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*Why Are the Effects of Money-Supply Shocks Asymmetric? Evidence from Prices, Consumption, and Investment**

This paper investigates why the effects of money on output are asymmetric. We show that Cover's (1992) methodology is a special case of a more general model which enables us to distinguish between two sets of theories consistent with the output asymmetries: a convex aggregate supply, and a pushing-on-a-string view. We find that the effects of money on prices are symmetric, which is consistent with both sets of theories being operative at once. We also show that consumption responds symmetrically to money, whereas the response of fixed investment is characterized by asymmetries very similar to those that affect output. Finally, we find that the asymmetries in the effects of money-supply shocks are intensified by increases in the rate of inflation.

1. Introduction

Recent research has shown that the effects of money-supply shocks on output are asymmetric. Examining quarterly U.S. postwar data, James Cover (1992) concluded that positive shocks in the money supply have had no effect on output, whereas negative shocks have reduced output.[1]

In this paper we generalize Cover's model in five dimensions. First, we endogenize the breakpoint of the asymmetry instead of imposing it at zero. Second, we ask whether output also responds asymmetrically to supply

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[1]De Long and Summers (1988) reached similar conclusions in their investigation of annual pre- and postwar U.S. data. Morgan (1993) discusses the history of asymmetry and also finds asymmetric effects in the U. S. using the federal funds rate and the Boschen-Mill index. For a number of countries, Caballero and Engel (1992) show that the output effects of money demand shocks are asymmetric. Karras (1996a) and Karras and Stokes (forthcoming) find asymmetric money-supply effects in a number of European and OECD countries. Using different data sets, Rhee and Rich (1995) and Buckle and Carlson (1998) show that the asymmetric output effects of money are systematically related to inflation. Evans (1986), however, has presented evidence against asymmetry in the U.S. by finding that monetary policy does not affect output more strongly when capacity utilization is low.

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disturbances, such as shocks in oil prices. Third, we investigate the asymmetric effects on two major components of output: private consumption and fixed investment. Fourth, we add an inflation equation to the estimated system, which enables us to test whether the asymmetric response of output to money-supply shocks is due to a convex aggregate supply or "pushing on a string" mechanisms. Last, we allow the coefficients of the money-supply shocks to interact with inflation to investigate whether the observed asymmetric effects are related to the rate of inflation itself as proposed by Ball and Mankiw (1994) and demonstrated by Rhee and Rich (1995) and Buckle and Carlson (1998).

The fourth extension, which can be illustrated with reference to the standard aggregate-demand/aggregate-supply model, aims to distinguish between two competing classes of models, both of which imply asymmetric effects of money on output but have different implications about how money-supply shocks affect prices.[2] In the first class belong all models that generate an aggregate supply curve that becomes vertical (or steeper) for price levels above expected prices (models with inverse "L-shaped" or convex aggregate supply curves). Standard Keynesian models with downwardly rigid nominal wages belong in this class.[3] These models imply that positive money-supply shocks have a *larger* effect on prices than negative ones.

In the second class belong "pushing on a string" views about monetary policy, which explain asymmetric effects of money on output by arguing that negative money-supply shocks affect aggregate demand more than positive shocks do. De Long and Summers (1988) associate this view with models that emphasize credit rationing, or credit (or "lending") theories of the monetary transmission mechanism.[4] In their words "banks can either remain healthy or they can fail. If banks fail there are negative macroeconomic ramifications, but there is no corresponding possibility on the positive side." The pushing-on-a-string class of models implies that positive money-supply shocks exert less pressure on aggregate demand and thus have a *smaller* effect on prices than negative monetary shocks.

It follows that we can test which one of the two classes of models is more consistent with the observed output asymmetry by comparing the effects of positive and negative money-supply shocks on prices: if positive money-supply shocks have a stronger (weaker) effect on prices than negative

[2]See Karras (1996b) and Karras and Stokes (forthcoming) for two recent cross-country applications.

[3]The insider-outsiders model of Lindbeck and Snower (1989), and the asymmetric rigidity model of Ball and Mankiw (1994) also belong in this class.

[4]Bernanke (1993) presents a comprehensive discussion and survey of research on the credit view of the monetary transmission mechanism.

shocks, the convex aggregate supply ("pushing on a string") model is supported.

The remainder of this paper is organized as follows: Section 2 discusses the empirical methodology and the data, Section 3 presents the empirical results, and Section 4 concludes.

2. Methodology and Data

To better illustrate the extensions we are proposing on Cover's methodology, we begin by presenting an outline of his 1992 model. Cover's money-output system consists of two equations, the first of which describes the money supply process:

$$m_t = \alpha_0 + \sum_{i=1}^{N} \alpha_i^m m_{t-i} + \sum_{i=1}^{M} x_{t-i}' \alpha_i^x + u_t , \tag{1}$$

where m_t is the money growth rate, x_t is a vector of other relevant variables (to be specified below), α_0, the α_i^ms and the vector α_i^x are coefficients, and u_t is the money-supply shock. Defining $u_t^+ = \max(u_t,0)$ and $u_t^- = \min(u_t,0)$, as the positive and negative money-supply shocks, respectively, Cover's second equation is

$$\begin{aligned} y_t = \beta_0 &+ \sum_{i=1}^{P} \beta_i^y y_{t-i} \\ &+ \sum_{i=0}^{Q} \beta_i^r r_{t-i} + \sum_{i=0}^{S} (\gamma_i^+ u_{t-i}^+ + \gamma_i^- u_{t-i}^-) + e_t , \end{aligned} \tag{2}$$

where y_t is the output growth rate in period t, r_t is the change in the three-month Treasury bill rate, β_i^y, β_i^r and γs are coefficients, and e_t is the output shock.

Our model generalizes Cover's in a number of different ways. First, we preserve Equation (1) as the money-supply equation, but redefine the money-supply shocks as $u_t^+ = \max(u_t - \tau^y,0)$ and $u_t^- = \min(u_t - \tau^y,0)$, where τ^y is a parameter to be estimated indicating the position of the break or knot in the function. We are thus endogenizing the breakpoint of the asymmetry instead of imposing it at zero.

Second, oil shocks are introduced as proxies of aggregate supply disturbances which are also allowed to have asymmetric effects on output. Define o_t as the rate of growth of the price of oil in period t and $o_t^+ = \max(o_t,0)$, and $o_t^- = \min(o_t,0)$.[5] In place of Equation (2), the output equation then becomes

[5]We also tried the "real" price of oil (the dollar price divided by the U.S. GDP deflator), as well as the residuals from an autoregressive oil-price equation as the supply shocks, but none of these changes affected our findings.

$$y_t = \beta_0 + \sum_{i=1}^{P}\beta_i^y y_{t-i} + \sum_{i=1}^{Q}\beta_i^r r_{t-i} + \sum_{i=0}^{R}(\beta_i^+ o_{t-i}^+ + \beta_i^- o_{t-i}^-) + \sum_{i=0}^{S}(\gamma_i^+ u_{t-i}^+ + \gamma_i^- u_{t-i}^-) + e_t , \quad (3)$$

where the βs and γs are parameters.[6] Of interest is the relationship between the positive and the negative oil shock parameters (β_i^+ and β_i^-, $i = 1, \ldots, R$) and the relationship between the positive and negative money-supply shock parameters (γ_i^+ and γ_i^-, $i = 1, \ldots, S$).

Third, money-supply and oil shocks are allowed to have asymmetric effects on inflation by adding a price equation to the system:

$$p_t = \delta_0 + \sum_{i=1}^{P}\delta_i^p p_{t-i} + \sum_{i=1}^{Q}\delta_i^r rt-i + \sum_{i=0}^{R}(\delta_i^+ o_{t-i}^+ + \delta_i^- o_{t-i}^-) + \sum_{i=0}^{S}(\zeta_i^+ u_{t-i}^{+*} + \zeta_i^- u_{t-i}^{-*}) + v_t , \quad (4)$$

where p_t is the rate of inflation, the δs and ζs are parameters, and v_t is a price shock. We redefine the money-supply shocks as $u_t^{+*} = \max(u_t - \tau^p, 0)$ and $u_t^{-*} = \min(u_t - \tau^p, 0)$, where τ^p is a parameter to be estimated indicating the position of the break or knot in the function.[7] In general $\tau^y \neq \tau^p$.[8] Examining the estimated ζs will allow us to distinguish between two alternative explanations for the asymmetric affects of money on output.

The systems (1)–(2) and (1)–(3)–(4) can be estimated with the 2-step OLS procedure used by Barro (1977, 1978), or by a system-wide method such as nonlinear least squares (Mishkin 1982, 1983) or multivariate maximum likelihood. The empirical section below reports only the maximum likelihood results.[9] To illustrate, the log-likelihood function for the money-output-price system is specified as

$$L(\alpha, \beta, \gamma, \delta, \zeta, \Sigma, \tau^y, \tau^p) = -0.5 \ln |\Sigma| - 0.5 (w'\Sigma^{-1}w) , \quad (5)$$

[6]Superscripts and subscripts will be omitted when no confusion would result.

[7]It is worthwhile noting that both the output and price equations should be thought of as reduced-form equations. Like most of the relevant literature, we do not attempt a structural identification of aggregate demand or supply, but this does not pose a problem as our testable hypotheses are readily expressed in reduced-form terms.

[8]Note that the restriction $\tau^y = \tau^p$ can be easily imposed on the estimation. However, there is no theoretical reason why τ^y and τ^p should be equal. Some theories, for example, predict that only unanticipated money has output effects, while inflation is affected by both anticipated and unanticipated money. Therefore, we chose to focus on the unrestricted specification in order to avoid the bias that could result from estimating subject to a false restriction.

[9]RATS version 4.21, which is documented in Doan (1992), was used for estimation. The SIMPLEX method was utilized, where necessary, to control the initial iterations before moving to the BFGS method for the final iterations.

where

$$\Sigma = \begin{bmatrix} \sigma_{11}\sigma_{12}\sigma_{13} \\ \sigma_{12}\sigma_{22}\sigma_{23} \\ \sigma_{13}\sigma_{23}\sigma_{33} \end{bmatrix} \qquad (6)$$

is the covariance matrix of u, e, and v. In Equation (5), α, β, γ, δ, and ζ are parameter vectors and $w' = (u', e', v')$. Initial values are obtained from the 2-step OLS regressions (except for the initial values of σ_{12}, σ_{13}, σ_{23}, τ^y, and τ^p which are set at zero), and the function is maximized with the BFGS method (a modification of the Davidon-Fletcher-Powell algorithm).

All data are quarterly and seasonally adjusted and obtained from CITIBASE, with the exception of the oil price which comes from the IMF's *International Financial Statistics on CD-ROM* (series 00176AAZZF). Output is measured by real GDP (series GDPQ), money supply by M1 (series FM1), and the price level by the GDP deflator (series DGPD). The estimation period for all reported results is 1960:*iv*–1993:*iv*.

3. Empirical Results

Cover's Money-Output System

We begin by estimating the system of Equations (1) and (2). Following Cover's specification, we set $N = S = 4$, $P = Q = 1$, and we include the following variables in x: the lagged first difference of the three-month Treasury bill rate (series FYGM3), the lagged unemployment rate (series LHUR), and two lags of the rate of growth of the monetary base (series FMFBA).

Column (i) of Table 1 reports a number of tests on the estimated γs.[10] The first two rows of panel 1 in column (i) test whether the coefficients of the positive or negative shocks are jointly zero. This is decisively rejected for the negative shocks ($\chi^2 = 60.98$), but cannot be rejected for the positive shocks ($\chi^2 = 4.49$). The next two rows test whether the sum of the coefficients of the positive or negative shocks is zero. Again, this is strongly rejected (in favor of a positive sum) for the negative shocks ($\chi^2 = 14.59$). On the other hand, the hypothesis that the positive coefficients add up to zero is not rejected ($\chi^2 = 0.78$). The fifth test is the test of symmetry. The null hypothesis here is that the sum of the positive-shock coefficients equals the

[10]We do not report the estimated γ's themselves because of space considerations. As expected, the statistically significant γ's are positive.

sum of the negative ones. The null of symmetry is soundly rejected in favor of the negative shocks having a greater effect ($\chi^2 = 11.74$). Consistent with the findings of Cover,[11] therefore, the effects of money-supply shocks on output are shown to be asymmetric.[12]

The Extended Money-Output-Prices System

Next we generalize the system and estimate Equations (1), (3), and (4). As noted earlier, Cover's (1992) model is a nested special case of this formulation. The complete set of estimated parameters is reported in Table 2, while column (ii) of Table 1 contains a number of symmetry tests.

Focusing on the coefficients of the output Equation (2) first, the results in the second column of Table 2 are as expected. Output growth has some persistence (β_1^y is significant); the oil coefficients (β_i^+, β_i^-), when statistically significant, are negative, and the money coefficients (γ_i^+, γ_i^-), when statistically significant, are positive. Turning to column (ii) in Table 1, the five tests of panel 1 strongly support asymmetry. The output effects of negative money-supply shocks are statistically significant ($\chi^2 = 17.30$) while the output effects of the positive shocks are not statistically significant ($\chi^2 = 9.01$). In addition, only the sum of the coefficients of the negative money-supply shocks is statistically significant ($\chi^2 = 11.10$), whereas the null of symmetry is soundly rejected ($\chi^2 = 12.96$).

Interestingly, our extended system can be used to show that asymmetries like these are not confined to money-supply shocks. As panel 2 of column (ii) reports, a similar asymmetry applies to oil shocks: output growth is statistically significantly retarded by positive shocks in oil prices ($\chi^2 = 21.44$), while negative oil shocks have no effect ($\chi^2 = 7.08$).[13] The sum of the positive oil price shocks is significant ($\chi^2 = 18.05$), while the sum of the negative shocks is not significant ($\chi^2 = 0.18$). The formal hypothesis that the sums of the positive and negative oil coefficients differ cannot be rejected at the 5% level, but this is a consequence of the imprecision in the estimation of the negative coefficients.

[11]The only substantive difference between Cover's (1992) model and that reported in column (i) of Table 1 is the difference in the estimation period. We did not use the pre-1959 M1 to splice the money series, so our period is 1960:*iv*–1993:*iv* compared to Cover's 1951:*i*–1987:*iv*.

[12]Interestingly, the finding of asymmetry supports the interpretation of the estimated u_ts as shocks to money supply (instead of money demand), since there is no theoretical reason for money demand to be asymmetric.

[13]As an anonymous referee brought to our attention, an obvious difference in the effects of oil prices is that positive oil shocks have more immediate effects than negative ones. One possible reason for this difference in timing is that firms reduce output as soon as energy prices increase, but they react more slowly when energy prices decline. This pattern appears to be consistent with the predictions of Ball and Mankiw's (1994) menu-cost pricing model in periods of positive inflation. See Buckle and Carlson (1998) for a related test.

Turning to the coefficients of the price equation, the results in the third column of Table 2 are also as expected from theory. The inflation rate exhibits significant persistence (δ_1^p is highly significant with $t = 21.8$), and both the oil (δ_i^+, δ_i^-) and the money coefficients (ζ_i^+, ζ_i^-), when statistically significant, have a positive sign. Panel 3 of column (ii) in Table 1 conducts a number of tests on the estimated ζ_s which measure the effect of monetary shocks on prices. The first two rows of the panel soundly reject the null hypotheses that positive or negative money-supply shocks do not affect inflation where $\chi^2 = 15.21$ and 23.97, respectively. On the other hand, only the sum of the coefficients of the negative money-supply shocks is statistically significant ($\chi^2 = 10.75$), whereas the null of symmetry is rejected with difficulty ($\chi^2 = 3.47$). This finding is inconsistent with a convex aggregate supply but consistent with "pushing on a string" explanations of the output asymmetry.[14]

Panel 4 of column (ii) in Table 1 looks at asymmetries of oil shocks on inflation. Consistent with our earlier observations on output growth, the inflationary effects of oil shocks are also asymmetric. Positive shocks in oil prices are statistically significant ($\chi^2 = 22.16$) in the inflation equation, whereas negative shocks in oil prices are not ($\chi^2 = 4.32$).

Finally, it is worthwhile noting that, while the estimated τ^p is not statistically significant, the estimated τ^y is statistically significantly negative with $t = -8.26$ (Table 2). This suggests that the asymmetry for output is not around zero, but around a -0.76% quarterly growth rate. Imposing zero for τ^y can severely bias the results against asymmetry.[15]

A Further Extension

In an attempt to shed additional light on the sources of the asymmetric effects of money-supply shocks on output, this section examines the effects of these shocks on the two most important components of GDP: private consumption, c, the largest component, and fixed investment, I, the most volatile component. The data are again quarterly, seasonally adjusted, and obtained from the CITIBASE. The new systems are estimated simply by

[14]It must be noted that this result is fragile. Increasing the lags of money supply shocks from four to eight, for example, preserves the output asymmetry but destroys the asymmetry of inflation.

[15]We also experimented with an alternate set up in which relatively small money-supply shocks have no effect on output or prices. We implement this by setting $u_t = 0$ within the range $[-\Theta^Y, \Theta^Y]$ in the output equation, and within $[-\Theta^P, \Theta^P]$ in the price equation, while positive and negative shocks outside the ranges are allowed to have different effects on output and prices as in Equations (3) and (4), but with $\tau^Y = \tau^P = 0$. Using the ML-SIMPLEX approach described in Section 2, we estimate $\Theta^Y = 0.00019$ and $\Theta^P = 0.00062$, so that the ranges are virtually nil.

TABLE 1. *Tests of Asymmetries: X^2-Statistics*

	Cover	Extended Systems		
	(i)	(ii)	(iii)	(iv)
Null Hypotheses				
1. m → y, c, or I				
$\gamma_i^+ = 0$, all i	4.49	9.01	9.17	16.51***
$\gamma_i^- = 0$, all i	60.98***	17.30***	10.18*	33.77***
$\Sigma_i\gamma_i^+ = 0$	0.78	1.85	0.06	1.09
$\Sigma_i\gamma_i^- = 0$	14.59***	11.10***	0.03	7.96***
$\Sigma_i\gamma_i^+ = \Sigma_i\gamma_i^-$	11.74***	12.96***	0.04	5.36**
2. Oil → y, c, or I				
$\beta_i^+ = 0$, all i		21.44***	29.11***	16.69***
$\beta_i^- = 0$, all i		7.08	9.82*	9.91*
$\Sigma_i\beta_i^+ = 0$		18.05***	3.72*	12.25***
$\Sigma_i\beta_i^- = 0$		0.18	3.68*	3.23*
$\Sigma_i\beta_i^+ = \Sigma_i\beta_i^-$		2.62	11.97***	7.70***
3. m → p				
$\zeta_+ i = 0$, all i		15.21***	32.44***	11.66**
$\zeta_i = 0$, all i		23.97***	14.01**	10.58*
$\Sigma_i\zeta_i^+ = 0$		1.50	0.88	3.87**
$\Sigma_i\zeta_i^- = 0$		10.75***	0.15	8.87***
$\Sigma_i\zeta_i^+ = \Sigma_i\zeta_i^-$		3.47*	0.24	3.59*
4. Oil → p				
$_i^+ = 0$, all i		22.16***	15.42***	17.69***
$\delta_i^- = 0$, all i		4.32	12.74**	5.88
$\Sigma_i\delta_i^+ = 0$		9.72***	2.06	15.01***
$\Sigma_i\delta_i^- = 0$		2.92*	0.70	5.76**
$\Sigma_i\delta_i^+ = \Sigma_i\delta_i^-$		0.73	0.43	1.11

NOTES: All systems are estimated with maximum likelihood over 1960:*iv*–1993:*iv*.
(i) money-output system
(ii) money-output-price system
(iii) money-private consumption-price system
(iv) money-fixed investment-price system
***significant at 1%; **significant at 5%; *significant at 10%.

TABLE 2. *Money-Output-Prices System*

		Output Equation (3)		Price Equation (4)	
σ_{11}	0.672***	β_0	1.103***	δ_0	0.427**
	(0.088)		(0.089)		(0.069)
σ_{12}	0.054	β_1^y	0.186**	δ_1^p	0.698**
	(0.073)		(0.073)		(0.032)
σ_{22}	0.469***	β_1^x	−0.001	δ_1^x	0.042*
	(0.056)		(0.047)		(0.023)
σ_{13}	−0.018	β_2^x	−0.104**	δ_2^x	−0.012
	(0.029)		(0.045)		(0.023)
σ_{23}	0.002				
	(0.021)	Oil Coefficients			
σ_{33}	0.117***	β_0^+	−0.006**	δ_0^+	−0.001
	(0.018)		(0.003)		(0.001)
τ^y	−0.760***	β_1^+	−0.002	δ_1^+	0.001
	(0.092)		(0.003)		(0.001)
τ^p	−0.111	β_2^+	−0.006**	δ_2^+	0.005***
	(0.079)		(0.003)		(0.001)
		β_3^+	−0.002	δ_3^+	−0.0003
Money Equation (1)			(0.003)		(0.001)
α_0	0.527***	β_4^+	−0.009***	δ_4^+	0.004***
	(0.095)		(0.003)		(0.001)
α_1^m	0.378***	β_0^-	0.013	δ_0^-	0.006
	(0.034)		(0.011)		(0.006)
α_2^m	0.260***	β_1^-	0.008	δ_1^-	0.006
	(0.042)		(0.012)		(0.006)
α_3^m	−0.096**	β_2^-	0.007	δ_2^-	0.001
	(0.040)		(0.013)		(0.006)
α_4^m	−0.081***	β_3^-	0.007	δ_3^-	0.006
	(0.031)		(0.013)		(0.006)
α_1^b	−0.113**	β_4^-	−0.026**	σ_4^-	−0.0003
	(0.056)		(0.012)		(0.006)
α_2^b	0.137				
	(0.087)				

(*continued*)

TABLE 2. *Continued*

		Output Equation (3)		Price Equation (4)	
		Money Coefficients			
α_1^x	−0.434***	γ_0^+	−0.089	ζ_0^+	0.070
	(0.014)		(0.116)		(0.063)
α_1^u	0.044***	γ_1^+	−0.154	ζ_1^+	−0.102
	(0.016)		(0.099)		(0.069)
α_1^y	0.039	γ_2^+	0.183*	ζ_2^+	0.199***
	(0.033)		(0.107)		(0.060)
		γ_3^+	−0.015	ζ_3^+	−0.055
			(0.096)		(0.067)
		γ_4^+	−0.110	ζ_4^+	0.047
			(0.086)		(0.071)
		γ_0^-	0.961***	ζ_0^-	0.097
			(0.293)		(0.084)
		γ_1^-	0.860***	ζ_1^-	0.274***
			(0.284)		(0.072)
		γ_2^-	0.672*	ζ_2^-	−0.043
			(0.366)		(0.076)
		γ_3^-	−0.168	ζ_3^-	0.161**
			(0.198)		(0.075)
		γ_4^-	0.304	ζ_4^-	0.013
			(0.214)		(0.073)

NOTES: The system is estimated with maximum likelihood over 1960:*iv*–1993:*iv*. Estimated standard errors in parentheses. ***significant at 1%; **significant at 5%; *significant at 10%.

replacing output growth in Equations (2) and (3)[16] by the rate of growth of real consumption or real fixed investment, and the GDP deflator by the consumption or investment deflator as appropriate.

Columns (iii) and (iv) of Table 1 report tests for the systems including personal consumption expenditures (series GCQ) and gross private domestic fixed investment (series GIFQ), respectively.[17] Focusing on the effects of money shocks on the real variables (panel 1), the results imply that the

[16]But not in Equation (1).

[17]We wish to thank Olivier Blanchard for suggesting this test. We also tried consumption of durables, nondurables, and services, as well as residential and non-residential investment finding results that are quantitatively similar to those for the broader aggregates in Table 2.

asymmetry is very pronounced for fixed investment in favor of the negative money-supply shocks ($\chi^2 = 33.77$), but almost nonexistent for consumption ($\chi^2 = 10.18$). This pattern, consistent with that of Karras (1996a) for a panel of European countries, suggests that the behavior of investment is the key to understanding the reasons for the asymmetric effects of money on output.[18] For fixed investment, positive monetary shocks are also significant ($\chi^2 = 16.51$), while for consumption, positive monetary shocks are not significant ($\chi^2 = 9.17$). For fixed investment only, the negative sums are significant ($\chi^2 = 7.96$), which is consistent with both column ii and i. The null that $\Sigma_i\gamma_i^+ = \Sigma_i\gamma_i^-$ is significantly rejected ($\chi^2 = 5.36$).

The Role of Inflation

Having established the (a)symmetric properties of money-supply shocks on output and prices, we investigate in this section whether the observed asymmetric effects are related to the rate of inflation itself (as predicted by Ball and Mankiw 1994). We do this by allowing the coefficients of the money-supply shocks to interact with inflation.[19] For example, the output equation is modified as follows:

$$y_t = \beta_0 + \sum_{i=1}^{P}\beta_i^y y_{t-i} + \sum_{i=1}^{O}\beta_i^r r_{t-i} + \sum_{i=0}^{R}(\beta_i^+ o_{t-i}^+ + \beta_i^- o_{t-i}^-)$$

$$+ \sum_{i=0}^{S}(\gamma_i^+ u_{t-i}^+ + \gamma_i^- u_{t-i}^-) + \sum_{i=0}^{S}(\pi_i^+ p_{t-1} u_{t-i}^+ + \pi_i^- p_{t-i} u_{t-i}^-) + e_t\,, \quad (3')$$

where the πs are coefficients that capture the extent to which the effects of the money-supply shocks depend on inflation, p. If the effects of money-supply shocks are the same at all inflation levels, then $\pi_i^+ = \pi_i^- = 0$. Moreover, the signs and relative magnitudes of the πs, if statistically significant, will reveal the direction and relative size of the inflation effects.

Table 3 reports estimated πs for two lag specifications in each of the three systems: output, private consumption, and fixed investment. While the results on the individual πs are somewhat fragile, the estimated π^-s tend to be positive, while the π^+s are either negative or statistically insignificant.

[18]This is not meant in the causality sense, as causation could run from output to investment through an accelerator mechanism. We are rather thinking of consumption and investment as components of GDP in the national income accounting sense.

[19]We are grateful to an anonymous referee for suggesting this test. For a similar test, see Buckle and Carlson (1998). Rhee and Rich (1995) investigate a similar hypothesis by looking across different inflation regimes, and Olekalns (1995) tests whether the response of output to changes in aggregate demand depends on the level of inflation. Note that we could also have allowed the oil coefficients to interact with inflation, since the Ball and Mankiw (1994) results apply to both demand and cost shocks. As the emphasis of the present paper is on the asymmetries of money-supply shocks, however, investigation of the oil-inflation interaction is left for future research.

TABLE 3. *The Role of Inflation*

System	s=1		s=4			
	π^+	π^-	$\Sigma_i\pi_i^+$	$\Sigma_i\pi_i^-$	$\Sigma_i\pi_i^- - \Sigma_i\pi_i^+$	χ^2
money-output-price	0.495	0.313***	−0.466*	0.466*	0.931***	12.633
money-private consumption-price	0.210	0.007	−0.517***	−0.029	0.489**	6.464
money-fixed investment-price	0.719	1.208***	−0.963	1.144	2.108**	4.820

NOTES: All systems are estimated with maximum likelihood over 1960:*iv*–1993:*iv*. S is the number of money-supply lags and inflation interaction lags in Equation (3′). χ^2 is the test statistic for the null hypothesis $\Sigma_i\pi_i^+ = \Sigma_i\pi_i^-$. ***significant at 1%; **significant at 5%; *significant at 10%.

More importantly, however, the hypothesis that the degree of asymmetry is not related to inflation is soundly rejected in each specification. Specifically, as the χ^2 column of Table 3 reports, the null hypothesis $\Sigma_i \pi_i^+ = \Sigma_i \pi_i^-$ can be rejected at the 5% significance level or less for all three systems in favor of the $\Sigma_i \pi_i^- > \Sigma_i \pi_i^+$ alternative. This implies that the asymmetric nature of the effects of monetary shocks on output, consumption, and investment is intensified by increases in the rate of inflation, as $\Sigma_i \pi_i^- - \Sigma_i \pi_i^+ > 0$. This finding is consistent with the theoretical predictions of Ball and Mankiw (1994) and the empirical results of Rhee and Rich (1995) and Buckle and Carlson (1998).

4. Conclusions

This paper investigated the asymmetric effects of money-supply shocks. Using quarterly data from the 1960:*iv*:–1993:*iv* period, we confirmed Cover's (1992) well known asymmetric result: negative money-supply shocks statistically significantly reduce output, whereas the effect of positive shocks is statistically insignificant. But we also showed that our model nests Cover's model as a special case that imposes a number of binding constraints.[20] Relaxing some of the constraints implicit in Cover's methodology has enabled us to arrive at a number of new interesting implications regarding the asymmetric effects of money on the economy.

First, we showed that asymmetries are not confined to money-supply shocks, but, consistent with the predictions of Ball and Mankiw's (1994) model, they characterize oil shocks as well. Second, we determined that the money-supply asymmetry is not around zero, but around a −0.76% quarterly money growth rate.

Then, we investigated the inflation effects of money-supply shocks in an attempt to distinguish between two types of theories that are consistent with the observed output effects: a convex aggregate supply, which predicts that positive money shocks have a greater effect on prices than negative shocks, and a credit, or "pushing on a string" view, which predicts that positive money shocks have a smaller effect on prices than negative shocks. While the response pattern of prices offers some evidence in favor of the credit view, other results (such as those supportive of the Ball-Mankiw model) are consistent with a convex aggregate supply. Moreover, compared with the very pronounced asymmetries of monetary shocks on output, we find the effects of monetary shocks on prices to be almost symmetric. This finding implies that neither of the two theories *individually* can fully explain both

[20]Using our model's notation, Cover's (1992) specification imposes $\beta = \delta = \gamma = \tau^p = \tau^y = 0$.

the output and price effects, but it suggests that *both* have to be operative at the same time.

Next, we also investigated the effects of money-supply shocks on the two most important components of GDP, private consumption and fixed investment. We found that consumption responds very symmetrically to shocks in the money supply, whereas investment is governed by asymmetries very similar to those that affect output. This suggests that future research on the sources of these asymmetries should focus on the behavior of fixed investment.

Finally, we allowed the coefficients of the money-supply shocks to interact with inflation in order to investigate whether the observed asymmetric effects are related to the rate of inflation itself. Consistent with the theoretical predictions of Ball and Mankiw (1994) and the empirical results of Rhee and Rich (1995) and Buckle and Carlson (1998), we found that the asymmetries in the effects of monetary shocks are intensified by increases in the rate of inflation.

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