Did Monetary Forces Cause the Great Depression? A Bayesian VAR Analysis for the U.S. Economy First Draft

Albrecht Ritschl*
Dept. of Economics, University of Zurich and CEPR
Ulrich Woitek
Dept. of Economics, University of Glasgow

April 2000

Abstract

This paper recasts Temin's (1976) question of whether monetary forces caused the Great Depression in a modern time series framework. We adopt a Bayesian estimation and forecasting algorithm to evaluate the effects of monetary policy against nonmonetary alternatives, allowing for time-varying parameters and coefficient updating. We find that the predictive power of monetary policy is very small for the early phase of the depression and breaks down almost entirely after 1931. During the propagation phase of 1930-31, monetary policy is able to forecast correctly at short time horizons put invariably predicts recovery at longer horizons. Confirming Temin (1976), we find that nonmonetary leading indicators, particularly on residential construction and equipment investment, have impressive predictive power. Already in September 1929, they forecast about two thirds of downturn correctly. Our time varying framework also permits us to examine the stability of the dynamic parameter structure of our estimates. We find that the monetary impulse responses exhibit remarkable structural instability and react clearly to changes in the monetary regime that occurred during the depression. We find this phenomenon to be discomforting in the light of the Lucas (1976) critique, as it suggests that the money/income relationship may itself have been endogenous to policy and was not in the set of deep parameters of the U.S. economy. Given the instability and poor predictive power of monetary instruments and the strong showing of leading indicators on real activity, we remain skeptical with regard to a monetary interpretation of the Great Depression in the U.S.

JEL classification: N12, E37, E47, C53

*Corresponding author: Albrecht Ritschl, Institute for Empirical Research in Economics, Economic History Section University of Zurich, Raemistrasse 64, CH-8001 Zuerich, Switzerland, email: ritschl@iew.unizh.ch.

1 Introduction

Since the work of Friedman and Schwartz (1963), monetary orthodoxy has associated the beginning of the Great Depression with restrictive monetary policies. From mid-1928 to August 1929, the Federal Reserve responded to the stock market boom with repeated interest rate hikes and a slowdown in monetary growth. Monetary policy continued to be restrictive during the depression, as The Federal Reserve interpreted bank failures such as the that of the Bank of the United States in late 1930s as the necessary purging of an unhealthy financial structure.[1] Impulses from monetary policy did not come to be expansionary until the New Deal, and when the swing finally occurred it apparently came as a surprise to economic agents (Temin and Wigmore, 1990).

The monetary paradigm has been augmented and challenged on various different grounds. Bernanke (1983, 1995) argued for financial rather than monetary channels of transmission, emphasizing the role of information asymmetries and participation constraints in debtor/creditor relations, as well as of debt deflation as in Fisher (1933). Fundamental criticism of the monetary view was presented by Temin (1976) who interpreted the evidence as a Keynesian demand slump. Temin viewed a housing recession and declining consumer spending at the end of a large boom as the fundamentals driving the economy into depression. In more recent work, Temin (1989) attempted to reconcile this perspective with the monetary and financial market paradigms.[2]

Research on price expectations during the depression has largely underscored the monetary interpretation. According to central banking theory (see e.g. Clarida et al. 1999), systematic monetary policy that follows pre-determined rules should have little real effect. Contractionary monetary policy would therefore be reflected by unpleasant deflationary surprises. Hamilton (1987, 1992) examined commodity futures prices and indeed found that investors consistently underestimated price declines during the downturn. Evans and Wachtel (1993) employed a Bayesian methodology to infer inflation expectations, only to conclude that the public's expectation of deflation remained consistently below its actual speed. The only paper we are aware of which does support the interpretation of well-anticipated inflation is by Cecchetti (1992).

In the present paper we reexamine the effectiveness of monetary policy before and during the Great Depression, employing modern time series techniques. Also, we evaluate monetary policy against the non-monetary alternatives suggested by Temin (1976). We essentially tackle the issue in a twofold way. First, we concentrate on the information set that economic agents could possess at a given point in time. In our statistical modeling framework we are unable to gather all the informal and anecdotal information available to contemporary agents.[3] We compensate for this by looking into economic and financial aggregates that we hope can map this information into the domain of quantitative analysis. If shocks to monetary policy had a major impact on the course of events, adding the monetary policy variable to this information set should enable us to predict output. We adhere to a strict Bayesian updating philosophy, allowing parameters to change as new information comes in. This methodology also enables us to overcome stationarity and small-sample problems in a smooth way. Since Perron's (1989) critique of the unit root

[1] See Wheelock 1991 on the doctrines of the Fed at the time.

[2] A supply-oriented strand of research, notably Borchardt (1979), has argued from labor time reductions and centralized wage setting in the inter-war economy to the output slump in the depression. A similar view has recently been put forward by Prescott (1999).

[3] An attempt to obtain such information through reading the contemporary business press is made by Nelson (1991).

hypothesis and Hamilton's (1989) work on regime switches, there has been widespread skepticism about the correct way of modeling economic time series in the presence of apparent structural breaks. This together with the shortness of the available time series appears to have impeded time series work on the inter-war period. In this context, Bayesian analysis seems particularly attractive, as it avoids imposing a specific time trend, allows for learning about stationarity and is thus flexible enough to accommodate both unit-root and trend-stationary time series (see Sims and Uhlig 1991).

In addition to forecasting the performance of the U.S. economy over time, we are also concerned with the conditional forecasts obtained through impulse-response functions. This now standard methodology consists in isolating the dynamic response of any given variable to a shock to another variable in the system. As the shocks to the different variables may be mutually correlated, isolating them from each other involves a prior decision that enables the researcher to assign shocks and variables to one another. Technically speaking, this consists in imposing identifying restrictions on the variance-covariance matrix of the disturbances through a suitable orthogonalization procedure, most commonly the Cholesky factorization, which we employ as well.

We also adhere to a common standard as far as the specification of our estimates and the list of variables are concerned (laid out e.g. in Bernanke and Mihov 1998, or Uhlig 1999). Our data we take from a standard source, the NBER Macrohistory database (see appendix for further details). Owing to the particularly violent swings of the U.S. economy at the time, we place emphasis on the time-dependent nature of our system. As Temin (1989) has noticed, the experience of the Great Depression may itself have generated breaks in expectations, and different monetary regimes may have prevailed. The precise theoretical nature of such regime changes continues to present a puzzle (Sargent, 1999). Thus, we take an agnostic approach here and allow for time dependence in all of our statistics, including the impulse-response functions. As expectation regimes evolved over time, so may have the dynamic effects of monetary policy. Updating the information about the U.S. economy necessarily implies updating the information about the dynamic responses to monetary shocks. The only "deep" parameters that we impose and keep unchanged concern the ordering of the variables in the Cholesky decomposition of the variance-covariance matrix.

The rest of this paper is organized as follows. Section 2 describes the basics of the model and the underlying prior assumptions. Section 3 obtains unconditional forecasts of output from the reduced form at various critical junctures and at different time intervals. Section 4 discusses the evidence on the efficacy of monetary policy from the impulse response functions. Section 5 briefly turns to an analysis of alternative nonmonetary indicators. Section 6 concludes.

2 The Basic Model Setup

In line with the VAR methodology established by Sims (e.g. 1980) and widely used nowadays, we study money-income causality in a reduced form that takes care of the dynamic lead-lag relationships among the variables in the equation:

$$\mathbf{x}_t = \mathbf{c} + \sum_{j=1}^{12} \mathbf{A}_j \mathbf{x}_{t-j} + \mathbf{u}_t, \mathbf{u}_t \sim N(\mathbf{0}, \mathbf{H}). \quad (1)$$

In this vector autoregression, $\mathbf{x}_t$ is the vector of variables at time t, to be regressed on lagged values of the same vector, where the maximum lag is of order p. The parameter matrix $\mathbf{A}_j$ (of dimension $n \times n$) contains the coefficients on the lagged variables of lag j. $\mathbf{H}$ is the variance-covariance matrix of the disturbances.

There is widespread agreement on the variables to be included in a reduced-form assessment of monetary policy. Following up on Leeper et al. (1996) and Bernanke and Mihov (1998), we include two different specifications that account for various channels of monetary and financial transmission. To account for the more traditional monetary paradigm that focused on the quantity of money, our workhouse specification includes money, output, a general price index, a wholesale price index as well as total and non-borrowed reserves held by banks. We also check for a more interest-rate oriented transmission mechanism, substituting the money aggregate with the Fed discount rate and, alternatively, short-term money market rates. For the monthly frequency which we use, the broadest output index we found was a series on manufacturing output (interpolated quarterly series on GNP would be in Balke and Gordon 1986). As a general price level, we take the CPI, while for the wholesale price index, we choose a series for manufactured goods, which excludes agricultural commodities (we do not want to attempt a monetary explanation of the agricultural crisis of the 1920s). All data come from the NBER macrohistory database (see the appendix for further details on data sources).

To attain maximum generality of our results, we allow the coefficients in the $\mathbf{A}_j$'s to be time dependent. Stacking these and the constants using the vec operator, we obtain an $(n^2p + n \times 1)$ vector

$$\mathbf{a} = \text{vec}\big(\mathbf{c} \quad \mathbf{A}_1 \quad \ldots \quad \mathbf{A}_p\big). \tag{2}$$

we assume that $\mathbf{a}_t$ follows an AR(1) process

$$\mathbf{a}_t = (1 - \pi_1)\,\bar{\mathbf{a}} + \pi_1 \mathbf{a}_{t-1} + \boldsymbol{\nu}_t, \boldsymbol{\nu}_t \sim (\mathbf{0}, \mathbf{Q}), \tag{3}$$

where π_1 is a weighting parameter and where $\bar{\mathbf{a}}$ is an assumed long-term value for $\mathbf{a}_t$. The disturbance term $\boldsymbol{\nu}_t$ is assumed to be uncorrelated with the disturbances in the original VAR, i.e.Cov$[\mathbf{u}_t, \boldsymbol{\nu}_t] = \mathbf{0}$. Together, equations (1) and (3) define a linear dynamic system, where equation (1) is the observation equation[4], (3) is the transition equation, and $\mathbf{a}_t$ is the (unobservable) state vector. In this general time-dependent formulation, the estimation problem for $\mathbf{a}$ is converted into a conditional forecasting problem for $\mathbf{a}_{t|t-1}$, given the information at time $t-1$. Under the normality and independence assumptions about the disturbances, $\mathbf{y}_{t|t-1}$ and $\mathbf{a}_{t|t-1}$ are jointly normally distributed conditional on $t-1$, and computation of $\mathbf{a}_t$ can be implemented using the Kalman filter algorithm (Harvey, 1992; Hamilton, 1994).

Prior information or prior beliefs about the system may enter at several stages. Among these is the Litterman prior, which represents the researcher's prior belief that each time series is an AR(1) process: only the first lags play a role, while higher-order lags are believed to be zero. In the particular case where $\pi_1 = 1$, the series are believed to be a random walk. Throughout, we assume the series to be near-random walks, i.e. we set $\pi_1 = .999$ (changes in the prior made little difference for the results, as promised by Uhlig 1994). To initialize the Kalman recursions, suitable specifications for $\mathbf{H}$ and $\mathbf{Q}$ have to be found. We adopt the parameter values originally proposed by Doan et al. (1984) and reproduced in Hamilton (1994) (see the appendix for details and further discussion).

[4]Equation 1 has to be reformulated folloeing eqaution (5) in the appendix.

3 Forecasting the Depression from Monetary Shocks

If monetary shocks contributed decisively to the Great Depression in its various stages, including the monetary instrument in a time series model of the critical period in question should replicate the empirical evidence in satisfactory fashion. As nonmonetary indicators appear to have consistently failed in predicting the 1929 downturn, even when VAR methods are applied (Dominguez et al., 1988; Klug and White, 1997), we concentrate our attention on standard specifications of monetary transmission mechanisms on output as the ones discussed in the preceding section. We adhere to a strict updating philosophy, which implies that we limit ourselves to out-of-sample forecasts. In this section, we will focus on forecasting the behavior of the economy in historical time at critical junctures, obtaining what has been labeled "unconditional forecasts" (Canova, 1995). In the next section, we shall turn to an analysis of the impulse response functions or "conditional forecasts".

Since the work of Friedman and Schwartz (1963), a common claim is that monetary restrictions after 1927 caused the slide of the U.S. economy into recession. The Fed reacted to the upcoming stock market boom by curtailing money supply and through repeated interest rate hikes, beginning in August, 1928 (Temin, 1989). We take an agnostic stance on whether the Fed's interest rate policies or its money supply were more effective and simply analyze both elements separately.

To see if monetary policy contributed to the onset of the Great Depression in quantitatively important fashion, we conduct two forecasting exercises for each model. First, we include all information up to September 1929 and then let our model forecast output up to late 1930. This forecast provides an idea of how the model's endogenous dynamics up to September, 1929, would have affected the US economy in 1930, had no other shocks occurred. As most of the monetary restriction occurred from the second half of 1928 on, we repeat our exercise. This time, however, we stop including additional information in August, 1928, and forecast over a two-year horizon into late 1930. This second forecasts gives us an idea of the endogenous model dynamics in the absence of any shocks after late 1928.

[Figure 1 about here]

The results in the first tow graphs of Figure 1 show very little difference between the two forecasts. In neither case, a depression of any sizeable magnitude would have occurred. The forecast from September 1929 does predict a mini recession for early 1930, but nothing similar to the downward spiral that actually occurred. If we start forecasting from 1927, the profile is entirely flat: there is no recession, nor is there the further upswing in output that occurred between mid-1928 and mid-1929.

Note that this observation appears to be robust to the change in the monetary instrument or to changes in the specification. Trying to beat this result, we experimented with numerous modifications and specifications, including a wide range of variables from stock market data and gold flows to agricultural exports, however to no avail. Given our frustrated efforts, we have little doubt left that the slide into the Great Depression caught U.S. monetary policy by surprise. The initial impulse appears to have come from other than monetary sources.

During the propagation of the Great Depression, we also find only a limited role for monetary policy. Repeating the above exercises for the late 1930, we again see that the data predict a recovery (last graph in Figure 1). Only at very short horizons could the model predict further declines in output correctly. In Figure 2 we plot rolling 3 and 6 month ahead forecasts from our money and interest models, which are being updated in monthly intervals. For the downswing of the depression, the 3 month ahead prediction of further decline appears to work well. Note that for the second phase of the depression from late 1931 on, there is a lot of new turbulence; the short term forecasts generally perform much worse than they do in the downturn. In contrast, the confidence bands for the 6 month prediction are already performing poorly during the downturn, indicating a recovery that was not to come. An analyst looking into the data would have concluded most of the time that an upswing was just around the corner.

[Figure 2 about here]

This seems consistent with the well-established observation that academic experts, advisors, and the Federal Reserve itself had it all wrong during the depression (Dominguez et al., 1988; Wheelock, 1991). We may criticize them for having done such a bad job but we cannot do much better, however hard we try.

4 The Quantitative Impact of Monetary Policy

We now turn to the quantitative effects of monetary policy on the U.S. economy before and during the Great Depression. Although monetary shocks appear to perform poorly in explaining the major turning points of the depression, it would be mistaken to conclude that money had no effects at all. To examine this question, we explore the dynamic multiplier effects of innovations to monetary policy, which are propagated through equation (1) by the coefficient matrices $\mathbf{A}_j$. As is standard in the VAR methodology, we obtain orthogonalized residuals and the impulse response functions from a Cholesky decomposition of $\mathbf{H}$, the variance-covariance matrix of the disturbances on the observation equation. The ordering of the variables is the usual one, proceeding from the exogenous monetary instrument (money or the Fed rate) to total and nonborrowed reserves, wholesale and general price indices and, finally, output.

A common procedure would be to treat the whole observation period from 1922 to 1935 as one monetary regime and accordingly obtain impulse responses using information from the whole span. However, we bear in mind Temin's (1989) warnings about changes in expectational regimes: if agents' perceptions of the effects of monetary policy changed rapidly between 1929 and 1933, imposing a time-invariant impulse-response pattern would essentially be a violation of the Lucas (1976) critique. A possible answer to this problem based on classical statistics could be to account for these regime changes through deterministic trend components, as suggested by Perron (1989), or through Markov switching models in the spirit of Hamilton (1989). This would imply fixing structural breaks and switchpoints exogenously, assuming that between any two switches the deep parameters of the system remain unchanged. The Bayesian methodology which we follow here provides a natural way of finding structural shifts endogenously, as it fully embraces time-dependency and GARCH effects on parameters. Changing parameter structures over time also translate into time dependency of the impulse response functions: as time goes on and new observations are added to the information set, the information pertaining to the conditional forecasts changes as well. We implement this by updating the impulse-response functions at our observation frequency, i.e. every month. As the Kalman recursions take time to converge from their initial conditions, we will always disregard the evidence for the first three or four years and start interpreting the results only from 1927 on.

Figure 3 graphs the evolution of the time-dependent impulse responses to the orthogonal one-standard deviation innovations in money.[5] To keep the graph readable, we plot the impulse responses only at selected fixed intervals (3, 6, and 12 months).

[Figure 3 about here]

We first look into the response of money to its own shock. As can be seen, the 1929 crash induces a structural break; money is apparently endogenous, at least to some extent. Turning to the impulse responses of wholesale and consumer prices, we find that during the two years preceding the depression, their responses have opposite signs. This is one version of the so-called price puzzle first described by Sims (1992). Prices tend to move in the wrong direction in reaction to a monetary shock. Note also that the output response to money, shown in the last chart of Figure 3, is positive and remarkably stable prior to the slump.

The advent of the depression affected the dynamic parameter structure in very marked fashion. The two price series now react strongly positively to quantity of money impulses, i.e. money and prices fall together. The same is true of output, which becomes more sensitive to money impulses as the depression deepens. If we had obtained the same result with high-powered money in the place of M1, we would be tempted to argue that evidence supports the account e.g. in Temin (1989) of an increased importance of monetary policy during the spread of the Great Depression. However, the fact that we could not replicate these results with high-powered money induces us to be cautious about such an interpretation. More research is still needed to determine whether the seeming increase in the impact of money impulses during the second phase of the depression is not an artifact generated by the endogenous components of money demand.

To account for a more demand-oriented perspective on monetary policy, as proposed e.g. in Bernanke and Blinder (1992), we again adopted an alternative specification in which money is replaced by the federal discount rate.[6] Results are plotted in Figure 4. Again, we refrain from interpreting the evidence before, say, 1926, where results may still be dominated by the Kalman filter algorithm's initial convergence. Later on, the responses again exhibit the price puzzle: the initial response in prices to a discount rate hike is positive. During the depression period, this puzzle even seems to become worse, as prices now move in the same direction as the fed discount rate even at 12-month lags. Interest rate policy was clearly ineffective in stabilizing prices; if anything it was counterproductive.

[Figure 4 about here]

Up until late 1931, interest rate policy does seem to have had the desired effects on reserves, contracting them during the stock market boom and expanding them during the recession. Note, however, the blips in either graph after the stock market crash of 1929. Apparently, the interest rate reductions of late 1929 and early 1930 failed to have an immediate effect on banks' behavior, contrary to previous experience. The converse is true for the interest rate hikes of late 1928, which apparently had a stronger than normal

[5] We employ a broader concept of money consistent with M1 in Friedman and Schwartz (1963). Attempts to employ high-powered money instead resulted in impulse responses which all had wrong signs. To make sure, we cross-checked this result with the standard RATS software package, however without obtaining any qualitative changes. We have no economic explanation to offer for this phenomenon.

[6] The modified system then has the ordering (ascending in the order of endogeneity): federal discount rate, non-borrowed reserves, total reserves, commodity prices, CPI, output.

effect on non-borrowed reserves but failed to influence total reserves. We also note that during the stock market boom, the output response to innovations in the interest rate is falling steadily: interest rate policy was less efficient than ever since 1926 in influencing output when the stock market collapsed. Only during 1930 do we see a correction; contrary to much folk wisdom, the interest rate cuts of that year did have a positive effect on output and were more effective than the increases in the two preceding years.

The salient feature of Figure 4 is again the structural shift that occurs in late 1931, when the Fed raised its discount rates several times in response to the European banking crises and Britain's departure from the gold standard. None of the impulse-response functions in the graph remains invariant to this regime change, and their subsequent behavior looks irregular. Clearly, conducting monetary policy in the chaotic conditions that prevailed after 1931 would have been a difficult task for anyone. This second phase of the depression, as Temin (1989) has termed it, exhibits all kinds of puzzles in the nominal variables concerned, while the real effects of interest policy on output seem to be erratic and on the decline.

In sum, the evidence on the effects of the Fed's discount policy seems to suggest that before the onset of the depression and in its initial phase, its effects remain within the normal bounds. Interest rate changes alone would probably have generated a mild recession in 1930 and an equally mild upswing thereafter. Furthermore, given the price puzzles in our results, the interest rate hikes before the stock market crash can only hardly be held responsible for the later deflationary collapse. Our data clearly show a second phase of the recession after late 1931. However, this period is marked by extreme lack of stability of the underlying dynamic structure. As the previous regularities faded away, no stable relation between interest rates, prices, and output was left that could have been exploited for economic policy.

5 "Real" Alternatives: Forecasting the Depression from Leading Indicators of Real Business Activity

Of course, we are slightly less agnostic about forecasting the depression than the previous sections suggested. In this section, we present an alternative based on leading indicators of investment activity. Temin (1976) had suggested that a sharp decline in residential construction led way into depression. We take this evidence on board by looking at residential building permits, another time series we found in the NBER macrohistory database. We combine this series with classical leading indicators of equipment investment as steel production and shipments of machinery to predict manufacturing output. The system we specified thus includes manufacturing output, building permits, production of steel sheets, steel ingots, machine shipments, and prices of metal products. As before in Section 3, we are interested in the performance of output forecasts before the stock market crash of October, 1929. We also leave the principal methodology unchanged, i.e. we infer the unconditional forecasts in historical time from a Bayesian VAR with time dependent coefficients and a Litterman prior. Results, shown in Figure 5, are clear-cut: a 36 month forecast produced with the information set of September, 1929, already predicts almost two thirds of the decline that actually occurred. As soon as we disregard money and the financial sector and concentrate on real indicators alone, the depression is already clearly in the data prior to the stock market crash.

[Figure 5 about here]

We also experimented with combining these series with financial and monetary information in our VARs, however with a striking result: as soon as we included financial variables in the equation, its predictive power decreased sharply. If there was information in the U.S. economy in 1929 about an imminent slump, it was in real activity. Each of the financial monetary variables we included turned out to obscure the facts. We also attempted reducing system size to just three or four series. The main results of 5 still hold if we include only building permits and machine shipments to explain output[7].

In order to see at which point the real economy started to show signs of a major downturn, we let the system stop at March and June 1929. The lower panel in 5 shows the result of this exercise. Already in March, 1929, the real data reveal signs of a major recession in the U.S. economy, almost half a year before the stock market collapsed.

Of course, this is consistent with conventional wisdom on the Great Depression. The fact that a turning point in real activity occurred in mid-1929 is mentioned in almost any major classroom text in economic history (we refer the reader to, e.g., Walton and Rockoff 1998). What is new and needs to be emphasized, though, is that the downturn in real activity was apparently more than just the onset of a normal recession,as Temin (1989) presumed it. Real data predict a severe decline in economic activity already in 1929, which means that most probably, no additional hypotheses are needed to explain why a normal recession turned into a depression.

6 Conclusion

This paper has undertaken a Bayesian VAR analysis for U.S. data to examine the question whether monetary forces caused the Great Depression. Our results confirm the skepticism that has been expressed in much of the literature since Temin (1976) raised this question. We find no evidence that monetary restriction prior to the stock market crash of 1929 produced anything beyond a very mild recession. During the subsequent spread of the depression, interest rate policy had positive output effects, while the contemporaneous decline in money circulation affected output adversely. In the second phase of the depression from late 1931 onwards, the underlying structures become unstable, and the effects of monetary policy appear to more erratic and puzzling.

The most visible feature of our results on monetary forces is their poor forecasting ability. If the Great Depression was largely driven by monetary surprises, incorporating the monetary instruments in a time series model should improve its predictive power. Except for very short time horizons, we do not obtain this. During the downturn of 1930/1, agents attempting to forecast at six month intervals from money instruments in a VAR would consistently overpredict output. We find this evidence to be difficult to reconcile with the concept of monetary surprise shocks.

This does not mean that the Great Depression was impossible to predict. We found very robust evidence that a major downturn was visible in U.S. data already in mid-1929, turning to leading indicators of business activity. Evaluating Temin's (1976) hypothesis that the depression was led by a major slump in residential construction, we combined data on residential building permits and a number of leading indicators on equipment investment with output. We found that these data predict a sharp and lasting decline in U.S. manufacturing production already from May, 1929, on. Forecasting power was

[7] We still prefer the system shown in Figure 5, as it exhibits stationary eigenvalues: the forecast reverts to the mean if only sufficient time is allowed. Smaller systems had a tendency to yield nonstationary eigenvalues, which means their forecasts would essentially predict a plane crash.

substantially reduced every time we attempted to include financial and monetary series in the equations.

At a more fundamental level, we were concerned in this paper with the stability of the parameter structures underlying monetary and financial transmission channels. To accommodate these shifts, we employed a Bayesian updating methodology that allows for time-dependent parameters and a flexible treatment of the stationarity problem in the underlying time series. We also extended the updating philosophy to our analysis of the impulse response functions, finding them to become highly unstable as the depression moved into its second phase.

In the light of the Lucas (1976) critique, we consider the instability of the parameters underlying the impulse responses of monetary policy during the Great Depression to be particularly discomforting. If these relationships were in the set of deep parameters of the U.S. economy, they should themselves be time invariant and not be endogenous to changes in the monetary regime. Given this instability and the clearly superior forecasting performance of real indicators, we are deeply skeptical about a standard monetary interpretation of the Great Depression.

References

Balke, Nathan S. and Robert J. Gordon, "Appendix B: Historical Data," in Robert J. Gordon, ed., *The American Business Cycle. Continuity and Change*, Chicago and London: University of Chicago Press, 1986, pp. 781–850.

Bernanke, B., "Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression," *American Economic Review*, 1983, *73*, 257–276.

_ , "The Macroeconomics of the Great Depression: A Comparative Approach," *Journal of Money, Credit and Banking*, 1995, *27*, 1–28.

_ **and A. Blinder**, "The Federal Funds Rate and the Channels of Monetary Transmission," *American Economic Review*, 1992, *82*, 901–921.

_ **and I. Mihov**, "Measuring Monetary Policy," *Quarterly Journal of Economics*, 1998, *113*, 869–902.

Borchardt, Knut, "Zwangslagen und Handlungsspielräume in der großen Weltwirtschaftskrise der frühen dreißiger Jahre. Zur Revision des überlieferten Geschichtsbildes," *Jahrbuch der Bayerischen Akademie der Wissenschaften*, 1979, pp. 85–132.

Canova, Fabio, "Vector Autoregressive Models: Specification, Estimation, Inference, adn Forecasting," in M.H̃ashem Pesaran and Michael R. Wickens, eds., *Handbook of Applied Econometrics. Volume I: Macroeconomics*, Oxford: Blackwell, 1995, chapter 2, pp. 73–138.

Cecchetti, S., "Prices during the Great Depression: Was the Deflation of 1930-1932 Really Unanticipated?," *American Economic Review*, 1992, *82*, 141–155.

Clarida, R., M. Gertler, and J. Galí, "The Science of Monetary Policy," *Journal of Economic Literature*, 1999, *37*, 1661–1707.

Doan, T., R. Litterman, and C. Sims, "Forecasting and Conditional Projection using Realistic Prior Distributions," *Econometric Reviews*, 1984, *3*, 1–100.

Dominguez, K., R. Fair, and M. Shapiro, "Forecasting the Depression: Harvard vs. Yale," *American Economic Review*, 1988, *78*, 595–612.

Evans, M. and P. Wachtel, "Were Price Changes During the Great Depression Anticipated?," *Journal of Monetary Economics*, 1993, *32*, 3–34.

Fisher, I., "The Debt Deflation Theory of Great Depressions," *Econometrica*, 1933, *1*, 337–357.

Friedman, Milton and Anna Schwartz, *A Monetary History of the United States, 1867-1960*, Princeton: Princeton University Press, 1963.

Hamilton, J., "Monetary Factors in the Great Depression," *Journal of Monetary Economics*, 1987, *19*, 145–169.

Hamilton, James, "Was the Deflation of the Great Depression anticipated? Evidence from the Commodity Future Market," *American Economic Review*, 1992, *82*, 157–177.

Hamilton, James D., "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle," *Econometrica*, 1989, *57*, 357–384.

_ , *Time Series Analysis*, Princeton, New Jersey: Princeton University Press, 1994.

Harvey, Andrew C., *Forecasting, Structural Time Series Models and the Kalman Filter*, Cambridge: Cambridge University Press, 1992.

Klug, Adam and Eugene N. White, "How could Irving Fisher Have Been So Wrong? Forecasting the Great Depression with Evidence from the Railroad Shippers Forecasts," 1997. Third World Congress of Cliometrics Conference Paper.

Leeper, E., C. Sims, and T. Zha, "What Does Monetary Policy Do?," *Brookings Papers on Economic Activity (series 2)*, 1996, pp. 1–63.

Lucas, Robert, "Macroeconomic Policy Evaluation: A Critique," *Journal of Monetary Economics (Supplementary Series)*, 1976, *1(2)*, 19–46.

Nelson, D., "Was the Deflation of 1929-1930 Anticipated? The Monetary Regime as Viewed by the Business Press," *Research in Economic History*, 1991, *13*, 1–65.

Perron, Pierre, "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis," *Econometrica*, 1989, *57*, 1361–1402.

Prescott, Edward, "Some Observations on the Great Depression," *Federal Reserve Bank of Minneapolis Quarterly Review*, 1999, *23*, 25–31.

Sargent, Thomas, *The Conquest of American Inflation*, Princeton: Princeton University Press, 1999.

Sims, C. and H. Uhlig, "Understanding Unit Rooters: A Helicopter Tour," *Econometrica*, 1991, *59*, 1591–1599.

Sims, Christopher A., "Macroeconomics and Reality," *Econometrica*, 1980, *48*, 1–48.

—, "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," 1992. Cowles Foundation Discussion Paper No.1011.

Temin, P. and B. Wigmore, "The End of One Big Deflation," *Explorations in Economic History*, 1990, *25*, 483–502.

Temin, Peter, *Did Monetary Forces Cause the Great Depression?*, New York: Norton, 1976.

—, *Lessons from the Great Depression*, Cambridge: MIT Press, 1989.

Uhlig, Harald, "What Macroeconomists should know about Unit Roots: A Bayesian Perspective," *Econometric Theory*, 1994, *10*, 645–671.

—, "What are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure," 1999. CEPR Discussion Paper No. 2137.

Walton, Gary M. and Hugh Rockoff, *History of the American Economy*, 8th ed., Orlando: Dryden Press, 1998.

Wheelock, D., *The Strategy and Consistency of Federal Reserve Monetary Policy, 1924-1933*, Cambridge: Cambridge University Press, 1991.

Appendix

We assume an n dimensional VAR of order $p = 12$:

$$\begin{aligned}\mathbf{x}_t &= \mathbf{c} + \sum_{j=1}^{12} \mathbf{A}_j \mathbf{x}_{t-j} + \mathbf{u}_t = \\ &= \underbrace{\begin{pmatrix}\mathbf{c} & \mathbf{A}_1 & \dots & \mathbf{A}_p\end{pmatrix}}_{\mathbf{A}} \underbrace{\begin{pmatrix}1 \\ \mathbf{x}_{t-1} \\ \vdots \\ \mathbf{x}_{t-p}\end{pmatrix}}_{\mathbf{Z}_{t-1}} + \mathbf{u}_t = \\ &= \mathbf{A}\mathbf{Z}_{t-1} + \mathbf{u}_t.\end{aligned} \tag{4}$$

Vectorizing this expression gives

$$\mathbf{x}_t = \left(\mathbf{Z}'_{t-1} \otimes \mathbf{I}_n\right) \underbrace{\mathrm{vec}\,\mathbf{A}}_{\mathbf{a}} + \mathbf{u}_t.$$

We need $\mathbf{a}$ to be time dependent, and obtain the following measurement equation:

$$\mathbf{x}_t = \left(\mathbf{Z}'_{t-1} \otimes \mathbf{I}_n\right) \mathbf{a}_{t-1} + \mathbf{u}_t. \tag{5}$$

We assume that the variance-covariance matrix of $\mathbf{u}_t$ is given by

$$\mathbf{H} = 0.9 \begin{pmatrix} \hat{\sigma}_{1,1} & \hat{\sigma}_{1,2} & \dots & \hat{\sigma}_{1,n} \\ \hat{\sigma}_{2,1} & \hat{\sigma}_{2,2} & \dots & \vdots \\ \vdots & & \ddots & \hat{\sigma}_{(n-1),n} \\ \hat{\sigma}_{n,1} & \dots & \hat{\sigma}_{n,(n-1)} & \hat{\sigma}_{n,n} \end{pmatrix},$$

Where the $\hat{\sigma}_{j,k}$ are from an OLS estimation of the VAR in equation (4). The n^2p+n equations of the transition equation system are given by

$$\mathbf{a}_t = (1-\pi_1)\,\bar{\mathbf{a}} + \pi_1 \mathbf{a}_{t-1} + \boldsymbol{\nu}_t. \tag{6}$$

We assume that the initial prior distribution for $\mathbf{a}_1$ is given by

$$\mathbf{a}_1 \sim N\left(\bar{\mathbf{a}}, \mathbf{P}_{1|0}\right).$$

The expected value $\bar{\mathbf{a}}$ is assumed to be a vector of zeros with one as elements corresponding to the own variables $x_{j,t-1}$ at lag 1 for each equation. (In addition, we could also include ones for the own variables $x_{j,t-12}$ at lag 12, since we are looking at monthly data). The matrix $\mathbf{P}_{1|0}$ is specified to be

$$\mathbf{P}_{1|0} = \begin{pmatrix} g\begin{pmatrix} \hat{\sigma}_{1,1} & 0 & \dots & 0 \\ 0 & \hat{\sigma}_{22} & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \dots & 0 & \hat{\sigma}_{n,n} \end{pmatrix} & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \mathbf{P}^1_{1|0} & & \vdots \\ \vdots & & \ddots & \mathbf{0} \\ \mathbf{0} & \dots & \mathbf{0} & \mathbf{P}^p_{1|0} \end{pmatrix},$$

where

$$\mathbf{P}^s_{1|0} = (\mathbf{B}^s \otimes \mathbf{C})\left((\text{vec}\mathbf{W})'\mathbf{I}_n\right),$$

with

$$\mathbf{B}^s = \begin{pmatrix} \frac{1}{s\hat{\sigma}_{1,1}} & 0 & \dots & 0 \\ 0 & \frac{1}{s\hat{\sigma}_{22}} & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \dots & 0 & \frac{1}{s\hat{\sigma}_{n,n}} \end{pmatrix}, \mathbf{C} = \begin{pmatrix} \gamma^2\hat{\sigma}_{1,1} & 0 & \dots & 0 \\ 0 & \gamma^2\hat{\sigma}_{2,2} & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \dots & 0 & \gamma^2\hat{\sigma}_{n,n} \end{pmatrix},$$

$$\mathbf{W} = \begin{pmatrix} 1 & w^2 & \dots & w^2 \\ w^2 & 1 & & \vdots \\ \vdots & & \ddots & w^2 \\ w^2 & \dots & w^2 & 1 \end{pmatrix}.$$

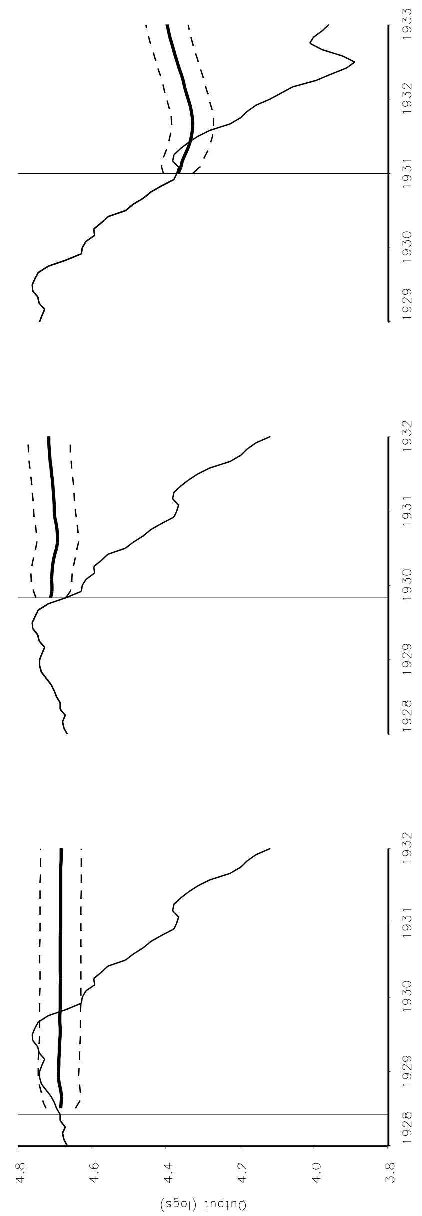
The variance of $\boldsymbol{\nu}_t$, $\mathbf{Q}$, is given by

$$\mathbf{Q} = \pi_2 \mathbf{P}_{1|0}.$$

The following assumptions are made:

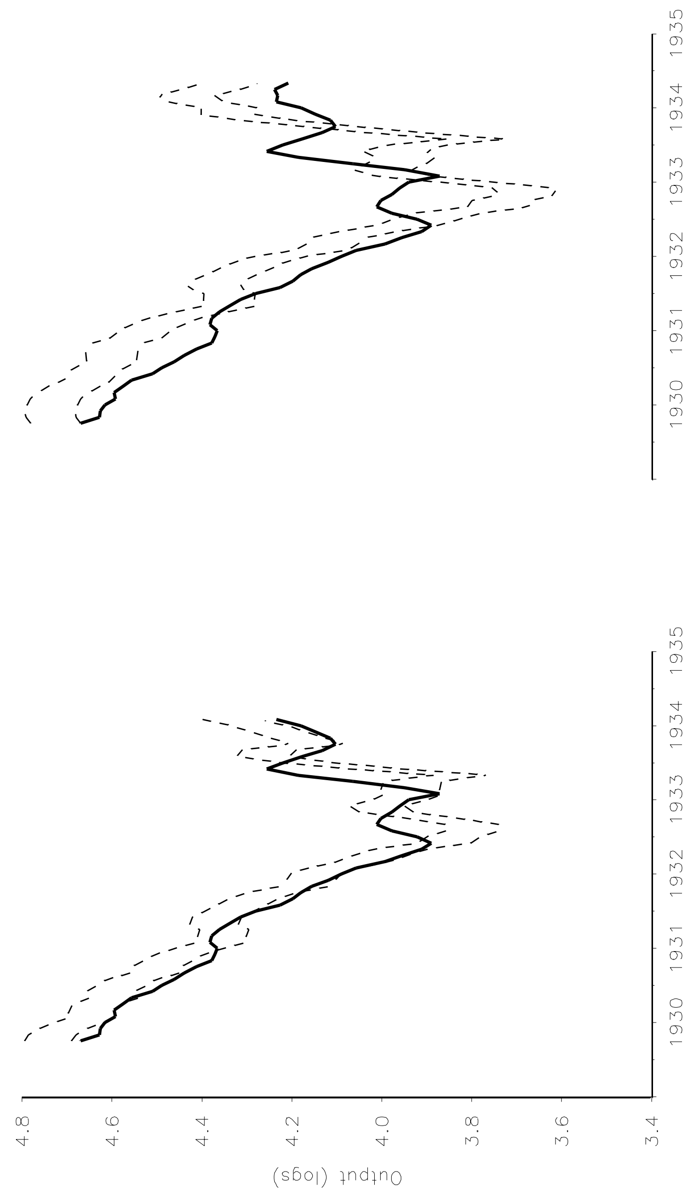
$$\gamma^2 = 0.07;\, w^2 = \frac{1}{74};\, g = 360;\, \pi_2 = 10^{-7};\, \pi_1 = 0.999.$$

Figure 1: Forecasting the Great Depression, Interest Rate Model



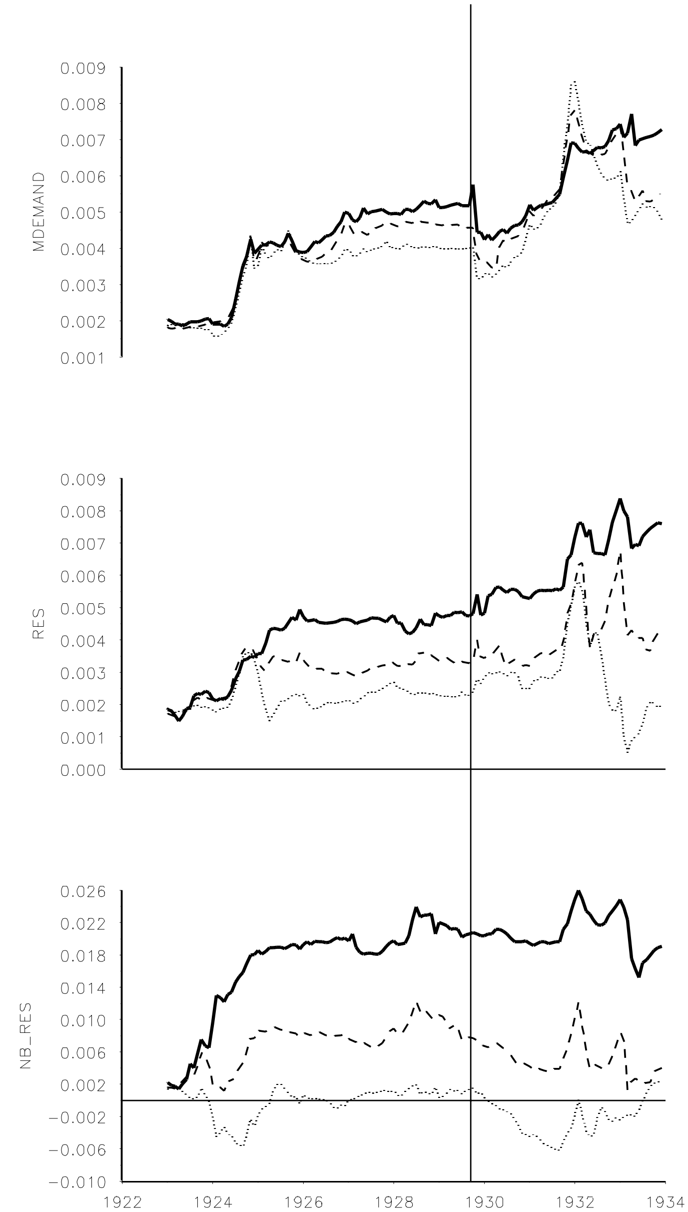
The dashed lines are 95 per cent confidence intervals.

Figure 2: Forecasting the Great Depression, 3 and 6 Months Rolling Forecasts



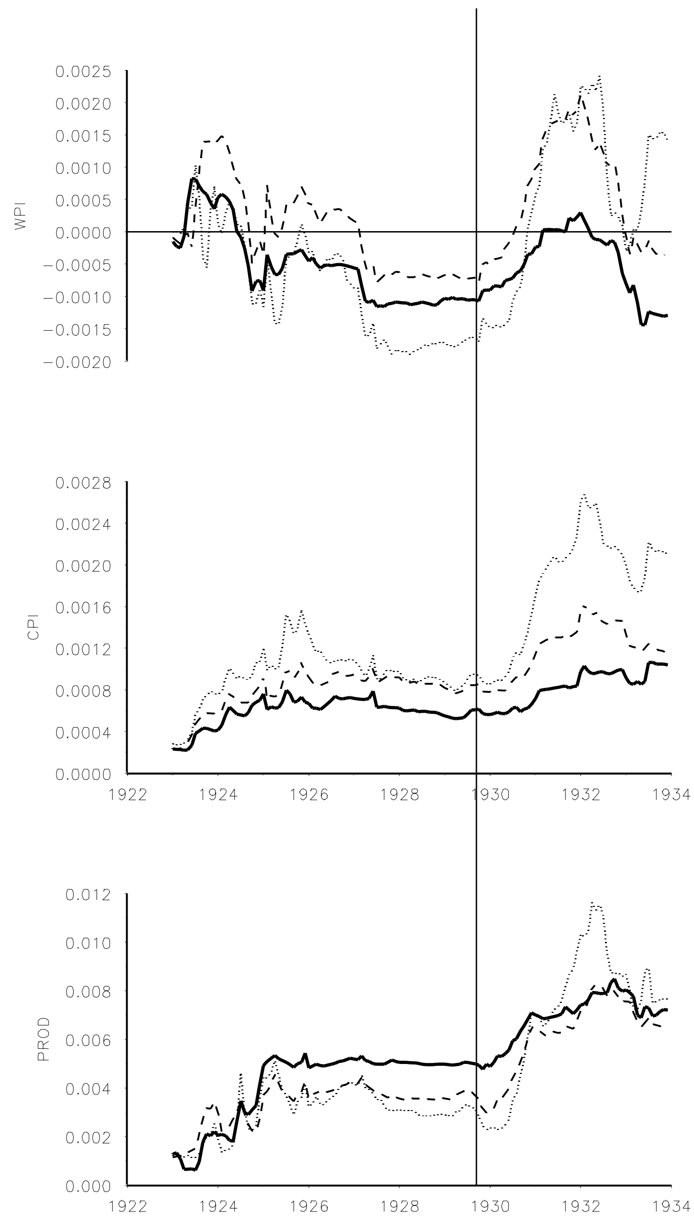
The dashed lines are 95 per cent confidence intervals, the solid line is the original series.

Figure 3: Response to Money Shock (1)



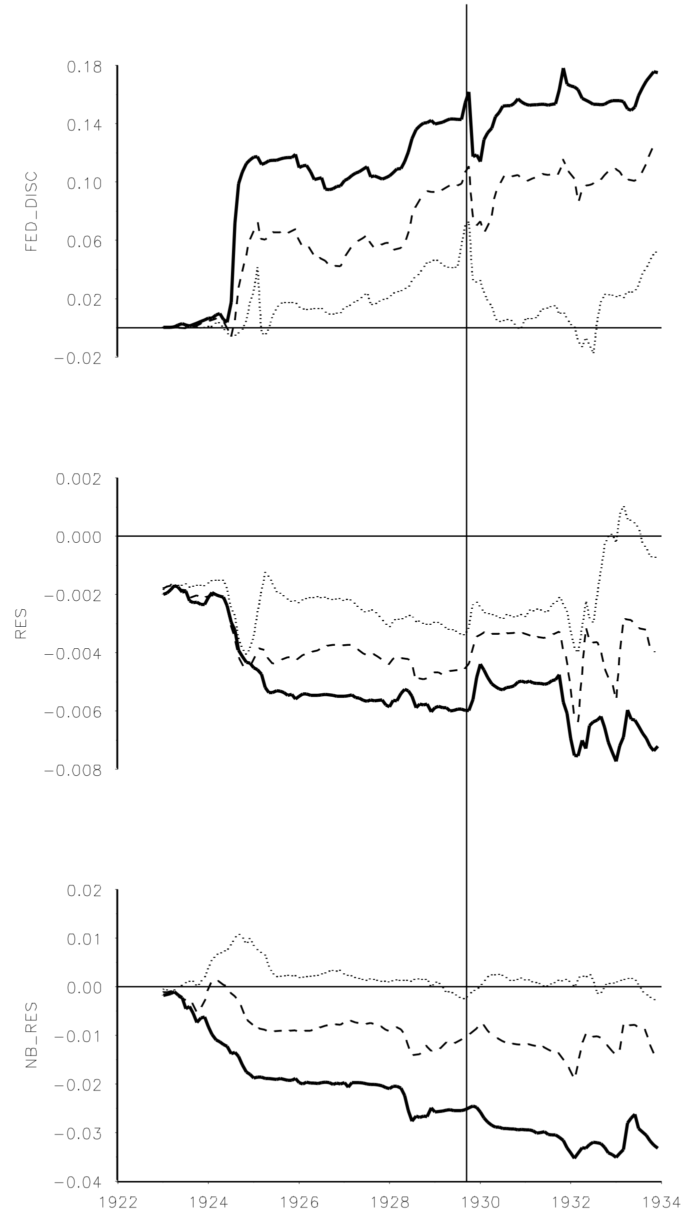
The solid line is the response after 3 months, the dashed line after 6 months, and the dotted line after 12 months.

Figure 3 (continued): Response to Money Shock (2)



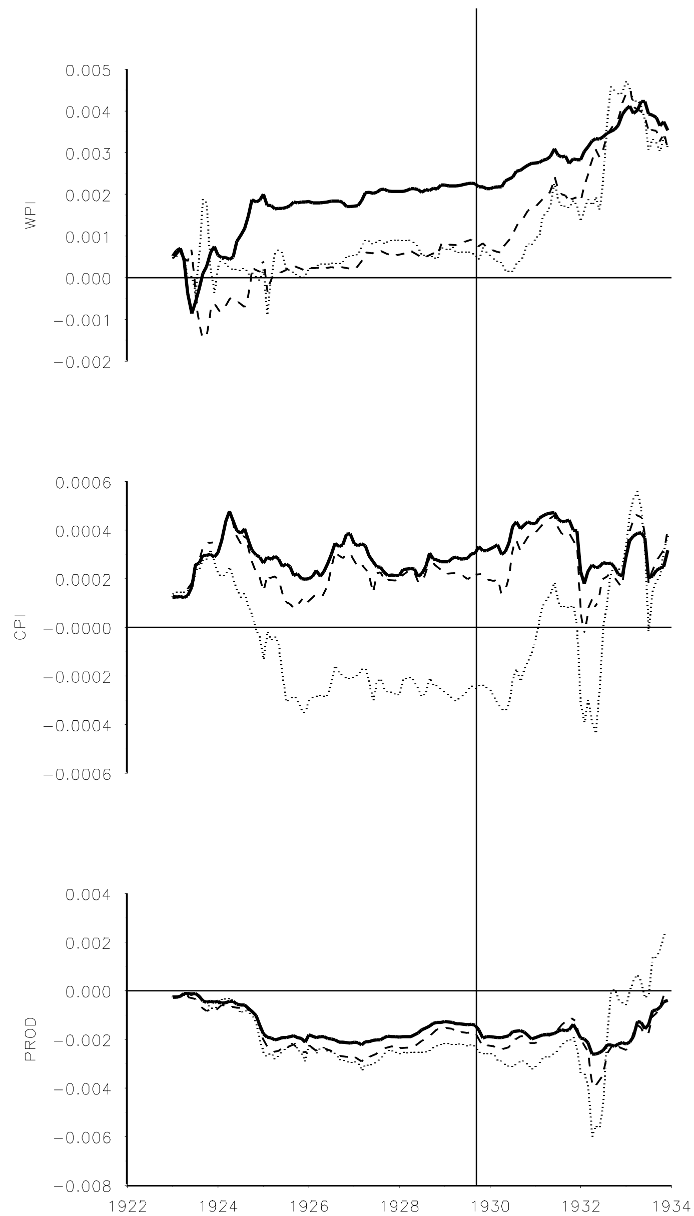
The solid line is the response after 3 months, the dashed line after 6 months, and the dotted line after 12 months.

Figure 4: Response to Discount Rate Shock (1)



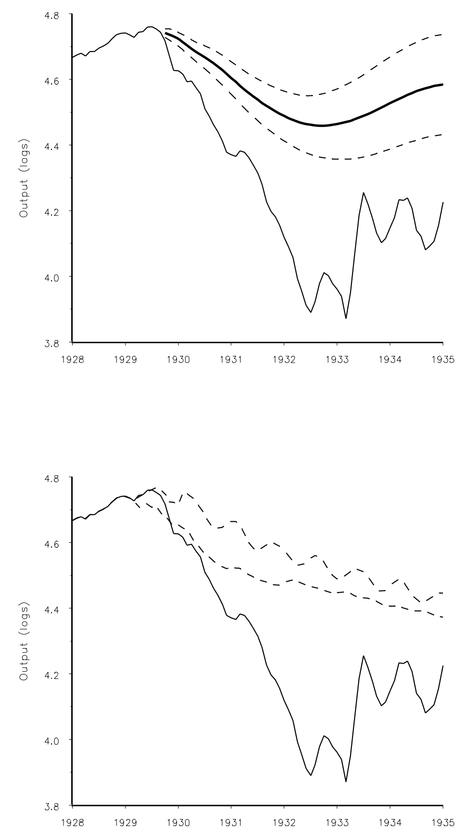
The solid line is the response after 3 months, the dashed line after 6 months, and the dotted line after 12 months.

Figure 4 (continued): Response to Discount Rate Shock (2)



The solid line is the response after 3 months, the dashed line after 6 months, and the dotted line after 12 months.

Figure 5: Forecasting the Great Depression, Leading Indicators



The dashed lines in the upper graphic are 95 per cent confidence intervals. The lower graphic contains forecasts starting in March and June 1929.