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“An Examination of the Asymmetric Effects of Money Supply Shocks in the
Pre-World War I and Interwar Periods”

Randall E. Parker
Department of Economics
East Carolina University
Greenville, NC 27858 USA

Phone: 252-328-6753
Email: parkerr@mail.ecu.edu

and

Philip Rothman*
Department of Economics
East Carolina University
Greenville, NC 27858 USA

Phone: 252-328-6151
Email: rothmanp@mail.ecu.edu

Abstract

We test whether monetary shocks had asymmetric output effects before World War II. Ball and Mankiw (1994) show that expectations of persistent inflation under fiat money can explain why negative monetary shocks had larger size effects than positive shocks after World War II. Consistent with this explanation, we find such asymmetry in the interwar period following the abandonment of the gold standard, and before it, when agents arguably anticipated this development. We find no monetary asymmetry before World War I, which is consistent with Ball and Mankiw (1994), because under a credible gold standard, agents do not expect persistent inflation.

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I. INTRODUCTION

Cover (1992) emphasizes that the empirical New Classical literature on the effects of monetary policy shocks makes no distinction between positive and negative shocks; see, e.g., Barro (1977, 1978) and Mishkin (1982). If such a distinction is important, then the traditional approach to testing the neutrality of unanticipated movements in money is misspecified and masks state-dependent dynamics which may have important consequences for both monetary theory and policy. Using quarterly post-World War II (WWII) data for the U.S. economy, Cover (1992) concludes that negative money supply shocks have a significantly larger effect on output than do positive shocks. He shows that these results are robust to exclusion of post-October 1979 data (to account for the subsequent shift in monetary policy regime) and to a number of alternative specifications of both the output and money growth equations used in his econometric framework.¹

Cover (1992) motivates his empirical search for monetary shock asymmetry on the basis of what Ravn and Sola (1999) call “traditional Keynesian asymmetry,” a claim that the aggregate supply curve is convex or, in its extreme version, “backward L-shaped.” Though weak on microfoundations, such behavior can be generated under the assumption of decreasing sticky and increasing flexible nominal wages or prices.

The relative strength of negative money supply shocks that Cover (1992) documents is also consistent with Ball and Mankiw’s (1994) (BM) dynamic menu-cost model in the presence of

1. Several authors report results that are consistent with Cover’s (1992) findings. For the post-WWII period, monetary shock asymmetry is supported by the work of Morgan (1993), Rhee and Rich (1995), Karras (1996a, 1996b), Macklem, Paquet and Phaneuf (1996), Demery and Duck (2000), and Senda (2001). However, not all results in the empirical literature support Cover’s analysis. For example, Evans (1986), Ravn and Sola (1999), and Belongia (1996) provide counter evidence.

trend inflation. Monetary policy shock asymmetry arises in this model as follows, under the assumption that firms can change prices subject to incurring a menu cost. All else equal, a positive money supply shock leads to an increase in a representative firm's desired relative price and a negative money supply shock leads to the opposite. With trend inflation a negative shock is likely to lead the firm to keep its nominal price unchanged and not pay the menu cost, since inflation induces an automatic decrease in its relative price. However, since the firm's optimal desired relative price increases in the presence of a positive shock, and the presence of trend inflation leads to a decrease in its actual relative price *ceteris paribus*, the firm is more likely to pay the menu cost and increase its nominal price in response to a positive money supply shock. With trend inflation, then, the BM model implies larger adjustments in output in response to negative money supply shocks than to positive money supply shocks.

While empirical examination of money supply shock asymmetry has primarily focused on the post-WWII era, the pre-WWI and interwar periods have also received attention. Using U.S. annual data, DeLong and Summers (1988) find that positive money supply shocks have weaker effects than do negative money supply shocks in the pre-WWII and pre-Depression sample periods they study.² Focusing on the interwar period for the U.S., Lee (2000) also presents evidence in favor of such monetary shock asymmetry. However, Lai and Cover (1999) and Senda (2001) report results showing that monetary shocks are symmetric in their effect on output with annual data for the U.S. during the 1873-1929 period and for a set of ten industrialized

2. Their two-step OLS procedure, however, makes use of generated regressors, calling into question the hypothesis testing they carry out; see Pagan (1984).

countries over the 1873-1913 period, respectively.³ In addition, Evans (1986) argues that the evidence in favor of monetary shock asymmetry is weak, since his analysis of the distributional properties of output and the price level, fitted reduced forms, and estimated structural equations for interwar annual data suggests that the effectiveness of monetary policy does not depend on capacity utilization.

We feel that further investigation of monetary shock asymmetry in the pre-WWI and interwar eras is important for at least two reasons. First, the behavior of inflation in the pre-WWI and interwar periods was quite different from that observed in the post-WWII era. As shown in Figures 1 and 2, which present time series plots of the U.S. wholesale price index for the 1875-1914 and 1920-1941 sample periods, both the pre-WWI and interwar eras were periods of significant deflationary spirals. This gives us the opportunity to test the BM model in the presence of trend deflation. If such deflation behavior indeed generates expectations of continued deflation, then the BM model's implications under trend inflation are reversed, such that positive monetary shocks are expected to have stronger effects on real output than negative shocks.⁴

3. Here we refer to the results in Column 6 of Senda's (2001) Table 2, the standard errors for which are likely inflated because they are also produced with generated regressors. Since the observed values of trend inflation for these countries in this pre-WWI sample did not fall within the range of interest of his theoretical model, Senda did not run any of his interesting cross-country regressions with these particular asymmetry measures; see Section 4 of Senda (2001).

4. To see this more formally, let π , x , $\bar{\theta}$, and $\underline{\theta}$ be defined as in Senda (2001). Then, from that paper's equations (3) and (5), $x = 0$ implies $\bar{\theta} > -\underline{\theta}$ conditional on $\pi < 0$.

It is not obvious, however, that the trend deflation in the periods we focus on actually induced economic agents to expect future deflation. Consider, for example, the implications of the gold standard, which was operative during most of the pre-WWI sample we study, for the formation of long-term price expectations in the presence of trend deflation. More specifically, under a credible gold standard regime, a bout of deflation would arguably lead to long-term expectations of inflation, since the price-specie-flow mechanism would be expected to eventually restore price stability. In such a scenario, the BM model's implications under trend inflation would not be reversed in the presence of trend deflation. We shall have more to say on this below. To the best of our knowledge, we are the first in the literature to focus on the BM model's properties under trend deflation. While we recognize that this model was developed with the post-WWII phenomenon of trend inflation in mind, we feel it is useful to examine whether the theory is compatible with other important periods of business cycle fluctuations.

Second, the findings of DeLong and Summers (1988) and Lee (2000) strongly conflict with those of the other studies mentioned above. Accordingly, no consensus exists on the presence of monetary shock asymmetry in the pre-WWII period. Through our use of higher frequency data than that generally used earlier, which yields a crucial increase in degrees of freedom, and our examination of inflationary and deflationary sub-samples, our analysis can help provide a step towards resolving this question. In addition, this allows us to investigate whether there exists a possible historical precedent for the asymmetric effects of money supply shocks that appear to be evident in the post-WWII era.

The paper proceeds as follows. In Section II we describe the data used. We present the econometric approach employed and empirical results for two different models in Sections III and IV. Section 5 concludes.

II. DATA

For the pre-WWI period we use quarterly data from Balke and Gordon (1986). The sample period is 1875:1-1914:2 and we use the following series: output, y_t , is defined as the growth rate of real GNP; m_t is the growth rate of the M2 money supply; i_t is the commercial paper rate; and p_t is the inflation rate as measured by the growth rate of the wholesale price index. With the exception of the commercial paper rate, each series is seasonally adjusted.

For the interwar period we use monthly data collected from various sources. The sample period is 1920:01-1941:12 and the data are all seasonally adjusted at the source except as noted. We use the following series for the interwar period: output, y_t , is defined as the growth rate of industrial production (*Federal Reserve Bulletin*); m_t is the growth rate of the M1 money supply (Friedman and Schwartz (1963)); i_t is the commercial paper rate (not seasonally adjusted, *Banking and Monetary Statistics*); and p_t is the inflation rate as measured by the growth rate of the wholesale price index (*Federal Reserve Bulletin*).

III. THE STANDARD MODEL

We base our analysis for the time periods considered using two different measures of monetary shocks. In the first specification we discuss, what we refer to as the “standard model,” monetary shocks are modeled as money supply shocks.

Econometric Approach

The empirical methodology we employ is very similar to that used by Cover (1992). The econometric model comprises a system of two equations, one for the money supply and one for real output, and a pair of identities for constructing the positive and negative money supply shocks. The money supply process is modeled as in equation (1):

$$m_t = \alpha_0 + \sum_{j=1}^{\lambda} \alpha_j^z z_{t-j} + \sum_{i=1}^q \alpha_i^m m_{t-i} + \sum_{i=1}^q \alpha_i^p y_{t-i} + \sum_{i=1}^q \alpha_i^p p_{t-i} + u_t, \quad (1)$$

where z_t is the log of the velocity of money and u_t is the money supply shock. This specification differs from that used by Cover (1992) and others in that we include lags of the inflation rate as well as lags of the log of the velocity of money as regressors.⁵ Our use of lags of the inflation rate follows Bernanke (1983), who employs a comparable specification to generate estimated monetary shocks in his study of the Great Depression’s propagation mechanism.

We incorporate the lag of the log-velocity of money into our model as a pre-specified error-correction term. In doing so, we follow Rothman, van Dijk, and Franses (2001), who analyze a

5. Since our measure of output for our interwar period of 1920:01-1941:12 is industrial production, which is not a measure of income, it is perhaps more accurate to refer to our velocity measure as “quasi-velocity” for our latter time period.

similar system in their Granger-causality analysis and, in contrast to carrying out an extensive statistically-based search for error-correction terms, make this “Hendry-style” specification decision with an appeal to economic theory.⁶ We feel that inclusion of error-correction terms is especially important for the time periods we focus on, given the post-Civil War (gradual deflation) and post-WWI (sharp deflation) adjustments of the price level that were brought about out of gold standard concerns, and the important effects that return to and general operation of the gold standard, including its eventual abandonment by the U.S. in 1933, had on price expectations.

From (1) the negative and positive money supply shocks are defined as $u_t^- = \min[0, u_t]$ and $u_t^+ = \max[0, u_t]$, respectively. The output equation of the system is given by:

$$y_t = \beta_0 + \sum_{j=1}^{\lambda} \beta_j^z z_{t-j} + \sum_{i=1}^q \beta_i^y y_{t-i} + \sum_{i=0}^q (\beta_i^+ u_{t-i}^+ + \beta_i^- u_{t-i}^-) + e_t, \quad (2)$$

where e_t is the output shock.

We call the system given by equations (1) and (2) the “standard model.” This conditional error-correction model is estimated by multivariate maximum likelihood via the BFGS algorithm. The parameters are initialized with values yielded by OLS estimation of equations (1) and (2), and with the cross-correlation between u_t and e_t initially set to zero. We follow the

6. It can be shown, e.g., that the Cooley and Hansen (1995) monetary equilibrium business cycle model implies that log-velocity is stationary. By not including a separate equation for the inflation rate, we are implicitly assuming it is weakly exogenous; see, e.g., Boswijk and Doornik (2002). We do so to simplify an already rather highly-parameterized system.

practice of the unrestricted vector autoregression literature by imposing a common lag length q on the non-error-correction variables in the system and determine q , as well as the lag length λ on the error-correction terms, by consideration of several standard diagnostics: the Akaike information criterion, the Schwarz information criterion, the Ljung-Box statistic, and likelihood ratio testing. By including lags of positive and negative monetary shocks as possible regressors in the output equation, we note that we are making allowance for persistence in the sense that the adjustment of output to these shocks may not be complete within the current period.

Sample Splitting and Inflationary Expectations

For estimation of the model, we divide the pre-WWI and interwar periods into two sub-samples. This sample splitting is motivated by the behavior of the aggregate price level depicted in Figures 1 and 2, i.e., in both the pre-WWI and interwar periods, initial regimes of trend deflation were followed by a generally rising aggregate price level. The two pre-WWI sub-samples we consider are 1875:1-1896:3 and 1896:4-1914:2, and our two interwar sub-samples are 1920:01-1933:03 and 1933:04-1941:12. The breakpoint dates we use, i.e., 1896:3 and 1933:03, represent the observations in which the aggregate price level achieved a global minimum value in the pre-WWI and interwar samples, respectively. Failure to focus on such sub-samples with clear and steady overall movement in the price level would allow the two price trends to mitigate one another; indeed, the average annual inflation rate was quite close to zero for both the full pre-WWI and interwar periods.

We feel there are a number of alternative good candidates in the 1890s for use as a breakpoint besides the one we use (e.g., 1893:4, the end of the Panic of 1893 and the observation

in which our output series achieved a global minimum value), and did not engage in an econometric search for an optimal breakpoint. As mentioned above, the key criterion we focused on is that our price level series achieves a global pre-WWI minimum in 1896:3. It is also useful to note that this breakpoint lies in the middle of the NBER-identified 1896:1-1897:2 recession.⁷

The average annual inflation rate in our first pre-WWI sub-sample was -2.2%. The deflation in the early part of this sub-sample was brought about by the return to the gold standard in 1879 at pre-Civil War parity. The continued deflation throughout the remainder of the sub-sample occurred because of a number of events that restrained the growth in the world stock of gold; see, e.g., Friedman and Schwartz (1963, Chapter 3). In contrast, in our second pre-WWI sub-sample the average annual rate of inflation was 2.6%. This inflationary movement took place in the midst of discoveries of large gold deposits in, e.g., Alaska and South Africa, and improvements in gold mining and refining methods in the 1890s, all of which unleashed the growth of the international stock of gold and permitted aggressive monetary expansion worldwide; see, e.g., Friedman and Schwartz (1963, Chapter 4). Thus, if the trend deflation in the 1875:1-1896:3 sub-sample generated expectations of deflation and the trend inflation in the 1896:4-1914:2 sub-sample generated expectations of inflation, then, according to the BM model, we would expect positive money supply shocks to have relatively stronger effects on output in our first sub-sample and the reverse to hold in our second sub-sample for the pre-WWI period.

However, there are good reasons for questioning whether the trend deflation in the 1875:1-1896:3 sub-sample generated expected deflation among economic agents. Friedman and

7. We have found that our results are robust to the use of slightly earlier and later breakpoint dates.

Schwartz (1963) and others argue, for example, that the free-silver movement may have caused expectations of inflation to be positive during a good deal of this time period. Moreover, as mentioned above, the functioning of the price-specie-flow mechanism under a credible gold standard regime arguably should have generated expectations of inflation, as agents anticipated deflationary movements in the price level to be reversed by subsequent equilibrating gold flows and responses in the stock of money. Additionally, as the price level decreased there was an increased incentive to mine gold. If the anticipated extra efforts to mine gold were thought to be successful, such beliefs led to predictions of future money supply increases, inflation, and restoration of long-run price stability. To the extent that free-silver agitation and the above mechanics of the gold standard actually induced positive expectations of inflation in this subsample, the BM model would imply monetary-shock asymmetric behavior consistent with the trend inflation case discussed above.

On the other hand, there are strong grounds for believing that the trend inflation during the 1896:4-1914:2 period was consistent with expectations of inflation. As pointed out by Friedman and Schwartz (1963, pp. 135-37), the world stock of gold virtually doubled between 1890 and 1914 and, in contrast to the 1870s, there was not a long list of countries either returning to the gold standard or replacing silver with gold in their monetary standards. This significant gold stock growth permitted worldwide sustained increases in the price levels of gold standard countries; in the U.S. this re-inflating, all else equal, led to the subsequent collapse of the free-silver movement. Moreover, the price level in 1914 was almost where it had been at the end of the expansion of 1882, and very near pre-Civil War parity. Under a credible gold standard regime, this reversal of previous deflationary impulses during to return of the price level back to

parity arguably was expected as per the price-specie-flow mechanism. Insofar as these historical events and their impact on the international functioning of the gold standard brought about positive expectations of inflation in this sub-sample, then the BM model would imply monetary-shock asymmetric behavior consistent with the trend inflation case discussed above.

With respect to our sample splitting of the interwar period, we believe that, in addition to being the observation in which the aggregate price level was at its lowest point, several economically important events argue in favor of using 1933:03 as a breakpoint. In particular, in this month the U.S. abandoned the gold standard, the trough of the Great Depression in the U.S. was reached, and the incipient rehabilitation of U.S. financial markets began. The average annual inflation rate in our first interwar sub-sample was -5.0% and in our second interwar sub-sample the average annual inflation rate was 6.1%. Accordingly, if trend deflation in the 1920:01-1933:03 sub-sample induced expectations of deflation while trend inflation generated expected inflation in the 1933:04-1941:12 sub-sample, the BM model suggests that positive monetary shocks more strongly affected output than did negative monetary shocks in the first interwar sub-sample, with the opposite holding for the second interwar sub-sample.

Given the abandonment of the gold standard and the effective establishment of a fiat currency in the U.S. in 1933:04, we believe that the trend inflation in our second interwar sub-sample indeed led to expectations of continued inflation. We have strong doubts, however, about whether the trend deflation in the 1920:01-1933:03 sub-sample generated long-term expectations of deflation. First, as stressed by Eichengreen (1992), when the gold standard was reinstated during the interwar period, the participating nations believed they were returning to an international financial system which would function as it had before WWI, such that, e.g.,

deflationary impulses by one country would not persist in the long run with a credible commitment to the gold standard and the proper functioning of the price-specie-flow mechanism. With hindsight we now know that the interwar gold standard was a dysfunctional system which imposed punishing deflation worldwide; but agents at the time did not. Accordingly, the deflation of our first interwar sub-sample arguably was expected to be reversed.

Second, while there is debate regarding the degree to which the deflation of 1929-1933 was forecastable at short horizons (see Dominguez, Fair, and Shapiro (1988), Hamilton (1992), Cecchetti (1992), and Nelson (1991)), our reading of the literature indicates that there was little expectation of long-term price deflation during 1929-1933. Indeed, as Evans and Wachtel (1993) and Hamilton (1992) convincingly demonstrate, the deflation of the time exerted little influence on agents' long-term price expectations even though the deflation process was persistent.

Moreover, the British abandonment of the gold standard in September 1931 likely led many to suspect the U.S. would soon follow and inflate thereafter. To the extent that the above considerations actually brought about positive expectations of inflation in the 1920:01-1933:03 sub-sample, the BM model would imply monetary-shock asymmetric behavior consistent with the trend inflation case discussed above.

Empirical Results

Our results for the standard model are reported in Table 1, which presents the p -values, test statistics, and degrees of freedom for Wald tests for five null hypotheses of interest: (i) the coefficients on positive monetary shocks are jointly equal to zero; (ii) the coefficients on positive

monetary shocks sum to zero; (iii) the coefficients on negative monetary shocks are jointly equal to zero; (iv) the coefficients on positive monetary shocks sum to zero; and (v) the sum of the coefficients on positive and negative monetary shocks equal one another, i.e., money supply shocks are symmetric in their effect on output. In addition, the last two columns of Table 1 show the values of sum of the estimated positive-shock and negative-shock coefficients, respectively. Similarly to Cover (1992), to be theoretically plausible both of these two sum measures should be positive.

We first discuss results for the 1875:1-1896:3 pre-WWI sub-sample. At conventional significance levels, only the positive money supply shocks are jointly significantly different from zero. However, the null that the sum of the coefficients on negative monetary shocks is zero is rejected at, e.g., the 10% significance level. Further, the p -value for the test of the money supply shock symmetry null hypothesis is extremely high. Overall, these results suggest that both positive and negative monetary shocks affect output, but they do so in a symmetric manner.

For our second pre-WWI period, 1896:4-1914:2, the results imply that both positive and negative money supply shocks have strong output effects. Indeed, in comparison to 1875:1-1896:3, the p -values for the null hypotheses that the positive/negative-shock coefficients jointly equal and sum to zero are orders of magnitude smaller. However, the effects of positive and negative monetary shocks on output are symmetric; the p -value for the symmetry null is 0.61.

So, for both pre-WWI sub-samples the standard model results suggest that positive and negative money supply shocks affect output symmetrically. In light of our arguments for why

gold standard related issues likely generated expectations of positive inflation in both of these pre-WWI periods, this set of findings is not consistent with the BM model.⁸

We believe our results for these two sub-samples may be due to the fact that, despite the observed large long-run movements in the price level (a 42% drop in 1875:1-1896:3 and a 43% increase in 1896:4-1914:2), the average annual inflation rates were not sufficiently large to generate the expected monetary shock asymmetry. To help evaluate this possibility it is useful to consider the calibration exercise of Senda (2001), who shows that his “degree of asymmetry” measure is much higher at an inflation rate of 6% (the approximate inflation rate in our 1933:04-1941:12 sub-sample, a period in which, as discussed below, we find strong evidence in favor of asymmetry) than it is at 3% (the approximate inflation rate in our 1896:4-1914:2 sub-sample).⁹ Moreover, given the objective of long-run price stability in a credible gold standard regime, the price level arguably was not expected to drift far its long-run level, such that economic agents

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8. Given how high the p -values are for the symmetry test in both cases, note that the evidence against the BM model is very strong even if one wanted to argue that economic agents expected future deflation in both of these sub-samples.
 9. In his calibration experiments, Senda (2001) sets expected inflation equal to trend inflation and only considers non-negative values of trend inflation. For two of the sub-samples we consider (1875:1-1896:3 and 1920:01-1933:03), however, we have trend deflation, such that it would appear Senda’s analysis is not applicable for these two periods. But given our argument that gold standard concerns likely generated expectations of future inflation in these deflationary sub-samples, we feel that Senda’s results provide useful insight if we assume that higher rates of deflation led to higher rates of expected inflation. Accordingly, under a credible gold standard the “degree of asymmetry” corresponding to the expected rate of inflation consistent with an inflation of -2% (the approximate inflation rate in our 1875:1-1896:3 sub-sample) would be considerably smaller than the expected rate of inflation consistent with an inflation rate of -6% (the approximate inflation rate in our 1920:01-1933:03 sub-sample).

anticipated only very weak inflation or deflation in the long run.¹⁰ Insofar as the above arguments indeed suggest relatively weak monetary shock asymmetry for the average deflation/inflation rates observed in our 1875:1-1896:3 and 1896:4-1914:2 sub-samples, our pre-WWI empirical results are consistent with the BM model.

We next discuss the standard model results for the interwar period. For the 1920:01-1933:03 interwar sub-sample, although the test of the null that the positive-shock coefficients are jointly equal to zero has a very low p -value, the test of the null that these coefficients sum to zero has a very high p -value. In contrast, for this sub-sample negative monetary shocks have statistically unambiguously strong output effects. Further, the p -value of the money supply shock symmetry null hypothesis is 0.03, suggesting monetary shock asymmetry for this period. Given our reasoning about why there were expectations of future inflation in this sub-sample, our evidence against the symmetry null hypothesis is consistent with the BM model. Additional support for this model is provided by our empirical result that the sum of the negative-shock coefficients is larger than the sum of the positive-shock coefficients in this period.

Turning to our second interwar sub-sample, 1933:03-1941:12, we once again find that the positive-shock coefficients do not sum to a value which is different from zero at conventional significance levels; the p -value is quite high at 0.51. In addition, as in our earlier interwar sub-sample, the output effects of negative monetary shocks are clearly statistically strong. Given the

10. Under a gold standard, the gold supply has endogenous responses to the price level and the money supply has endogenous responses to the gold supply. For example, if the price level were to fall below parity, there would be an increased incentive to mine gold, the gold supply would rise, the money supply would expand in response, and there would then be upward pressure on the price level. The reverse would also be the case. These endogenous responses of the gold supply and money supply could combine to create very weak long-run trends in the price level.

trend inflation and expectations of inflation that abandonment of the gold standard presumably generated during this sub-sample, the BM model implies that the output effects of positive money supply shocks were much weaker than those of negative money supply shocks, and our results are solidly consistent with this on three grounds. First, the test of the monetary shock symmetry null is strongly rejected. Second, the sum of the negative-shock coefficients is larger than the (absolute value of) the sum of the positive-shock coefficients. Third, since the positive-shock coefficients sum to a theoretically implausible negative number, we follow Cover (1992) in interpreting these results as evidence indicating that positive money supply shocks do not significantly influence output in this sub-sample; note that this is consistent with the traditional Keynesian backward L-shaped aggregate supply curve model.

Thus, for both interwar periods the standard model results suggest that positive and negative monetary shocks have asymmetric output effects. Our rejection of the money supply shock symmetry null hypothesis is consistent with the implications of the BM model, given the nature of inflationary expectations we assume was operative during the 1920:01-1933:03 and 1933:04-1941:12 sub-samples.

IV. THE INTEREST RATE SHOCK MODEL

To check the robustness of our results, we also consider a system in which we use nominal interest rate shocks as an alternative measure of monetary policy actions, along the lines of Bernanke and Blinder (1992), except that we separate out positive and negative shocks. Bernanke and Blinder use the federal funds rate in their analysis of post-WWII monetary transmission mechanisms, while we employ the commercial paper rate. We do this since we feel

that the commercial paper rate is the best pre-WWI and interwar proxy for a short-term interest rate with features similar to those exhibited by the federal funds rate in the post-WWII period. The interest rate shock, ω_t , is obtained from a regression of the nominal commercial paper rate, i_t , on its own lags and lagged values of z_t , m_t , and y_t as in equation (3):

$$i_t = \gamma_0 + \sum_{j=1}^{\lambda} \alpha_j^z z_{t-j} + \sum_{i=1}^q \gamma_i^i i_{t-i} + \sum_{i=1}^q \gamma_i^y y_{t-i} + \sum_{i=1}^q \gamma_i^m m_{t-i} + \omega_t. \quad (3)$$

where once again the pre-specified error-correction term z_t is the log of the velocity of money. From (3) the interest rate shock series are computed as $\omega_t^+ = \max[0, \omega_t]$ and $\omega_t^- = \min[0, \omega_t]$.

The output equation for this system is given by:

$$y_t = \beta_0 + \sum_{j=1}^{\lambda} \beta_j^z z_{t-j} + \sum_{i=1}^q \beta_i^y y_{t-i} + \sum_{i=0}^q (\beta_i^+ \omega_{t-i}^+ + \beta_i^- \omega_{t-i}^-) + v_t. \quad (4)$$

We note that for the conditional error-correction model given by equations (3) and (4), negative (positive) interest rate shocks represent positive (negative) money supply shocks, so that, e.g., if strict traditional Keynesian asymmetry holds, we expect $\beta_i^- = 0$ for all i and $\beta_i^+ \neq 0$ for some i under trend inflation and associated expectations of future inflation, whereas the opposite is expected for the coefficients on the monetary shock variables in equation (2). Unless indicated otherwise, below we use the term “monetary shock” to refer to both “money supply

shocks” (as in equation (2)) and “interest rate shocks” (as in equation (4)). We call the system given by equations (3) and (4) the “interest rate shock model.”¹¹

Results for the interest rate shock model are reported in Table 2, which is analogous to Table 1. In reading this table, it is useful to recall that the positive (negative) interest rate shock coefficients, i.e., the β_i^+ (β_i^-) parameters, capture the effects of negative (positive) monetary shocks. Accordingly, the entries in the last two columns should be negative to make economic sense.

With respect to the main question of monetary shock symmetry, our results for the interest rate shock model are quite consistent with those we obtain for the standard model for all periods we consider. More specifically, at conventional significance levels there is no evidence in favor of monetary shock asymmetry in either of the pre-WWI sub-samples, while the interwar sub-sample results strongly reject the symmetry null hypothesis.

As in the standard model case, however, for the interwar period we obtain theoretically implausible values for some coefficient sums. In particular, for both interwar sub-samples the sum of the negative interest rate shock coefficients is positive, implying that unexpected interest rate decreases lead, all else equal, to lower output growth. Thus, we again follow Cover (1992) to interpret these results as evidence that negative interest rate shocks do not significantly affect output in either interwar sub-sample. With such an interpretation, the apparent monetary shock

11. Karras (1996b) considers a system quite similar to equations (3) and (4), with three exceptions. First, in his panel study he uses interest rates on short-term government bonds or discount rates. Second, he includes the relative price of oil in the output equation as an aggregate supply shock measure. Third, he does not allow for any error-correction terms.

asymmetry found with the interest rate shock model for the 1920:01-1933:03 and 1933:04-1941:12 sub-samples is consistent with both the BM model under expected inflation, as well as the backward L-shaped aggregate supply curve model. Note that this is consistent with the standard model result that, for the interwar sub-samples, the effect of negative monetary shocks is larger than that of positive monetary shocks.

V. CONCLUSIONS

Our empirical results for the two pre-WWI sub-samples suggest that positive and negative monetary shocks had symmetric output effects in these two periods. In light of Senda's (2001) calibration exercise, we believe that the evidence in favor of monetary shock symmetry in our pre-WWI sub-samples may simply reflect the low degree of asymmetry likely to be generated from the low levels of trend deflation and inflation as were observed. Under this argument our pre-WWI sub-sample evidence in favor of monetary shock symmetry is consistent with the BM model.

The monetary shock asymmetry results we obtain for both interwar sub-samples are also consistent with the BM model. Thus, our analysis suggests that the BM model, which was developed to explain the monetary shock asymmetry of the trend inflationary post-WWII period, is compatible with other important periods of business cycle fluctuations.

A possible explanation for our 1920:01-1933:03 sub-sample monetary shock asymmetry evidence is the downward stickiness in the behavior of nominal wages observed during this period. The Hoover Administration, along with much of the business community at the time, felt that maintaining high wages during an economic downturn preserved purchasing power, kept

demand strong, and shortened recovery times; see Hoover (1952). O'Brien (1989) also reports that contemporary observers believed as of the mid-1920s that firms would follow a new policy of not cutting wages during the next recession or "sales decline." As discussed by O'Brien (1989, p. 20), even as the cyclical peak that began the Depression occurred in August 1929, both qualitative and quantitative evidence indicate it was not until October 1931 that any significant wage reductions took place in the manufacturing sector (the only sector for which monthly wage data are available).¹²

We speculate that our evidence of BM-type monetary shock asymmetry for the 1933:04-1941:12 sub-sample may result from several factors. A primary cause, we feel, was the shift to a fiat monetary system marked by the abandonment of the gold standard in 1933:03, which most likely had profound effects on the formation of price expectations. The absence of a nominal anchor, we surmise, at a minimum led economic decision makers to place a very small weight on future sustained decreases in the price level. The monetary regime shift, in our view and in the opinion of many others, laid the basis for subsequent systemic positive expectations of inflation in the U.S. economy.

In addition, we believe that our 1933:03-1941:12 monetary shock asymmetry results were also generated by the peculiar circumstances that prevailed institutionally and in financial markets after the Great Depression bottomed out in the U.S. in March 1933. First, it is well known that the National Industrial Recovery Act (NIRA), for a time, created industry-wide

12. A similar discussion on the role of nominal wage maintenance in the propagation of the Depression is presented in the interview with Anna Schwartz contained in Parker (2002). Moreover, some of the most recent and enlightening research on the causes of the depth and protracted length of the Great Depression focuses on the effects of sticky wages; see Chari, Kehoe, and McGrattan (2002).

cartels and institutionalized wage and price stickiness. For example, Bordo, Erceg, and Evans (2000) argue that the legislative mandates of the NIRA codes and the subsequent real wage rigidity they generated shoulder much of the blame for the sluggish recovery of the U.S. economy from the trough of the Depression; also see Cole and Ohanian (2002). In this framework participants in cartels during the June 1933 to December 1935 period may have been more likely, relative to the no-collusion case, to agree to increase prices and wages in response to the positive monetary shocks and not respond to negative money shocks. We can not think of a more direct manner by which monetary asymmetry can be, and perhaps was, induced.¹³

Second, we believe that the asymmetry of negative and positive money shocks for the 1933:04-1941:12 period may have resulted from the fact that the nominal interest rate was at or close to its binding floor of zero. For example, if negative money shocks were stronger signals to market participants that the deflationary regime that had existed was likely to continue than positive shocks were signals that it was likely to end, this would have increased the *ex ante* real interest rate more in response to negative money shocks than it was lowered in response to positive money shocks. The closer the nominal interest rate comes to its binding floor of zero, the more we would expect these effects to gain in strength. If the Federal Reserve were unwilling to drive real rates negative, then the binding floor of zero on the nominal interest rate effectively put a lower limit on downward interest rate movements. However, there was no limit

13. Moreover, the monetary shock asymmetry possibly induced by imposition of the NIRA codes may very well have lasted beyond the short period in which the codes were in place *de jure* since, even though they were declared unconstitutional, they did not abruptly end in January 1936.

on upward interest rate changes that could be produced with negative money shocks, as the recession of 1937-38 capably demonstrated.

Two of the factors discussed above, the effects of both the National Industrial Recovery Act and the fact that the nominal interest in this period was quite close to its lower bound of zero, have not been replicated in the post-WWII U.S. economic experience. As such, these two proposed sources of monetary shock asymmetry in the latter interwar period should not be considered explanations for the apparent emergence of asymmetry in the effects of positive and negative monetary shocks in the U.S. economy after 1945.

One important common feature between the latter interwar and post-WWII periods, though, has been a monetary system based on fiat money. We conjecture that, all else equal, the U.S. monetary regime shift brought about by the abandonment of the gold standard in 1933 laid the basis for the post-1945 monetary shock asymmetry reported by many researchers in the literature. Further analysis is required to examine this proposition more thoroughly.

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TABLE 1

Test Results for the Standard Model

Sample Period	Null Hypothesis				Coefficient Sums		
	$\beta_i^+ = 0, \forall i$	$\sum \beta_i^+ = 0$	$\beta_i^- = 0, \forall i$	$\sum \beta_i^- = 0$	$\sum \beta_i^+ = \sum \beta_i^-$	$\sum \beta_i^+$	$\sum \beta_i^-$
<i>Pre-World War I</i>							
1875:1-1896:3	0.01 , 10.53, 2	0.03 , 5.01, 1	0.13, 4.11, 2	0.06, 3.63, 1	0.96, 3.0×10^{-3} , 1	0.98	0.93
1896:4-1914:2	1.0×10^{-3} , 15.76, 3	8.0×10^{-5} , 15.54, 1	4.2×10^{-4} , 18.09, 3	4.3×10^{-4} , 12.38, 1	0.61, 0.26, 1	2.11	1.75
<i>Interwar</i>							
1920:01-1933:03	1.0×10^{-8} , 78.93, 8	0.86, 0.03, 1	1.0×10^{-8} , 73.73, 8	7.6×10^{-4} , 11.33, 1	0.03 , 4.83, 1	0.09	1.81
1933:04-1941:12	1.0×10^{-8} , 59.16, 9	0.51, 0.44, 1	1.0×10^{-8} , 73.52, 9	2.6×10^{-6} , 22.07, 1	8.1×10^{-5} , 15.53, 1	-0.69	8.42

Notes: For each null hypothesis, the p -value, test statistic, and degrees of freedom are presented for the Wald test of the specific null hypothesis for the system given by equations (1) and (2); for cases in which the null hypothesis is rejected at the 5% significance level, the p -value appears in bold font. Since they play an important role in the interpretation of several of the Wald tests, the last two columns reports the sums of the positive and negative monetary shock parameters.

TABLE 2
Test Results for the Interest Rate Shock Model

Sample Period	Null Hypothesis				Coefficient Sums		
	$\beta_i^+ = 0, \forall i$	$\sum \beta_i^+ = 0$	$\beta_i^- = 0, \forall i$	$\sum \beta_i^- = 0$	$\sum \beta_i^+ = \sum \beta_i^-$	$\sum \beta_i^+$	$\sum \beta_i^-$
<i>Pre-World War I</i>							
1875:1-1896:3	2.8x10 ⁻⁷ , 41.09, 6	0.99, 3.1x10 ⁻⁴ , 1	0.23, 8.09, 6	0.85, 0.04, 1	0.94, 0.01, 1	-2x10 ⁻³	-6x10 ⁻³
1896:4-1914:2	5.9x10 ⁻⁵ , 26.91, 5	0.02 , 5.78, 1	0.01 , 14.27, 5	0.31, 1.02, 1	0.49, 0.49, 1	-0.04	-0.02
<i>Interwar</i>							
1920:01-1933:03	1.0x10 ⁻⁸ , 94.80, 9	2.7x10 ⁻⁵ , 17.59, 1	1.0x10 ⁻⁶ , 44.77, 9	5.2x10 ⁻⁶ , 20.76, 1	8.0x10 ⁻⁶ , 28.69, 1	-0.10	0.17
1933:04-1941:12	1.0x10 ⁻⁸ , 59.75, 9	1.0x10 ⁻⁸ , 38.62, 1	1.0x10 ⁻⁸ , 62.87, 9	0.61, 0.26, 1	2.1x10 ⁻⁶ , 22.47, 1	-1.01	0.08

Notes: For each null hypothesis, the p -value, test statistic, and degrees of freedom are presented for the Wald test of the specific null hypothesis for the system given by equations (3) and (4); for cases in which the null hypothesis is rejected at the 5% significance level, the p -value appears in bold font. Since they play an important role in the interpretation of several of the Wald tests, the last two columns reports the sums of the positive and negative monetary shock parameters.

FIGURE 1

Time Series Plot of Pre-WWI U.S. Quarterly Wholesale Price Index: 1975:1-1914:2



FIGURE 2

Time Series Plot of U.S. Monthly Wholesale Price Index: 1920:01-1941:12

