SOURCES OF OUTPUT FLUCTUATIONS DURING THE INTERWAR PERIOD: FURTHER EVIDENCE ON THE CAUSES OF THE GREAT DEPRESSION

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Abstract—This paper decomposes output fluctuations during the 1913 to 1940 period into components resulting from aggregate supply and aggregate demand shocks. We estimate a number of structural models, all of which yield qualitatively similar results. While identification is normally achieved by assuming that aggregate demand shocks have no long-run real effects, we also estimate models that allow demand shocks to permanently affect output. Our findings support the following three conclusions: (i) there was a large negative aggregate demand shock in November 1929, immediately after the stock market crash; (ii) aggregate demand shocks are largely responsible for the decline in output through mid-1931; and (iii) beginning in mid-1931 there is an aggregate supply collapse that coincides with the onset of severe bank panics.

I. Introduction

The economic turmoil of the interwar period continues to provide a fertile ground for empirical macroeconomic research. In particular, there remain several competing theories for both the initiation and the severity of the Great Depression of the 1930s. Using a recently developed set of econometric tools, we decompose output fluctuations during the interwar period into movements that were caused by aggregate supply innovations and those that resulted from innovations to aggregate demand. The purpose of this paper is to provide a description of the data that must be accounted for by any explanation of the Great Depression that maintains that only aggregate supply disturbances can have permanent effects on the level of output. In doing this, we supply estimates of both the timing and the magnitude of supply and demand shocks during the period from mid-1913 to 1940.

While our empirical results include an examination of the periods from 1913 to 1928 and 1934 to 1940, our main interest is in studying the years of the Great Depression—1929 to 1933. As a result, it is useful to begin with a very brief summary of what we think is the current consensus description of the causes of the Depression. Any complete explanation for the Depression must address three questions: (1) Why did it start? (2) Why was it so deep? And (3), Why did it last so long? The monetary hypothesis of Friedman and Schwartz (1963) appears to be dominant in answering the first question. Tight money, beginning in 1928, bears primary responsibility for the onset of the Depression. Hamilton (1987) provides a convincing discussion of both the extent and importance of this contractionary monetary policy.

The answer to the second question—why the depression was so deep—is the most contentious. The leading candidate is the debt-deflation hypothesis suggested by Fisher in his 1933 paper, and more recently formalized by Bernanke and Gertler (1989 and 1990). The debt-deflation hypothesis is based on the notion that the nearly 30% cumulative deflation of 1930–32 was primarily responsible for the depth of the Depression. The argument proceeds as follows. Since unanticipated deflation increases the burden of nominal debt, it caused debtors to default on loans. This led to bank failures and the collapse of the financial system. But there is some debate over

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1 Clearly this summary cannot do justice to the individual theories cited. For a statement of all of the implications of any given piece of the story, the reader must go to the original sources. Furthermore, we do not mean to imply that everyone necessarily agrees with all aspects of the views we state. Recent papers by Bernanke and James (1991) and Romer (1993) provide excellent surveys of some of the current issues under debate.

2 While Temin appeared to disagree with the thrust of this argument in his original 1976 book, he no longer does. See Temin (1989).
whether the deflation was actually unanticipated (see Cecchetti (1992a), Hamilton (1992), and Nelson (1991)). If not, then theories that rely on high ex ante real interest rates, and the resulting collapse of consumption and investment, might be more relevant than the debt-deflation hypothesis.3

The reason for the Depression's length, the answer to the third question, seems to be the least controversial of the three. Bernanke's (1983) theory of the collapse of financial intermediation is the leading explanation. He argues that there was an increase in the cost of intermediation that resulted in a large number of otherwise credit-worthy borrowers being denied loans. This increase in cost was essentially a risk premium demanded by risk-averse bankers who had withstood the series of banking panics beginning in late 1930. While there are demand side effects, the story is mainly one of contraction in aggregate supply.4

Finally, Romer (1990) provides evidence that some of the blame for the contraction can be traced directly to the stock market crash of 1929. This substantiates certain aspects of Temin's (1976) original thesis that the initial contraction in output in 1929 resulted from a collapse of consumption expenditure. Romer argues that the stock market crash created immediate income uncertainty resulting in a decline in the purchase of consumer durables, for which she provides substantial empirical support.5

This paper employs two related econometric procedures, together with monthly U.S. data, to provide evidence that clarifies the relative importance of these various theories both in the timing and magnitude of their effects. First, we apply the methodology developed by Blanchard and Quah (1989). They show that, if demand disturbances are assumed to die out in the long run, then a vector autoregression can be used to separate aggregate demand innovations from aggregate supply innovations.6 In addition, we use Shapiro and Watson's (1988) modification of Blanchard and Quah. Shapiro and Watson make a further identifying assumption in order to decompose aggregate supply fluctuations into those that arise from labor supply disturbances, and those that can be traced to technology shocks.

The second procedure we use is the one suggested in Gali (1992). By assuming that neither money demand nor money supply shocks have a contemporaneous effect on output, and that contemporaneous price shocks do not enter the money supply rule, he shows how to separate aggregate demand movements into fluctuations that result from shocks to money demand, a money supply component, and a residual that he labels “IS” innovations.

All of our results support three important conclusions about the course of the Great Depression. First, there was a very large negative aggregate demand shock in November 1929, immediately following the stock market crash. Furthermore, the Gali procedure suggests that, consistent with the Romer thesis, this shock did not have monetary origins. Second, aggregate demand contraction was responsible for output declines from the peak of the business cycle in August 1929 through the middle of 1931. After this, aggregate supply declines are entirely responsible for the continued drop in output.

Table 1 summarizes our main findings by giving the fraction of the change in output due to aggregate supply, money supply, money demand, and IS shocks for three different periods (from the Gali decomposition). Regarding the initial downturn, our results are somewhere between those of Friedman and Schwartz, and Temin and Romer. We find that money supply and IS shocks are about equally (and solely) responsible for this first phase. Aggregate supply innovations, however, are primarily responsible for the continuation of the Depression in 1932, explaining about one-half

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3 Examples of these competing theories can be found in the simple IS-LM theory of Gordon and Wilcox (1981) and the classical theory in Cecchetti (1988).

4 It is worth noting that the gold standard has become increasingly prominent in discussions of the Great Depression. The main argument, due to Eichengreen (1990) and Hamilton (1988), is that the operation of the gold standard was largely responsible for the propagation of the Depression from the U.S. to other industrialized countries. The contention is that as soon as the U.S. began to deflate in 1930, the gold standard forced all countries that were running current account deficits to deflate as well. See Temin (1989) and Bernanke and James (1991) for discussions.

5 Cecchetti (1992b) argues that the stock market crash itself was caused by monetary forces, suggesting that the Temin/Romer consumption-collapse hypothesis may not be completely distinct from the Friedman and Schwartz monetary hypothesis.

6 In fact, this identification assumption appears to have originated with King, Plosser, Stock, and Watson (1992), although their paper was published later.
TABLE I.—DECOMPOSITION OF OUTPUT FLUCTUATIONS

<table>
<thead>
<tr>
<th>Category</th>
<th>Period</th>
<th>Aggregate Supply</th>
<th>Money Supply</th>
<th>Money Demand</th>
<th>IS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Downturn</td>
<td>1929:10—1931:12</td>
<td>1.7</td>
<td>59.8</td>
<td>-7.0</td>
<td>45.5</td>
</tr>
<tr>
<td>Entire Depression</td>
<td>1929:08—1933:03</td>
<td>49.1</td>
<td>29.5</td>
<td>-6.1</td>
<td>27.5</td>
</tr>
<tr>
<td>Recovery</td>
<td>1933:03—1937:05</td>
<td>88.0</td>
<td>-4.3</td>
<td>15.3</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Note: The table reports the percentage of the output decline during the Depression, or increase during the recovery, that is accounted for by the four structural innovations. The identification used is due to Gali, and is described in section IIB and estimated in section IVC. The column labelled “IS” refers to nonmonetary aggregate demand shocks.

...of the entire episode. Finally, we find that aggregate supply shocks are the main source of the recovery (with some initial help from IS—see figure 5). While we do identify the monetary expansion of 1932, our results suggest that it only prevented the depression from becoming even deeper—it did not bring about the recovery.

The remainder of the paper is divided into five sections. Section II provides a summary of the structural models we study. Section III discusses two econometric issues. Following a brief description of the data, we examine a number of unit root and structural stability tests. We then discuss the construction of both point estimates, adjusted for bias, and standard deviation bands for various quantities of interest. Section IV reports the empirical results. In addition to making comments about the Great Depression, the results allow us to draw conclusions about the likely causes of output fluctuations in both the 1920–21 recession and the 1937–38 downturn. In Section V we examine the robustness of our conclusions to a change in the identifying assumptions by allowing aggregate demand shocks to have permanent effects. This change has very little impact on our primary conclusions about the sources of output fluctuations. Section VI offers concluding remarks.

II. Modeling Output Fluctuations

The purpose of this section is to describe the structural models that we study. The discussion is divided into two parts. In the first, we present the models based solely on the Blanchard and Quah (1989), and Shapiro and Watson (1988) assumptions about long-run effects. We discuss the way in which the restrictions allow for identification. Section IIB presents the Galí (1992) model, and describes how the use of short-run restrictions allows identification of various demand side shocks.

A. The Blanchard-Quah Identification

Suppose that the economy is driven by two sets of shocks, aggregate supply and aggregate demand. We are interested in distinguishing between the two in order to study their relative importance for output fluctuations. Blanchard and Quah (1989) proposed an identifying restriction the assumption that aggregate demand shocks have no permanent effect on output. Put differently, they assume that output in the long run is determined only by aggregate supply shocks, with aggregate demand innovations resulting in purely temporary deviations around the “trend.” The Blanchard-Quah assumption is consistent with a wide class of theoretical models. For example, it nests certain equilibrium, or “real,” business cycle models since it allows aggregate supply disturbances to affect output in the short run. However, models that violate this assumption do exist, such as models that generate the “Tobin effect” of money growth on capital accumulation. It is plausible, however, that the potential permanent effects of aggregate demand disturbances on output are much less significant in size than the effects of aggregate supply shocks, and thus, as Blanchard-Quah argue, the assumption is a good (although imperfect) approximation to the real world.

It is worth noting that the essence of the long-run restrictions is to separate permanent from transitory components of output movements. An alternative to the aggregate supply—aggregate demand labels used by Blanchard and Quah is to note that in most models nominal shocks do not have long-run real effects. This would dictate that we label the permanent shocks as real and the temporary shocks as nominal. While some aspects of our interpretation may be affected by this change, the major implications of our empirical findings are not.
The Blanchard-Quah restriction is sufficient for identification if the set of aggregate supply shocks has a single element. To illustrate, consider our first model given by

\[
\begin{bmatrix}
(1 - L) y_t \\
(1 - L) p_t \\
r_t
\end{bmatrix} = A(L) \begin{bmatrix} u_t \\
v^1_t \\
v^2_t \end{bmatrix},
\]

(1)

where \( y \) is output and \( p \) is the price level, both in logs, \( r \) is the real interest rate, \( u \) is an aggregate supply shock, \( v^1 \) and \( v^2 \) are aggregate demand shocks, and \( A(L) \) is a \( 3 \times 3 \) matrix polynomial in the lag operator \( L \). All of the innovations in (1) are assumed to be i.i.d. and uncorrelated contemporaneously. The long-run effects of the three structural shocks on the variables are given by the elements of \( A(1) \):

\[
A(1) = \begin{bmatrix}
a_{ys} & a_{y1} & a_{y2} \\
a_{px} & a_{p1} & a_{p2} \\
a_{rs} & a_{r1} & a_{r2} \end{bmatrix},
\]

so that \( a_{ij} \) gives the long-run response of variable \( i \) to the shock \( j \) (and where 1 and 2 denote \( v^1 \) and \( v^2 \), respectively). The Blanchard-Quah restriction that the aggregate demand shocks have no long-run effect on output implies that \( a_{ys} = a_{y2} = 0 \). (The assumption that none of the variables permanently affects the real interest rate is implied by the inclusion of the level of the real interest rate, rather than its first difference, in (1)).

As in Shapiro and Watson (1988), the two aggregate demand shocks \( v^1 \) and \( v^2 \) cannot be separately identified, but can be thought of as linear combinations of the underlying IS and LM shocks. Nevertheless, we are able to estimate the innovations to aggregate supply and aggregate demand, from which we can draw conclusions about their relative importance for output fluctuations.

Of course, the Blanchard-Quah restriction is not sufficient if we want to identify more than one aggregate supply disturbance. In this case, additional assumptions are necessary. Consider, for example, our second specification, which uses the Shapiro and Watson (1988) identification restriction that long-run labor supply is unaffected by either demand or technological shocks. The model is now driven by four structural shocks: the labor supply shock, the technology shock, and the two aggregate demand shocks.\(^8\)

The Blanchard-Quah restriction still enables us to separate the demand from the supply shocks. But to disentangle the labor supply from the technology innovations we must impose the additional restriction that in the long-run labor supply is determined only by its own innovations. The restriction is that in the long-run, technological shocks only affect the real wage, not employment. This means that the long-run labor supply curve is vertical. This assumption seems questionable. While we do present results for the effects of labor supply and technology separately, we note that if the long-run labor supply curve has positive slope, the two shocks will represent linear combinations of the true innovations to labor supply and technology. Without some additional information we can only identify total aggregate supply disturbances by adding the two effects together.

B. The Gali Identification

The attractive feature of the Blanchard-Quah identifying restriction is that it relies on plausible and generally defensible assumptions about the long-run behavior of real variables. A disadvantage is its failure to identify separate components of the aggregate demand shock. Such an identification would be of significant value in our attempt to explain the causes of the Great Depression. For example, measuring the relative contribution of the Friedman and Schwartz (1963) monetary hypothesis and the consumption hypothesis of Temin (1976) and Romer (1990) requires that monetary shocks be explicitly identified.

Gali (1992) has proposed a method that allows identification of four structural disturbances: aggregate supply shocks, money supply shocks, money demand shocks, and IS shocks. The model

\(^8\) We refer to this as the "Shapiro-Watson model," which is not quite accurate. Our model differs from theirs in two small ways. First, they use the second difference of prices—the change in inflation—while we use the first difference. As we discuss in section III below, we believe that inflation is stationary over our sample, while it may be the difference in inflation that is stationary during the post-WWII period that Shapiro and Watson study. In addition, they include oil prices as a fifth variable. Given their interest in fluctuations from 1951 to 1987, this is clearly appropriate, but there is no equivalent justification for the interwar period.
includes four variables: output growth, nominal and real interest rates, and growth in real money balances.

The Blanchard and Quah restriction continues to suffice for identifying the aggregate supply shock. But identifying the three aggregate demand shocks requires two additional assumptions. Gali proposes assuming first that neither money demand nor money supply affect output contemporaneously. This assumption seems particularly plausible in our case, since we use monthly data. Following Blanchard and Watson (1986), Gali's second assumption is that contemporaneous prices do not enter the money supply rule. This restriction, which is more questionable than the first one, identifies a money demand function, and allows estimation of money demand and supply innovations separately.

III. Econometric Issues

In this section we discuss two econometric issues that are preliminary to the presentation of the main results of the paper. In section A we examine tests for unit roots and structural stability. This is followed in section B by a brief discussion of the estimation of the structural models.

A. Unit Roots and Structural Stability

Prior to the estimation of the three models of section II, it is useful to present two sets of test results: (1) univariate tests for unit roots at both seasonal frequencies and the zero frequency for the raw data series, and (2) tests for the structural stability of the reduced form VARs that are used in constructing the estimates of the structural models.

The stationarity tests are needed to determine both the degree of differencing and the nature of seasonal adjustment that is required prior to estimating the structural models described in section II. The purpose of this is to ensure that the error vector is covariance stationary for each of the models that we estimate and that we treat seasonality properly. While the tests have numerous well-known problems, they do provide information about the low frequency properties of the data.

The purpose of testing the structural stability of the VARs is to allay fears that the model parameters are substantially different before and during the Great Depression. If the model is not stable, it would be difficult to interpret results based on full sample estimates.

Before proceeding, it is worth providing a brief description of the data itself. (A full description, along with a list of sources, is in the appendix.) Output is measured by industrial production. For prices, we use a cost of living index. Hours is total man hours worked in twenty-five manufacturing industries surveyed by the National Industrial Conference Board. The commercial paper rate is used to measure the nominal interest rate, and money is M2 from Friedman and Schwartz (1963).

First, we examine the seasonal pattern of the data using the Beaulieu and Miron (1993) extension of the analysis of Hylleberg, Engle, Granger and Yoo (1990). They develop a testing procedure that examines whether unit roots are present at both seasonal frequencies and frequency zero.

For the sake of brevity we will simply characterize the results from the Miron-Beaulieu tests. We examined cases both with and without a time trend. The results suggest that there are no unit roots at any of the seasonal frequencies, and so we seasonally adjust the data on hours, output, prices, and money using deterministic dummy variables. Furthermore, we find that, except for the real interest rate, all of the variables contain one unit root at the zero frequency, and so they require differencing.

Next, we study Dickey-Fuller tests for the presence of a unit root at the zero frequency using the seasonally adjusted data. The results of these are reported in table A.1 of appendix A. From these we conclude that output, hours, prices, and real money are well modeled as stationary in first differences, while the real rate is likely to be stationary in levels. This all implies that the nominal interest rate is stationary in levels as well. It is interesting to note that there is evidence that inflation is stationary, implying that we need to difference the price level once at most. This is in

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9 See the survey by Campbell and Perron (1991).

10 For the methodology and the full set of results, see the table of reported statistics in section 4.1 of our working paper (Cecchetti and Karras (1992)).
contrast to most results for the post-WWII period that suggest inflation has a unit root, and so it is
the second difference of the price level that is
used in the analysis.11

In order to test for the structural stability of
the models we study, we employ a procedure
described by Christiano (1986) that is based on
Sims (1980). The method requires estimating the system:

\[ R_0(L)x_t + R_x(L)x_t d_t = \eta_t , \quad (2) \]

where \( d_t \) is a set of dummy variables that equal
one from the beginning of the second period to
the end of the sample. The test statistic is equal
to \((T - k)[\ln(\Sigma^c) - \ln(\Sigma^u)]\), where \( T \) is
the number of observations, \( k \) is the number of co-
efficients in one equation in (2) and \( \Sigma^c \) and \( \Sigma^u \)
are the covariance matrices of the errors in the
constrained system in which \( R_0(L) = 0 \), and the
unconstrained system, respectively. The test
statistic is asymptotically Chi-squared with degrees of freedom equal to the number of con-
straints—\((k/2)\) times the number of equations.

Table 2 presents results for five possible breaks:
(1) the beginning of 1929; (2) September 1929,
the month following the business cycle peak; (3)
November 1929, the month following the stock
market crash; (4) September 1931, one month
after Britain left the gold standard; and (5) April
1933, the month following both the end of the
contraction and when the U.S. left the gold stan-
dard. The results are mixed.12 There is certainly
evidence that the VARs estimated using data
beginning in 1910 shift during 1929, although it is
not overwhelming. But this is clearly not the case
for the four variable model estimated beginning
in mid-1920. This leads us to conclude that the

11 There is substantial disagreement in the literature over
the differencing required to achieve stationarity in these se-
ries. For example, Cecchetti (1992a) concludes that inflation is
likely to be stationary over the 1920 to 1940 period, while
Hamilton (1992) prefers to model the price level as a station-
ary variable. There is a similar divergence of opinion over
whether output is stationary in levels or first differences.
Cecchetti and Lam (1991) discuss this problem in a univariate
context, and conclude that for the study of fluctuations at
horizons of five to ten years, difference and trend stationary
models have very similar implications. This suggests that our
results would be robust to estimating the models in levels, but
including a trend.

12 Since the break-dates we have chosen are data depen-
dent, rejection at standard critical values may not be ap-
propriate. We view these results as suggestive rather than defini-
tive on the point.

B. Point Estimates and Standard Deviation Bands

The next step is estimation of the coefficients
in the structural models, and the implied struc-
tural innovations. From these we can calculate
estimates of the two quantities in which we are
most interested. These are the variance decom-
position, which measure the portion of the vari-
ance in output forecast errors accounted for by
each of the shocks, and the historical forecast
decompositions which allocate output movements
into the portions accounted for by each of the
shocks.13 But interpretation of these decomposi-
tions is difficult without some notion of the preci-
sion with which they are estimated. This leads us
to construct standard deviation bands using
Monte Carlo procedures. For the case of the
historical forecast error decompositions, these
Monte Carlo experiments allow us to measure
the bias in the estimates as well, and so we are
able to report bias-corrected point estimates.

In order to construct standard deviation bands
and estimates of the bias, we follow the method
described in Doan (1990), chapter 10.1. While the
procedure lacks formal statistical justification, it

\begin{table}
\centering
\begin{tabular}{|l|c|c|c|}
\hline
\textbf{Beginning of} & \textbf{\((Y, P, R)\)} & \textbf{\((H, Y, P, R)\)} & \textbf{Galí} \\
\textbf{2nd Period Model} & \textbf{Model} & \textbf{Model} & \textbf{Model} \\
\hline
1929:1 & 133.86 & 191.97 & 221.82 \\
& (0.07) & (0.57) & (0.10) \\
1929:9 & 138.04 & 203.33 & 226.05 \\
& (0.04) & (0.34) & (0.07) \\
1929:11 & 143.24 & 212.89 & 244.69 \\
& (0.02) & (0.19) & (0.01) \\
1931:9 & 126.30 & 217.08 & 237.49 \\
& (0.15) & (0.14) & (0.02) \\
1933:4 & 105.16 & 16.61 & 199.78 \\
& (0.64) & (0.47) & (0.41) \\
\hline
\textbf{Degrees of} & \textbf{111} & \textbf{196} & \textbf{196} \\
\textbf{Freedom} & & & \\
\textbf{Full Sample} & \textbf{1910:1 to} & \textbf{1920:6 to} & \textbf{1910:1 to} \\
\hline
\end{tabular}
\caption{Tests of Structural Stability \((p\)-values are in parentheses\)}
\end{table}

\begin{footnotesize}
\begin{itemize}
\item Note: Test statistics are asymptotically \(\chi^2\) with degrees of freedom equal to the value listed in each column. See the text for a description of the test.
\item Point estimates of the structural model are derived from reduced-form VARs using techniques described in Blanchard and Quah (1989) and Galí (1992). For a complete description of the procedure, see section 3.1 of our working paper, Cecchetti and Karras (1992).
\end{itemize}
\end{footnotesize}
has intuitive appeal. We begin with a sequence of Monte Carlo draws of $\Sigma$, the variance-covariance matrix of the reduced-form residuals, from an inverted-Wishart distribution, each of which is then used to generate a draw for the reduced-form coefficients. For each draw we can compute the structural model, and then values of the variance decomposition and historical forecast error decompositions follow immediately. The Monte Carlo draws yield estimates of both the mean and the standard deviation of the decompositions computed over the draws. From the means, we are able to estimate the bias in the point estimates, and construct the bias-adjusted historical forecast error decompositions.

To see how the bias adjustment is made, define $H_{yu}(t)$ as the deviation in the level of output, $y_t$, from its forecast that can be assigned to aggregate supply shocks $u$. Then the estimated bias is

$$\text{Bias} = \hat{H}_{yu}(t) - \bar{H}_{yu}(t),$$

where, $\hat{H}_{yu}(t)$ is the point estimate of $H_{yu}(t)$ constructed using the point estimates of the structural coefficients and innovations, and $\bar{H}_{yu}(t)$ is the mean of the draws. So, the bias-corrected estimate of the historical forecast error decomposition is

$$\tilde{H}_{yu}(t) = 2\hat{H}_{yu}(t) - \bar{H}_{yu}(t).$$

The estimates of the deviation bands of the bias-corrected estimates of the historical forecast error decompositions are just the standard deviations of the Monte Carlo draws computed using the mean of the draws.

While we report bias-corrected estimates of the historical forecast error decomposition where the bias appears quite large, we follow the standard practice in reporting the variance decomposition.

In theory, individual elements of a variance decomposition must lie between zero and one hundred. This is true of both the point estimate and of the mean of the Monte Carlo draws. But it need not be true of a bias-corrected estimate. In fact, as is obvious from the bias-correction, the result can be less than zero or exceed one hundred.\(^{15}\)

### IV. Empirical Results

This section presents the estimates of the models described in section II. We present three sets of results: (1) the output–price–interest rate model for 1910 to 1940; (2) the Shapiro–Watson output–hours–price–interest rate for 1920 to 1940; and (3) the Galí output–price–interest rate–money model for 1910 to 1940.

For all three models, we begin by examining the standard variance decomposition, and then present bias-adjusted estimates of the historical forecast error decompositions together with standard deviation bands. These results allow us to draw conclusions about the likely sources of movements in output at specific times.

#### A. Blanchard and Quah: 1910–1940

Table 3 presents the variance decomposition for the output–price–interest rate model described in section IIA. Since the model's two aggregate demand shocks cannot be separately identified, we report the fraction of the forecast error variance for each variable that is attributable to the sum of the two. The impact of aggregate supply is simply 100 minus the value in the table.

The estimates imply that, at a one year horizon, over one-half of the variance in output is explained by aggregate demand, and that the effect dies out slowly, remaining at 32% at a three year horizon, even though the identifying restrictions require that the infinite horizon impact be zero. While imprecise, these estimates are well within the range reported by Blanchard and Quah (1989) in their study of quarterly post-WWII data. They find that demand explains between 39% and 98% of the output forecast error.

\(^{15}\) In practice this problem is likely the result of the fact that the distributional assumptions used to generate the Monte Carlo draws are incorrect. But we know of no real alternative, and so the solution to this problem awaits further research.
at the one year horizon, and between 13% and 68% at a three year horizon.\footnote{The range of the Blanchard and Quah results, reported in their tables 2 and 2A–C, reflects differences in detrending procedures.}

The variance decomposition confirms the general belief that aggregate demand innovations are largely responsible for changes in both prices and the nominal interest rate. Even at a one month horizon, aggregate demand shocks account for over 90% of the variance in prices, and over 50% of the variance in the nominal interest rate. These increase to 98.0% and 80.8% at thirty-six months, at which point they are growing very slowly.

While the variance decomposition in table 3 provides substantial information about the importance assigned to both aggregate demand and aggregate supply shocks, it is silent on the actual effect of a given shock at a specific time. This is the purpose of calculating the historical forecast error decompositions. As described in section IIIB, these allocate output fluctuations among the various structural shocks in the model. In all of our calculations, we choose to measure forecast errors over a twenty-four month horizon, and so we are reporting estimates of the influences of shocks on the deviation of output from the level that would have been forecast from information two years earlier.

Figures 1A and 1B report the bias-adjusted historical forecast error decomposition of output fluctuations from November 1913 to December 1940, together with one standard deviation bands—the first three plus years are lost to differencing variables, including lags in the estimation, and computing the first value of the cumulative effect. We also include vertical lines indicating NBER reference cycle peaks and troughs, labelled “P” and “T.” Unlike the variance decomposition, these historical forecast error decompositions are estimated fairly precisely—the standard deviation bands are small. The results clearly illustrate that both demand and supply shocks are of substantial importance in generating output fluctuations. But closer inspection allows several interesting conclusions. First, aggregate demand contractions play a dominant role in every downturn during the period. Furthermore, the estimates confirm Romer’s (1988) claims that the 1920–22 recession would have been worse, had it not been for positive aggregate supply shocks.

The figure also provides substantial information about the period of the Great Depression. We note three findings that we believe to be robust to any analysis of this type. First, aggregate demand contraction bears primary responsibility for the downturn from November 1929 through late 1931. Second, the aggregate demand contraction began in earnest immediately following the stock market crash of 1929. This is the sharp decline traced out just to the right of the vertical line representing the August 1929 business cycle peak. The shock following the stock market crash is estimated to be \(-3.18\)—the innovations are standard normal variables, and so this is a very unlikely event. In fact, it is the second largest negative shock between 1921 and 1940. The largest is an aggregate supply innovation of \(-4.47\) in October of 1931, the month that Britain left gold and a time when the banking system was collapsing.

The third and final result concerns the importance of aggregate supply beginning in mid-1931. As figure 1 shows, negative innovations to aggregate supply bear full responsibility for the continued decline in output throughout 1932. This is consistent with Bernanke’s (1983) hypothesis that the banking panics beginning in late 1931 raised

Table 3.—Variance Decomposition, Output–Prices–Interest Rate Model (monthly, 1910 to 1940, estimated standard deviations are in parentheses)

<table>
<thead>
<tr>
<th>Horizon in Months</th>
<th>Output</th>
<th>Prices</th>
<th>Nominal Interest Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52.1</td>
<td>93.3</td>
<td>50.1</td>
</tr>
<tr>
<td>(33.5)</td>
<td>(17.4)</td>
<td>(28.8)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>55.4</td>
<td>97.8</td>
<td>58.5</td>
</tr>
<tr>
<td>(33.1)</td>
<td>(18.1)</td>
<td>(28.6)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>51.4</td>
<td>99.1</td>
<td>67.8</td>
</tr>
<tr>
<td>(31.9)</td>
<td>(17.4)</td>
<td>(27.5)</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>39.0</td>
<td>98.9</td>
<td>76.5</td>
</tr>
<tr>
<td>(30.5)</td>
<td>(18.1)</td>
<td>(27.6)</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>32.2</td>
<td>98.0</td>
<td>80.8</td>
</tr>
<tr>
<td>(29.1)</td>
<td>(18.9)</td>
<td>(27.8)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Values are the percentage of the forecast error variance explained by shocks to aggregate demand. They are computed from the estimation of (1) subject to the constraints described in the text. Numbers in parentheses are one standard deviation computed using the Monte Carlo procedure described in section III. All of the Monte Carlo results are based on 2500 draws with random numbers generated using the GAUSS \texttt{rndn} procedure with the default settings.
Figure 1A. Components of Forecast Error for Output: Aggregate Supply Output, Price and Interest Rate Model, Monthly 1910–1940 Bias Adjusted with One Std. Error Band

Figure 1B. Components of Forecast Error for Output: Aggregate Demand Output, Price and Interest Rate Model, Monthly 1910–1940 Bias Adjusted with One Std. Error Band
the cost of credit intermediation, and caused a form of credit rationing whereby small business borrowers could no longer qualify for loans.

It is worth noting that these results provide evidence concerning the likely causes of the 1937–38 downturn. This is the recession that Friedman and Schwartz (1963) believe to have been caused by the increase in the reserve requirement in May of 1937—a purely monetary aggregate demand disturbance. The plot in figure 1 suggests that the causes of this output decline can be traced in large part to negative innovations in aggregate supply. While there is a large aggregate demand contraction, it does not come until November 1937, five months after the reserve requirement increase was implemented.

In the remainder of the paper we have two goals. First, we show that these results, especially those in figure 1, are robust to changes in the specification. To this end we provide estimates of the Shapiro–Watson model. Second, we present estimates of the Gali model in an attempt to extract from the aggregate demand innovations a component that can be traced to monetary disturbances. Finally, in section V we examine the implications of altering the identifying assumptions used to construct the estimates.

**B. Shapiro–Watson: 1920–1940**

By adding an equation for hours, together with an additional identifying restriction, we obtain the output–hours–prices–interest rate model. Following Shapiro and Watson, we can separate aggregate supply innovations into two components: one that they label labor supply and the rest, which they call technology. We present this decomposition below, but reiterate that it relies on the assumption that the labor supply curve is vertical in the long run.

Table 4 presents the variance decomposition for the Shapiro–Watson model estimated over

<table>
<thead>
<tr>
<th>TABLE 4.—VARIANCE DECOMPOSITION, OUTPUT–HOURS–PRICES–INTEREST RATE MODEL</th>
<th>Horizon in Months</th>
<th>1</th>
<th>6</th>
<th>12</th>
<th>24</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source of Innovation</strong></td>
<td><strong>Fraction of Variance in Output</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>46.0</td>
<td>29.6</td>
<td>21.9</td>
<td>18.7</td>
<td>16.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24.5)</td>
<td>(22.0)</td>
<td>(20.3)</td>
<td>(19.7)</td>
<td>(18.7)</td>
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</tr>
<tr>
<td>Aggregate Demand</td>
<td>0.3</td>
<td>16.5</td>
<td>13.5</td>
<td>10.9</td>
<td>9.0</td>
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<td></td>
<td>(16.6)</td>
<td>(19.6)</td>
<td>(18.4)</td>
<td>(17.0)</td>
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<tr>
<td><strong>Fraction of Variance in Hours</strong></td>
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<td></td>
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</tr>
<tr>
<td>Technology</td>
<td>0.98</td>
<td>18.0</td>
<td>13.1</td>
<td>10.3</td>
<td>8.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(14.9)</td>
<td>(19.3)</td>
<td>(18.2)</td>
<td>(17.4)</td>
<td>(16.1)</td>
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</tr>
<tr>
<td>Aggregate Demand</td>
<td>22.2</td>
<td>24.2</td>
<td>18.8</td>
<td>14.9</td>
<td>12.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(22.8)</td>
<td>(21.9)</td>
<td>(20.3)</td>
<td>(18.5)</td>
<td>(16.3)</td>
<td></td>
</tr>
<tr>
<td><strong>Fraction of Variance in Prices</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Technology</td>
<td>0.12</td>
<td>8.66</td>
<td>14.0</td>
<td>15.2</td>
<td>13.9</td>
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</tr>
<tr>
<td></td>
<td>(5.41)</td>
<td>(10.8)</td>
<td>(13.9)</td>
<td>(15.6)</td>
<td>(15.7)</td>
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</tr>
<tr>
<td>Aggregate Demand</td>
<td>98.2</td>
<td>73.8</td>
<td>56.8</td>
<td>43.5</td>
<td>39.4</td>
<td></td>
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<td></td>
<td>(8.6)</td>
<td>(15.3)</td>
<td>(17.3)</td>
<td>(17.5)</td>
<td>(17.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Fraction of Variance in Nominal Interest Rates</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Technology</td>
<td>26.5</td>
<td>22.2</td>
<td>28.2</td>
<td>30.5</td>
<td>30.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(21.9)</td>
<td>(20.3)</td>
<td>(20.4)</td>
<td>(20.5)</td>
<td>(20.6)</td>
<td></td>
</tr>
<tr>
<td>Aggregate Demand</td>
<td>31.2</td>
<td>43.3</td>
<td>49.4</td>
<td>54.9</td>
<td>56.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24.7)</td>
<td>(25.9)</td>
<td>(25.3)</td>
<td>(25.3)</td>
<td>(25.4)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Values are the percentage of the forecast error variance explained by shocks to a particular variable. They are computed from the estimation of the four variable structural model equivalent to equation (1). Numbers in parentheses are standard deviations computed using the Monte Carlo procedure described in section III with 2500 draws.
the 1920 to 1940 sample, along with estimated standard deviations.\footnote{We are prevented from estimating the Shapiro–Watson model that includes hours for the full sample period beginning in 1910 since we have been unable to locate monthly data on hours worked prior to June 1920.} The table includes the sum of the effects of the two aggregate demand disturbances, and omits the percentage of the variance accounted for directly by the labor supply/hours innovations, which is just 100 minus the sum of the two values reported. These results are in sharp contrast to those in table 3.\footnote{They also differ from what Shapiro and Watson (1988) and Karras (forthcoming) find for the U.S. and three European countries, respectively, using quarterly post-WWII data.} In particular, aggregate demand disturbances bear only a small amount of the responsibility for both output and hours fluctuations over all horizons, even those of less than one year.

In fact, the percentage of the output forecast error variance accounted for by aggregate demand at a six month horizon is 16.5%. This is far below the 55% reported in table 3. In addition, aggregate supply disturbances, in large part in the form of labor supply shocks, now bear a much larger responsibility for real interest rate movements.

The change in the sample period is the primary reason for the difference in the variance decompositions reported in tables 3 and 4. In estimating the three variable system of section IVA, we are able to use data beginning in 1910. This period includes substantial variation in output, including six full business cycles. With data from 1920 forward, our estimation actually begins in October 1921, which means that we lose the entire 1918–19 recession and part of the recession of 1920–21. Furthermore, in the longer sample period there is a clear sense in which output moves away from some trend and then comes back several times prior to the Depression. For the shorter sample, the Depression provides virtually all of the variation in output, and the economy has not moved back to trend by December 1940. This means that in the 1920 to 1940 period the identifying assumption that demand shocks are temporary forces aggregate supply to account for a larger fraction of the variance in output.\footnote{These observations are confirmed by estimating the three variable model over the 1920 to 1940 sample yields results similar to those reported in table 4 for the Shapiro and Watson formulation. The estimates of the contribution of aggregate demand to output variation falls by one-half.}

Figures 2A and 2B graph the bias-adjusted historical forecast error decomposition of output into the aggregate demand and aggregate supply components, together with one standard deviation bands. These calculations now begin in October 1923. The results are very similar to those in figure 1, although the standard deviation bands are somewhat larger. In particular, there is an aggregate demand innovation of $-4.35$ standard deviations in November of 1929. This is the third largest drop in the sample, with larger aggregate supply drops occurring in October 1931 and in March 1933. The figure also confirms that aggregate demand declines are the major cause of the initial fall in output beginning in 1929 and continuing through mid-1931, and that, beginning in mid-1931, aggregate supply contraction is the major cause of the continued decline. Finally, these results reinforce the conclusion that aggregate demand shocks cannot fully account for the 1937–38 downturn.

Figures 3A–C plot the results of using the Shapiro–Watson identification to decompose output fluctuations into a portion due to labor supply shocks and one resulting from technological innovations. The estimates imply that the bulk of the decline in output from July 1931 to March 1933 can be accounted for by negative labor supply innovations. This very unappealing result causes us to question the relevance for our sample period of the assumption used by Shapiro and Watson to identify labor supply shocks.

While we present evidence for two specific models, we have examined numerous other specifications in order to insure the robustness of the conclusions stated above. These alternatives included using both M1 and M2 in place of the interest rate in both models, replacing the commercial paper rate with either the stock market time loan rate or a Treasury security rate, substituting the wage for hours in the Shapiro–Watson model, and changing the sample period for the estimation, including estimating the three variable model using data from 1910 to 1990. Regardless of the specification, the major results for the historical forecast error decompositions always survive: (1) there was a very large negative innovation to aggregate demand immediately following the stock market crash of October 1929, (2) aggregate demand accounts for the bulk of output fluctuations from August 1929 to mid-1931,
OUTPUT FLUCTUATIONS

FIGURE 2A.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—AGGREGATE SUPPLY HOURS, OUTPUT, PRICE AND INTEREST RATE MODEL, 1920–1940
BIAS ADJUSTED WITH ONE STD. ERROR BANDS

FIGURE 2B.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—AGGREGATE DEMAND HOURS, OUTPUT, PRICE AND INTEREST RATE MODEL, 1920–1940
BIAS ADJUSTED WITH ONE STD. ERROR BANDS
FIGURE 3A.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—LABOR SUPPLY
HOURS, OUTPUT, PRICE AND INTEREST RATE MODEL, 1920–1940
BIAS ADJUSTED WITH ONE STD. ERROR BANDS

FIGURE 3B.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—TECHNOLOGY
HOURS, OUTPUT, PRICE AND INTEREST RATE MODEL, 1920–1940
BIAS ADJUSTED WITH ONE STD. ERROR BANDS
and (3) aggregate supply contraction accounts for
the continued decline in output from mid-1931 to
early 1933.

C. IS-LM Decomposition: The Galí Model

We now move to the results implied by the
Galí estimation procedure discussed in section
IIB. Table 5 reports the variance decomposition
when the model is estimated using data on out-
put, the nominal interest rate, the real interest
rate, and real M2 from 1910 to 1940. The table
reports the impact of the three components of
aggregate demand separately—money supply
shocks, money demand shocks, and IS shocks—on
the four variables in the model. We omit the
impact of aggregate supply innovations, as this is
simply 100 minus the three values that are re-
ported.

Aggregate demand shocks now account for
roughly one-half of the output forecast error vari-
ance at horizons of less than twelve months. IS
shocks appear substantially more important than
LM shocks. For example, at a twelve month hori-
zon, 43.6% of the variance in output forecasts is
accounted for by IS innovations, 3.2% by money
supply innovations and 2.2% by money demand
innovations. It is also interesting to note that the
variance of nominal interest rate forecasts is ac-
counted for almost entirely by a combination of
money supply and IS shocks, while it is money
demand shocks that are important in accounting
for real interest rate variability. This last finding
diffs substantially from the Galí estimates de-
"rived using quarterly post-WWII data and re-
ported in his table IV (p. 725). He finds that the
nominal interest rate is substantially affected by
money supply shocks at short horizons but the
impact dies off rapidly, falling to 15% after 5
quarters. At longer horizons it is IS shocks that
dominate. Finally, Galí finds that money supply
innovations are largely responsible for real inter-
est rate fluctuations, accounting for 88% of the
forecast error variance at one quarter, falling to
58% at a 10 quarter horizon.

Figures 4A, 4B and 5A through 5D present the
bias-adjusted estimates and one standard devia-
tion bands of the historical forecast error decom-
position of output forecast errors using the Galí
framework. Figure 4 provides the aggregate sup-
ply and aggregate demand components together,
while figure 5 plots aggregate supply and the
three identifiable components of aggregate de-
mand separately.

The results in figures 4A and 4B are very
similar to those in figures 1A and 1B, although
### Table 5.—Variance Decomposition, Galí Model
(Output—nominal interest rate—real interest rate—real M2, monthly, 1910 to 1940, estimated standard deviations are in parentheses)

<table>
<thead>
<tr>
<th>Source of Innovation</th>
<th>Horizon in Months</th>
<th>Fraction of Variance in Output</th>
<th>Fraction of Variance in Nominal Interest Rate</th>
<th>Fraction of Variance in Real Interest Rates</th>
<th>Fraction of Variance in Real M2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Money Supply</td>
<td>1</td>
<td>0.00 (0.00)</td>
<td>6.53 (31.4)</td>
<td>4.47 (2.28)</td>
<td>66.6 (50.6)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.61 (2.27)</td>
<td>3.68 (31.1)</td>
<td>3.57 (2.68)</td>
<td>51.4 (42.8)</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>3.21 (4.06)</td>
<td>2.89 (28.0)</td>
<td>4.43 (3.55)</td>
<td>39.2 (35.9)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>5.47 (6.74)</td>
<td>5.77 (22.5)</td>
<td>10.0 (4.70)</td>
<td>39.1 (37.3)</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>5.62 (7.83)</td>
<td>(18.0)</td>
<td>(5.11)</td>
<td>39.2 (37.8)</td>
</tr>
<tr>
<td>Money Demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.00 (1.59)</td>
<td>33.5 (19.4)</td>
<td>48.4 (23.0)</td>
<td>14.7 (37.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.83 (2.70)</td>
<td>33.9 (19.2)</td>
<td>47.8 (19.2)</td>
<td>11.0 (36.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1 (16.3)</td>
<td>27.8 (16.3)</td>
<td>50.3 (16.3)</td>
<td>34.1 (36.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.59 (12.5)</td>
<td>18.8 (12.5)</td>
<td>46.2 (12.5)</td>
<td>30.3 (31.8)</td>
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<tr>
<td></td>
<td></td>
<td>1.52 (10.6)</td>
<td>14.1 (10.6)</td>
<td>45.3 (10.6)</td>
<td>29.4 (29.4)</td>
</tr>
<tr>
<td>IS</td>
<td></td>
<td>52.5 (29.0)</td>
<td>25.0 (17.4)</td>
<td>39.2 (17.4)</td>
<td>37.9 (20.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53.3 (29.5)</td>
<td>43.6 (18.6)</td>
<td>39.2 (18.6)</td>
<td>34.1 (19.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43.6 (28.5)</td>
<td>26.8 (19.6)</td>
<td>39.2 (19.6)</td>
<td>30.3 (16.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.0 (24.1)</td>
<td>(29.8)</td>
<td>(22.5)</td>
<td>(13.6)</td>
</tr>
</tbody>
</table>

Note: Variance decomposition computed from estimation of the Galí model. Numbers in parentheses are standard deviations computed using the Monte Carlo procedure described in section III with 2500 draws.

The estimates contain more noise and the one standard deviation bands are somewhat wider beginning in 1931. But again, the figures reveal a large aggregate demand decline following the stock market crash, with a continued decline through the middle of 1931. Beginning in mid-1931 aggregate supply begins to fall, bearing the bulk of the responsibility for the continued output contraction through 1932 and into 1933.

Figures 5A–D report the components of the output forecast error that can be accounted for by aggregate supply, money supply, money demand, and the IS component separately. Several features of these plots are worth noting. First, the decline in output from the peak in August 1929 until late 1931 is entirely due to money supply and IS shocks. Money demand and aggregate supply shocks bear responsibility for the continued decline during 1932. Furthermore, the money supply and IS components are of roughly equal magnitude in their contributions to the output decline during the entire Depression period, while their sum is approximately the same size as that attributable to aggregate supply. (Recall the results reported in table 1.) The plots also reveal that negative IS shocks are present during all of the recessions in the sample, and that, with the exception of a sharp fall during the 1920–22 recession, money demand is relatively unimportant.
OUTPUT FLUCTUATIONS

**Figure 4A.** Components of Forecast Error for Output—Aggregate Supply
Gálı Model, Monthly 1910–1940, SA
Bias Adjusted with One Std. Error Bands

**Figure 4B.** Components of Forecast Error for Output—Aggregate Demand
Gálı Model, Monthly 1910–1940, SA
Bias Adjusted with One Std. Error Bands
FIGURE 5A.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—AGGREGATE SUPPLY
GALÍ MODEL, MONTHLY 1910–1940
BIAS ADJUSTED WITH ONE STD. ERROR BANDS

FIGURE 5B.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—MONEY SUPPLY
GALÍ MODEL, MONTHLY 1910–1940
BIAS ADJUSTED WITH ONE STD. ERROR BANDS
OUTPUT FLUCTUATIONS

FIGURE 5C.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—MONEY DEMAND
Galí Model, Monthly 1910–1940
Bias Adjusted with One Std. Error Bands

FIGURE 5D.—COMPONENTS OF FORECAST ERROR FOR OUTPUT—IS
Galí Model, Monthly 1910–1940
Bias Adjusted with One Std. Error Bands
These results suggest several conclusions. First, they substantiate Romer's (1990) hypothesis that the stock market crash created an immediate decline in aggregate demand that was nonmonetary in its origin. Second, there is clearly evidence that monetary shocks, both demand and supply, contributed to the output decline beginning in late 1929 and going through mid-1932, and that the magnitude of the effects were large. Taken as a whole, these results suggest that the simplest form of the Friedman and Schwartz (1963) monetary hypothesis must be supplemented in order to explain the full extent of the contraction in the early 1930s.  

V. Robustness  

The results presented thus far all point to the same conclusions. The historical forecast error decompositions show the same pattern, and the estimates for the three variable output–price–interest rate model and for the Gali model are very precise. But the results all rely on the use of the long-run identifying restrictions suggested by Blanchard and Quah, in which only aggregate supply shocks have permanent effects.

Concentrating on the three variable model of section IIA, we examine the implication of assuming that \( a_{y2} = 0 \) and that \( a_{y1} = \rho a_{y1} > 0 \). This identification implies that the first aggregate demand shock, \( \nu_1 \), has a permanent positive impact on output that is \( \rho \) times the magnitude of the long-run impact of the aggregate supply shock. In addition, the second aggregate demand shock, \( \nu_2 \), has a purely temporary effect on output.

20 These results are also supported by a three variable model with output, prices and interest rates in which we distinguish IS from LM shocks by assuming that only IS shocks can affect the real interest rate in the long run. Estimation of this model over the 1910 to 1940 sample yields results that are very similar to those reported for the Gali model above.

21 In a recent paper, Gali and Hammour (1991) estimate the long run effects of aggregate demand fluctuations by assuming that aggregate demand shocks have no contemporaneous influence on productivity. Their findings suggest that aggregate demand and aggregate supply shocks have long-run impacts that are roughly of the same magnitude, but of opposite sign (\( \rho < 0 \)). Saint-Paul (1993) reports similar findings for 22 OECD countries. While we believe this result to be driven by incorrect associations in the data (i.e., the 1970s productivity slowdown followed by the demand expansion of the 1960s) we also consider negative values for \( \rho \).

Figures 6A and 6B report the results of the historical forecast error decompositions for the base case of \( \rho = 0 \) and for the case of \( \rho = 0.25 \).

VI. Conclusion  

This paper has used long-run restrictions to decompose output fluctuations during the interwar period into components resulting from various aggregate supply and aggregate demand shocks. We provide estimates of both the relative importance of aggregate supply and demand on average—the variance decomposition—as well as an accounting of the likely source of specific movements in output—the historical forecast error decomposition of the output forecast errors. The historical forecast error decomposition allows us to draw conclusions about the empirical importance of competing hypotheses about the causes of the length and depth of the Great Depression of the 1930s.

We present estimates of three models that all support the following conclusions. First, there was a large, negative aggregate demand shock in November 1929, immediately following the stock market crash. In addition, continued negative aggregate demand shocks are largely responsible for the decline in output through mid to late 1931. This is consistent with the Romer (1990) version of Temin's (1976) hypothesis that a consumption collapse contributed greatly to the onset of the Depression. In fact, our results are somewhere between those of Friedman and Schwartz, and Temin and Romer: we find that money supply and IS shocks are about equally (and solely) responsible for the initial downturn. Finally, beginning in mid to late 1931, there is an aggregate supply collapse, including a very large negative

22 We obtain similar results for \( \rho \) equals \(-0.50\), \(-0.25\), and \(0.50\).
OUTPUT FLUCTUATIONS

FIGURE 6A.—COMPONENTS OF FORECAST ERROR FOR OUTPUT
OUTPUT, PRICE AND INTEREST RATE MODEL, MONTHLY 1910–1940
RHO = 0

FIGURE 6B.—COMPONENTS OF FORECAST ERROR FOR OUTPUT
OUTPUT, PRICE AND INTEREST RATE MODEL, MONTHLY 1910–1940
RHO = +0.25
shock in October of 1931. The timing of the aggregate supply decline coincides with the onset of severe bank panics, suggesting an association between the permanent shocks we estimate and models in general use today. While the bulk of the credit channels emphasized by Bernanke do not have long-run real effects, we also provide evidence that our conclusions are the same when demand shocks are allowed to have permanent effects on output. Any explanation of output movements during the 1930s that employs one of these models must account for the pattern of shocks that we find. In particular, any theory primarily based on monetary policy errors must include some explanation of the aggregate supply contraction that began in 1931 and ended in 1933.

APPENDIX A

Unit Root Tests

This appendix reports results for Dickey-Fuller tests that a unit root is present in the seasonally adjusted monthly data we use. Table A.1 reports two statistics. The t-test is for the null hypothesis of a unit root versus the alternative that it is stationary. Fuller (1976) refers to these statistics as \( \hat{z}_p \) and \( \hat{z}_r \), for the case without a trend, and \( \hat{z}_p \) when a trend is included. We also report results for Dickey and Fuller's \( \Phi_p \), which is an F-test. For all of these computations we include twelve lags of the first-difference in the dependent variable.

APPENDIX B

Data

This appendix describes the data used in the paper. For the three variable model of section IIA, and the Gali model of section IIC, the sample period is from January 1910 to December 1940. For the Shaprio and Watson model of section section II B, we use data from June 1920 to December 1940. All data are seasonally unadjusted, and are available in machine readable form upon request.

Industrial Production

Prior to 1919, the data are the new series collected by Miron and Romer (1990). Beginning in January 1919, we use the Federal Reserve index of industrial production for manufacturing. Since it has wider coverage, we use the FRB index for the period when it is available.

Hours

The monthly data on hours are from the various publications of the National Industrial Conference Board. The numbers measure total manhours worked for all wage earners in twenty-five manufacturing industries. From June 1920 to December 1921, and July 1922 to December 1933, the data are from Beney (1936), table 2, pages 44 to 47. From January 1934 to December 1938 the data are from Sayre (1940), table 1, pp. 115 to 116. From January 1939 to December 1939, the data are from Sayre (1941a) p. 17. And, for 1940 the data are from Sayre (1941b) p. 144. To construct the six missing observations

---

**Table A.1.—Dickey-Fuller Tests**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>First Difference</th>
<th>Level</th>
<th>First Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( t )-test</td>
<td>F-test</td>
<td>( t )-test</td>
<td>F-test</td>
</tr>
<tr>
<td>( \hat{z}_p ) and ( \hat{z}_r )</td>
<td>( \Phi_3 )</td>
<td>( \hat{z}_p ) and ( \hat{z}_r )</td>
<td>( \Phi_3 )</td>
<td></td>
</tr>
<tr>
<td>Sample Period: 1911:06–1940:12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output ( (y) )</td>
<td>-1.89 (-3.13)</td>
<td>5.06 (-4.82)</td>
<td>-11.99 (-4.82)</td>
<td></td>
</tr>
<tr>
<td>Prices ( (p) )</td>
<td>-2.18 (-1.97)</td>
<td>2.44 (-3.51)</td>
<td>-7.01 (-3.69)</td>
<td></td>
</tr>
<tr>
<td>Real Money ( (m) )</td>
<td>-0.10 (-2.72)</td>
<td>3.98 (-4.23)</td>
<td>-9.46 (-4.26)</td>
<td></td>
</tr>
<tr>
<td>Real Interest Rates ( (r) )</td>
<td>-3.60 (-3.61)</td>
<td>6.74 (-3.61)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Period: 1921:10–1940:12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output ( (y) )</td>
<td>-2.24 (-2.34)</td>
<td>2.87 (-4.88)</td>
<td>9.33 (-4.88)</td>
<td></td>
</tr>
<tr>
<td>Prices ( (p) )</td>
<td>-1.25 (-3.12)</td>
<td>3.68 (-3.11)</td>
<td>5.09 (-3.05)</td>
<td></td>
</tr>
<tr>
<td>Hours ( (h) )</td>
<td>-1.92 (-2.34)</td>
<td>2.87 (-4.88)</td>
<td>12.52 (-4.88)</td>
<td></td>
</tr>
<tr>
<td>Real Interest Rates ( (r) )</td>
<td>-2.45 (-2.81)</td>
<td>4.52 (-2.81)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Values in parentheses are for tests that include the trend. Test are for the null hypothesis that the series contains unit root versus the alternative that it is stationary. The \( t \)-tests are based on Fuller (1976), while the F-tests are from Dickey and Fuller (1981). The critical values for \( \hat{z}_p \) and \( \hat{z}_r \) are from Fuller (1976), table 8.5.2 p. 373, and for \( \Phi_3 \) they are from Dickey and Fuller (1981) table VI, p. 1063. With the exception of the interest rate, all of the variables are in logs. Data sources are listed in the appendix.

* Significant at the 10% level.
\(^{5}\) Significant at the 5% level.
\(^{6}\) Significant at the 1% level.
from January to June 1922, we constructed an index by multiplying total production worker employment from U.S. Department of Labor (1991), p. 56 times NBER (1991) Series M08628, average hours of work per week, production workers, manufacturing.

**Prices**

The monthly consumer price series was constructed by splicing together three series. From January 1910 to January 1912, the data are NBER (1991) Series M04055, the cost of living index for Massachusetts. For the period 1913 to 1940, this series has correlation 0.988 with the level of price series described below, and a correlation of 0.728 with the growth rates. From January 1913 to December 1919 the raw data are the U.S. Department of Labor, Bureau of Labor Statistics Consumer Price Index. From January 1920 to December 1940 the raw data are the National Industrial Conference Board all-items consumers’ price index published in Sayre (1948), table 1. It does not appear that the BLS collected and published a monthly series on the prices of consumer goods during the 1920s and 1930s. The all items CPI data that are currently available for this period seem to have been created from data sampled at a lower frequency and then interpolated using some component series. The quarterly consumer price series is then constructed by taking the last observation of each quarter of the monthly series.

**Interest Rates**

The interest rate data are the sixty to ninety day commercial rate, NBER (1991) Series M13024. From January 1910 to January 1937, these are from Macaulay (1938) pp. A142–161. From February 1937 to December 1940, the data are computed by the NBER from weekly data in the Commercial and Financial Chronicle.

**Money Stock**

All data on money are from Friedman and Schwartz (1963) appendix A. Data on M2 are taken from table A-1.

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