_{t+j}.$$

If the monetary policy is endogenous, say it is given by

$$\hat{m}_t = \alpha \hat{s}_t,$$

where s_t is a vector of endogenous variables that the monetary authority employs for feedback, then the private sector's decision rule takes the form:

$$\hat{c}_t = \pi'_{ck}(\alpha)\hat{k}_t + \pi'_{ca}(\alpha)\hat{A}_t + \sum_{j=1}^{k} \pi'_{cwj}(\alpha)\hat{w}_{t-j}.$$

Notice that the decision rules depend now on the policy rule α. If the monetary policy is optimal (denoted by the mapping α^*), then we must have

$$Y_t^{KEY}(\alpha^*) = Y_t^{RBC},$$

where Y denotes the vector of all endogenous variables in the model excluding the set of nominal variables $\{w_t, p_t\}$, and where Y^{RBC} denotes RBC allocations ($\theta = 0$).

Figure 6 shows the impulse responses of output, consumption, investment and employment to a technology shock under the intervention of the monetary authority. It is seen there that the allocations are exactly the same as those of RBC. The response of the optimal monetary policy to the technology shock is clearly counter-cyclical, as it is inversely related to the level of employment (equation 18). This is shown in figure 6_1. It suggests that during the early 70s oil price crisis, an expansionary monetary policy (rather than an contractionary monetary policy) would have been optimal in mitigating the impact of the shocks.

5 Optimal Monetary Policy under Incomplete Information

In the previous section, we showed that the optimal policy to achieve the RBC allocation in the presence of wage inertia is to set the market clearing nominal wage w^* completely sticky (exogenous). In this section, we show that a similar result holds even when the monetary authority does not have complete information regarding the economy in designing monetary policy.

Suppose that the central bank cannot not access time t information available to the private sector, including the technology shock, at the beginning of time t. The central bank instead can only observe the state of the economy with one period lag. What is the optimal monetary policy in that circumstance? To facilitate discussions, we use log-linearized version of the model in the following discussions.

Proposition 4 *With incomplete information, an optimal monetary policy should target the expected nominal wage such that*

$$E_{t-1}\hat{w}_t = E_{t-1}\hat{w}_t^* = \sum_{j=1}^{k} \theta_j \hat{w}_{t-j}. \tag{5.1}$$

Proof. The first-best outcome:

$$Y^{KEY} = Y^{RBC},$$

is achieved when the real wage in the new Keynesian economy is equal to that in the neoclassical economy. Due to information lag, however, the government can achieve only the second-best outcome at time t:

$$E_{t-1}Y_t^{KET} = E_{t-1}Y_t^{RBC}.$$

The first order conditions (14) and (15) suggest that the second-best outcome can be achieved by equalizing the expected real wages:

$$E_{t-1}\left(\hat{w}_t - \hat{p}_t\right) = E_{t-1}\left(\hat{w}_t^* - \hat{p}_t\right).$$

Cancelling $E_{t-1}\hat{p}_t$ on both sides yields $E_{t-1}\hat{w}_t = E_{t-1}\hat{w}_t^*$. Substituting this into the wage equation (16) yields the desired result.■

Proposition 5 *The optimal money supply rule under incomplete information is given by*

$$\hat{m}_t = E_{t-1}\hat{m}_t = \sum_{j=1}^{k} \theta_j \hat{w}_{t-j} - \gamma E_{t-1}\hat{n}_t.$$

Proof. Since the expected market-clearing nominal wage follows

$$E_{t-1}\hat{w}_t^* = E_{t-1}\left(\gamma \hat{n}_t + \hat{p}_t + \hat{c}_t\right),$$

and since

$$E_{t-1}\left(\hat{p}_t + \hat{c}_t\right) = E_{t-1}\hat{m}_t,$$

combining the two equations gives:

$$\begin{aligned} E_{t-1}\hat{m}_t &= E_{t-1}\hat{w}_t^* - \gamma E_{t-1}\hat{n}_t \\ &= \sum_{j=1}^{k} \theta_j \hat{w}_{t-j} - \gamma E_{t-1}\hat{n}_t. \end{aligned}$$

■

Corollary 6 *Under the optimal monetary policy that achieves (20), the nominal wage is completely exogenous in the sense that no lagged variables except its own history has predictive power on the nominal wage* w_t^*.

Proof. Equation (20) implies the linear projection:

$$\hat{w}_t^* = \sum_{j=1}^{k} \theta_j \hat{w}_{t-j} + e_t,$$

where the error term, $e_t \equiv \hat{w}_t^* - E_{t-1}\hat{w}_t^*$, satisfies $E_{t-1}e_t = 0$, implying that it is orthogonal to time $t-1$ information set.■

It is instructive to demonstrate how e_t is related to time t innovations in technology, as the demonstration also illustrates how agents solve for the decision rules under endogenous monetary policy with incomplete information.

Notice that the reduced-form first order conditions in the Keynesian economy can be characterized by:

$$E_t \begin{bmatrix} \hat{k}_{t+1} \\ \hat{c}_{t+1} \\ \hat{A}_{t+1} \\ \hat{w}_t \\ \vdots \\ \hat{w}_{t-k+1} \end{bmatrix} = M \begin{bmatrix} \hat{k}_t \\ \hat{c}_t \\ \hat{A}_t \\ \hat{w}_{t-1} \\ \vdots \\ \hat{w}_{t-k} \end{bmatrix} + R_1 E_t \hat{m}_{t+1} + R_2 \hat{m}_t. \tag{5.2}$$

Taking expectation on both sides of the equation against $t-1$ information set, and substituting out the monetary policy by $\hat{m}_t = \alpha E_{t-1}\hat{s}_t$ gives:

$$E_{t-1} \begin{bmatrix} \hat{k}_{t+1} \\ \hat{c}_{t+1} \\ \hat{A}_{t+1} \\ \hat{w}_t \\ \vdots \\ \hat{w}_{t-k+1} \end{bmatrix} = (I - R_1\alpha)^{-1} (M + R_2\alpha) E_{t-1} \begin{bmatrix} \hat{k}_t \\ \hat{c}_t \\ \hat{A}_t \\ \hat{w}_{t-1} \\ \vdots \\ \hat{w}_{t-k} \end{bmatrix},$$

where the monetary policy rule α remains to be determined, and $s_t \equiv \begin{bmatrix} k_t & c_t & A_t & w_{t-1} & \cdots & w_{t-k} \end{bmatrix}'$.[10] Solving for the system forward under transversality conditions gives a decision rule for expected

[10]It can be shown easily that any endogenous monetary rule can be reduced to a form depending on the vector s.

consumption:

$$E_{t-1}\hat{c}_t = \pi_{cs} E_{t-1} s_{1t}, \tag{5.3}$$

where the new state vector $s_{1t} \equiv \begin{bmatrix} k_t & A_t & w_{t-1} & \cdots & w_{t-k} \end{bmatrix}'$. Given the specified $AR(1)$ technology shock process, the expected state vector s_{1t} can be written as

$$s_{2t} = E_{t-1} s_{1t} = \begin{bmatrix} k_t & \rho_a A_{t-1} & w_{t-1} & \cdots & w_{t-k} \end{bmatrix}',$$

which is known in time period $t-1$. Hence, the optimal monetary policy under incomplete information is given by (after substituting out the expected consumption):

$$\hat{m}_t = \alpha' \hat{s}_{2t}, \tag{5.4}$$

which is the same as $E_{t-1}\hat{m}_t$ since s_{2t} is known in time period $t-1$.

Substituting the monetary policy rule (23) into the original system (24), we can solve for the decision rule of consumption:

$$\hat{c}_t = \pi_{cs}' S_t,$$

where the state vector S_t includes lagged technology A_{t-1} :

$$S_t = \begin{bmatrix} k_t & A_t & A_{t-1} & w_{t-1} & \cdots & w_{t-k} \end{bmatrix}'.$$

As a result, all variables y in the economy are determined by S_t :

$$\hat{y}_t = \pi_{ys} S_t,$$

including the nominal wage w_t^* :

$$\hat{w}_t^* = \hat{w}_t = \pi_{ws} S_t.$$

Hence, the one-step ahead forecasting error, e_t, follows

$$\begin{aligned} & \hat{w}_t - E_{t-1}\hat{w}_t \\ = \; & \pi_{ws}\left(S_t - E_{t-1}S_t\right) \\ = \; & \pi_{ws}\begin{bmatrix} 0 & \varepsilon_{at} & 0 & 0 & 0 & 0 \end{bmatrix}' \\ = \; & \pi_{ws}[2]\varepsilon_{at}. \end{aligned}$$

This shows how e_t depends on the innovations in technology shocks. Consequently, the nominal wage $w_t^*(w_{t-1}, ..., w_{t-k}, e_t)$ is completely exogenous in the sense that no lagged variables except its own history has predictive power on its current behavior.

The quantitative effectiveness of optimal monetary policy under incomplete information are shown in figure 7. It is seen there that due to the information lag, the central bank is not able to mitigate the technology shock at the impact period, hence it is impossible to fully achieve the RBC allocation. The central bank's intervention, nevertheless, substantially improves the economy's performance in the subsequent periods. For example, the Okun's gap in terms of output is substantially reduced compared to the case of no intervention (see figure 8). The variance of output is reduced by ? percent under the policy intervention.

6 An Econometric Assessment

The fact that the nominal wage is rendered completely exogenous under optimal monetary policies has the implication for testing the effectiveness of monetary policy in a Keynesian economy. In the case of complete information, the nominal wage is independent of both contemporaneous and lagged endogenous variables. In the case of incomplete information, the nominal wage may be correlated with contemporaneous variables because innovations in technology also affect other endogenous variables, but it is independent of the history of any endogenous variables. Hence we develop two types of test for the effectiveness of the post-war US monetary policy, both of which are kin to the Granger causality test.

The first type tests whether the nominal wage (w_t) is correlated with any contemporaneous endogenous variables, given its own history ($w_{t-j}, j = 1, 2, ...$). The lack of such correlation indicates both monetary non-neutrality and the effectiveness of monetary policy.

The second type tests whether the nominal wage is correlated with any lagged endogenous variables given its own history. The lack of Granger causality from lagged endogenous variables supports the view of monetary non-neutrality and the effectiveness of monetary policy.[11]

A. Granger Test 1: Complete Information

We estimate the following equations for the US economy (1964:1-1995:2):

$$w_t = f(w_{t-j}), \quad j = 1, 2, ...k; \tag{A}$$

[11] If the actual economy is a classical one, then the nominal wage is predictable by lagged endogenous variables such as output, as long as technology shocks or any fundamental shocks are serially correlated. Even if these shocks are not serially correlated, habit formation in labor supply (Wen, 1998) and dynamic labor adjustment costs (Sargent, 1987, p199) all render the nominal wage dependent on lagged endogenous variables.

$$w_t = f\left(w_{t-j}, X_t\right), \quad j = 1, 2, ...k; \tag{B}$$

$$w_t = f\left(w_{t-j}, x_t\right), \quad j = 1, 2, ...k; \tag{C}$$

$$w_t = f\left(w_{t-j}, p_t\right), \quad j = 1, 2, ...k; \tag{C}$$

where all variables are in growth rates, and where w denotes the nominal wage, x is a vector of real variables that influence the labor supply and labor demand decisions, including the aggregate consumption, the rate of capacity utilization (we use GDP as the proxy), the level of employment, and the money stock, m. X is simply the nominal counterpart of x, and p is the price index (GDP deflator). We choose the number of lags $k = 10$ in each regression.

We use two aggregate wage series in our test. One is the average hourly earnings for production workers in the manufacturing sector, and another is the average hourly earnings for the total private sector. The OLS estimation results are reported in table 1 and table 2, where values in the third to fifth column indicate the significance level of a corresponding set of variables under the F test. Estimating (1) to (4) using manufacturing wage series gives the following results:

Table 1. Manufacturing Sector

Equation	R^2	$F-Test\ (X_t)$	$F-Test\ (x_t)$	$F-Test\ (p_t)$	$D-W$ stat.
(A)	0.68				1.99
(B)	0.77	0.08			2.21
(C)	0.77		0.22		1.93
(D)	0.74			0.000002	1.98

Table 1 shows that the manufacturing nominal wage is exogenous with respect to X_t and x_t (at the 5% significance level), but not with respect to p_t. The current price inflation rate has a very significant predicting power on the current wage inflation rate. However, with regard to the wage series for the total private sector, all the contemporaneous variables, X_t, x_t, and p_t, that influence labor supply and demand, do have significant predictive power on the behavior of nominal wage, as can be seen from table 2 below:

Table 2. Total Private Sector

Equation	R^2	$F-Test\ (X_t)$	$F-Test\ (x_t)$	$F-Test\ (p_t)$	$D-W$ stat.
(A)	0.73				2.00
(B)	0.81	0.003			2.47
(C)	0.77		0.0015		1.91
(D)	0.78			0.000009	1.89

It is worth mentioning that money growth rate is always an insignificant variable in predicting the behavior of the nominal wage, indicating the endogeneity of the money supply. According to our theoretical models, if money were exogenous, the wage inflation rate is at least in part related to money growth rate by the equation:

$$w_t = f\left(\gamma n_t + m_t\right).$$

Hence, money should have predictive power on the nominal wage unless it is endogenous.

The overall results indicate that if the central bank has complete information and has been pursuing active monetary policy, then the monetary policy has not been very effective in fine-tuning the economy.

B. Granger Test 2: Incomplete Information

The results in the above section could imply, however, that the central bank is not able to act immediately to respond to economic shocks due to incomplete information (information lag). This subsection tests the effectiveness of monetary policy under that circumstance. According to our earlier analyses, with incomplete information, an active monetary policy will result in nominal wages that are not predictable by lagged endogenous variables. Both table 3 and table 4 indicate that this is broadly true for the US economy. Namely, the nominal wages are broadly exogenous with respect to lagged variables. The only exception is that the lagged price inflation rate appears to be significant at the 5% level in predicting the manufacturing nominal wage. The inflation rate has no predictive power on the total private sector's nominal wage. No variables in X_{t-1} or x_{t-1} have predictive power on either wage series.

Table 3. Manufacturing Sector

Equation	R^2	$F-Test\ (X_{t-1})$	$F-Test\ (x_{t-1})$	$F-Test\ (p_{t-1})$	$D-W$ stat.
(A)	0.68				1.99
(B)	0.78	0.62			2.09
(C)	0.68		0.88		1.98
(D)	0.69			0.04	1.98

Table 4. Total Private Sector

Equation	R^2	$F-Test\ (X_{t-1})$	$F-Test\ (x_{t-1})$	$F-Test\ (p_{t-1})$	$D-W$ stat.
(A)	0.73				2.00
(B)	0.78	0.96			2.01
(C)	0.75		0.28		1.99
(D)	0.73			0.35	1.99

The empirical evidence seems consistent with rational expectations models in which monetary authorities pursue optimal policies under lagged information. The fact that only the aggregate price level has predictive power on one of the nominal wage series could imply that some nominal wages are set or indexed in practice in accordance with price inflation rate rather than the ineffectiveness of monetary policies. In order to be able to differentiate this possibility from the implication of ineffective monetary policies, however, further investigations are needed.

7 Conclusion

This paper showed that under active monetary policies, endogenous variables that are the culprits of monetary non-neutrality are rendered completely exogenous. We tested that implication using post war US data. Although our findings are still very preliminary and not conclusive, they seem to suggest that the nominal wage is exogenous with respect to those lagged macro variables that are expected to have significant influences on the nominal wage dynamics. This is consistent with the implication of a new Keynesian model in which money is not neutral due to nominal wage stickiness and in which monetary policies are optimal and effective.

While we find this simple exercise to have been worthwhile, we believe that further work is needed to validate and to refine our empirical findings. Specifically, testing the exogeneity of aggregate prices is another line worth pursuing, if it is not the nominal wage, but the sticky nominal price that is the source of monetary non-neutrality. In addition, if there are more than one sources of monetary non-neutrality, then a single monetary instrument is unlikely to correct all of the distortions. In that case, depending on the monetary target, failing the Granger causality test does not necessarily imply a rejection of the hypothesis that monetary policy is effective.

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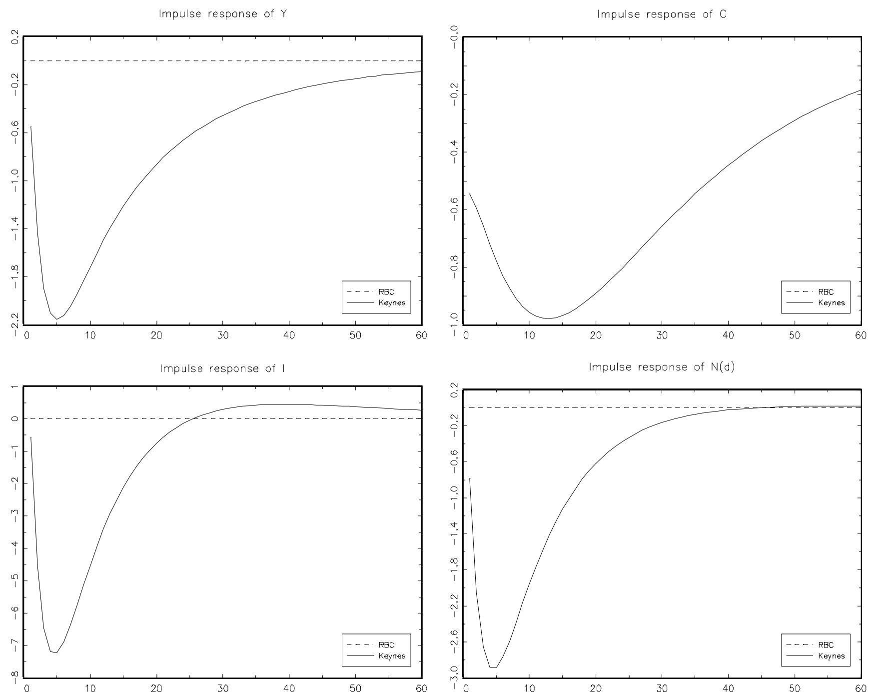

Figure 2. Impulse Responses to a Negative Money Supply Shock

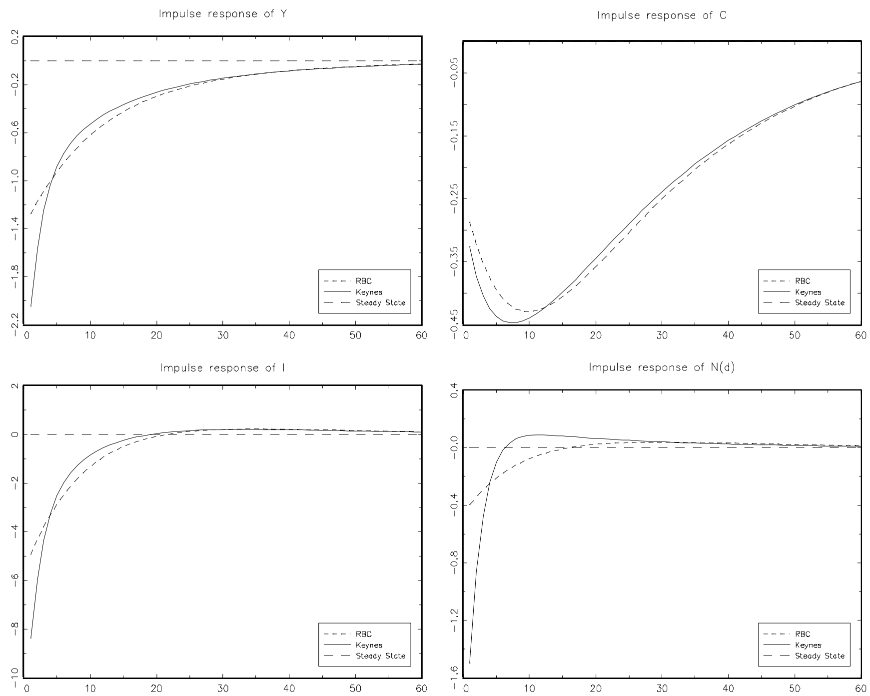

Figure 3. Impulse Responses to a Negative Technology Shock

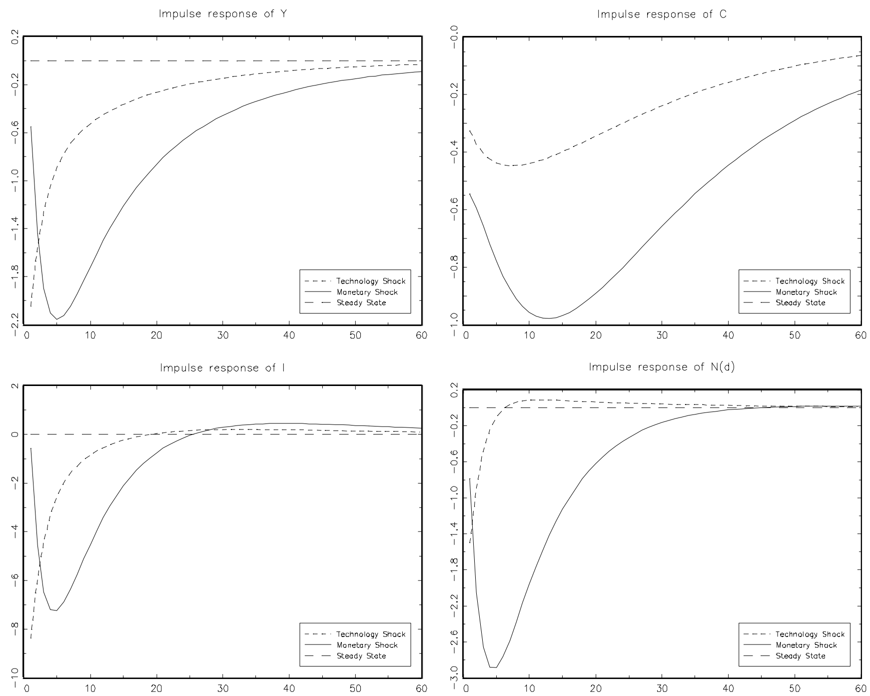

Figure 4. Comparison of Different Impact of Technology and Monetary Shocks.

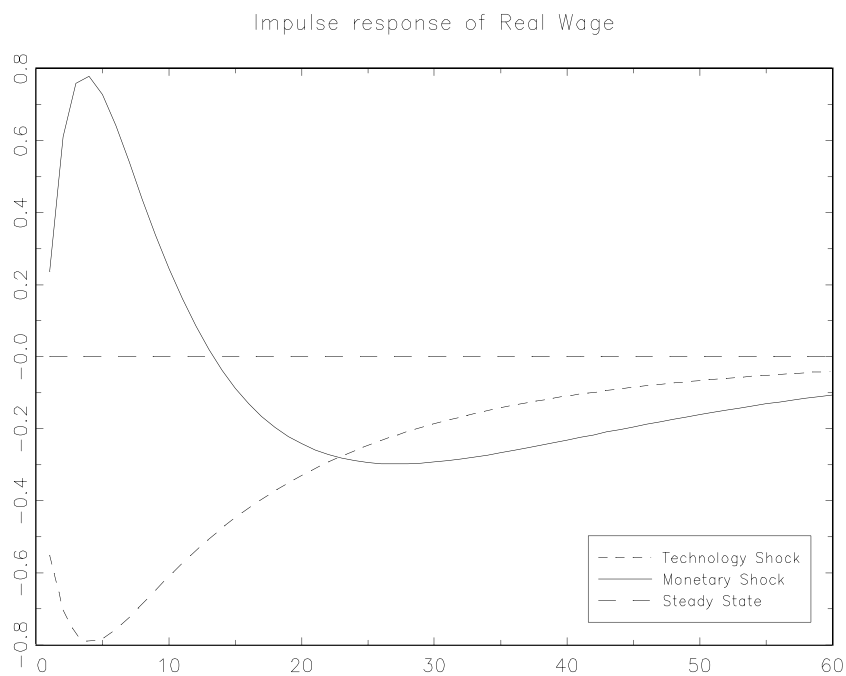
Impulse response of Real Wage
0.8
0.6
0.4
0.2
−0.0
−0.2
−0.4
−0.6
−0.8
0
10
20
30
40
50
60
Technology Shock
Monetary Shock
Steady State

Figure 5.

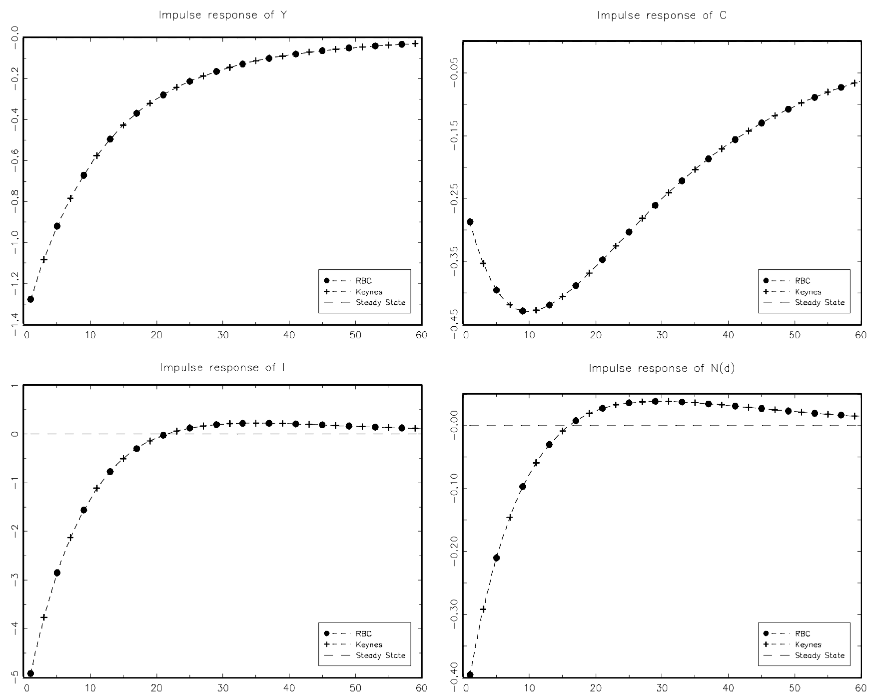

Figure 6. The Effectiveness of Monetary Policy under Full Information.

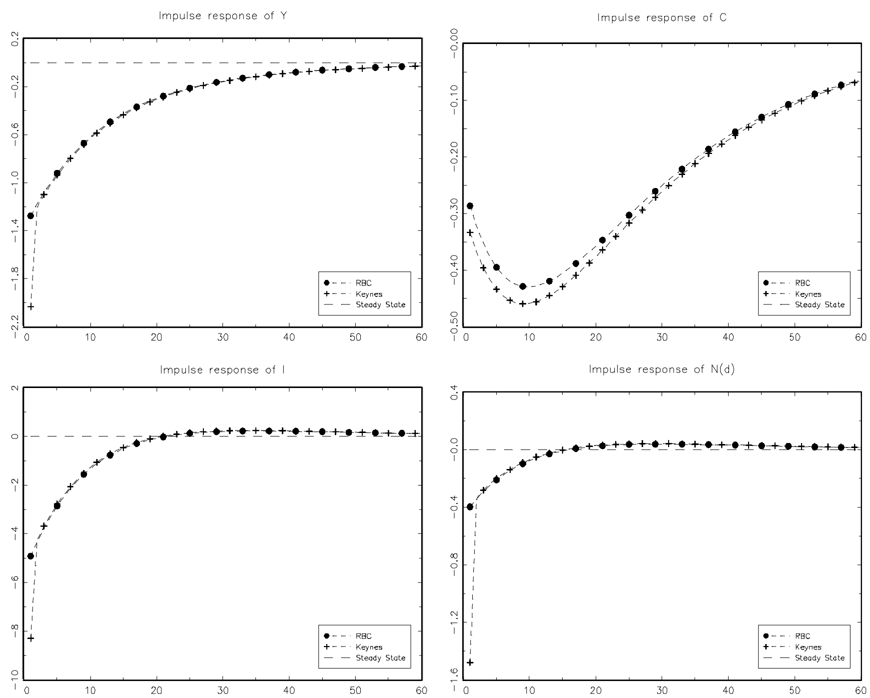

Figure 7. The Effectiveness of Monetary Policy under Incomplete Information.

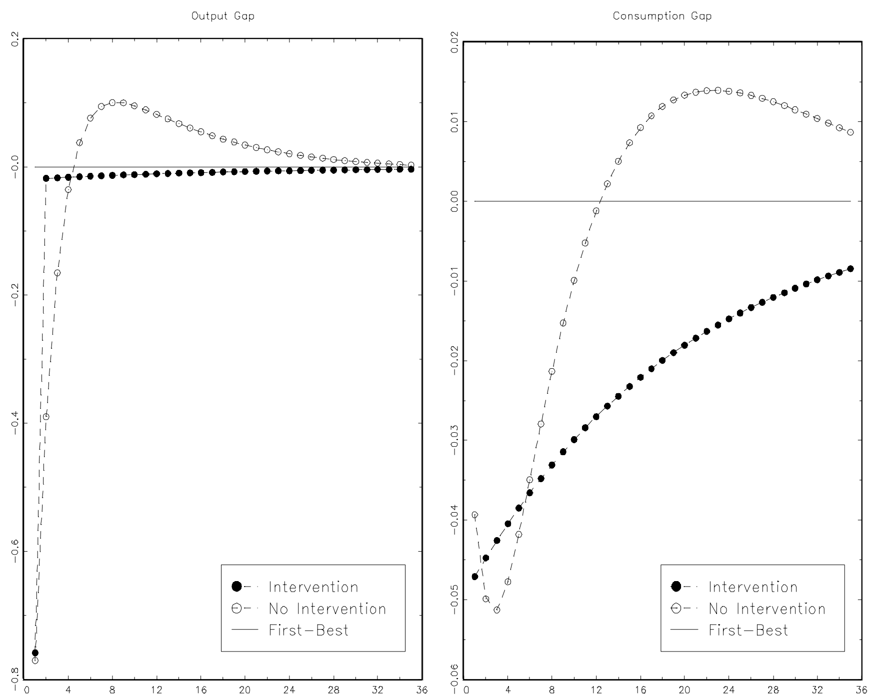

Figure 8. Okun's Gap with and without Policy Intervention.