

Breitenlechner, Max; Scharler, Johann

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Decomposing the U.S. Great Depression: How important were Loan Supply Shocks?

Max Breitenlechner*

Johann Scharler[†]

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Abstract

We evaluate contributions of exogenous loan supply shocks to output dynamics during the Great Depression. Based on a structural vector autoregression, we impose sign restrictions to identify loan supply shocks in addition to standard macroeconomic shocks. Our results indicate that the banking panics that occurred in the early 1930s were associated with negative loan supply shocks, supporting the view that disruptions in financial intermediation contributed significantly to the depth and length of the Great Depression. We also find that a slump in aggregate demand is most closely linked to the initial downturn. In contrast, monetary policy shocks caused output losses only after September 1931.

Keywords: Great Depression, Loan Supply Shocks, Structural Vector Autoregression, Sign Restrictions, Historical Decomposition

JEL codes: C32, E32, E44, N12, N22

*University of Innsbruck, Department of Economics, Universitaetsstrasse 15, A-6020 Innsbruck, Austria, Phone: +43 (512) 507 71025, E-mail: max.breitenlechner@uibk.ac.at.

[†]University of Innsbruck, Department of Economics, Universitaetsstrasse 15, A-6020 Innsbruck, Austria, Phone: +43 (512) 507 7357, Fax: +43 (512) 507 7357 2980, E-mail: johann.scharler@uibk.ac.at.

1 Introduction

The Great Depression of the 1930s remains an outstanding event in economic history and a substantial amount of research has produced a number of competing theories providing possible explanations for the exceptional depth and length of the downturn. Friedman and Schwartz (1963) provide a monetary explanation stressing the large decline in the money stock and the inept response of the Federal Reserve. Temin (1976), in contrast, argues that monetary conditions were not tight during the early 1930s and that autonomous shocks to aggregate demand were responsible for the downturn. Romer (1990) suggests that persistently high uncertainty in the aftermath of the stock market crash may have led to a decline in consumption spending.

The consequences of widespread distress in the banking sector also remain controversial.¹ Friedman and Schwartz (1963) argue that bank failures affected real economic activity through the resulting decline in the money stock. In addition to these monetary effects, Bernanke (1983) emphasizes disruptions in financial intermediation and in the supply of bank loans. Romer and Romer (2013) conclude that the empirical evidence for adverse loan supply effects remains weak and that it is unclear whether such effects were pronounced enough to account for a sizable part of the decline at the aggregate level. The purpose of this paper is to address this issue. We provide a quantitative comparison of the contributions of loan supply shocks and standard macroeconomic shocks (aggregate demand, aggregate supply, and monetary policy shocks) to output dynamics during the Great Depression.

We estimate a vector autoregressive (VAR) model with monthly U.S. data ranging from 1919:1 to 1938:2. Based on historical decompositions we are able to quantify the contributions of individual shocks and to evaluate the effects associated with proposed explanations. To identify structural shocks we impose sign restrictions on the impulse response functions (see e.g. Faust, 1998; Uhlig, 2005). This approach is well suited for our purposes as it allows us to identify loan supply shocks in addition to standard macroeconomic shocks. Thus, despite our focus on loan supply shocks, we are able to analyze the contributions of multiple shocks, accounting for the non-monocausal nature of the Great Depression (Cecchetti and Karras, 1994; Fackler and Parker, 1994).

The restrictions that we impose to identify aggregate demand, aggregate supply and monetary

¹Between 1929 and 1933 about 9,000 to 10,000 of the initial 24,000 financial institutions closed down or suspended operations in the U.S. (Richardson, 2007; Romer, 1993).

policy shocks are well accepted in the literature (see e.g. Fry and Pagan, 2011; Peersman, 2005; Vargas-Silva, 2008) and are generally consistent with the dynamics implied by standard DSGE models (see e.g. Erceg et al., 2000; Smets and Wouters, 2003). In particular, we assume that output and prices move in the same direction after an aggregate demand shock and in opposite directions following an aggregate demand shock. To distinguish between aggregate demand and monetary policy shocks, we require the interest rate to increase in case of a contractionary policy shock that gives rise to lower output and prices, whereas the endogenous policy response to a negative aggregate demand shock results in lower interest rates. Several approaches have been proposed to identify loan supply shocks using sign restrictions (see e.g. Busch et al., 2010; Gambetti and Musso, 2016; Helbling et al., 2011; Hristov et al., 2012; Meeks, 2012). While the exact restrictions differ across studies, most approaches rely on the idea that a decline in the supply of loans gives rise to higher borrowing costs and a lower volumes of loans, whereas lower demand for loans reduces borrowing costs and volumes at the same time.

To our knowledge, this paper provides the first analysis of the contribution of loan supply shocks to output dynamics during the Great Depression. Nevertheless non-monetary effects of disruptions in financial intermediation and loan supply effects have been studied empirically. Bernanke (1983) shows that proxies for non-monetary effects, such as the deposits of failed banks, the liabilities of failed businesses, or dummies for periods of distress, are significantly negatively related to the growth of industrial production. In our analysis, in contrast, we focus on identified, structural loan supply shocks. Calomiris and Mason (2003) use bank-level data and apply an instrumental variable strategy to deal with endogeneity issues. They conclude that variations in loan supply had large and significant effects on income growth between 1930 and 1932 at the state and county level.² Carlson and Rose (2015) exploit data from a survey on credit availability conducted by the Federal Reserve in 1934. While they find that bank failures as well as funding constraints reduced the availability of credit, they do not provide a quantitative evaluation of the influence of these effects on the macroeconomic level.

Our analysis is also related to the literature that uses historical decompositions to study the Great Depression.³ So far, researchers have applied historical decompositions to study the role

²Ziebarth (2013) analyze the effects of banking crisis on firm level output during the Great Depression in a quasi-experimental setting. While their research design allows them to handle endogeneity problems, they do not analyze loan supply. Furthermore, using VARs Anari et al. (2005) study the impact of financial variables on aggregate output and employment and Chin and Warusawitharana (2010) assess the role of deposits in failed U.S. banks. While both studies find that their output measurements are affected by the analyzed financial and banking variables, they also do not identify exogenous changes in loan supply.

³Historical decompositions provide a time varying characterization of the contributions of shocks. This is

of monetary policy shocks (Burbidge and Harrison, 1985; Fackler and Parker, 1994), the effects of aggregate supply and demand shocks (Cecchetti and Karras, 1994), and more specifically the role of uncertainty shocks (Mathy, 2015) and oil price shocks (Mcmillin and Parker, 1994). While we evaluate loan supply shocks, we also differ in terms of identification. In contrast to these studies, which apply contemporaneous zero or long-run restrictions, we identify shocks using sign restrictions.

We find that during the early stages of the Great Depression, negative aggregate demand contributions account for the largest share of the drop in output, in line with results presented in Cecchetti and Karras (1994). Starting in late 1930, coinciding with the first banking crisis, exogenous loan supply shocks exerted increasingly negative effects on output. The loan supply effects intensified throughout the second banking crises until September 1931. The tight link between banking panics and adverse loan supply shocks provides evidence in favor of Bernanke (1983). Monetary policy shocks also contributed negatively to the dynamics of industrial production, but only after September 1931. Therefore our results indicate that after the initial downturn, non-monetary effects were particularly important for the deepening of the recession in 1931, while monetary effects as described by Friedman and Schwartz (1963) appear most relevant in explaining the extreme length of the recession.

Although industrial production starts to recover in 1933, a number of contractionary shocks slow down the upswing. First, negative effects of monetary policy shocks last until 1935. Second, simultaneously with the implementation of the first New Deal policies, we observe negative effects on output resulting from aggregate supply shocks. Therefore we can provide some evidence in favor of Christiano et al. (2003) who argues that the New Deal policies increased the market power of workers. Third, consistent with Bernanke (1983), negative loan supply effects persist until late 1935, indicating that tight credit conditions also delayed the recovery.

The paper is structured as following. In Section 2 we present our empirical model, the data and our identification approach. Section 3 shows our results and in Section 4 we illustrate our robustness checks. Section 5 provides the conclusion.

important, since most of the theories about the Great Depression apply to different time periods.

2 Empirical Approach

We estimate a structural VAR over the period from 1919:1 to 1939:2 using monthly U.S. data. For the identification of structural shocks we impose sign restrictions on the impulse response functions (see e.g. Faust, 1998; Uhlig, 2005).

2.1 Estimation and Data

The VAR in reduced form is specified as following:

$$Y_t = c + \sum_{j=1}^p A_j Y_{t-j} + e_t, \quad (1)$$

where Y_t represents the vector of endogenous variables, including the index of production of manufactures (IPM), the consumer price index (CPI), the discount rate (DR), total loans (TOLN), and the interest rate on customer loans (LR). A_j represents the coefficient matrix at lag j , c being the constant term and e_t represents the vector of white noise reduced form residuals with $E(e_t) = 0$ and $\Sigma_e = E(e_t e_t')$. In our baseline specification we use two lags according to Bayesian (Schwarz) information criteria. All variables except the discount rate and the loan rate are in log levels and are seasonally adjusted (using the X-12 ARIMA method). Total loans are deflated with the consumer price index.⁴ All time-series are obtained from the NBER Macrohistory Database, except data of the first 11 and last eight month of total loan volumes. The missing data is added from the Banking and Monetary Statistics which provides exactly the same loan data (but is only available in text format). Following Almunia et al. (2010) we use the discount rate as our preferred policy variable, as this measurement is directly managed by the Federal Reserve. Table 1 lists the exact composition and description of the data and Figure 1 shows time-series plots of all variables.

In line with the standard approach in the sign-restriction literature, we estimate the model with Bayesian methods.⁵ We refrain from specific prior assumptions and estimate the model with an uninformative prior.⁶ As we assume a Gaussian process of the data we use a Normal-Wishart distribution as prior density. Following Uhlig (1994), we obtain the posterior distribution of the

⁴The robustness of our results are evaluated in Section 4.

⁵See Moon et al. (2013) for a frequentist perspective of the sign-restriction approach.

⁶However, as we impose sign-restrictions in order to identify the structural parameters, we are only flat over the reduced form parameters and not over the structural coefficients (see Baumeister and Hamilton, 2015).

reduced form coefficients, which is again a Normal-Wishart density, with the estimates of A_j and Σ_{e_t} as location parameters. The sign restriction algorithm is implemented as suggested by Rubio-Ramrez et al. (2010). In particular we draw 3,000 models from the posterior distribution and sequentially work through each draw as following:

(i) First we orthogonalize the reduced form model, represented in Equation 1, using a Cholesky decomposition of the variance-covariance matrix. With $PP' = \Sigma_{e_t}$, where P is a lower triangular matrix, orthogonal shocks \tilde{e}_t , can be obtained by $\tilde{e}_t = P^{-1}e_t$, as then $\Sigma_{\tilde{e}_t} = \tilde{e}_t\tilde{e}_t' = P^{-1}e_te_t'P^{-1'} = I$.

(ii) As the Cholesky decomposition is only one admissible orthogonalization of the system, we derive in the second step another random orthogonalization of the reduced form VAR. Using a random orthogonal matrix Q , with the property $Q'Q = I$, we see that $\hat{e}_t = QP^{-1}e_t$ also represents orthogonal shocks, since again $\Sigma_{\hat{e}_t} = QP^{-1}e_te_t'P^{-1'}Q' = I$. Following Rubio-Ramrez et al. (2010) we obtain the matrix Q with a QR-decomposition of a symmetric matrix, which is drawn from the normal distribution.

(iii) Subsequently, we check whether the corresponding impulse responses of \hat{e}_t fulfill the imposed sign restrictions (as described in the next subsection). If yes, the orthogonal shocks reveal a structural interpretation and the impulse responses are saved as part of the sign-identified posterior distribution. If not, we derive a new Q matrix and check the impulse responses again (we check a maximum of 3,000 Q -transformations).

(iv) When the sign restrictions are fulfilled or the limit of Q -transformations is reached, the algorithm proceeded with the next model, working through steps (i) to (iv) again. The algorithm found 2,548 models satisfying the imposed sign restrictions from the initial 3,000 models drawn from the unrestricted posterior distribution.

2.2 Identification

We identify loan supply shocks using sign restrictions on the impulse response functions. The shocks are identified in addition to aggregate demand, aggregate supply and monetary policy shocks. In our baseline we impose the minimum set of restrictions that is necessary to achieve identification. In the robustness section we add additional restrictions to limit the set of admissible models (following Paustian, 2007, who argues in favor of a rather rich set of restrictions).

Table 2 summarizes our identification approach. The restrictions are imposed on impact and the first period and all shocks are normalized to be contractionary.

The restrictions in the first three rows and columns are standard in the literature to identify aggregate demand, aggregate supply and monetary policy shocks. They are commonly used (see e.g. Fry and Pagan, 2011; Peersman, 2005; Vargas-Silva, 2008) and are consistent with standard DSGE models (see e.g. Erceg et al., 2000; Smets and Wouters, 2003). In particular, it is well accepted that prices and output move in the same direction after an aggregate demand shock while after an aggregate supply shock these two variables respond with opposite signs. Furthermore, monetary policy is generally expected to respond counter-cyclical (i.e. consistent with a Taylor rule) after an aggregate demand shock, while after monetary policy shocks, output and prices respond in the opposite direction of the policy rate.

In the last row of Table 2 we present the restrictions for loan supply shocks. While sign restrictions are also frequently used in the literature to identify loan supply shocks (see e.g. Busch et al., 2010; Gambetti and Musso, 2016; Helbling et al., 2011; Hristov et al., 2012; Meeks, 2012) the imposed restrictions vary across studies. However, most studies are consistent with the idea that an exogenous change in the supply of loans results in an opposite response of loan volumes and the lending rate, i.e. the two variables respond according to a shift in the supply curve of loans.⁷ Furthermore, as we identify a contractionary loan supply shock, the response of industrial production is restricted to be negative. The restriction on the policy rate is consistent with the idea, that given monetary authorities observe a contractionary loan supply shock, they do not respond contractionary. Following Gambetti and Musso (2016) and Hristov et al. (2012) who evaluate recent DSGE models that consider structural loan supply shocks, the imposed restrictions are most consistent with theory.

The remaining two restrictions on the loan rate in relation to aggregate demand and aggregate supply shocks are required to separate both shocks from the exogenous loan supply shocks. These two restrictions can be motivated by a general decline in economic activity which decreases the demand for bank loans. According to the decline in the demand for bank loans the loan rate is expected to decline as well.

⁷As we identify changes in the supply of banks loans on the aggregate level, we cannot capture possible changes in the composition of loan supply. More precisely, if banks over-proportionally decrease the supply of loans provided to riskier borrowers, i.e. supply relatively more loans to credit-worthy borrowers, the price of loans may decrease simultaneous to an overall decline in total loans. Therefore, our identification approach may not capture the entire scope of possible loan supply shifts (see also Peersman, 2011).

3 Results

Before we present the main findings of our analysis, the historical decomposition of industrial production, we present the impulse response functions and the forecast error variance decomposition (FEVD). The aim is to provide first an overview of the basic dynamics in our model.

3.1 Impulse Response Analysis and Forecast Error Variance Decomposition

Figure 2 shows impulse response functions of all variables to the four identified macroeconomic shocks over a forecast horizon of 24 month.⁸ The solid line in the figure shows the point-wise median response at each forecast horizon and the dashed line corresponds to impulse responses of the closest to median model.⁹ The light gray and dark gray shaded areas indicate 90% and 68% of the sign-identified posterior distribution (corresponding to two and one standard deviation error bands, respectively).

The first column of Figure 2 shows responses of all variables to an aggregate demand shock. We see a clear and persistent decline of output, prices the policy rate and the loan rate. While the responses of these four variables are restricted on impact and the first period, the persistence of the responses shows that our restrictions are well supported by the data. The unrestricted response of total loans shows a relatively high degree of dispersion. However after about one year the mass of the distribution lies below zero, indicating a delayed decline of total loan volumes in response to a contractionary aggregate demand shock.

In the second column we present impulse responses arising from aggregate supply shocks. For the identification of the aggregate supply shock we restricted the responses of output, prices and the loan rate. While we see again a rather persistent decline of output, the responses of prices and the loan rate are rather short lived returning to zero relatively quickly after the restrictions terminate in period one. Although the restrictions on prices and the loan rate are necessary to identify aggregate supply shocks, these specific characteristics appear less pronounced in the data. Turning to the unrestricted variables, we see no systematic response of both the discount rate and of total loan volumes. While the mass of the distribution of the policy responses tend

⁸We do not present impulse responses of the residual shock as it holds no structural interpretation.

⁹The closest to median model, or median target model, represent one structural model which produces impulse responses that are as close as possible to the point-wise median responses. The model is selected as suggested in Fry and Pagan (2011). The point-wise median response represents the median of the restricted posterior distribution of impulse responses at each forecast horizon.

to be negative during the first 6 month, the high dispersion of the response may support the view that monetary policy did not aggressively respond to aggregate supply shocks during our observation period. Total loans tend to respond negatively but in contrast to the response arising from aggregate demand shocks, a substantial part of the distribution remains above zero.

Responses to a monetary policy shock are presented in column three. For the identification of the policy shocks we require a negative response of output and prices, while the response of the discount rate is restricted to be positive. In contrast to studies that identify monetary policy using sign restrictions with more recent U.S. data (see e.g. Vargas-Silva, 2008), we see a clear and persistent decline in output and prices. Also the positive response of the policy rate shows that with a contractionary monetary policy shock the discount rate remains at least half a year above its steady state level. The unrestricted response of total loans shows now again a relatively clear pattern. The mass of the distribution lies already below zero after about 4 month, indicating a persistent decline of total loan volumes. The unrestricted response of the loan rate shows, while again with a relatively high degree of dispersion, that interest rates of bank loans increase in response to a exogenous policy contraction.

In the final column, we see impulse responses to an exogenous loan supply shock. Concerning the restricted responses of output, the discount rate and the two loan variables, we see a persistent decline in the output measurement and in total loan volumes. In contrast, the responses of both the discount rate and the loan rate are only short lived and reveal no systematic patterns shortly after the restrictions terminate. However, this pattern is not surprising as we restrict the response of the loan rate in the opposite direction of the policy rate, although interest rates tend to move jointly over time.

Before we turn to the historical decomposition of industrial production, we provide in Table 3 the FEVD of industrial production at selected horizons.¹⁰ The FEVD shows how much the identified shocks contribute on average to the unexpected variation in industrial production when the shocks occur as well as 4, 8 and 12 month ahead.

In contrast to studies that analyze Post-World War II data from the U.S., we find that in our observation period, monetary policy represents on average the main driver for output dynamics in the U.S. (see Ramey, 2016, for an excellent summary of recent studies). Monetary policy shocks account between 20% and 30% of the forecast error variance, depending on the

¹⁰As we focus in the remaining analysis on output dynamics, we discuss only the FEVD of industrial production. For completeness, the FEVDs of all other variables in our model are provided in the Appendix in Table A.1.

forecast horizon. Remarkably, loan supply shocks explain a higher share of output dynamics as compared to aggregate demand and aggregate supply shocks. However, as these values represent average effects over the entire observation period, we now turn to the historical decomposition of industrial production to obtain a more detailed picture of the Great Depression.

3.2 A Historical Decomposition of Industrial Production

In this section we discuss historical decompositions of industrial production to show the economic relevance and timing of each of the four shocks from 1927:1 to 1938:1. Figure 3 shows the historical decomposition of industrial production, which, in contrast to the FEVD, shows the effects of the individual shocks at different points in time. In Panel A we show the contributions of the four identified shocks together with the log of industrial production.¹¹ The values correspond to the point-wise median values of the sign-identified posterior distribution. For an easier comparison across shocks, we present the values in Panel B as a share of the absolute sum of all effects in each period. The vertical lines indicate peaks and troughs in the U.S. business cycle following the NBER dating and the dashed lines show the stock market crash in October 1929 and Great Britain's exit from the gold standard in September 1931.

Overall, we see in Panel A of Figure 3 that our model captures the dynamics of industrial production quite accurately. Each of the turning points in the U.S. business cycle correspond with a peak or trough in the historical decomposition. While in general a relatively high share of the output dynamics can be attributed to the four identified shocks, particularly around 1932 and after 1935, the four identified shocks capture only about half of the dynamics in output. However, our model supports the view that most of the dynamics in output during the Great Depression, were driven by unexpected events.

In Panel A we see that starting with the expansion phase that preceded the Great Depression, aggregate demand shocks strongly contributed to the pronounced increase of industrial production in 1928 and 1929. While exerting negative effects until early 1928, aggregate supply shocks also contributed positively in 1928 and 1929, albeit to a somewhat lesser extent than aggregate demand. From Panel B we see that averaged over the year prior to the stock market crash, aggregate demand shocks account for roughly 45% of the overall effects on output while aggregate supply shocks account for about 30%. The relatively high share of aggregate supply

¹¹In the Appendix we also present the historical decomposition of industrial production for the entire observation period (1919:1–1939:2) including the residual shock (see Figure A.1).

effects potentially captures the deflationary dynamics which were already present before the business cycle peak in August 1929. According to the time series plot in Figure 1, the price index declined throughout 1928. Turning back to Panel A of Figure 3, we see that monetary policy was unusually expansionary and contributed positively to the expansion until mid 1928. At that time monetary policy was tightened, which is consistent with the view that the Federal Reserve switched to a contractionary policy to curb stock market speculation (see e.g. Friedman and Schwartz, 1963; Romer, 1993, also Eichengreen) and to dampen gold outflows to France, which at that time was considered a safe haven for international capital flows (see Hamilton, 1987). It has to be stressed, however, that the tightening only reduced expansionary effects of monetary policy rather than causing negative effects on output. Finally, loan supply shocks also contributed positively to output dynamics, especially during the early months of the boom-period. This finding is in line with the interpretation that the Great Depression represented a credit boom gone bust (see Eichengreen and Mitchener, 2004), at least to some extent. However, as we can see from Panel B, our analysis shows that quantitatively, expansionary loan supply shocks did not dominate the business cycle dynamics prior to the Great Depression. In the boom period before the crisis, aggregate demand shocks explain the highest share of the variation in industrial production.

Turning to the contraction phase associated with the Great Depression, we find that coinciding with the stock market crash in October 1929, which occurred two months after the business cycle peak in August 1929, the positive aggregate demand contributions in Panel A start to decline sharply. And from early 1930 onwards, aggregate demand shocks contributed persistently negatively to output dynamics until the trough in 1933. Similarly, the initially positive contributions of aggregate supply shocks turned negative at around the same time, although the contributions of aggregate supply shocks during the downturn were substantially less pronounced than those of aggregate demand shocks (see also Panel B).

While monetary policy was tightened before the peak in 1929, the contributions in Panel A turn positive shortly after the stock market crash indicating expansionary effects of monetary policy, i.e. counteracting the contractionary aggregate demand and aggregate supply contributions. This result provides support for the view that monetary policy was loose during the early stages of the Great Depression (Temin, 1976). However, with the significant increase of the discount rate in October 1931 (which is also clearly visible in the time series plot presented in Figure 1), in response to Great Britain's exit from the gold standard and the Federal Reserve's

attempt to counteract any gold outflows (Eichengreen, 1992; Friedman and Schwartz, 1963), we observe increasingly negative contributions from monetary policy shocks. Panel B shows that in late 1930 monetary policy shocks became within a few month the main driver of the continuing slowdown in the U.S. economy.

Finally, loan supply effects started to turn negative at the end of 1930. In Panel A we see that negativ loan supply effects started to intensify during a period in which the negative effects of aggregate demand and aggregate supply shocks stabilized or even declined. Therefore, loan supply shocks seem essential for the deepening of the recession. Panel B shows that in late 1931, loan supply shocks actually account for the same share of output dynamics as compared to aggregate demand and monetary policy shocks. As we will discuss in greater detail below, the timing of the negative shocks corresponds to the different waves of banking panics that took place during the early 1930s as argued by Bernanke (1983). Hence, in terms of timing and magnitude, our results provide evidence supporting Bernanke (1983). In contrast to our findings, Cecchetti and Karras (1994) identify aggregate supply shocks as a dominant factor for the deepening of the Great Depression. However, their results are consistent with our findings as their identification approach does not distinguish between aggregate supply and loan supply shocks, whereas we identify loan supply and aggregate supply shocks separately in our analysis.

Starting with the business cycle trough in March 1933, which corresponds closely to the inauguration of Roosevelt and the implementation of New Deal policies, the negative contributions of aggregate demand shocks in Panel A become substantially smaller, and in fact, disappear almost entirely during the early phase of the recovery. Aggregate supply shocks remain relatively unimportant during the recovery phase except when they began to exert negative contributions by the end of 1933. While these negative contributions of aggregate supply shocks provide some evidence for the view that the New Deal gave rise to adverse supply side developments potentially related to increased market power of workers (Christiano et al., 2003; Cole and Ohanian, 2004), overall aggregate supply contributions are fairly small during the recovery. Interestingly, the effects of monetary policy shocks remain negative well beyond the business cycle trough in 1933. Although loan supply shocks also cause negative effects on output until the end of 1935, the final upswing in the business cycle is mainly driven by positive loan supply effects. These findings are in line with Bernanke (1983) who documents that credit conditions remained tight during the early period, up to the end of 1935. While explanations of the recovery focus on aggregate demand (see Romer, 1992) and aggregate supply (Christiano et al., 2003), our results

highlight the role of loan supply, as a new aspect of the final recovery from the Great Depression, which has attracted less attention so far.

To sum up, our results in Figure 3 suggest that adverse aggregate demand developments played a dominant role during the downturn that started in 1929, consistent with Temin (1976) and Romer (1993).¹² Thus, we confirm the results presented by Cecchetti and Karras (1994) in this respect, although the identification approaches differ substantially. Also the prominent role of exogenous loan supply effects during the deepening of the recession is consistent with the findings from Cecchetti and Karras (1994). While the authors find that aggregate supply effects are particularly important during this period, they note that the identified aggregate supply effects potentially capture loan supply effects as well. Furthermore, our findings are consistent with results from Fackler and Parker (1994) who identify shocks related to the banking sector and consumption to be sufficient to capture the decline in industrial production between October 1929 and September 1931.

Concerning the question if and to what extent monetary policy actions may have contributed to the Great Depression, which is still intensively discussed, our results show that the time period matters crucially. We find that monetary policy was loose early during the downturn, supporting Temin (1976). In fact, our results suggests that policy shocks contributed even positively during the early downturn phase. Nevertheless, tight monetary policy contributed dominantly to the persistence of the downturn from 1931 onwards, which provides evidence in favor of Friedman and Schwartz (1963). While Fackler and Parker (1994) do not find that monetary effects were expansionary during the early period of the recession, their results also suggest that monetary effects became only important for the dynamics of industrial production after July 1931. Similarly, the results from Burbidge and Harrison (1985) show that shocks from the money base cause increasingly negative effects from late 1931 onwards. While our identification approach differs as compared to these earlier studies, the timing of monetary effects is consistent with our findings.

Although the final rebound in aggregate demand is closely linked to the start of the recovery in March 1933, we do not observe expansionary effects. Therefore, a recovery in aggregate demand seems to have supported the economic recovery but it appears less pronounced in our

¹²Although we do not split up demand shocks any further, our results are consistent with uncertainty shocks being the ultimate source behind the aggregate demand developments. As uncertainty and aggregate demand shocks imply very similar effects on macroeconomic aggregates (see Leduc and Liu, 2015) our identification approach is consistent with both interpretations.

analysis as suggested by Romer (1992). Furthermore, although credit condition seem tight until 1935, exogenous loan supply shocks represent the main driver fueling the boom before the next recession of 1937.

To provide some notion of precision of our results we present in Figure 4 the historical decomposition of industrial production for each shock separately. The dashed lines represent the 16th and the 84th percentiles of the sign-identified posterior distribution. The solid lines corresponds to the stacked areas presented in Panel A of Figure 3 and represent the point-wise median values of the sign-identified posterior distribution. Although we face a relatively high degree of dispersion across all shocks, we obtain the same conclusions as above, if we consider the pattern of the distributions. For example, if we consider the aggregate demand contributions in Panel A of Figure 4, the mass of the distribution clearly lies above zero before the stock market crash and within a few month after the crash the mass of the distribution lies below zero. While a relatively high share of the distributions remains below zero until March 1933, no systematic pattern is visible during the recovery. Therefore, the overall pattern of the distribution support our previous findings. Similarly, if we look at the distribution of monetary policy contributions, presented in Panel C, we see that consistent with the previous results, monetary policy exerted rather expansionary effects on output during the early period of the recession, while the mass of the distribution clearly lies below zero after Great Britain resigned from the gold standard. The distribution of loan supply effects, presented in Panel D, supports the conclusion that negative effects on output were present during the early 1930s and only turned positive after 1935. Finally, the distribution of aggregate supply effects, presented in Panel E, reveal less systematic patterns and therefore also suggests that aggregate supply shocks contributed only to a limited extend to the Great Depression.

As the uncertainty in the historical decomposition results from several sources the high dispersions is likely to be a common but not often reported feature. The historical decomposition represents the cumulative effects from all shocks in the past and therefore the dispersion combines uncertainty over the identification of shocks as well as their propagation (i.e. the moving average coefficients). Furthermore, as we identify shocks using sign restrictions, the sign-identified posterior distribution does not only capture sampling uncertainty but also uncertainty over the exact specification of the model (see Fry and Pagan, 2011) and therefore the dispersion is generally high. While it is not common to present a notion of precision in the context of historical decompositions Figure 4 reveals that reporting only simple point estimates

appears to be problematic.

3.3 The Four Waves of Banking Panics

We now study in greater detail the timing of shocks and the occurrence of banking crises during the Great Depression. While most researcher may agree that four periods of banking crises took place between the end of 1930 and early 1933 the views concerning the economic relevance of these events tend to differ substantially. While the empirical evidence seems in favor of the view that banking crises did cause exogenous effects on output during the Great Depression (see Calomiris and Mason, 2003; Richardson and Troost, 2009; Ziebarth, 2013), some researchers challenge whether these effects mattered for output dynamics on the aggregate level (see Romer and Romer, 2013; Wicker, 1996). Furthermore, as Romer and Romer (2013) point out, the existing empirical evidence fails to evaluate the relative importance of monetary and non-monetary effects during the Great Depression and therefore it remains unclear how bank failures were actually transmitted to the real economy.

We evaluate the role of the banking crises during the Great Depression, by studying whether the identified shocks are systematically linked to the occurrence of banking crises. While so far we have focused on the historical decomposition of industrial production, we are now interested in the exact timing of the shocks.

Figure 5 shows the time series of the four identified shocks. The bars correspond to the point-wise median values of the sign identified posterior distribution and the whiskers indicate the 16th and the 84th percentiles.¹³ The gray areas highlight the four waves of banking panics as identified in the literature (see e.g. Calomiris and Mason, 2000; Friedman and Schwartz, 1963): October 1930 to December 1930, March 1931 to August 1931, September 1931 to December 1931, and January 1933 to March 1933. The solid line represents again the contributions of each shock to the dynamics of industrial production (replicating the values presented in Figure 4).

Turning to Panel A of Figure 5 we see the identified loan supply shocks. We observe relatively high negative shocks in January, May and June 1931, i.e. at the end of the first and in the middle of the second banking crisis. The largest negative shock in our sample occurs in March 1933 which coincides with the national banking holidays that ended the final wave of banking failures.

¹³The shocks are standardized to be standard normally distributed and therefore the values of the shocks correspond to the probability that a shock of similar (or larger) magnitude arises.

While we do not observe negative loan supply shocks during the third banking crises, several negative shocks occurred in 1932 with a large shock in March. Although Friedman and Schwartz (1963) note that banking failures intensified in response to Britain's exit from the gold standard, Wicker (1996) claims that Britain's exit did not cause any bank failures in the U.S. (see also Calomiris and Mason, 2000). Furthermore, Wicker (1996) notes that a reasonable high share of banks suspended operations in 1932.

The solid line in Panel A indicates that loan supply shocks started to cause negative effects on output, just at the end of the first banking panic. The negative loan supply effects intensify throughout the second banking crisis in Spring 1931 and until the onset of the third banking crisis in Fall of 1931. As no negative loan supply shocks are present until mid 1932, negative effects on output declined during the third banking crisis. Interestingly, the exceptional large negative loan supply shock in March 1933 occurred during months in which credit conditions improved and therefore the effect on output is only muted and temporary. Overall, the timing of negative loan supply shocks support the view that during the periods of banking failures negative loan supply developments were present and exerted negative effects on aggregate output, as argued in Bernanke (1983).

In Panel B of Figure 5 we see that in contrast to loan supply shocks, monetary policy shocks were mainly positive during the the first two banking crises causing expansionary effects on industrial production. Only at the start of the third banking crisis in September 1931, monetary policy shocks turned negative. The shocks remain mainly negative until the end of the final banking crisis in March 1933. The two largest negative shocks occurred in October 1931, one month after Great Britain left the gold standard and in March 1933. Therefore, only the third and fourth banking crisis coincide with negative monetary effects, as suggested by Friedman and Schwartz (1963).

Concerning aggregate demand and aggregate supply shocks (presented in Panels C and D of Figure 5) we do not find specific large shocks during the periods of banking crises. Negative shocks were already present well before the first banking crisis and they do not change systematically with the occurrences of the banking crises. Hence, although both shocks contributed negatively to output dynamics until the business cycle trough in March 1933, our results do not indicate any tight link between the banking panics and aggregate demand as well as aggregate supply shocks.

From Figure 5, some additional findings arise, which are not related to the banking crises but are worth mentioning. First, consistent with the view that monetary policy tightened in early 1928 to dampen stock market speculation (see e.g. Eichengreen, 1992; Friedman and Schwartz, 1963; Romer, 1993) in Panel B we observe several negative monetary policy shocks around this time. Although they do not appear exceptional high, the timing exactly coincides with the literature.

Second, one month after the stock market crash in October 1929, we observe the largest negative aggregate demand shocks in our sample.¹⁴ The presence of this large negative aggregate demand shock ultimately after the stock market crash perfectly matches Romer’s (1990) view of the early downturn. Since the identified aggregate demand shocks account for exogenous changes in uncertainty, our findings are consistent with a substantial rise in uncertainty linked to the stock market crash and resulting declines in aggregate demand.¹⁵

4 Robustness Checks

4.1 Alternative Policy Variable

In our baseline specification, we follow Almunia et al. (2010) and use the discount rate as the monetary policy indicator. The short-term treasury bill rate is another risk-free money rate, which is frequently used to capture monetary policy (see e.g. Gambetti and Musso, 2016; Helbling et al., 2011). Therefore, we re-estimate our model using the short-term treasury bill rate as the policy variable. In Figure 6 we show the historical decomposition.¹⁶

The contributions of aggregate demand and aggregate supply shocks (presented in Panel A and B of Figure 6) reveal very similar pattern to the results of our baseline estimation. In contrast, the effects of monetary policy, presented in Panel C, appear now rather neutral during the first period of the recession, whereas they seem rather expansionary in the baseline results. However, the dispersion is still relatively high and therefore we do not gain much additional information. Anyway, consistent with the conclusion from the baseline model, monetary policy

¹⁴The value of the aggregate demand shock in November 1929 is -2.74 and hence, a shock of this magnitude (or larger) occurs only with a probability of 0.31% and therefore represents a very unusual event.

¹⁵Mathy (2015) identifies uncertainty shocks explicitly and finds that stock market volatility measures are an important source for output dynamics during the Great Depression.

¹⁶The short-term treasury bill rate is obtained from the NBER Macrohistory Database (see Table 1 for more information). Due to data limitations the observation period starts one year later in 1920:1 as compared to the baseline specification.

caused substantial negative effects on output starting from September 1931 onwards. Concerning loan supply shocks in Panel D, we observe generally very similar pattern as before, but the effects on output appear now relatively more pronounced. Especially, the dip after the third banking crisis appears especially strong. Nevertheless, the main conclusions remain the same.

4.2 Additional Identification Restrictions

We perform also an alternative identification approach, in which we add additional restrictions on total loan volumes. The aim is to rule out explicitly any changes in the supply of loans in respect to aggregate demand and aggregate supply shocks. The identification approach is summarized in Table 4 and the historical decomposition is provided in Figure 7.

As the effects of loan supply shocks appear very similar to our baseline estimation, we can conclude that the exogenous effects of changes in the supply of bank loans are already sufficiently separated from the other macroeconomic shocks in our baseline model. Concerning aggregate demand and aggregate supply shocks, we observe that contributions of both shocks during the second half of the recession appear less pronounced as compared to our baseline estimation. However the basic pattern remains similar to the baseline estimation.

4.3 Further Robustness Checks

Finally, we also check the robustness of our results in respect of the exact model specification, the sign restriction horizon and the seasonality of our data. In the Appendix we provide historical decompositions of an estimation in which sign restrictions hold for four periods (Figure A.2), the lag-length is set to 12 month (Figure A.3), the data is not seasonally adjusted and loan volumes are not deflated (Figure A.4), and the specification includes a linear time trend (Figure A.5). In general, our results and conclusions are very consistent across these different variations.

5 Conclusion

The effects of the widespread banking panics during the Great Depression remain controversially discussed in the literature. While Bernanke (1983) emphasizes that disruptions in financial intermediation caused exogenous negative effects on output, Romer and Romer (2013) conclude

that from existing empirical evidence it remains unclear whether such loan supply effects were pronounced enough to influence output at the aggregate level. We provide an analysis which allows us to evaluate the effects of structural loan supply shocks during the Great Depression and compare the effects to aggregate demand, aggregate supply and monetary policy shocks. In particular, we estimate a structural VAR and use historical decompositions to assess the timing and economic relevance of the identified shocks.

Our analysis provides evidence that three of the four banking panics during the early 1930s coincided with exceptional high negative loan supply shocks. The deepening of the recession in late 1930 is clearly linked to the first banking crisis and the initial raise of negative loan supply effects. The tight link between the banking crises and the strong output losses arising from loan supply shocks, strongly support Bernanke (1983) and his non-monetary explanation of the Great Depression.

Furthermore, we find that, consistent with findings from Cecchetti and Karras (1994), the onset of the Great Depression and the initial downturn are both closely linked to a drop in aggregate demand. As we do not observe that monetary policy shocks caused negative effects on output during the 1930s, our results support Romer (1993) and Temin (1976) who emphasize that severe declines in consumption spending explain the early period of the Great Depression. In our analysis, tight monetary policy effects, consistent with the view of Friedman and Schwartz (1963), contributed to the continuation of the recession but only after the significant increase of the discount rate in October 1931.

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A Additional Tables and Figures

INSERT TABLE A.1 HERE.

INSERT FIGURE A.1 HERE.

INSERT FIGURE A.2 HERE.

INSERT FIGURE A.3 HERE.

INSERT FIGURE A.4 HERE.

Table 1: Variable descriptions and data sources

Variable	Description	Start	End	Dataset	Indicator
IPM	Index of Production of Manufactures, Total for United States (1957-1959=100, NSA)	1919:1	1939:2	NBER	m01175
CPI	Consumer Price Index, All Items for United States (1957-1959=100, NSA)	1919:1	1939:2	NBER	m04128
DR	Discount Rates, Federal Reserve Bank of New York for United States (percent, NSA)	1919:1	1939:2	NBER	m13009
TOLN	Total Loans from Weekly Reporting Member Banks in 101 Leading Cities (billions of dollars, NSA)	1919:1 1938:7	1919:11 1939:2	BMS	Table No.48
	All Other Loans, Reporting Member Banks, Federal Reserve System for United States (billions of dollars, NSA)	1919:12	1938:6	NBER	m14075a
	+ Loans On Securities, Reporting Member Banks, Federal Reserve System for United States (billions of dollars, NSA)	1919:12	1938:6	NBER	m14074
LR	Bank Rates On Customer Loans, Leading Cities for United States (percent, NSA)	1919:1	1939:2	NBER	m13031
TBILL	Yields On Short-Term United States Securities, Three-Six Month Treasury Notes and Certificates,	1920:1	1930:12	NBER	m13029a
	Three Month Treasury Bills for United States (percent per annum, NSA)	1931:1	1939:2	NBER	m13029b

Abbreviations: NBER – National Bureau of Economic Research Macrohistory Database; BMS – Banking and Monetary Statistics; NSA – not seasonally adjusted.

Table 2: Sign restrictions on impulse response functions

Shock	IPM	CPI	Discount Rate	TOLN	Loan Rate
Ag. Demand	↓	↓	↓		↓
Ag. Supply	↓	↑			↓
Monetary Policy	↓	↓	↑		
Loan Supply	↓		↓	↓	↑

Notes: Restrictions hold on impact and the subsequent period; the residual shock is normalized (with a positive response of the loan rate).

Table 3: Forecast error variance decomposition of industrial production

Horizon	AD Shock	AS Shock	MP Shock	LS Shock	Residual
0	7.02 (0.74, 27.84)	7.30 (0.75, 26.87)	28.56 (7.46, 58.27)	17.81 (2.97, 47.87)	9.68 (1.01, 35.49)
4	10.92 (2.12, 33.85)	10.56 (2.03, 32.71)	22.14 (3.71, 52.06)	16.21 (1.99, 46.79)	9.25 (1.08, 34.71)
8	11.42 (2.01, 34.47)	10.59 (1.92, 32.73)	21.04 (3.32, 50.80)	16.97 (2.18, 47.36)	9.50 (1.16, 34.85)
12	11.08 (2.12, 33.72)	10.16 (2.01, 31.66)	21.50 (3.48, 51.47)	17.03 (2.32, 47.03)	9.87 (1.33, 35.08)

Notes: Values correspond to the point-wise median of the sign-identified posterior distribution; values in parentheses show the 16th and 84th percentiles; all values are in percent.

Table 4: Sign restrictions on impulse response functions (alternative identification with additional restrictions on loan volumes)

Shock	IPM	CPI	Discount Rate	TOLN	Loan Rate
Ag. Demand	↓	↓	↓	↓	↓
Ag. Supply	↓	↑		↓	↓
Monetary Policy	↓	↓	↑	↓	
Loan Supply	↓		↓	↓	↑

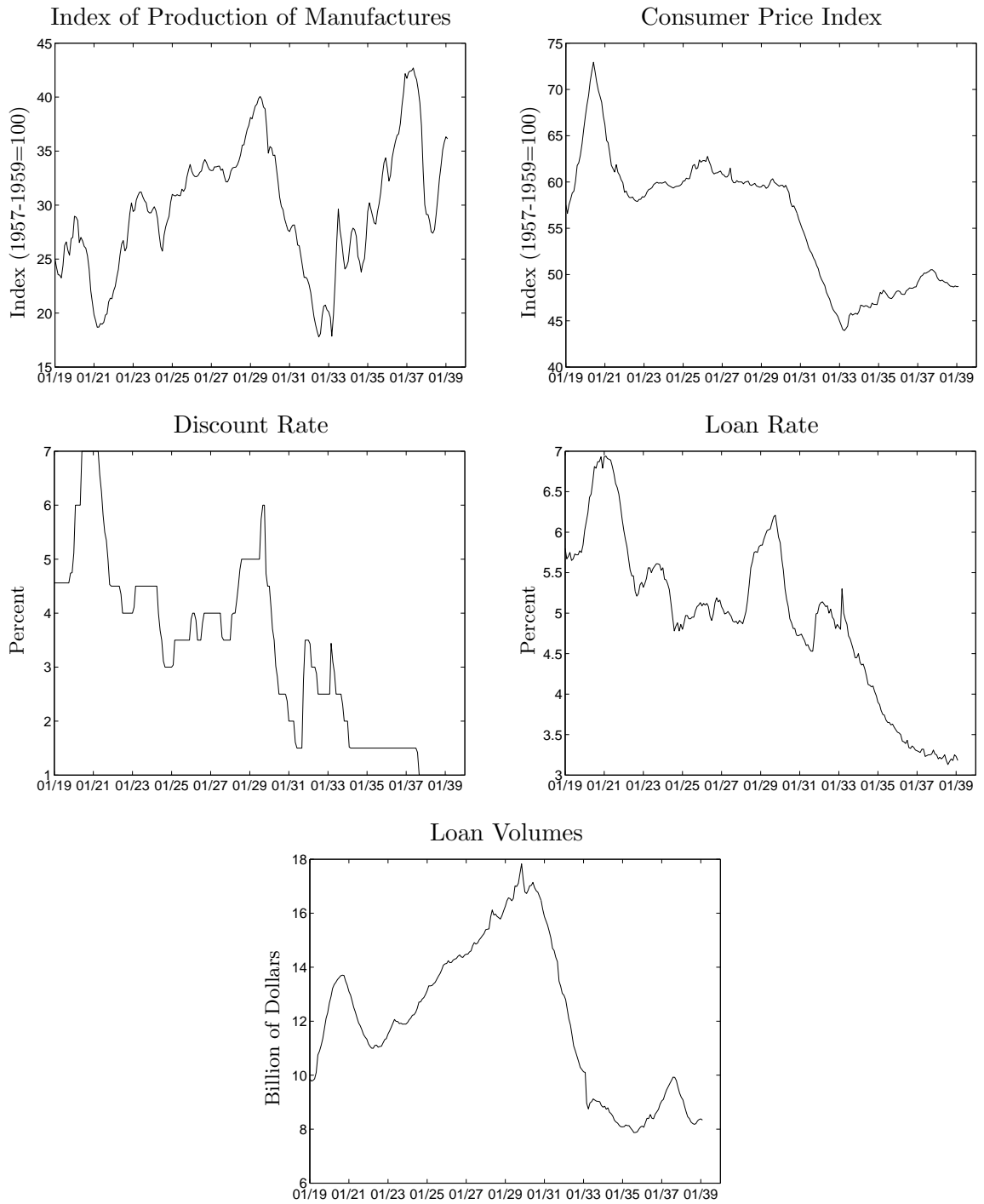
Notes: Restrictions hold on impact and the subsequent period; the residual shock is normalized (with a positive response of the loan rate).

Table A.1: Forecast error variance decompositions

Horizon	AD Shock	AS Shock	MP Shock	LS Shock	Residual
Consumer Price Index					
0	26.88 (5.88, 56.62)	16.39 (4.33, 41.97)	10.26 (1.18, 33.33)	7.64 (0.63, 30.29)	9.45 (0.96, 35.15)
4	35.46 (12.28, 62.87)	3.99 (1.10, 18.69)	21.60 (6.28, 47.54)	6.90 (1.17, 24.87)	9.20 (1.46, 31.91)
8	36.94 (14.51, 63.77)	3.20 (1.01, 12.54)	24.16 (7.14, 50.17)	6.48 (1.10, 22.79)	8.95 (1.39, 31.70)
12	37.81 (14.91, 64.45)	3.10 (0.92, 11.55)	24.73 (6.82, 50.90)	6.13 (1.00, 22.04)	8.92 (1.37, 31.87)
Discount Rate					
0	23.79 (4.25, 52.96)	5.98 (0.51, 27.47)	24.83 (5.46, 55.19)	4.19 (0.77, 13.56)	14.82 (1.42, 47.82)
4	35.10 (12.05, 65.11)	5.12 (0.79, 23.82)	17.29 (3.48, 45.86)	2.78 (0.69, 9.15)	15.14 (2.50, 48.11)
8	42.04 (17.66, 70.09)	4.91 (1.01, 20.93)	12.79 (4.03, 36.96)	3.25 (0.94, 8.75)	15.21 (3.22, 46.32)
12	45.49 (20.69, 70.44)	5.08 (1.17, 18.91)	12.23 (4.55, 31.44)	3.93 (1.26, 9.43)	15.46 (3.63, 44.75)
Loan Rate					
0	20.00 (3.55, 47.82)	14.63 (3.24, 39.26)	12.55 (1.63, 37.15)	18.21 (7.49, 34.51)	9.60 (0.94, 33.79)
4	37.03 (12.44, 66.33)	5.46 (1.35, 25.59)	13.65 (2.29, 40.18)	4.07 (1.75, 10.19)	15.79 (2.38, 48.42)
8	41.08 (13.91, 69.96)	4.57 (1.24, 21.13)	11.97 (2.14, 37.57)	3.26 (1.31, 9.25)	16.84 (2.47, 51.18)
12	43.58 (14.01, 70.59)	4.82 (1.32, 18.07)	10.72 (2.44, 33.92)	3.30 (1.22, 10.43)	17.50 (2.53, 51.14)
Loan Volumes					
0	12.23 (1.31, 37.21)	11.61 (1.30, 39.90)	9.57 (0.86, 34.30)	13.16 (1.43, 40.36)	20.39 (2.03, 55.56)
4	8.10 (1.95, 25.83)	10.45 (1.52, 33.39)	10.87 (1.66, 35.88)	26.72 (9.66, 55.53)	15.24 (2.34, 46.98)
8	7.73 (2.85, 23.39)	9.97 (1.77, 30.52)	12.67 (2.59, 38.03)	30.28 (11.69, 57.39)	12.98 (2.86, 40.13)
12	8.34 (3.36, 24.56)	9.41 (1.76, 28.95)	15.00 (3.26, 40.62)	30.58 (11.60, 56.54)	11.76 (2.77, 35.57)

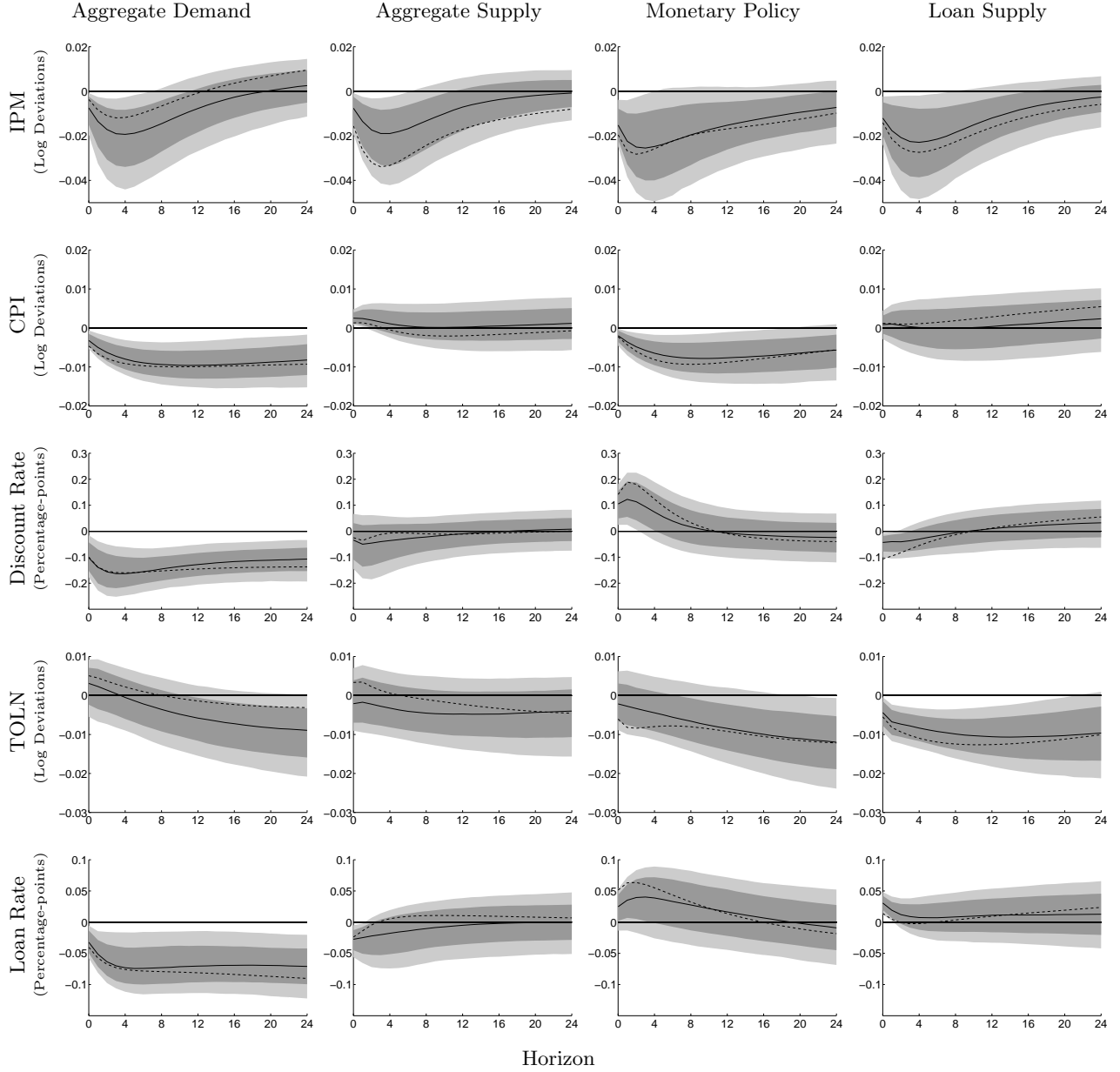
Notes: Values correspond to the point-wise median of the sign-identified posterior distribution; values in parentheses show the 16th and 84th percentiles; all values are in percent.

Figure 1: Time-series plots of variables



Notes: Variables are seasonally adjusted; a description of the data is provided in Section 2.1 and Table 1.

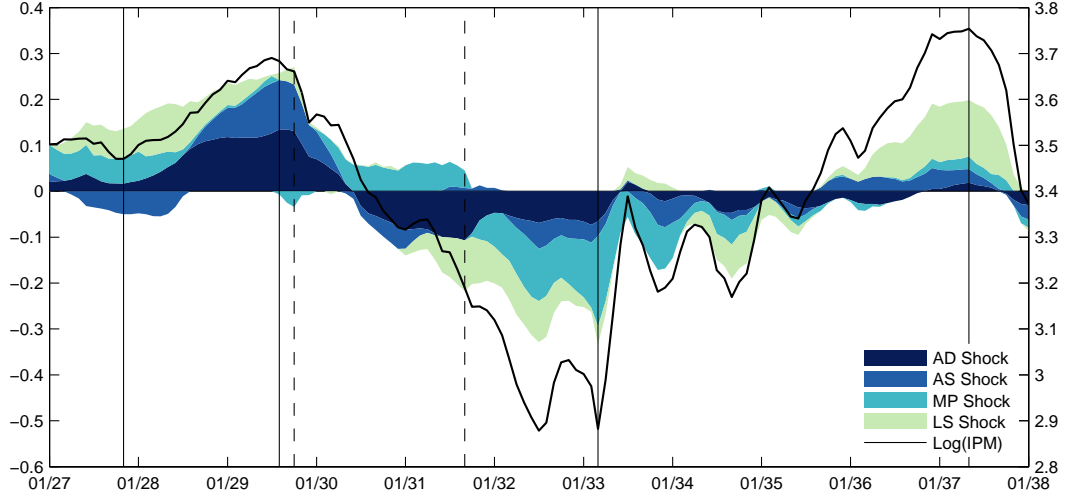
Figure 2: Impulse responses to identified macroeconomic shocks



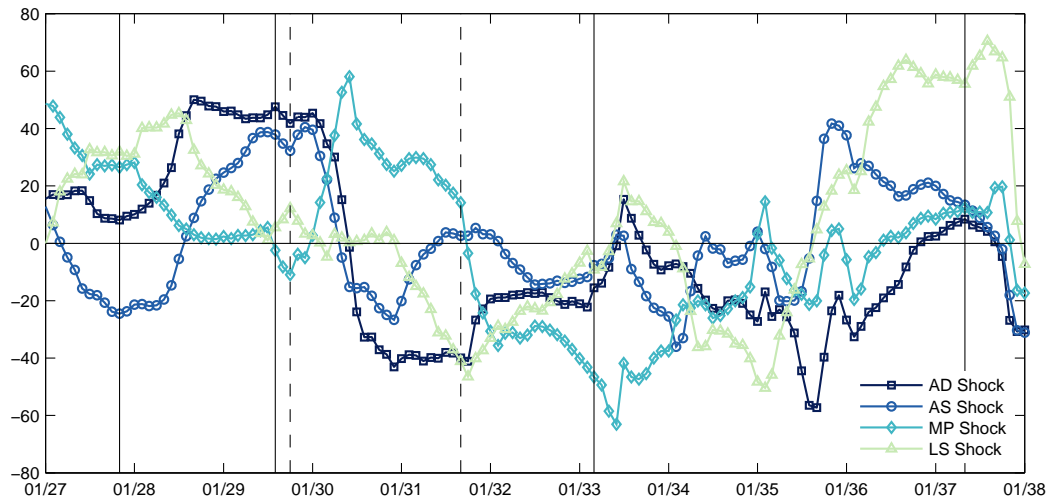
Notes: The light gray and dark gray areas represent 90% and 68% of the sign-identified posterior distribution. The solid line shows the point-wise median response and the dashed line represents responses of the closest to median model (which is selected as suggested by Fry and Pagan, 2011).

Figure 3: Historical decomposition of industrial production – an overview over the Great Depression (1927:1-1938:1)

(A) Contribution of shocks to the dynamics of industrial production (stacked)

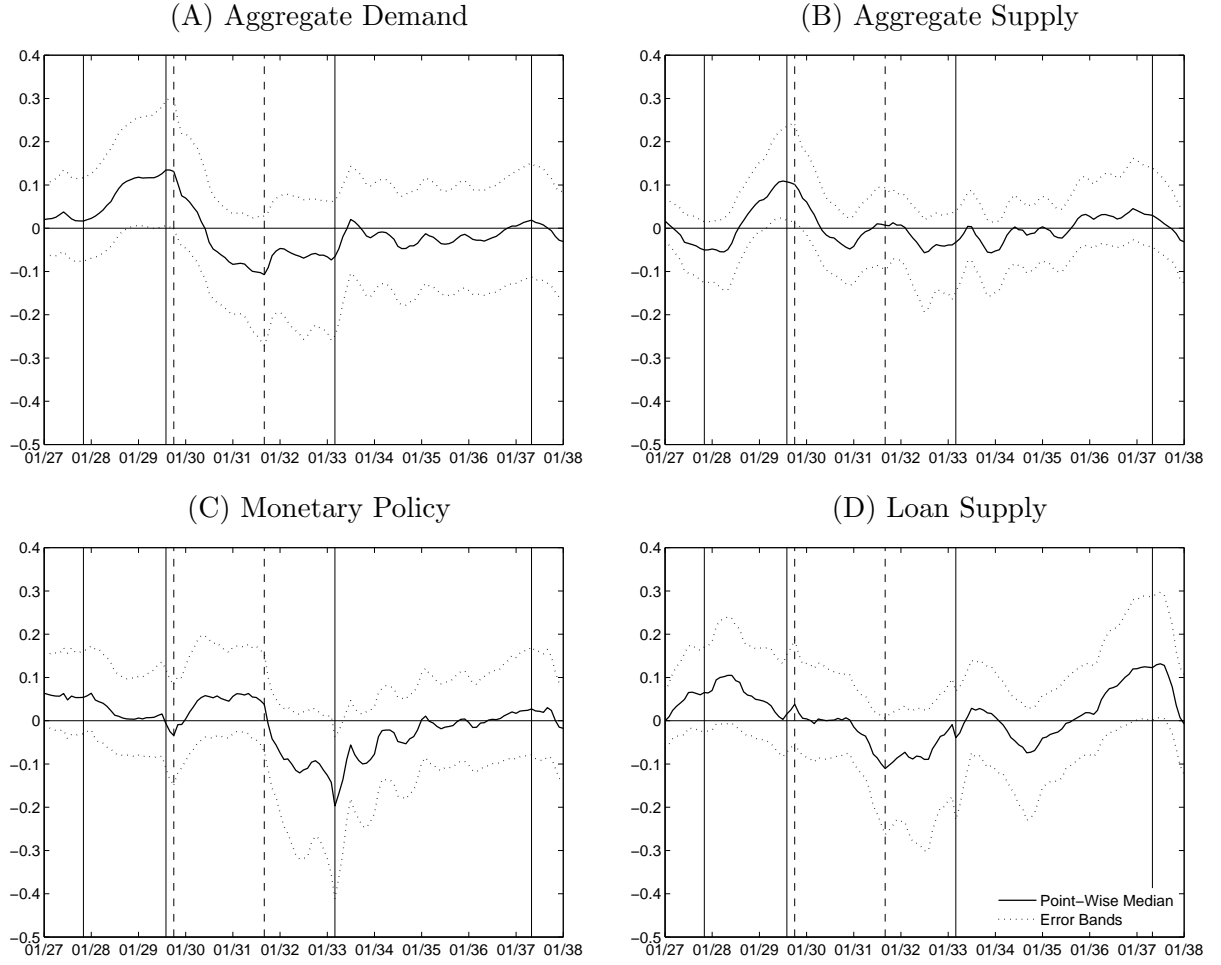


(B) Contributions of shocks as a relative share to the absolute variation in each period



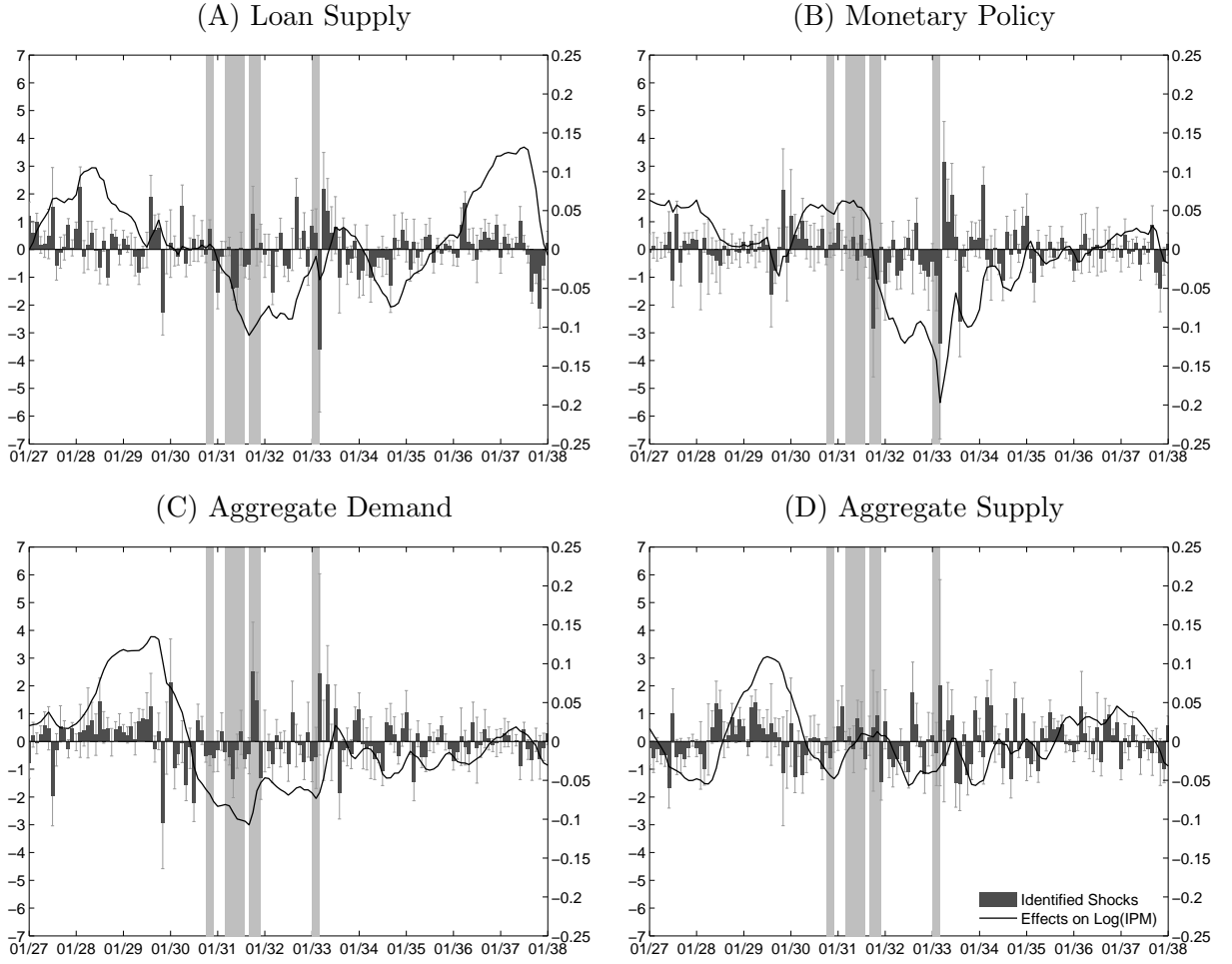
Notes: In the figure we present point-wise median values of the sign-identified posterior distribution; in Panel A the effects on industrial production of the identified shocks are stacked above each other; in Panel B we present the effects of each shock as a percentage share of the absolute sum of all effects in each periods (residual effects are excluded); vertical solid lines correspond to the NBER dating of peaks and troughs in the U.S. business cycle (November 1927, August 1929, March 1933, May 1937) and the vertical dashed lines correspond to the stock market crash in October 1929 and Britain's departure from the gold standard in September 1931; values in Panel A are in log scale and $\log(\text{IPM})$ corresponds to the Y-axis on the right; values in Panel B are in percent.

Figure 4: Historical decomposition of industrial production – split across individual shocks (1927:1-1938:1)



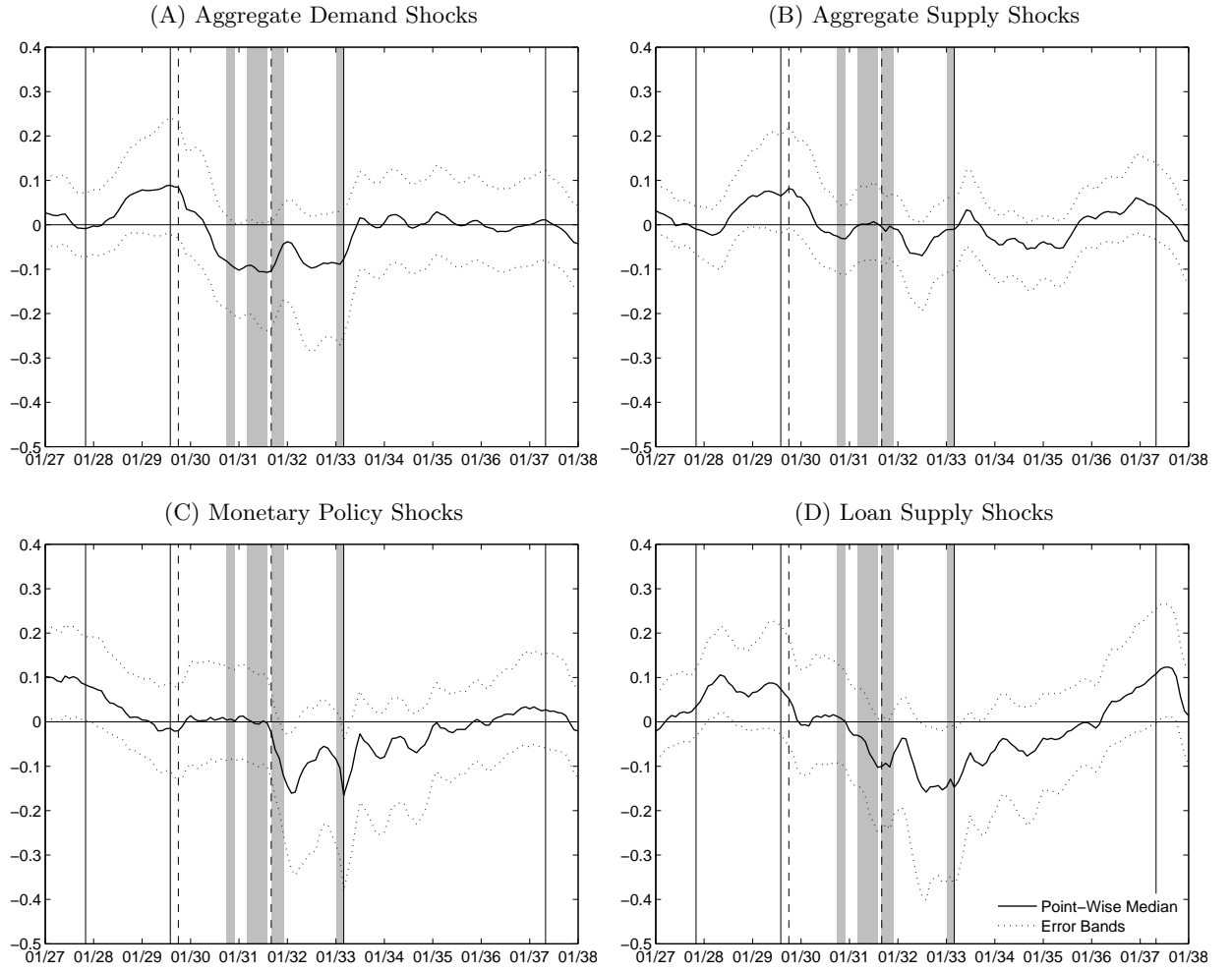
Notes: In the figure we present point-wise median values of the sign-identified posterior distribution (solid lines) plus the 16th and 84th percentiles as error bands (dotted lines); vertical solid lines correspond to the NBER dating of peaks and troughs in the U.S. business cycle (November 1927, August 1929, March 1933, May 1937) and the vertical dashed lines correspond to the stock market crash in October 1929 and Britain's departure from the gold standard in September 1931; all values are in log scale.

Figure 5: Identified structural shocks (1927:1-1938:1)



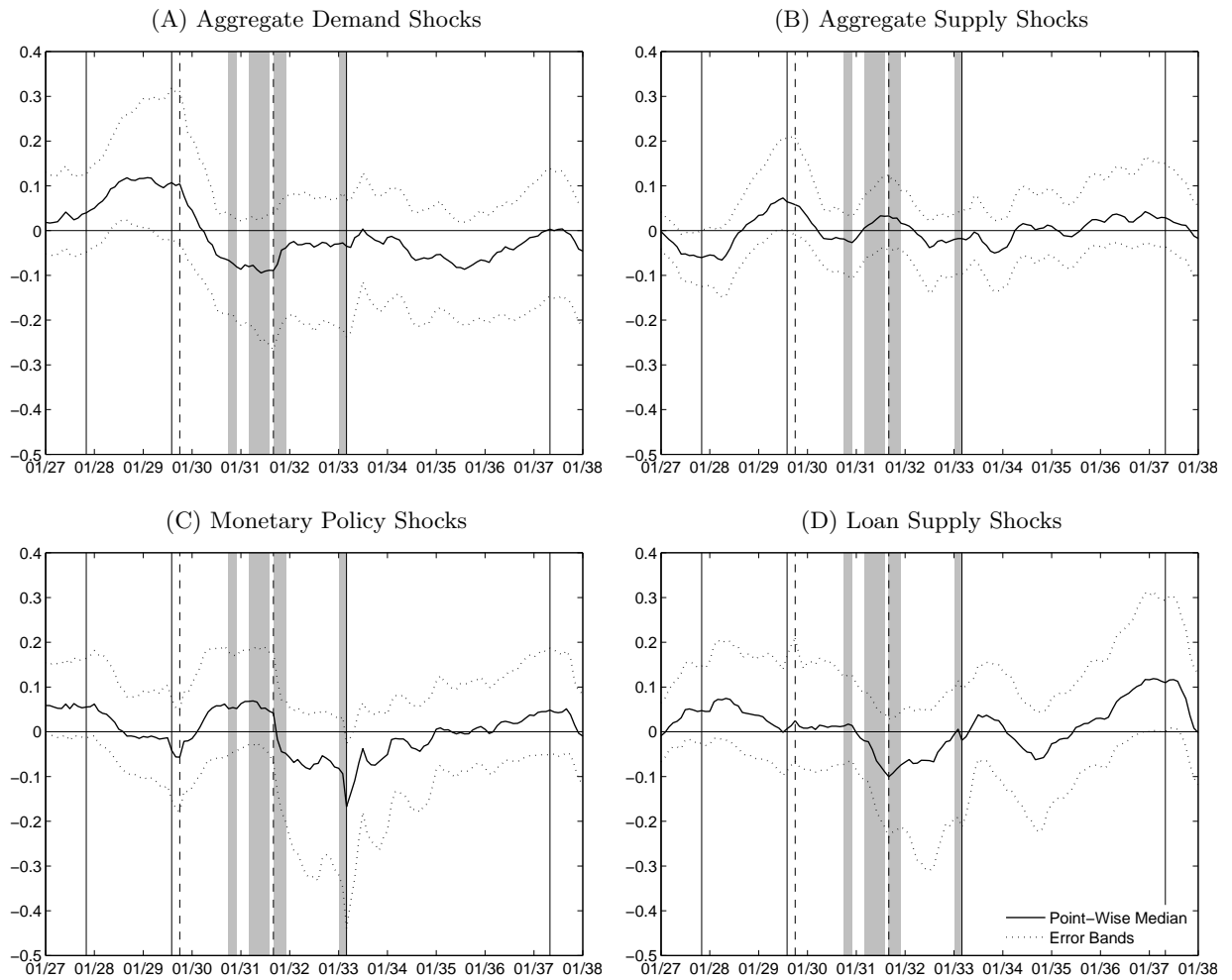
Notes: The bars correspond to the point-wise median values of the sign-identified posterior distribution of shocks; the whiskers indicate the 16th and 84th percentiles; the solid line shows the effects on industrial production (replicating the point-wise median values presented in Figure 4); the gray shaded areas correspond to the four periods of banking crises (October 1930 to December 1930, March 1931 to August 1931, September 1931 to December 1931, and January 1933 to March 1933); the shocks are reported in standard deviations (left axis) and the effects of industrial production are in log scale.

Figure 6: Historical decomposition of industrial production: results of an estimation using the T-bill rate as policy variable (1927:1-1938:1)



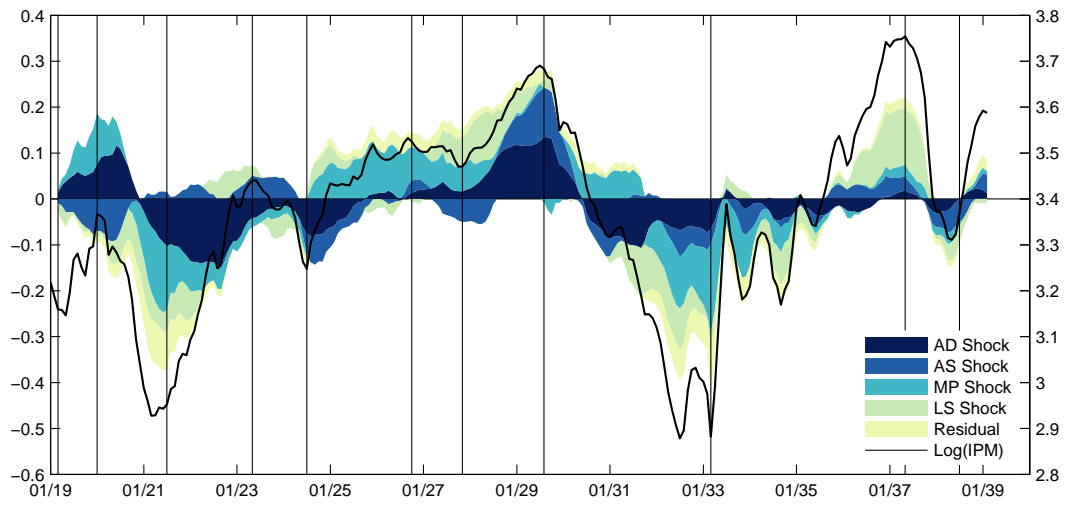
Notes: In the figure we present point-wise median values of the sign-identified posterior distribution (solid lines) plus the 16th and 84th percentiles as error bands (dotted lines); vertical solid lines correspond to the NBER dating of peaks and troughs in the U.S. business cycle (November 1927, August 1929, March 1933, May 1937) and the vertical dashed lines correspond to the stock market crash in October 1929 and Britain's departure from the gold standard in September 1931; the gray shaded areas correspond to the four periods of banking crises (October 1930 to Dezember 1930, March 1931 to August 1931, September 1931 to Dezember 1931, and January 1933 to March 1933); all values are in log scale.

Figure 7: Historical decomposition of industrial production: : results of an estimation using the alternative identification approach (1927:1-1938:1)



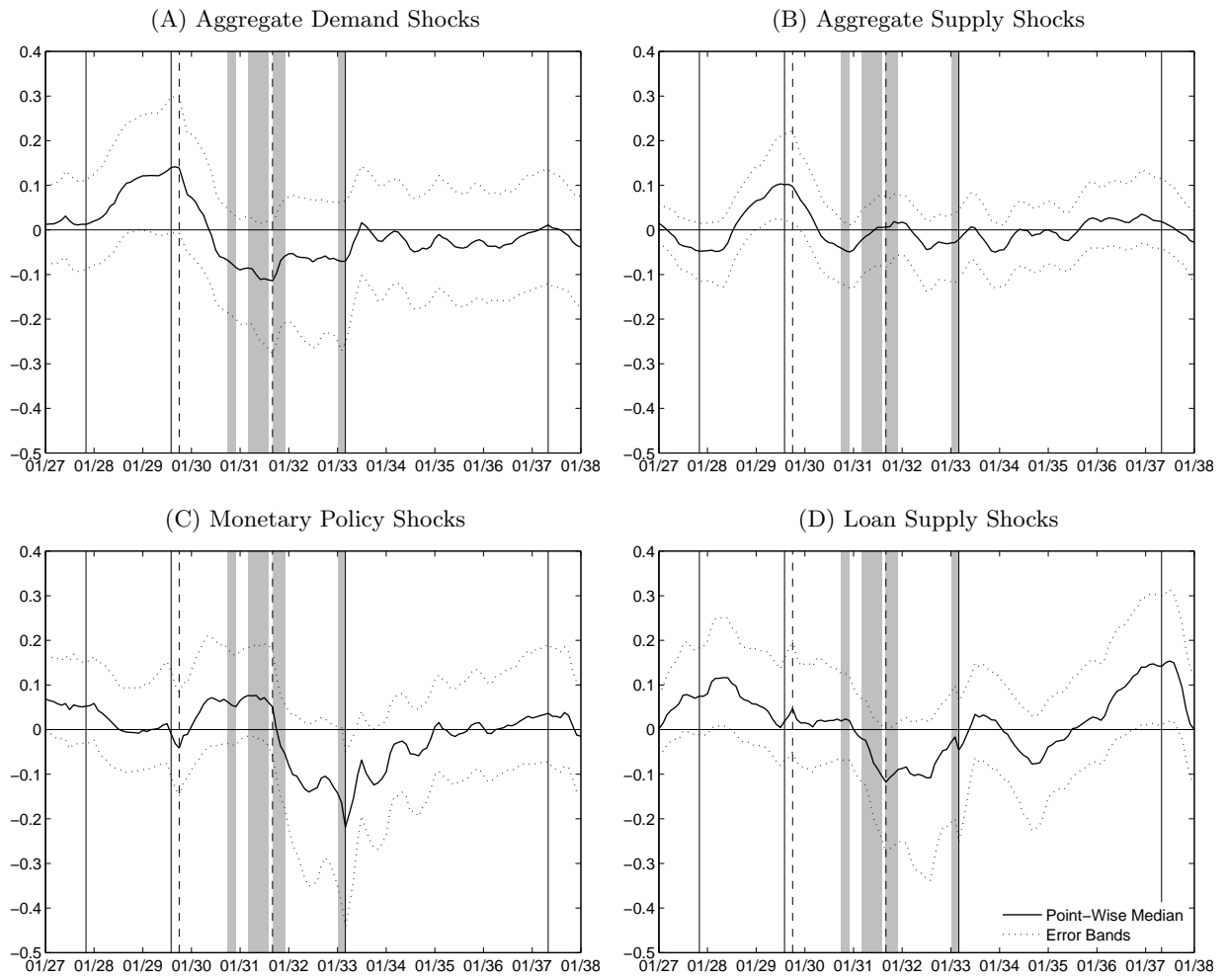
Notes: Please refer to notes of Figure 6.

Figure A.1: Stacked historical decomposition of industrial production (1919:3-1939:2)



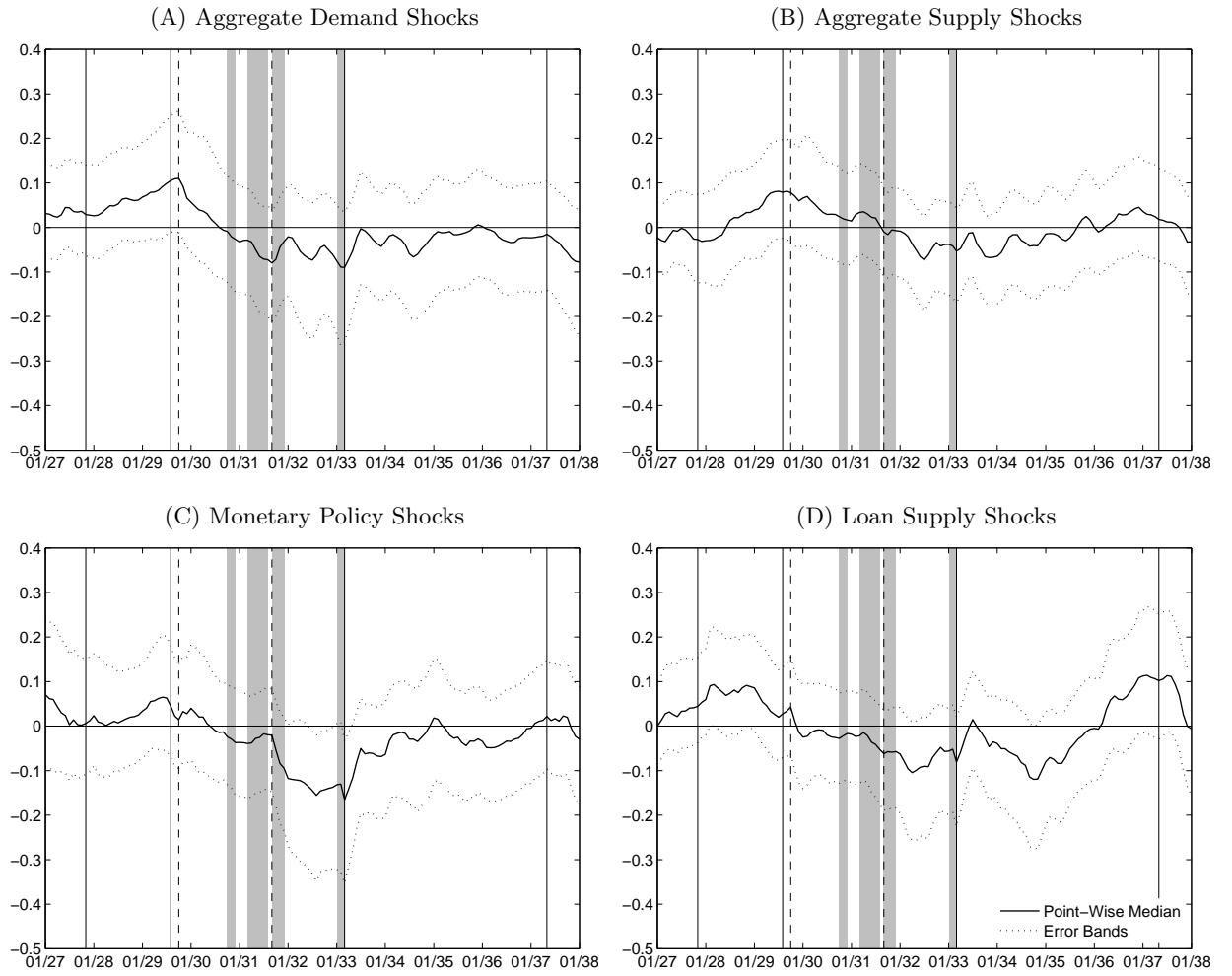
Notes: In the figure we present point-wise median values of the sign-identified posterior distribution; vertical solid lines correspond to the NBER dating of peaks and troughs in the U.S. business cycle (March 1919, January 1920, July 1921, May 1923, July 1924, October 1926, November 1927, August 1929, March 1933, May 1937, June 1938); all values are in log scale; log(IPM) corresponds to the Y-axis on the right.

Figure A.2: Historical decomposition of industrial production: results of an estimation in which sign restrictions are imposed for four periods (1927:1-1938:1)



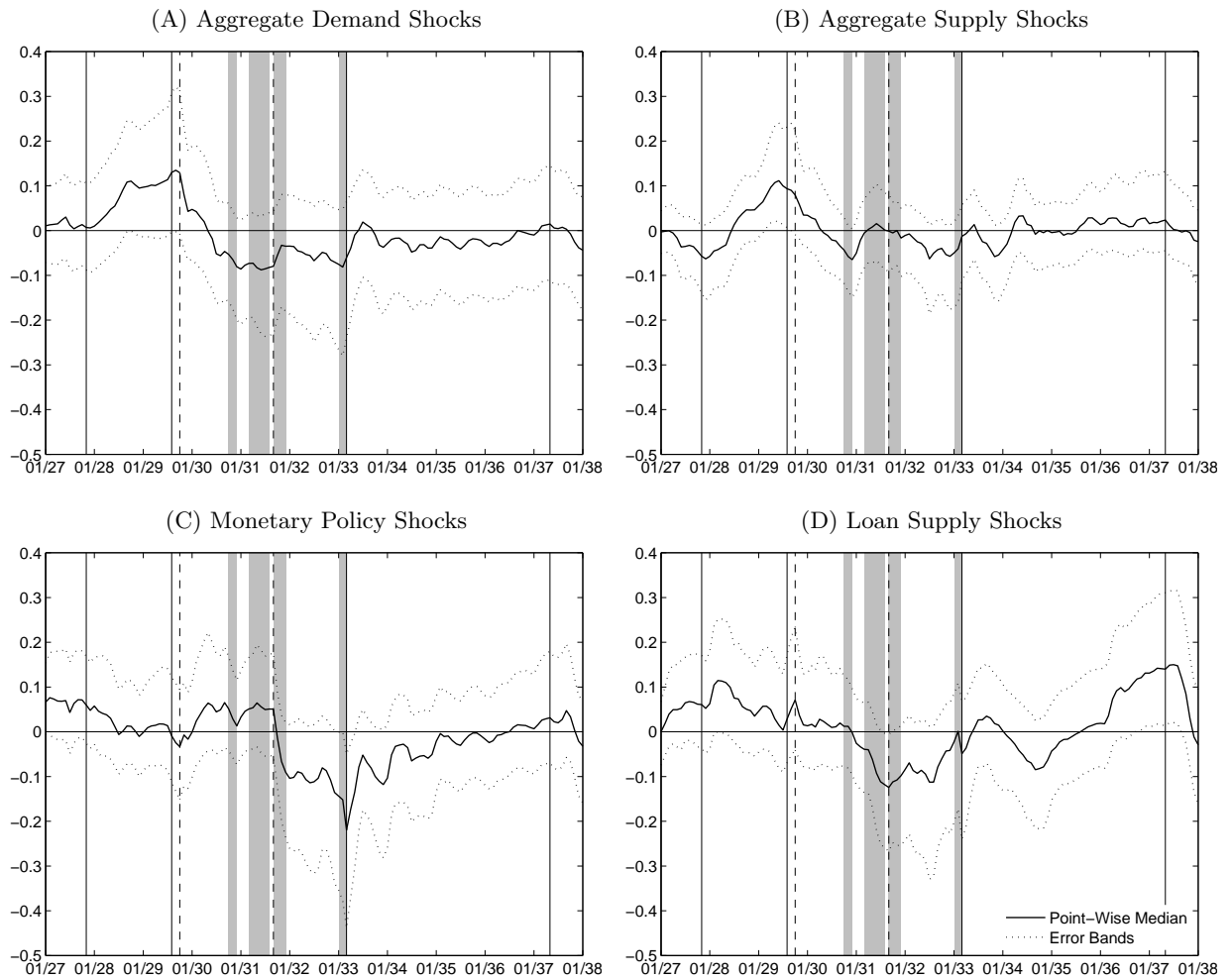
Notes: Please refer to notes of Figure 6.

Figure A.3: Historical decomposition of industrial production: results of an estimation using 12 lags (1927:1-1938:1)



Notes: Please refer to notes of Figure 6.

Figure A.4: Historical decomposition of industrial production: results of an estimation using the original seasonal unadjusted data and nominal loan volumes (1927:1-1938:1)



Notes: Please refer to notes of Figure 6.

Figure A.5: Historical decomposition of industrial production: results of an estimation including a linear trend in the model (1927:1-1938:1)

