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Decomposing the U.S. Great Depression: How important were loan supply shocks?

Max Breitenlechner[a], Gabriel P. Mathy[b,*], Johann Scharler[a]

[a] Department of Economics, University of Innsbruck, Universitaetsstrasse 15, Innsbruck A-6020, Austria
[b] Department of Economics, American University, 4400 Massachusetts Avenue, Washington, DC 20016, USA

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ABSTRACT

We measure the contributions of loan supply shocks and other macroeconomic shocks to U.S. output dynamics during the Great Depression. Using structural vector autoregressions, we impose sign restrictions to identify shocks. We find that loan supply shocks contributed negatively to output growth between 1931 and 1933, at the same time as the U.S. experienced several waves of banking crises. Thus, our results support the view that disruptions in credit availability contributed to the depth and length of the Great Depression. We also find that adverse aggregate demand and monetary policy shocks were important factors in the downturn.

1. Introduction

The Great Depression of the 1930s was one of the worst economic crises in world history. Naturally, much has been written about this episode in the nine decades since it began, in particular regarding the role of monetary policy. Friedman and Schwartz (1963) provide a monetary explanation stressing the large decline in the money stock and the inept response of the Federal Reserve in allowing the U.S. banking system and the credit supply to collapse. Temin (1976), in contrast, argues that monetary conditions were not tight during the early 1930s, as demonstrated by low and declining interest rates. Temin (1976) instead focuses on the role of autonomous shocks to aggregate demand as the primary cause of the downturn.

The widespread distress in the banking sector has also received a substantial amount of attention, even outside of the direct monetary consequences of banking and financial distress.[1] Starting with Bernanke (1983), a large literature has shown that disruptions to financial intermediation had real effects during the Great Depression.[2] In this paper, we contribute to this literature by measuring the extent to which shocks to the supply of bank loans contributed to output dynamics at the aggregate level. We compute the time-varying contributions of loan supply shocks to U.S. output dynamics using historical decompositions based on a vector autoregressive

* Corresponding author.
E-mail addresses: max.breitenlechner@uibk.ac.at (M. Breitenlechner), mathy@american.edu (G.P. Mathy), johann.scharler@uibk.ac.at (J. Scharler).

[1] Between 1929 and 1933 about 10,000 of the initial 24,000 financial institutions closed down or suspended operations in the U.S. (Richardson, 2007). According to Heitfield et al. (2017) contagion effects fueled the banking panic and forced illiquid and insolvent banks out of business.

[2] See Hansen and Ziebarth (2017), Benmelech et al. (2019), Mitchener and Richardson (2019), and Cohen et al. (2020), *inter alia*, for recent contributions to this literature.

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(VAR) model with monthly U.S. data ranging from December 1919 to December 1937. To obtain orthogonal, structural shocks we impose sign restrictions on the impulse response functions (see e.g. Faust, 1998; Uhlig, 2005). While we focus on loan supply shocks, obviously these were just one type of shock among many to matter in the Depression. The application of sign restrictions allows us to consider multiple shocks in our analysis. Therefore we are able to account for the non-monocausal nature of the Great Depression and we can compare the contributions of loan supply shocks to the contributions of other shocks. This provides additional information about the role of loan supply shocks relative to other factors across the different phases of the Great Depression.

Since changes in bank lending may reflect changes in loan supply as well as in the demand for loans, we disentangle shifts in the supply of bank loans by imposing the restriction that the interest rate charged by banks and the volume of loans do not move in the same direction in response to a loan supply shock as our main identifying assumption. Several approaches have been proposed to identify loan supply shocks using sign restrictions (see e.g. Bijsterbosch and Falagiarda, 2015; Gambetti and Musso, 2017; Hristov et al., 2012). While the exact restrictions differ across studies, these approaches have in common that they rely on the idea that a decline in the demand for loans reduces borrowing costs and volumes, whereas a reduced supply of loans decreases the volume of loans but not borrowing costs. Based on these assumptions, we should be able to capture loan supply shocks that result from a higher cost of credit intermediation due to financial frictions (see e.g. Bernanke, 1983). It should be noted that our characterization of loan supply shocks cannot identify all types of financial frictions. In particular, our approach is not suitable to study implications of quantity rationing without corresponding movements in the cost of credit as analyzed in Stiglitz and Weiss (1981), *inter alia.*[3] In this sense, our estimated contributions are unlikely to comprise the full effect of financial frictions.

To distinguish between aggregate demand and aggregate supply shocks, we assume that output and prices move in the same direction after an aggregate demand shock and in opposite directions following an aggregate supply shock. Characterizing monetary policy, and hence monetary policy shocks, during the 1930s is less straight-forward, as we will discuss in more detail in Section 2.3. Therefore, we use different identification schemes to identify monetary policy shocks. In our baseline analysis, we impose a minimal set of restrictions, namely that the discount rate and the loan rate increase in response to contractionary monetary policy shocks and that output declines.

Based on the estimation results and the identifying assumptions, we find that although exogenous loan supply shocks contributed positively to output dynamics in the years preceding the Great Depression, their contributions turned negative in 1931 and intensified over time. The contributions of loan supply shocks to the deepening of the slowdown and to the duration of the Great Depression were quantitatively non-negligible. In late 1931, loan supply shocks accounted for roughly 40% of the combined effect of the four shocks that we consider in our analysis. Although loan supply shocks continued to contribute negatively to output dynamics well beyond the business cycle through in 1933, they exerted positive contributions during the later stages of the recovery.

Our results also suggest that aggregate demand shocks explain a particularly large share of output dynamics during the early downturn that started in 1929 and therefore support the view that the early phase of the Great Depression can be characterized by a drop in aggregate demand (Romer, 1993; Temin, 1976). While the exact timing of the contributions of monetary policy shocks depends on the restrictions that we impose to characterize the policy shock, we find that contractionary monetary policy also contributed to the depth and the length of the Great Depression.

Nonmonetary effects associated with disruptions to financial intermediation have been explored extensively in the existing literature. Bernanke (1983) shows that proxies for nonmonetary effects of the banking crises are negatively related to the growth of industrial production. Hamilton (1987) concludes that the banking sector was an important channel for the transmission of monetary policy in the 1930s (see also Hamilton, 1992). Proxies for financial distress and financial crises, such as the deposits and liabilities of failed banks, have also been used to study nonmonetary effects in VAR models (Anari et al., 2005; Chin and Warusawitharana, 2010; Fackler and Parker, 1994). Our paper differs from these contributions primarily in terms of the identification approach and in terms of our focus on loan supply shocks. Instead of including proxies for banking sector distress, we directly characterize loan supply shocks using sign restrictions.[4] Thus, although we should be able to capture changes in the intensity of banking distress and financial frictions as long as they result in a shift of the loan supply curve in the aggregate, our approach does not require us to specify or proxy a specific type of financial disruption.

A number of papers study credit market frictions and credit availability based on disaggregated data. Calomiris and Mason (2003a) use bank-level data and apply an instrumental variable strategy to identify loan supply based on the assumption that banks' characteristics predict bank distress and, ultimately, loan supply. As such, their identification strategy differs strongly from our approach. 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. Carlson and Rose (2015) exploit data from a survey on credit availability conducted by the Federal Reserve in 1934 and relate survey responses to proxies for bank distress and find that bank failures as well as funding constraints reduced the availability of credit, but they do not analyze the broader implications for the Great Depression. Consistent with these results, we find that although the influence of negative loan supply shocks on industrial production slowly declined after 1932, it turned negative again in 1934. Benmelech et al. (2019) identify loan supply effects using detailed firm-level data that links information on employment to firms' financing needs. While their analysis focuses on firm level data, extrapolating their estimates to the aggregate level shows that disruptions in credit supply had pronounced negative effects on aggregate employment between 1928 and 1933. Cohen et al. (2020) develop a new measure of lending relationships and demonstrate that bank suspensions and the collapse of lending

[3] Carlson and Rose (2015) examine gaps between the supply of and demand for credit that are distinct from increases in the cost of credit intermediation during the Great Depression.

[4] Anari et al. (2005), for instance, note that their measure of financial distress is potentially driven by shocks to credit demand and/or supply.

relationships, leading to an increase in the cost of credit intermediation, contributed to the deepening of the Great Depression at the regional level between 1929 and 1933. Mitchener and Richardson (2019) find that interbank networks amplified the contraction of lending in the Depression, shrinking aggregate lending by an additional 15%. Our analysis essentially corroborates these findings, in the sense that increasingly negative contributions of loan supply shocks to output dynamics are consistent with the view that financial frictions intensified over the course of the Great Depression. We provide additional insights concerning the variation over time, and we can compare loan supply shocks to other factors that contributed to the Great Depression.

Richardson and Troost (2009) use a quasi-experimental setting, exploiting policy differences across regional Federal Reserve Banks, to show that more activist monetary policy was able to support the availability of credit during the banking crises. Using a similar approach, Ziebarth (2013) finds that although the banking crises had little impact on the plant-level, it gave rise to a large decline in employment at the county-level. Hansen and Ziebarth (2017) also use a quasi-experimental setting to highlight the role of credit relationships as a channel for the transmission of bank distress to business distress. Although our analysis differs in important ways from these studies in terms of the data and the methodology, it complements them by providing an explicitly macroeconomic perspective. Since the aggregate framework allows us to quantify loan supply shocks along with other standard business cycle shocks, we are able to provide a comparison of different drivers of the Great Depression in a unified setting.

Cole and Ohanian (2001) use a calibrated general equilibrium model to evaluate the contribution of bank failures to the Great Depression. Their simulations show that disruptions in the banking sector account for only a small fraction of the Great Depression. Chari et al. (2002) perform a business cycle accounting exercise and decompose deviations of a general equilibrium model from the data into three wedges: labor, investment, and efficiency. They find that investment wedges, and hence financial frictions arising from agency costs, played little role during the Great Depression, but given the methodological differences, their findings cannot be directly compared to ours.

Finally, our paper is related to contributions that apply VAR models to study the Great Depression in a more general sense. Burbidge and Harrison (1985) find that contractionary monetary policy shocks mattered particularly after 1931. Cecchetti and Karras (1994) study the contributions of aggregate supply and demand shocks and show that the early downturn was dominated by aggregate demand developments. Ritschl and Sarferaz (2014) construct banking factors for Germany and the U.S. and study the international transmission of financial shocks. Historical decompositions are also used by McMillin and Parker (1994) to evaluate the role of oil price shocks, and by Mathy (2020), who studies uncertainty shocks. Amir-Ahmadi et al. (2020) use structural VAR models and impose sign restrictions to study regional monetary policy shocks. In contrast to these studies, we focus on loan supply shocks.

2. Empirical approach

We estimate a structural VAR from December 1919 to December 1937 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).[5]

2.1. Estimation

The VAR in reduced-form is specified as follows:

$$Y_t = c + \sum_{j=1}^{p} A_j Y_{t-j} + \lambda t + e_t, \tag{1}$$

where the vector of endogenous variables, Y_t, contains the index of production of manufactures (IP), the consumer price index (CPI), the discount rate, the loan volume, and the loan rate. A_j are the coefficient matrices at lag j, c is a vector of constants, t is a linear time trend, and e_t is a vector of white noise reduced-form residuals with $E(e_t) = 0$ and $\Sigma_e = E(e_t e_t')$. We include a linear time trend as in Almunia et al. (2010) and estimate the VAR with two lags of the endogenous variables as indicated by the Bayesian (Schwarz) information criteria.[6]

As is standard, we estimate the model using Bayesian methods. Following Uhlig (2005), we refrain from specific prior assumptions about the reduced-form model and use the Normal-Wishart distribution as our prior density. We obtain the posterior distribution of the reduced-form coefficients, which is also a Normal-Wishart density, with the estimates of the coefficients and the variance-covariance matrix, A_j and Σ_{e_t}, as location parameters (see e.g. Uhlig, 1994). As we identify the structural parameters using sign restrictions, the system is set-identified and therefore the prior is flat over the reduced-form coefficients but not necessarily over the structural coefficients (Baumeister and Hamilton, 2015).[7]

Our sign restriction algorithm works as follows. We draw 3000 models from the reduced-form posterior distribution and sequentially work through each draw following steps (i) to (iv):

[5] All data and necessary files to replicate the results of this article are available in Breitenlechner et al. (2020).

[6] In a robustness analysis, we re-estimate the VAR without a trend and also in first and yearly differences. We also estimate the VAR with twelve lags of the endogenous variables.

[7] In set-identified systems, distributional assumptions over the structural parameters are not updated by the data, and therefore are informative for the structural posterior distribution (see also Moon and Schorfheide, 2012). In our estimations the structural parameters are generally normally distributed and truncated by the sign restrictions.

(i) First we orthogonalize the reduced-form model, represented in Eq. (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 $\tilde{e}_t = P^{-1}e_t$. The shocks in $\tilde{e}_t$ are uncorrelated as then $\Sigma_{\tilde{e}_t} = \tilde{e}_t\tilde{e}_t' = P^{-1}e_t e_t' P^{-1'} = I$.
(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 $\Sigma_{\hat{e}_t} = QP^{-1}e_t e_t' P^{-1'} Q' = I$. Following Rubio-Ramírez et al. (2010) we obtain the matrix Q applying a QR-decomposition on a symmetric matrix, which is drawn from the standard normal distribution.
(iii) Subsequently, we check whether the corresponding impulse responses of $\hat{e}_t$ fulfill the imposed sign restrictions (as described in Section 2.3). 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 1000 Q-transformations). To improve the efficiency of the algorithm we check for each Q-transformation the impulse responses of the orthogonal shocks sequentially. This means, we individually compare the impulse responses of each orthogonal shock to the sign restrictions of all structural shocks and rearrange the columns of matrix Q if necessary.
(iv) When the sign restrictions are fulfilled or the limit of Q-transformations is reached, the algorithm proceeds with the next model.

The algorithm finds for all 3000 models from the reduced-form posterior distribution Q-transformations that yield impulse responses consistent with the restrictions described in Section 2.3.

2.2. Data

Data are from the NBER Macrohistory Database and the Banking and Monetary Statistics. In our baseline specification, we follow the literature and use the discount rate as our preferred policy variable (see e.g. Almunia et al., 2010). While the Fed policy was not identical throughout the entire interwar period, there were not major changes in the policy stance during the Depression Wheelock (2004). Nevertheless, as the Federal Reserve Banks used various policy instruments, we consider alternative policy measures in the robustness analysis in Section 4.

Fed member banks, once they made a loan, could rediscount this loan at their regional Federal Reserve Bank and thus the bank could increase their reserve balances. In this way, the Federal Reserve Banks were able to influence the liquidity of banks and conduct monetary policy. As discount rates varied across districts, we use a weighted average of the 12 Federal Reserve discount rates.[8] To weight the discount rates we use the balance sheet size of the respective Federal Reserve Banks, averaged between 1921 and 1941.[9] Moreover, to take into account that rates change during a month, we weight the monthly interest rate by the number of days in a month the rates are in force.

The Federal Reserve was not the only institution that rediscounted loans. Banks continued to make little use of the Fed's discount window facility, as there were restrictions on the quality of collateral that became more difficult to satisfy as the Depression worsened. In response, other financial institutions were developed to try and provide for easier discounting of loans. The National Credit Corporation began in 1931 in the wake of the financial and banking crisis that arose that year, to pool resources across banks that were reluctant to lend given their impaired balance sheets (Olson, 1972). This effort was unsuccessful, and the next year, the Reconstruction Finance Corporation (RFC) was chartered as a lender of last resort to discount loans and provide assistance to weak banks (Mason, 2003; Vossmeyer, 2016). The RFC financed itself by issuing its own debt on private capital markets (see e.g. Mason, 2003), in contrast to the Federal Reserve. One year later the Emergency Banking Act of 1933 expanded the mission of the RFC to include lending to non-banks and shifted the support to banks to purchases of preferred stock (see e.g. Vossmeyer, 2016). Calomiris et al. (2013) found this to be more effective at helping banks weather the Depression, as it recapitalized banks without burdening them with additional debt on their balance sheets (Butkiewicz, 1995; Jones, 1951; Mason, 2001).[10] Mason (2001) shows that the RFC aided bank survival and Vossmeyer (2016) finds that the RFC stimulated bank lending.

Since the Fed did not rely on the discount rate as its only policy tool, we are unlikely to fully capture monetary policy with a single measure. To address this issue, we conduct a number of additional analyses with alternative monetary policy measures, including loans given by the RFC, as well as with additional variables, which capture policy actions that where implemented through quantity-oriented discount window policies. We discuss these estimations in Section 4.

For the loan volume, we consider loan data from weekly-reporting Federal Reserve member banks (located in leading cities), deflated by the consumer price index. While this series allows us to obtain loan volumes at a monthly frequency, it is only reported on a voluntary basis by a sample of member banks and thus may not necessarily represent the whole U.S. banking sector. However, the Board of Governors and the Federal Reserve Banks collected these data to assess the condition on money and credit markets more promptly as it was possible using call report data. In terms of loan volume the sample of banks represents roughly 70% of the loans of all member banks, averaged between 1919 and 1941.[11] Still the sample of banks is not constant over time and therefore short-term

[8] Fig. A.1 in the Appendix shows the Federal Reserve Banks' district specific discount rates.

[9] In the robustness analysis (Section 4) we use a principal component analysis to summarize the common variation in the discount rate series. This analysis does not require a specific weighting scheme.

[10] The RFC charged an interest rate at least 50 basis points above regular discount rates (Chandler, 1971).

[11] We calculate the average share using loan data on all member banks and yearly averages since the data are not available at a monthly frequency (Table 18 in Banking and Monetary Statistics).

Table 1
Variable descriptions and data sources.

Variable	Description	Start	End	Dataset	Indicator
IP	Index of production of manufactures, total for United States (1957–1959=100, NSA)	1919:1	1940:1	NBER	m01175
CPI	Consumer price index, all items for United States (1957–1959=100, NSA)	1919:1	1940:1	NBER	m04128
Discount rates	Federal Reserve Bank discount rates on eligible paper (all districts, percent, NSA)	1919:1	1940:1	BMS	Table No.115
Total loans	Total loans from weekly reporting member banks in 101 leading cities (billions of dollars, NSA)	1919:1	1940:1	BMS	Table No.48
Loans on securities	Loans on securities from weekly reporting member banks in 101 leading cities (to broker, dealers and others, billions of dollars, NSA)	1919:12	1937:12	BMS	Table No.48
Loan rate	Rates charged on customers' loans by banks in principal cities (percent, NSA)	1919:1	1939:2	BMS	Table No.124
Bills discounted	Bills discounted, Federal Reserve Banks for United States (millions of Dollars, NSA)	1919:1	1940:1	BMS	Table No.101
Total reserve credit	Total reserve bank credit outstanding (millions of dollars, NSA)	1919:1	1940:1	BMS	Table No.101
Monetary base	St. Louis adjusted monetary base (billions of dollars, NSA)	1919:1	1940:1	FRED	AMBNS
Failed bank deposits	Estimated monthly stock of deposits in closed national banks	1920:1	1940:1	Anari et al. (2005)	Column C
Bankers' accep. rate	Banker's acceptance rates for New York (percent, NSA)	1919:1	1940:1	NBER	m13007
Treasury bill rate	Yields on short-term United States securities, three-six month treasury notes and certificates, three month treasury bills for United States (percent per annum, NSA)	1920:1 1931:1	1930:12 1940:1	NBER NBER	m13029a m13029b
Gov. bond yield	Long-term government bond yields (until October 1925 callable due or after eight years and after October 1925 callable due or after twelve years, percent)	1919:1	1940:1	BMS	Table No.128

Abbreviations: NBER – National Bureau of Economic Research Macrohistory Database; BMS – Banking and Monetary Statistics; Federal Reserve Bank of St. Louis Economic Data (FRED); NSA – not seasonally adjusted.

fluctuations in the loan series may be due to changes in the sample composition, at least to some extent.[12] Another limitation is that our credit data do not provide information about non-member banks.[13] Finally, until 1934, loan categories are very broadly defined. As we are interested in loans to private customers (e.g. commercial and industrial loans, construction loans etc.), we subtract loans on securities from the total loan series. While other loans still captures loans to banks and open market papers, the data starting in 1934 show that loans to customers represent the largest share of other loans accounting for 65–74% between September 1934 and December 1937.[14]

The loan rate is an average prevailing rate on commercial loans and time and demand security loans. The Board of Governors gathered these data from member banks in leading cities. Table 1 lists the exact description of the data and Fig. 1 displays the corresponding time series plots. In the estimations all variables are seasonally adjusted using the X12 ARIMA method and are in logs with the exception of the interest rates.

2.3. Identification

We impose sign restrictions on the impulse response functions to identify loan supply shocks together with macroeconomic shocks. These restrictions are summarized in Table 2. All restrictions are imposed on impact and the first period and all shocks are normalized to be contractionary. The first two rows of Table 2 contain the restrictions that we impose to identify aggregate demand and aggregate supply shocks. We assume that prices and output move in the same direction after an aggregate demand shock while these two variables respond with opposite signs to an aggregate supply shock.[15]

[12] For instance, banks may have stopped reporting if they experienced financial difficulties. However, member banks also merged during the 1930s and therefore the effect of banks suspensions on our aggregate measure should be mitigated.
[13] According to Calomiris and Mason (2003b) most bank failures were nonmember banks and therefore our estimates for loan supply potentially represents a lower bound and are somewhat conservative.
[14] In Appendix Fig. A.2 shows the available loan categories between 1919M1 and 1941M1.
[15] From a more structural point of view, aggregate supply and aggregate demand shocks represent broad categories of shocks. The dynamics associated with aggregate supply shocks are consistent, among other things, with the mechanism modeled in Cole and Ohanian (2004) and aggregate demand shocks may comprise e.g. pessimism shocks (Cogley and Sargent, 2008) as well as uncertainty shocks (Mathy, 2020).

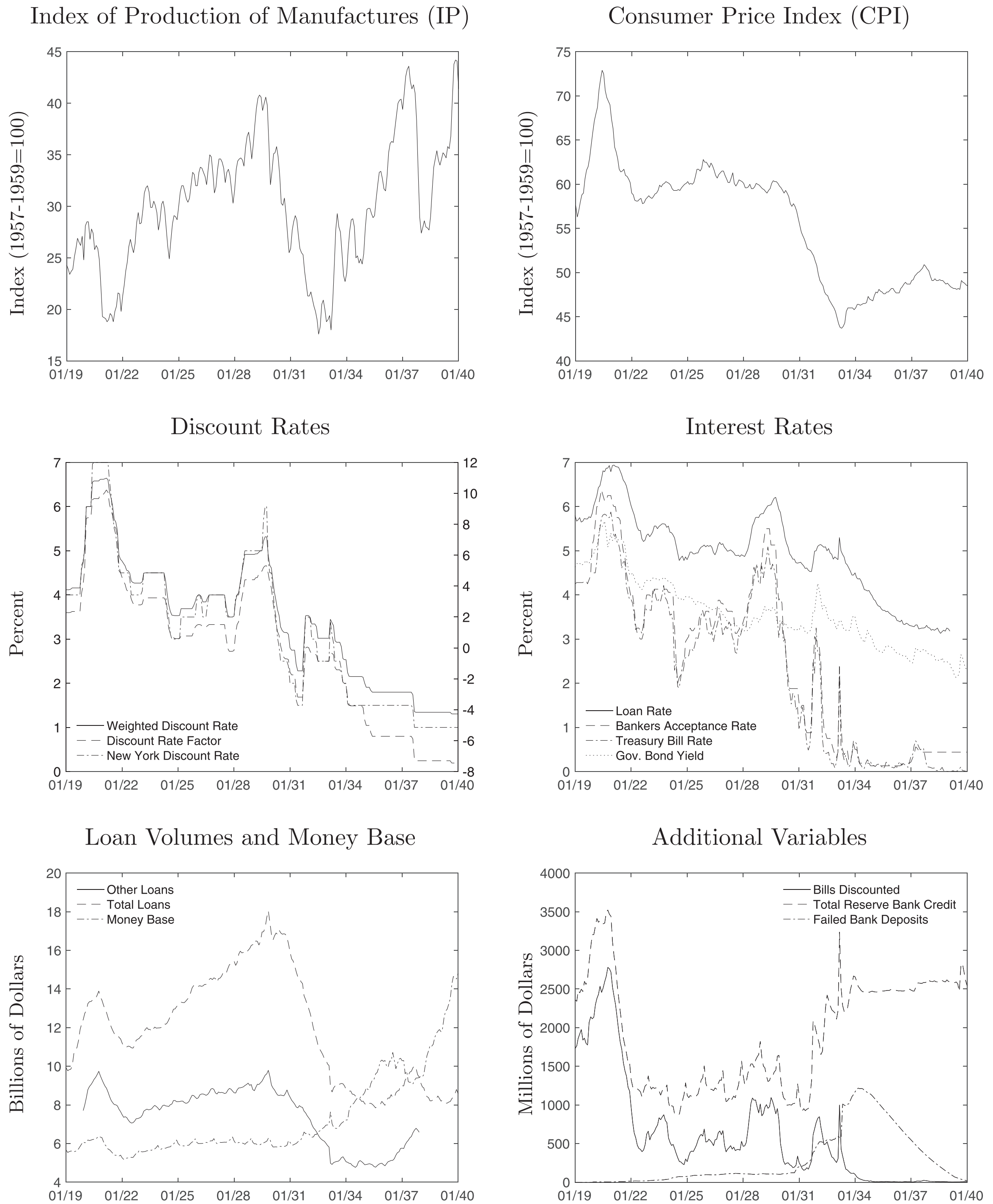

Fig. 1. Time series plots of variables. Notes: For the data description please see Table 1. The first principal component of the discount rate is measured in standard deviations on the right hand side axis.

Table 2
Sign restrictions on impulse response functions.

Shock	IP	CPI	Discount rate	Loan volume	Loan rate
Aggregate demand	≤ 0	≤ 0			≤ 0
Aggregate supply	≤ 0	≥ 0			≤ 0
Monetary policy	≤ 0		≥ 0		≥ 0
Loan supply	≤ 0		≤ 0	≤ 0	≥ 0

Notes: Sign restrictions are imposed on impact and the subsequent period; the residual shock is normalized (with a positive response of the loan rate).

While the identification of aggregate supply and aggregate demand shocks corresponds closely to how these shocks are identified in studies analyzing post-war data, we adopt a somewhat different approach to identify monetary policy shocks as the Federal Reserve of the 1930s operated differently than a modern central bank. As shown in the third row of Table 2, we characterize a monetary policy shock as an increase in the discount rate that occurs together with a decline in output. To distinguish the monetary shock from aggregate supply and aggregate demand shocks, we assume that the loan rate declines in response to contractionary aggregate supply and aggregate demand shocks, due to lower loan demand, but increases following a monetary policy shock, along with the discount rate. Our assumption that the loan rate co-moves positively with he discount rate is in line with empirical evidence presented in Cohen et al. (2020).[16]

Note that we do not impose any restrictions on how monetary policy reacted to aggregate supply and aggregate demand shocks since it is not clear if and to what extent the Fed responded to business cycle shocks. The Federal Reserve was founded in 1913 in the wake of the panic of 1907 and endemic financial panics, monetary disturbances, and economic recessions during the 19th century. The Fed was set up to have some of the functions of a central bank, especially to provide for an “elastic currency” where monetary conditions could adjust to the needs of trade (essentially money demand). However, the Fed was never set up to function as a lender of last resort as discussed by Bagehot (1873), though numerous authors later would assume that this was a responsibility of the Fed in this period, especially after the publication of Friedman and Schwartz’s seminal work on the Great Depression (Friedman and Schwartz, 1963). While the Fed’s operating procedure was not entirely straight-forward, the so-called “Riefler-Burgess” doctrine provides a good description along with the real bills doctrine (Wheelock, 1990).[17] The real bills doctrine viewed monetary expansion as non-inflationary if it was backed by real activity. The Fed, following the real bills doctrine, would view monetary conditions as being too tight if banks were rediscounting more often, as then banks were short of reserves, while a situation where there was little rediscounting implied that monetary condition were loose, as banks already had sufficient reserves. However, Fed policies were also district-specific. Richardson and Troost (2009) show that the Atlanta Federal Reserve Bank did not follow the real bills doctrine, while the Saint Louis Fed did, with better economic outcomes in those parts of Mississippi in the Atlanta district.

The last row of Table 2 shows the restrictions that we impose to identify loan supply shocks. Our key assumption here is that a shift in the supply curve of loans does not move the volume of loans and the interest rate on loans into the same direction (see e.g. Bijsterbosch and Falagiarda, 2015; Gambetti and Musso, 2017; Helbling et al., 2011; Hristov et al., 2012; Meeks, 2012; Mumtaz et al., 2018). Specifically a reduction in loan supply is accompanied by a decline of loan volumes but not of the loan rate. In this way, the identified loan supply shocks should capture the effects of financial frictions that gave rise to a higher cost of credit intermediation (Bernanke, 1983). Moreover, to account for the possibility that banks tried to keep loan rates constant during the financial crisis (see e.g. Cohen et al., 2020; Richardson and Van Horn, 2018), we impose weak inequalities and also classify a reduction of the loan volume at constant loan rates as a loan supply shock. Since adverse aggregate supply and aggregate demand shocks are assumed to be accompanied by a lower demand for loans, and therefore a lower loan rate, the restrictions ensure that these shocks are orthogonal to loan supply shocks. However, the loan rate also increases along with the discount rate in case of the monetary policy shock. Thus, the restriction on the loan rate is not sufficient to disentangle monetary policy from loan supply shocks. We therefore impose the additional restriction that the discount rate does not increase in response to an adverse loan supply shock. In other words, we assume that monetary policy either remained passive in response to the shock, or expansionary, which may be a better description of, e.g., the Atlanta Fed.

Overall, by imposing these restrictions we are able to distinguish between loan supply shocks and the other macroeconomic shocks. In other words, loan supply shocks capture any dynamics in loan supply that are not induced by the other identified shocks. In this sense, the identification of loan supply shocks is rather general.

[16] Cohen et al. (2020) gather semi-annual data on interest earnings of banks and loan volumes aggregated by Federal Reserve district, state, and major municipality over the period from 1923 to 1929. With these data they estimate the elasticity between the loan rate and the district specific discount rate for 82 locations and find a positive relationship.

[17] Epstein and Ferguson (1984) dispute the coherence of this doctrine and that Riefler and Burgess subscribed to it consistently, but Meltzer (2010) considers the real bills doctrine to be the guiding principle at the Fed for the domestic economy during this period. “The basis of that system was the Real Bills Doctrine” according to Wheelock (2004, p. 11). See also Chandler (1971, Ch. 1) for a description of the Fed’s policy during this period.

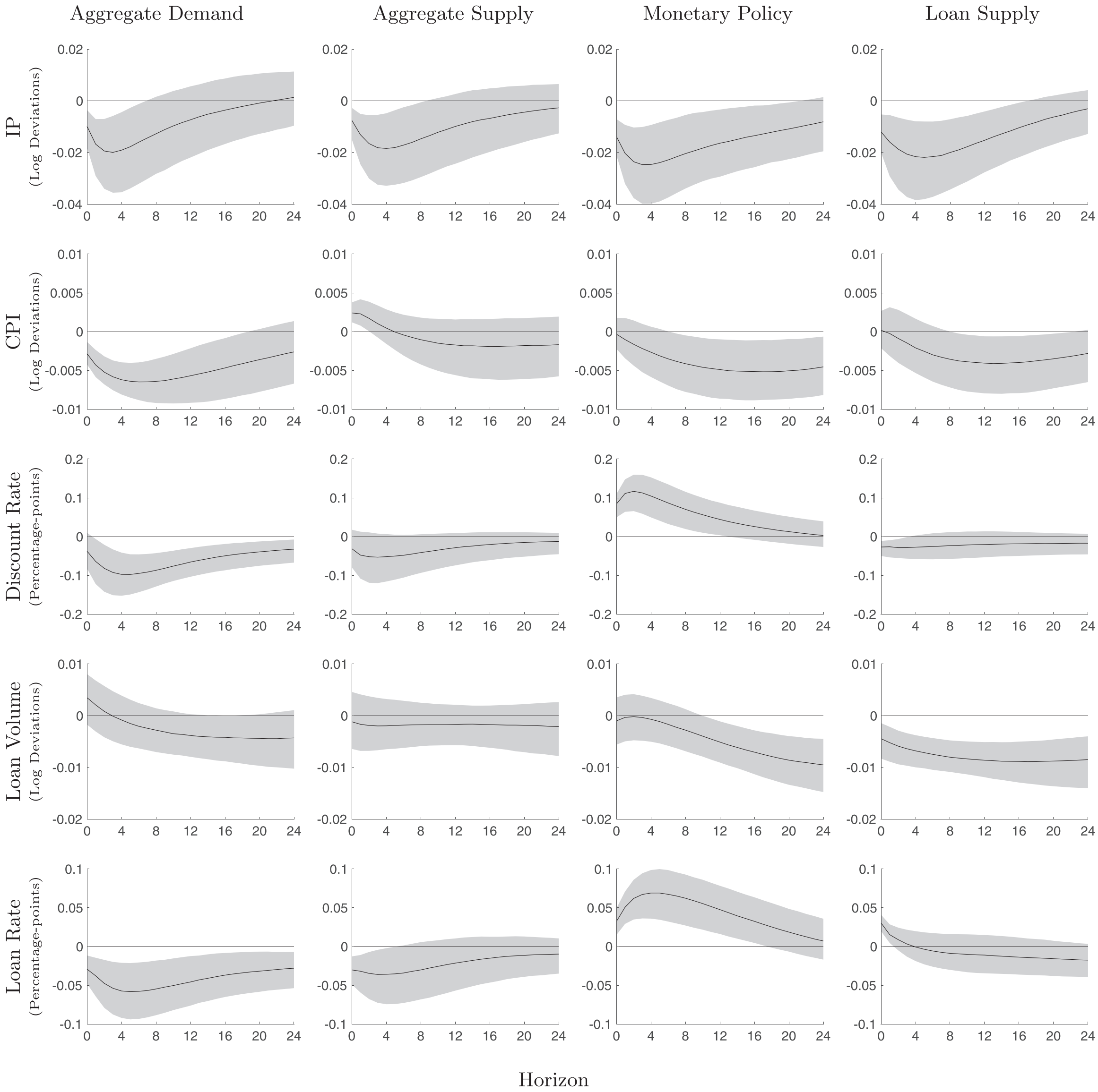

Fig. 2. Impulse responses to identified macroeconomic shocks.

3. Results

Before we present the main findings of our analysis based on the historical decomposition of industrial production, we discuss the impulse response functions and the forecast error variance decomposition (FEVD).[18]

3.1. Impulse response analysis and forecast error variance decomposition

Fig. 2 shows the impulse responses of the endogenous variables to the four identified macroeconomic shocks over a horizon of 24 month.[19] The solid lines in the figure show the point-wise median responses of the sign-identified posterior distribution at each forecast horizon. The gray shaded areas contain 68% of the sign-identified posterior distribution.

[18] In the Appendix (Fig. A.5) we also provide results of the median target model, or closest to median model. The median target model is one structural model for which the impulse responses reveal the closest fit to the point-wise median responses (Fry and Pagan, 2011). Alternatively we also consider median target models which are selected based on the values of the FEVD or the historical decomposition.

[19] Due to the lack of a structural interpretation, we do not present results for the residual shock.

Table 3
Forecast error variance decomposition of industrial production.

Horizon	AD shock	AS shock	MP shock	LS shock	Residual
0	12.24	7.12	24.22	18.61	3.86
	(1.60, 40.44)	(0.94, 27.95)	(6.31, 55.13)	(3.63, 50.74)	(0.25, 27.48)
6	12.09	10.54	19.82	14.99	8.93
	(1.67, 38.70)	(1.29, 32.39)	(3.83, 49.58)	(2.30, 45.92)	(1.58, 37.20)
12	10.16	10.34	19.36	16.25	11.13
	(2.12, 35.51)	(1.67, 32.33)	(3.74, 48.83)	(2.70, 46.01)	(2.16, 39.14)
24	11.02	10.74	20.66	15.40	13.51
	(3.24, 32.56)	(2.38, 31.44)	(4.74, 48.59)	(3.19, 42.68)	(2.99, 40.40)

Notes: The table shows point-wise median values of the sign-identified posterior distribution and the values in parentheses indicate 68% of the sign-identified posterior distribution. All values are reported in percent.

The first column shows the responses to an aggregate demand shock. We see persistent declines in output, prices, the discount rate, and the loan rate.[20] While the responses of these variables, with the exception of the discount rate, are restricted on impact and for the first period, the fact that the responses are rather persistent indicates that the restrictions are well supported by the data. The loan volume, which we leave unrestricted, initially increases but then declines over time. The second column displays the impulse responses to an aggregate supply shock. Although we again see a rather persistent decline of output and the loan rate, the response of prices is relatively short-lived. The unrestricted variables, the discount rate and the loan volume, tend to decline. The responses to a monetary policy shock are presented in the third column. The policy shock leads to an increase in the discount rate and persistent declines in industrial production and prices.[21] The loan volume declines and the loan rate increases.

The last column displays the responses to a loan supply shock. Industrial production and the loan volume decline persistently, whereas the responses of the discount rate and the loan rate are short-lived. We also find that the unrestricted price level declines in response to a loan supply shock, which is in line with the view that exogenous loan supply developments are essentially transmitted through demand-side channels (Gambetti and Musso, 2017; Hristov et al., 2012).

To see how strongly the individual shocks contribute to output dynamics, we present the FEVD of industrial production at selected horizons in Table 3.[22] Aggregate demand shocks account for roughly 10–12% of the variation in industrial production over the sample period. The share assigned to aggregate supply shocks ranges from roughly 7% to 11%. Monetary policy shocks, in contrast, account for around 24% of the forecast error variance on impact. The rather strong contribution of the monetary policy shock differs somewhat from findings reported in studies that examine postwar data,[23] and supports the view that monetary policy actions became more systematic over time. And finally, loan supply shocks account for 15–19% of the unexpected variation in industrial production. Interestingly, the contributions of loan supply shocks are of a similar order of magnitude as estimates based on postwar data (see Helbling et al., 2011; Meeks, 2012).

3.2. Historical decomposition of industrial production

While the variance decomposition presented in the last section provides information about the average contributions of the structural shocks, the historical decomposition allows us to characterize the time-varying contributions of the shocks. Although the decomposition is obtained with the full estimation sample, we focus in the presentation on results for the period from January 1927 to December 1937 to highlight the onset of the Great Depression, the downturn, and the recovery.[24]

Panel A of Fig. 3 shows the contributions of the four identified shocks to the forecast errors of industrial production together with the time series of industrial production, both measured in log scale and displayed on the left and right hand side axis, respectively. The contributions are obtained based on the point-wise median values of the sign-identified posterior distribution.[25] The vertical

[20] Aggregate demand and loan supply shocks both lead to a maximum decline of industrial production of roughly 2%. Mathy (2020) explicitly identifies uncertainty shocks, which can be interpreted as an aggregate demand shock in our setting, and finds that a typical uncertainty shock reduces industrial production by roughly 2%.

[21] Vargas-Silva (2008), for instance, finds only a muted and rather short-lived effect on output using U.S. postwar data (January 1965 to December 2005), which suggests that monetary policy operated differently during the 1930s as compared to a modern central bank.

[22] As we focus in the remaining analysis on output dynamics, we only discuss the FEVD of industrial production. The FEVDs of all other variables are provided in Table A.2 in the Appendix.

[23] Using different empirical frameworks, studies based on post-World-War-II data, with samples starting roughly in 1960, typically find that monetary policy shocks account only up to roughly 10% of the variation in economic activity (see e.g. Ramey, 2016, for an overview).

[24] The calculation of the historical decomposition starts with the first observation period in February 1920. In the Appendix (Fig. A.6), we also presents the historical decomposition of industrial production for the entire observation period (February 1920 to December 1937).

[25] Panel A also shows that some of the variation in industrial production remains unexplained, especially between 1931 and 1938. In other words, the four identified shocks shocks account only for part of the variation in industrial production. Fig. A.6 in the Appendix shows the historical decomposition including the residual shock. While the residual shock increases the amount of variation in industrial production that is accounted for by the shocks, it has no structural interpretation.

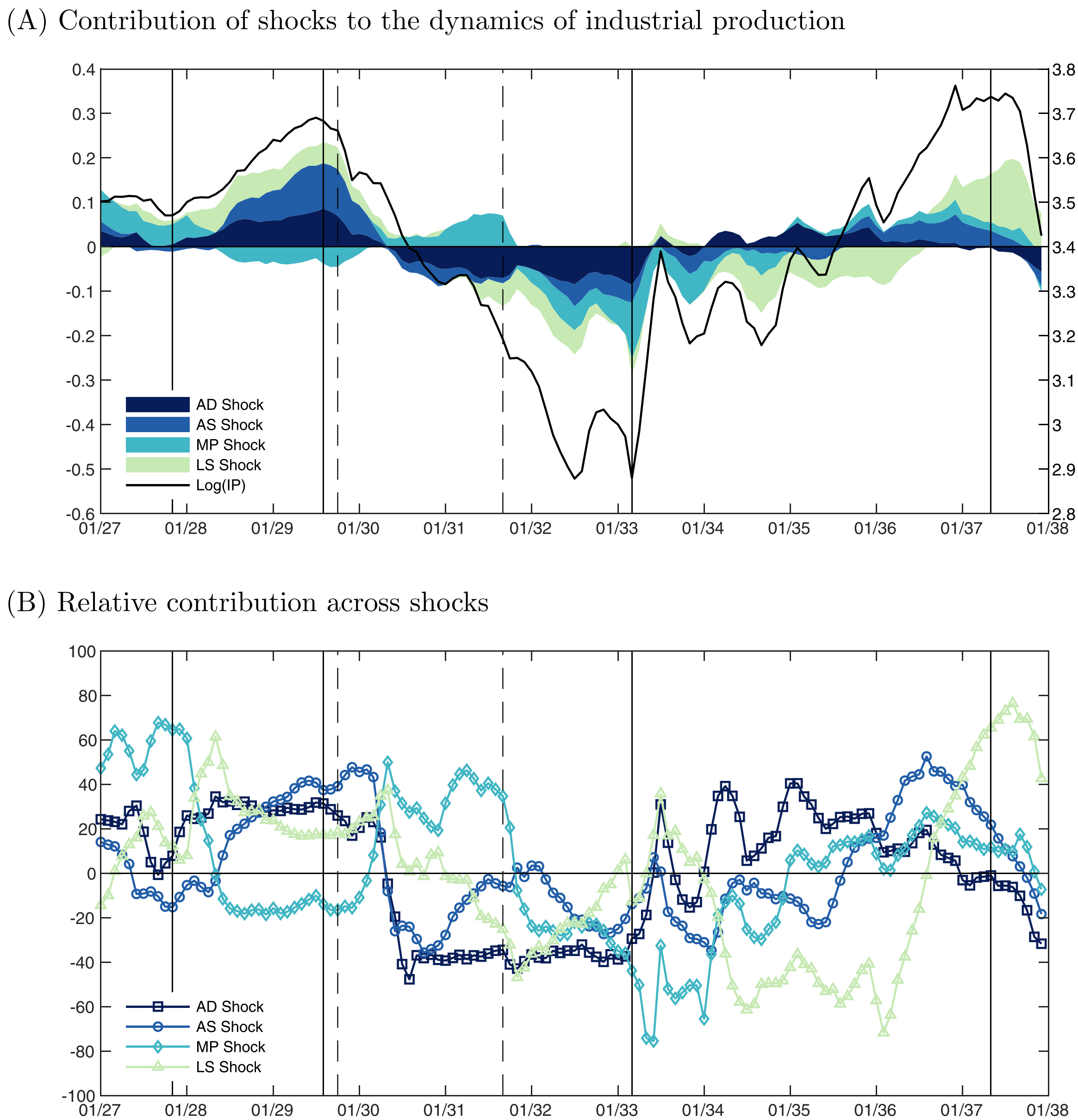

Fig. 3. Historical decomposition of industrial production – an overview over the Great Depression (1927:1–1937:12).

lines correspond to the business cycle peaks and troughs (as dated by the NBER) and the dashed lines indicate the stock market crash in October 1929 and Great Britain's exit from the gold standard in September 1931. To facilitate the comparison across shocks, Panel B presents the individual contributions of shocks as percentage shares of the absolute sum of all four contributions in each period.

According to Panel A, aggregate demand shocks strongly contributed to the increase of industrial production from 1927 to 1929, which marks the end of the expansion phase that preceded the Great Depression, with especially pronounced contributions after mid 1928. Aggregate supply shocks also contributed positively in late 1928 and in 1929. In Panel B we see that aggregate demand shocks account for roughly 29% of the combined effects of the identified shocks on industrial production and aggregate supply shocks account for about 21%, averaged over the boom period prior to the stock market crash (1927M12–1929M10). The relatively high share of variation attributed to aggregate supply effects in 1929 is consistent with the observation that deflationary dynamics were already present before the business cycle peak in August 1929. Monetary policy shocks contributed positively to the initial expansion until early 1928 when positive contributions originating from monetary policy shocks turned negative. Finally, loan supply shocks also contributed positively to output dynamics in the years preceding the Great Depression. In fact, loan supply shocks accounted for the largest share of the variation in industrial production in early 1928. This finding is in line with the interpretation that the Great Depression represents a credit boom gone bust (see Eichengreen and Mitchener, 2004), at least to some extent.

The famous stock market crash in October 1929 occurred two months after the business cycle peak, and that's when we see the positive contributions from aggregate demand shocks started to decline sharply. From mid 1930 onward, aggregate demand shocks contributed negatively to output dynamics through the trough in 1933. Thus, a decline in aggregate demand played a crucial role during the early period of the Great Depression (Romer, 1993; Temin, 1976), confirming the results in Cecchetti and Karras (1994). Aggregate supply shocks also started to contribute negatively in mid-1930, albeit less persistently than aggregate demand shocks. While monetary policy was tightened in 1928, it turned expansionary shortly after the stock market crash. Although this result suggests that monetary policy was rather loose during the initial downturn, expansionary policy contributions were rather short-lived. Fig. 3 also shows that monetary policy shocks contributed negatively to output dynamics from 1931 onward, which roughly corresponds to Great Britain's exit from the gold standard, when the Federal Reserve raised the interest rate sharply to counteract gold outflows (Eichengreen, 1992; Friedman and Schwartz, 1963). While this finding is in line with Fackler and Parker (1994) and Burbidge and Harrison (1985), we will see in Section 4 that this result depends somewhat on the identification of monetary policy shocks.

The contributions of loan supply shocks turned negative at the beginning of 1931 and intensified when the negative contributions of aggregate demand and aggregate supply shocks stabilized or even declined. In late 1931, loan supply shocks accounted for roughly 40% of the combined effects of all four identified shocks (see Panel B). Thus, adverse loan supply shocks were a quantitatively important factor behind the deepening of the slowdown in economic activity, as emphasized by Bernanke (1983) in his account of the Great Depression.

The negative contributions of all four shocks became substantially smaller starting with the business cycle trough in March 1933. In particular, the contribution of aggregate demand shocks vanished almost entirely during the early phase of the recovery. Although monetary policy still contributed negatively after the business cycle trough, the magnitude of the negative contributions declined sharply as well. Aggregate supply shocks had been relatively unimportant since early 1932 and remained so throughout the recovery phase, except for a brief period towards the end of 1933 and early 1934, when they exerted a negative influence on output dynamics.

These negative contributions are in line with the view that New Deal policies gave rise to contractionary supply side developments (Chicu et al., 2013; Christiano et al., 2003; Cole and Ohanian, 2004) through diminished competition and increased cartelization, although our results suggest that these effects contributed little to output dynamics.[26]

Adverse loan supply contributions initially declined in a way similar to what we observe for the other shocks during the recovery period, but intensified again in early 1934. Thus, credit conditions remained tight until early 1936. This is consistent with Cohen et al. (2020), who find that financial conditions remained tight beyond the business cycle trough.[27] Nevertheless, positive loan supply shocks contributed strongly to the upswing in economic activity from 1936 to 1937, when the U.S. entered a short recession. Our historical decomposition suggests that the 1937–38 recession was linked to a short credit boom and bust cycle rather than to mistakes in monetary policy, as suggested by Friedman and Schwartz (1963) and Romer (1992).

In summary, we find that adverse aggregate demand developments played an important role throughout the downturn and during the early phase of the Great Depression, consistent with Temin (1976) and Romer (1993). While aggregate supply shocks also mattered for the initial drop in industrial production, the effects were only short-lived and rather muted during the later phases of the Great Depression. At the end of 1931, it was mostly aggregate demand and loan supply shocks that accounted for the drop in industrial production and therefore, in line with Bernanke (1983), adverse loan supply developments contributed strongly to the deepening of the Great Depression. We also find that credit conditions remained relatively tight beyond the business cycle trough, but contributed strongly and positively during the later stages of the recovery.

So far, the presentation of our results has relied on the point-wise median values of the historical decomposition. To provide a notion of precision we present in Fig. 4 the distribution of the historical decomposition for each shock separately. The gray areas show 68% of the sign-identified posterior distribution and the solid lines display the point-wise median values, corresponding to the stacked areas presented in Fig. 3.

While we see that the dispersion is relatively high across shocks, the distributions displayed in Fig. 4 support our interpretation.[28] In particular, the mass of the distribution of the aggregate demand contributions (in Panel A of Fig. 4) lies mainly above zero before the stock market crash and within a few month after the crash the mass of the distribution is located in the negative territory. While the distribution of aggregate demand contributions shows mainly negative effects until March 1933, no systematic pattern is visible during the recovery. The distribution of aggregate supply contributions (presented in Panel B) reveals expansionary effects on output before the stock market crash and relatively unsystematic effects afterwards. Similarly, the distribution of monetary policy contributions also largely confirms our conclusions. Finally, the distribution of loan supply effects (Panel D) shows the credit boom before the onset of the Great Depression and the tightening of credit supply starting in early 1931. Hence, in general the interpretations of the distributions support the findings from the point-wise median values.

[26] That said, Cole and Ohanian (2001) do not find that banking panics or loan supply shocks were significant factors in the Great Depression.

[27] Similarly, survey evidence indicates that credit conditions remained tight during the early stages of the recovery (Kimmel, 1939; Stoddard, 1940).

[28] As the sign-identified posterior distribution summarizes model uncertainty in addition to sampling uncertainty (Fry and Pagan, 2011), the dispersion is naturally wider as compared to exactly identified models. In other words, the dispersion captures that in case of sign restrictions a weaker set of restrictions is imposed as compared to exactly identified models.

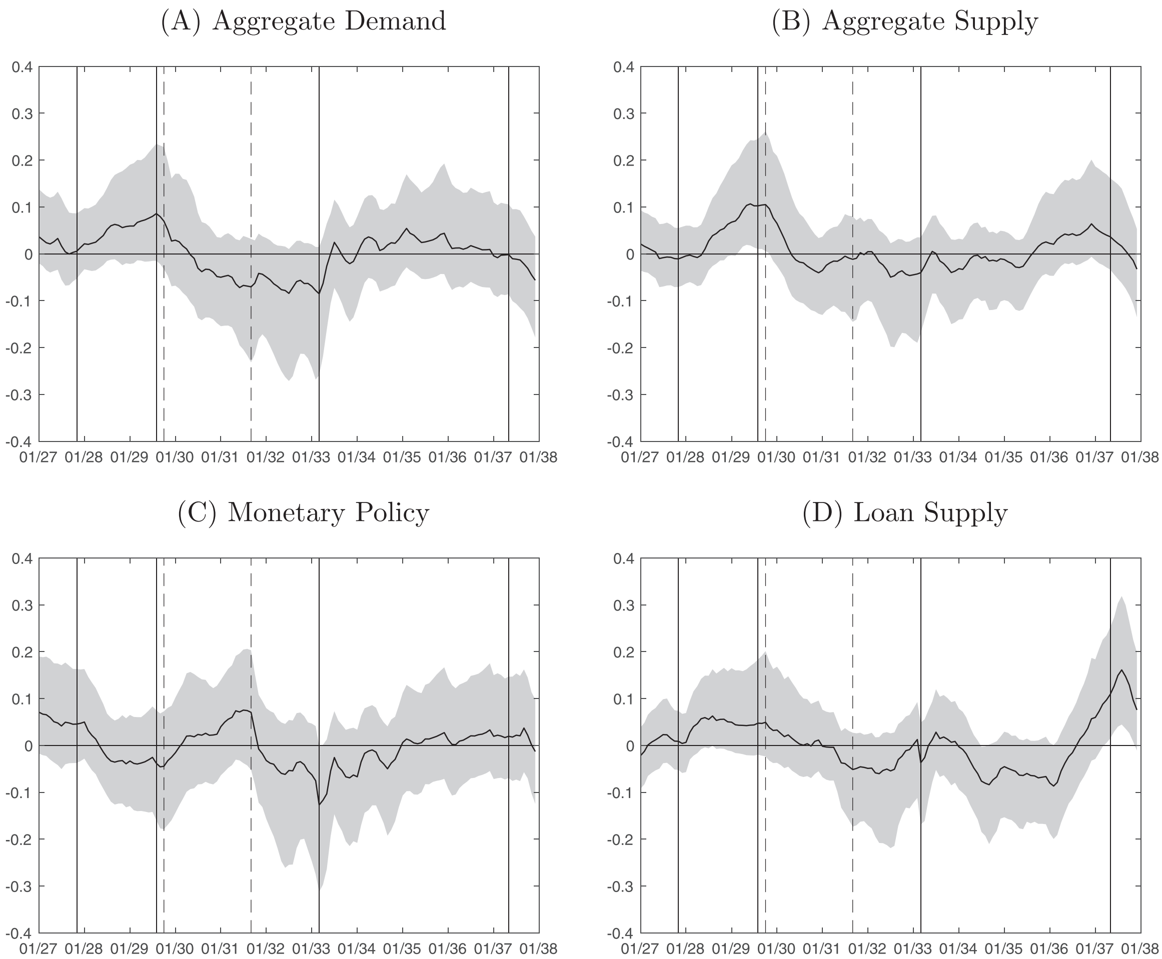

Fig. 4. Historical decomposition of industrial production – split across individual shocks (1927:1–1937:12).

3.3. Banking crises and loan supply shocks

To obtain a more detailed picture of how loan supply developments were linked to the financial crisis that evolved in the U.S. between 1930 and 1933, we now study the occurrence of loan supply shocks during the individual stages of the financial crisis.[29] In particular, we focus on distress in the banking sector during this period, which is well documented in the literature.

The potential causes and characteristics of bank failures are discussed extensively in the literature. According to Friedman and Schwartz (1963) the waves of banking failures were important sources of shocks, while Calomiris and Mason (2003b) argue that the banking crises in 1930 and 1931 were mainly due to solvency issues rather than liquidity problems, suggesting that these crises were a consequence of the general decline in economic activity, rather than a source of shocks. In contrast, Richardson (2007) shows that the banking crises resulted from both liquidity and insolvency issues.

Friedman and Schwartz (1963) provide a timeline of four distinct waves of banking panics, though this categorization has been largely superseded or revised in later work. Wicker (1996) presents a more granular description and argues that bank failures were largely local in flavor and often resembled the orderly liquidations of the roaring 20's rather than widespread panics in the entire banking sector. More recently, Mitchener and Richardson (2019) study regional banking crises and identify seven specific crisis periods. We follow this later work in framing how we think about panics in this period.[30]

Fig. 5 shows the identified loan supply shocks between June 1930 and 1933. The bars correspond to the point-wise median values of the sign-identified posterior distribution of the identified shocks and the whiskers indicate 68% of the sign-identified posterior distribution. For easy reference the figure also reproduces the contribution of the shocks to the dynamics of industrial production (solid lines), as shown in Fig. 4. The gray areas highlight the seven periods of banking crises as defined by Mitchener and

[29] In Fig. A.7 in the Appendix we also show the identified shocks over the period from January 1927 to December 1937.

[30] Table A.3 in the Appendix lists the different classifications. While the national banking holiday in March 1933 is generally viewed to have ended the final wave of bank failures, Coe (2002) finds that the probability of a financial crisis remained high through early 1934.

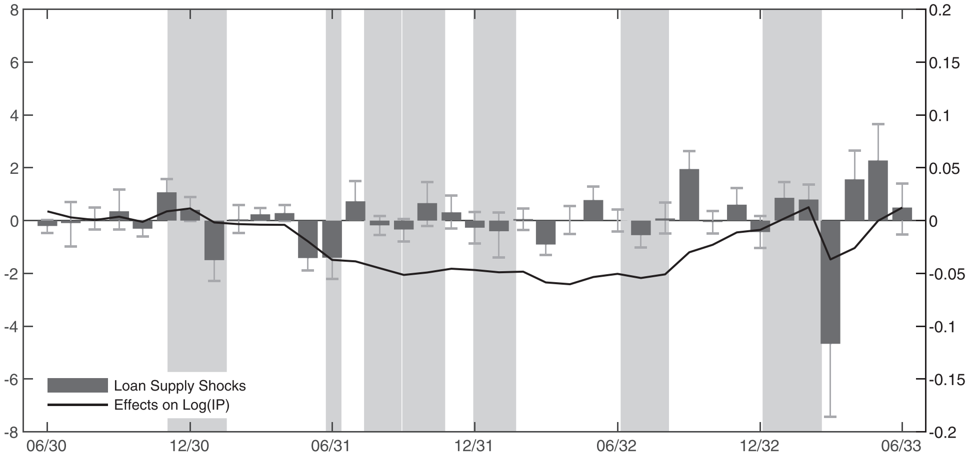

Fig. 5. Identified loan supply shocks (1930:6–1933:6).

Richardson (2019): 16th of November 1930 to 31st of January 1931 (Caldwell crisis), 7th of June 1931 to 27th of June 1931 (first Chicago panic), 26th of July 1931 to 12th of September 1931 (crisis in response to German panic), 13th of September 1931 to 7th of November 1931 (crisis after Great Britain's departure from gold), 13th of December 1931 to 6th of February 1932 (winter 1932 crisis), 19th of June 1932 to 20th of August 1932 (second Chicago panic), and 18th of December 1932 to 4th of March 1933 (winter 1933 crisis).

The figure shows that particularly large and negative loan supply shock occurred during the banking crisis in late 1930 and in May and June 1931, when loan supply shocks started to contribute negatively to the dynamics of industrial production. Since we do not find any additional negative loan supply shocks that were particularly large until March 1933, we conclude that the negative contribution of loan supply shocks to the dynamics in industrial production between early 1931 and late 1932, which we find in our historical decomposition, was primarily driven by adverse shocks that coincided roughly with the first two banking crises. Calomiris and Mason (2003b), in contrast, conclude that aggregate effects of these early waves of bank failures should have been limited.[31] Although Wicker (1996) notes that these two crises were rather regional events and should therefore not have had aggregate effects, Mitchener and Richardson (2019) show how regional crises can give rise to pronounced aggregate effects through bank networks.

The largest negative shock in our sample occurred in March 1933 along with the national bank holiday that ended the final wave of bank failures. According to Wicker (1996), this final wave of bank failures occurred at the national level. Calomiris and Mason (2003b) find that bank failure risk was largely unexplained by fundamental factors and, according to Richardson (2007), liquidity problems were particularly relevant around December 1932. Interestingly, however, this exceptionally large shock happened at a time when the adverse effects of earlier adverse shocks had already faded out. Moreover, the shock itself was immediately followed by a series of positive shocks. Thus, despite the size of the shock, its effect on output was only temporary.[32]

In Fig. 6 we present the dynamics of aggregate demand, aggregate supply, and monetary policy shocks during the banking crises. We see that aggregate demand and aggregate supply shocks do not show systematic patterns during the crises periods. We also see that monetary policy shocks were mainly positive, albeit quantitatively small, during the first two banking crises. Starting with the beginning of the banking crisis in late 1931, when Great Britain left the gold standard, we observe a series of contractionary monetary policy shocks. Thus, while bank failures coincided with monetary policy actions during this period, these actions were partly intended to stabilize the Dollar. A new series of negative policy shocks hit the economy from October 1932 onward, with a particularly large negative shock in March 1933.

4. Robustness checks

We perform several robustness exercises to support our main results. First, we re-estimate our baseline model and consider alternative monetary policy measures, including a different approach to derive a common discount rate for all twelve Federal Reserve

[31] It has to be noted that our results are not directly comparable to Calomiris and Mason (2003b) since they do not explicitly analyze loan supply effects associated with the banking crises.

[32] In Fig. A.3 in the Appendix we show the identified loan supply shocks together with outstanding RFC loans and investments over the period from January 1930 to January 1938 using data in Jones (1939). We see that RFC support substantially increased in 1933 and reached its maximum volume between 1934 and 1936. During this time, however, we still observe primarily negative loan supply shocks. Thus, while the RFC support was likely to have increased bank survival and loan supply and thereby reduced the influence of factors that exerted negative effects on loan supply (Mason, 2001; Vossmeyer, 2016), our results suggest that RFC actions did not manage to fully compensate the generally adverse loan supply developments during the financial crisis and the early recovery.

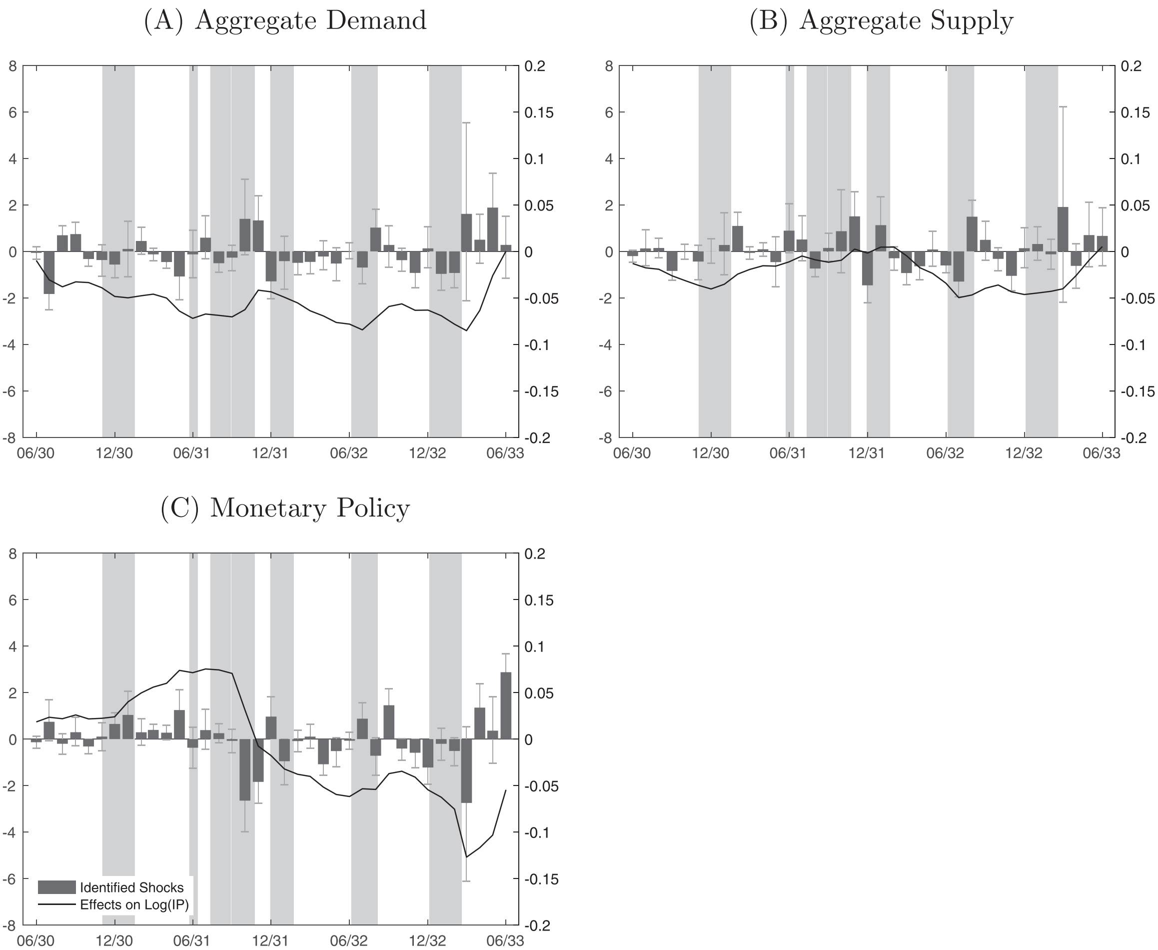

Fig. 6. Identified structural shocks (1930:6–1933:6).

districts, alternative short-term rates, a long-term government bond yield, and the monetary base. Second, we augment our baseline specification with potentially important additional variables. Third, we consider modified identification schemes, impose the sign restriction over a longer horizon, and also consider an estimation with a longer sample period. And fourth, we evaluate whether our findings depend on specific assumptions regarding the underlying data generating process, the applied data transformations, and the number of lags of the endogenous variables.

4.1. Monetary policy measure

First, we consider a principal component analysis to derive a common discount rate for the U.S. In contrast to our baseline measure, this approach requires no specific weighting scheme. Second, we consider the short-term Treasury bill rate as an alternative monetary policy measures. Although the Treasury bill rate is not directly controlled by the Federal Reserve, it also captures the general behavior of short-term interest rates. Furthermore, we use the Federal Reserve buying rates on prime bankers' acceptances as another policy measure. The purchase of bankers' acceptances was one integral part of the Federal Reserve open market operations. Given that the Federal Reserve Bank of New York conducted open market operations as the main financial center was in New York, this is the relevant bond buying rate. Furthermore, while the Federal Reserve Banks were able to set different discount rates, in general districts did coordinate their rates, especially in reference to the major money center in New York Wheelock (2004). Thus, we follow Romer and Romer (2013) and also use the New York Fed discount rate as an alternative policy measure.[33]

[33] Cohen et al. (2020) provide empirical evidence that changes in the New York Fed's discount rate are correlated with market rates in New York and the rest of the U.S.

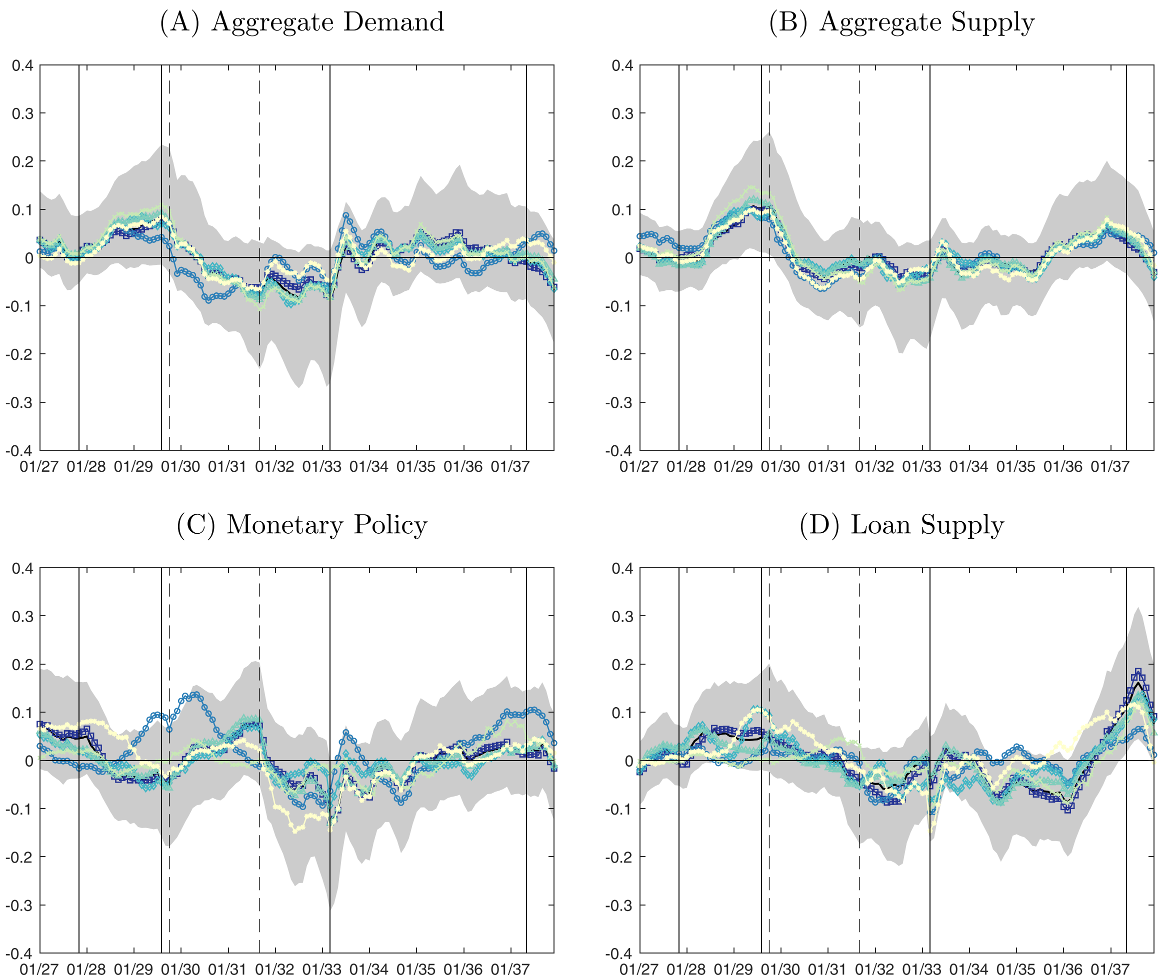

Fig. 7. Robustness checks I: historical decomposition of industrial production (1927:1–1937:12).

Alternatively, to capture monetary effects more broadly and to address concerns related to nominal interest rates approaching the zero lower bound during the recovery period (see e.g. Fackler and Parker, 1994; Mathy, 2020),[34] we also consider estimations using the monetary base or a long-term government bond yield as monetary policy measures.[35]

Fig. 7 summarizes the results of the first set of robustness checks. Each subfigure displays the contribution of one of the four identified shocks to the forecast errors of industrial production, obtained as the point-wise median values, for each robustness check, together with the point-wise median values obtained from the baseline specification and the corresponding 68% of the sign identified posterior distribution. When we use the monetary base or the long-term government bond yield instead of the discount rate, we find that the contributions of the monetary policy shock are of a similar order of magnitude as in our baseline specification during the recovery period when nominal interest approached the zero lower bound. Thus, our baseline results do not appear to be influenced by the zero lower bound. With the Treasury bill rate, monetary policy was more expansionary than in our baseline specification during the onset of the downturn. However, this pattern is not present in any other short-term rate, so overall our main conclusions are not reliant on a particular policy measure.

[34] The discount rate remained constant at 1.5% between March 1934 and August 1937, which complicates the interpretation of the interest rate as an indicator for monetary policy. Bordo and Sinha (2016) discuss open market operations and their relationship with quantitative easing measures in 1932 as an alternative to interest rate easing.

[35] See Table 1 for more information on the additional data. Due to data limitations for the Treasury bill rate, the sample in this estimation starts one month later (in January 1920) as compared to the baseline and the other robustness checks. For the monetary base we use the adjusted monetary base measure of the Federal Reserve Bank of St. Louis, which before 1941 consists of (i) money in circulation and (ii) total member bank reserve balances, both variables taken from the Banking and Monetary Statistics (Table 101, monthly averages of daily figures). The Federal Reserve Bank of St. Louis adjust the monetary base for changes in the reserve requirements in St. Louise in 1922 and the Banking Act of 1935. However, results remain also robust if we use the unadjusted raw data (results are available upon request). Concerning the identification, we impose the opposite sign restriction on the responses of money base as compared to the restrictions on the discount rate in our baseline estimation.

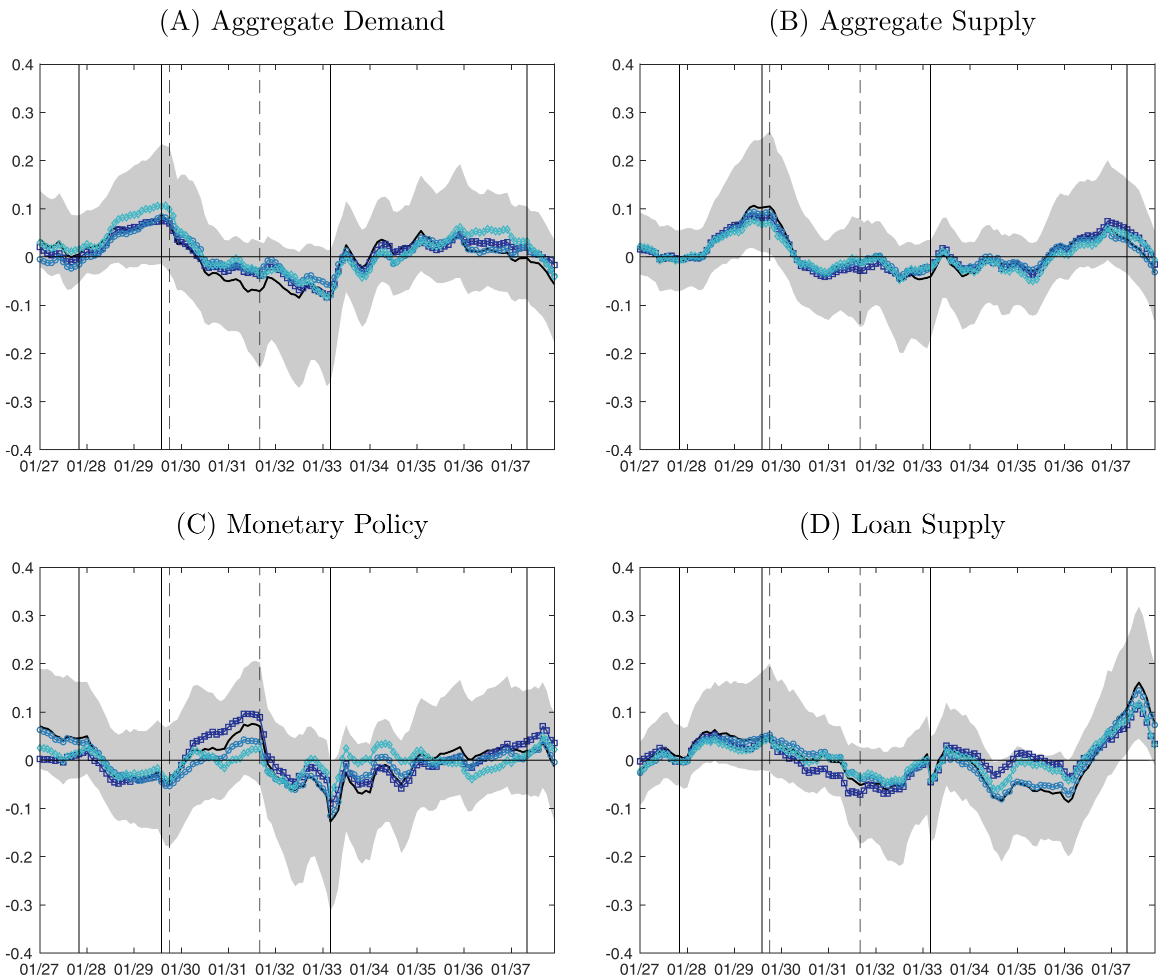

Fig. 8. Robustness checks II: historical decomposition of industrial production (1927:1–1937:12).

4.2. Augmented models

In the existing literature, financial disruptions and disintermediation are often measured using different proxies, such as the deposits of failing banks (see e.g. Bernanke, 1983). Thus, to check whether our baseline specification misses an important variable, which potentially impairs the identification of loan supply shocks, we augment our baseline specification with the stock of failed bank deposits from Anari et al. (2005), who provide an improved monthly estimate of the stock of failed bank deposits by focusing on national banks in liquidation (excluding banks that have just been suspended). In a VAR analysis (Anari et al., 2005) show that their measure has explanatory power for output changes during the Great Depression (see also Amir-Ahmadi et al., 2020).

Next, we run estimations in which we include additional monetary policy measures. While the discount rate is often used as the relevant policy interest rate during this period (Almunia et al., 2010; Romer and Romer, 2013; Temin, 1976), it does not fully capture the whole variety of policy actions at that time, such as changes in the eligibility of collateral. To account for policy measures in a broader sense, we extend our baseline model and include the volume of bills discounted at the Federal Reserve Banks. The volume of bills discounted encompasses rediscounted bills, member bank collateral notes, and discounts for individuals, partnerships, and corporations. Moreover, to account for any type of Federal Reserve credit we re-estimate our baseline and include the total credit outstanding at Federal Reserve Banks.

Fig. 8 shows the historical decompositions for the second set of robustness checks.[36] We find very similar patterns across the different estimations and thus conclude that the identified shocks in our baseline specification already sufficiently capture the underlying dynamics of the additional variables.

[36] Since additional sign restrictions are not required for the identification of the structural shocks, we always leave the responses of the additional variable unrestricted.

Table 4
Sign restrictions on impulse response functions (robustness checks).

Shock	IP	CPI	Discount rate	Loan volume	Loan rate
(A) Loan supply with additional restriction on price response					
Aggregate demand	≤ 0	≤ 0			≤ 0
Aggregate supply	≤ 0	≥ 0			≤ 0
Monetary policy	≤ 0		≥ 0		≥ 0
Loan supply	≤ 0	≤ 0	≤ 0	≤ 0	≥ 0
(B) Identification with additional loan restrictions					
Aggregate demand	≤ 0	≤ 0		≤ 0	≤ 0
Aggregate supply	≤ 0	≥ 0		≤ 0	≤ 0
Monetary policy	≤ 0		≥ 0	≤ 0	≥ 0
Loan supply	≤ 0		≤ 0	≤ 0	≥ 0

Notes: Sign restrictions are imposed on impact and the subsequent period; the residual shock is normalized (with a positive response of the loan rate).

4.3. Identification and loan volumes

In our baseline approach, we consider the minimum set of restrictions necessary to disentangle the four identified shocks. We now consider additional restrictions to potentially improve the identification. First, we additionally restrict the price level to be negative after a contractionary loan supply shock (see Bijsterbosch and Falagiarda, 2015; Gambetti and Musso, 2017). Second, we consider an identification approach that imposes additional restrictions on the loan volume. The aim is to explicitly rule out any changes in the supply of loans in response to aggregate demand and aggregate supply shocks. The two alternative identification approaches are summarized in Table 4. Finally, we also consider an identification scheme where we impose the baseline restrictions for four months.

Additionally, we consider a broader measure of loan volume to increase the sample size of our analysis. While the broader measure (total loans) also includes loans on securities, it is available since January 1919 and allows to estimate the model on data ranging up to February 1939, where the end date is then determined by the availability of the consumer loan rate.

Finally, we account for the fact that some of the short-term fluctuations in the loan variable may be driven by discount window operations. If the Federal Reserve Banks bought loans from member banks, these loans were no longer be reported in the banks' balance sheets, although these loans were still available to borrowers. To purge our loan series from short-term fluctuations in bills bought, we regress the first log difference of the loan volume on the first log difference of bills bought and add up the estimated residuals from this regression to obtain an adjusted loan volume series in levels, and re-estimate the baseline VAR with this adjusted series.[37]

Fig. 9 summarizes the results of the third set of robustness checks. With the alternative identification approaches we obtain results that are largely similar to our baseline findings. Similarly, the estimation with the extended sample and the estimation with the adjusted loan series also support our findings obtained with the baseline specification.

In the Appendix we present two alternative approaches to identify monetary policy shocks. One of these approaches identifies monetary policy shocks by imposing restrictions on the responses of the policy rate to shocks (see e.g. Fry and Pagan, 2011; Peersman, 2005; Vargas-Silva, 2008), which is frequently used with modern data. In addition, we consider an approach based on timing assumptions rather than sign restrictions on the response of the Federal Reserve to developments in the market for loans. The corresponding restrictions are shown in Table A.1 and the historical decompositions based on these alternative identification schemes are shown in Fig. A.4. Is has to be stressed, however, that these results are difficult to compare, as they are based on different identification schemes. Nevertheless, we see that although the effects associated with the monetary policy shock, especially in terms of the timing of the contributions, depend somewhat on the characterization of monetary policy, the effects of loan supply shocks remain robust with respect to the exact restrictions we impose to identify monetary policy shocks.

4.4. Data and lag length

In the literature applying VAR techniques to the Great Depression, different assumptions about the data generating process can be found. Therefore we re-estimate our baseline model in log-levels without a linear time trend, in first differences, and in yearly differences. Furthermore, we consider estimations in which we increase the lag length up to twelve month, and estimate our baseline model with seasonally unadjusted data and with the loan volume in nominal terms. Fig. 10 shows that the results are nearly identical to our baseline findings, when we re-estimate our model without a trend, or use seasonally unadjusted data. In contrast, when we fit the baseline model to monthly and yearly growth rates, or use twelve lags of the endogenous variables, we find somehow larger deviations in some instances, particularly in terms of timing. However, we still obtain results that qualitatively support our main findings.

[37] Since the loan volume series is only available for a sample of banks and the volume of bills bought is reported for all member banks, simply subtracting the volume of bills bought from the loan series would give misleading results. Note that the identified loan supply shocks and the first log difference of bills bought is only correlated by 14%.

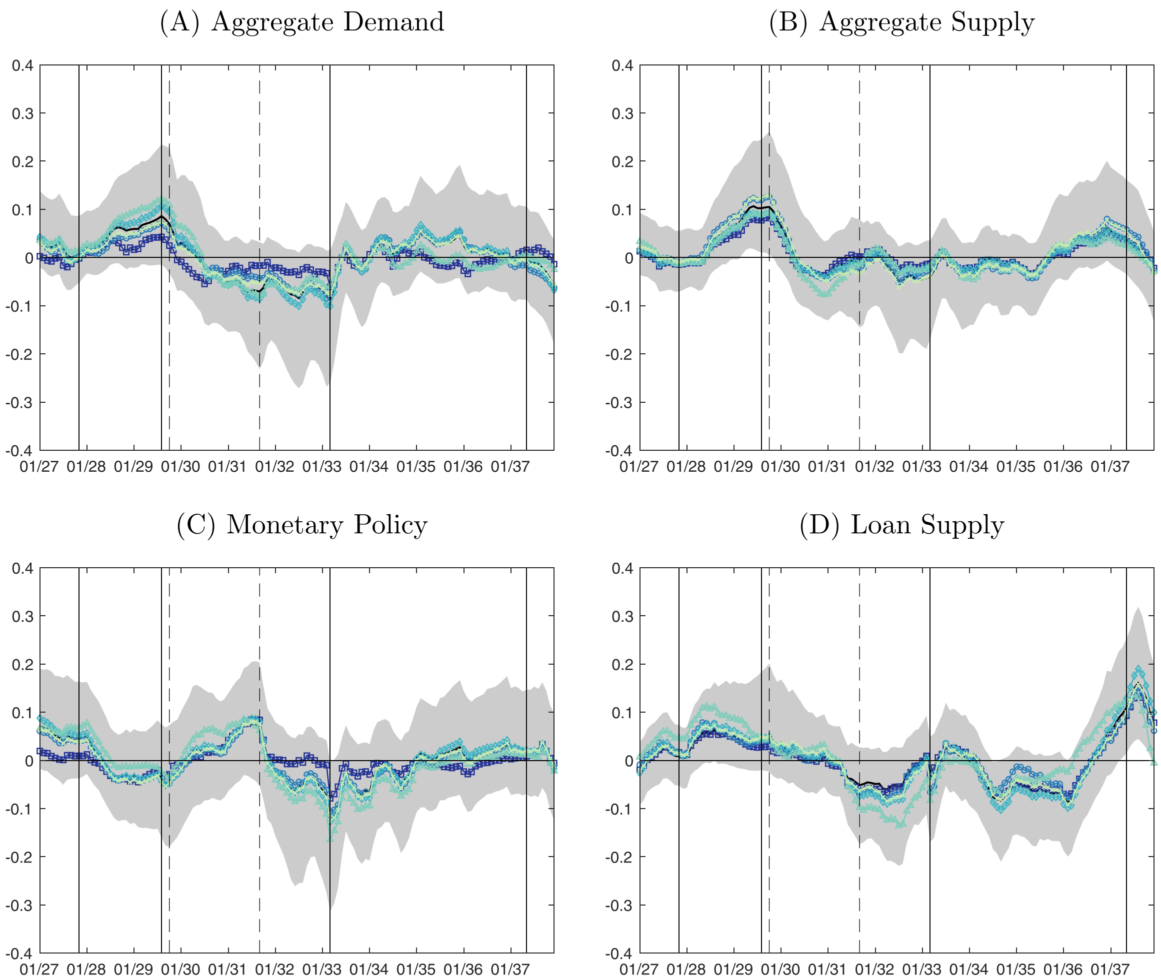

Fig. 9. Robustness checks III: historical decomposition of industrial production (1927:1–1937:12).

Table A.1
Sign restrictions on impulse response functions (alternative identification of monetary policy).

Shock	IP	CPI	Discount rate	Loan volume	Loan rate
(A) With restrictions on the discount rate					
Aggregate demand	≤ 0	≤ 0	≤ 0		≤ 0
Aggregate supply	≤ 0	≥ 0			≤ 0
Monetary policy	≤ 0	≤ 0	≥ 0		
Loan supply	≤ 0		≤ 0	≤ 0	≥ 0
(B) With zero restrictions					
Aggregate demand	≤ 0	≤ 0	0		≤ 0
Aggregate supply	≤ 0	≥ 0	0		≤ 0
Monetary policy			≥ 0		
Loan supply	≤ 0		0	≤ 0	≥ 0

Notes: Sign restrictions are imposed on impact and the subsequent period; the residual shock is normalized (with a positive response of the loan rate).

5. Conclusion

What were the effects of the financial crisis of the early 1930s for aggregate economic activity in the U.S.? While it is well-documented that the U.S. financial system experienced considerable distress during the early 1930s, it remains unclear how strongly these events contributed to the exceptional depth and length of the Great Depression. In this paper we provide estimates of the importance of loan supply shocks relative to other macroeconomic shocks based on historical decompositions. We find that adverse

Table A.2
Forecast error variance decompositions.

Horizon	AD shock	AS shock	MP shock	LS shock	Residual
Consumer price index					
0	25.69	18.51	6.38	8.81	10.38
	(5.59, 56.05)	(4.63, 45.28)	(0.54, 24.64)	(0.80, 33.71)	(0.67, 40.14)
6	40.36	5.73	10.35	10.73	10.80
	(16.68, 66.01)	(1.90, 15.39)	(2.02, 35.09)	(2.43, 30.35)	(2.23, 36.74)
12	33.38	5.94	13.59	11.10	11.90
	(12.47, 60.00)	(1.78, 14.61)	(2.58, 41.33)	(2.97, 34.91)	(3.21, 36.98)
24	23.65	6.45	17.77	11.65	14.33
	(7.99, 50.49)	(1.85, 18.80)	(3.29, 45.78)	(2.88, 35.75)	(4.04, 40.92)
Discount rate					
0	10.30	9.41	41.67	4.25	6.26
	(0.92, 40.41)	(0.84, 37.21)	(14.17, 70.65)	(0.75, 14.82)	(0.48, 30.62)
6	22.64	8.99	33.76	3.02	5.31
	(4.52, 58.28)	(1.33, 36.59)	(10.08, 64.35)	(0.70, 9.11)	(1.11, 24.98)
12	26.80	9.27	28.88	3.73	6.39
	(6.74, 60.56)	(1.63, 35.92)	(8.17, 59.36)	(0.92, 11.05)	(1.38, 25.38)
24	28.75	9.94	25.58	5.00	7.50
	(7.74, 59.41)	(2.08, 34.40)	(8.49, 53.75)	(1.37, 14.23)	(1.98, 25.69)
Loan rate					
0	16.52	17.92	20.13	18.07	2.60
	(2.56, 44.65)	(3.19, 46.28)	(4.23, 46.89)	(7.78, 33.05)	(0.18, 18.62)
6	22.70	10.36	33.23	3.12	6.53
	(3.70, 57.05)	(1.58, 39.33)	(10.07, 64.00)	(1.48, 6.46)	(1.13, 24.00)
12	23.40	9.37	31.71	3.29	8.04
	(3.77, 57.70)	(1.70, 36.46)	(8.84, 62.13)	(1.35, 7.99)	(1.37, 26.86)
24	24.67	9.70	27.46	4.98	9.49
	(4.79, 56.19)	(2.21, 33.45)	(8.34, 57.05)	(1.63, 12.70)	(2.04, 29.03)
Loan volume					
0	11.10	8.99	5.79	11.51	32.35
	(1.09, 38.77)	(0.87, 31.81)	(0.52, 24.64)	(1.21, 40.07)	(6.87, 65.66)
6	9.16	9.37	5.87	24.57	26.82
	(2.88, 27.57)	(1.55, 29.40)	(1.27, 22.85)	(7.73, 54.24)	(5.66, 56.48)
12	10.64	8.12	9.59	33.51	18.83
	(3.75, 26.32)	(1.86, 24.78)	(2.78, 26.10)	(12.76, 59.03)	(6.14, 43.37)
24	11.06	7.38	19.86	32.61	15.02
	(3.26, 26.99)	(2.17, 18.15)	(6.39, 40.73)	(13.86, 56.22)	(6.23, 28.79)

Notes: The table shows point-wise median values of the sign-identified posterior distribution and the values in parentheses indicate 68% of the sign-identified posterior distribution. All values are reported in percent.

Table A.3
Timeline of banking crises during the 1930s according to different classifications in the literature.

Classification	Crisis/Name	Start	End
Friedman and Schwartz (1963)	First banking crisis	Oct. 1930	Dec. 1930
	Second banking crisis	Mar. 1931	Aug. 1931
	Third banking crisis	Sep. 1931	Dec. 1931
	Fourth banking crisis	Jan. 1933	Mar. 1933
Wicker (1996)	First banking crisis	Nov. 1930	Jan. 1930
	Second banking crisis	April 1931	Aug. 1931
	Third banking crisis	Sep. 1931	Oct. 1931
	Fourth banking crisis	Jun. 1932	July 1932
	Fifth banking crisis	Jan. 1933	Mar. 1933
Calomiris and Mason (2003b)	First banking crisis	Nov. 1930	Jan. 1931
	Second banking crisis	May. 1931	Jun. 1931
	Third banking crisis	Sep. 1931	Nov. 1931
	Fourth banking crisis	Jan. 1933	Mar. 1933
Mitchener and Richardson (2019)	Caldwell crisis	16th of Nov. 1930	31st of Jan. 1931
	First Chicago panic	7th of Jun. 1931	27th of Jun. 1931
	After German panic	26th of July 1931	12th of Sep. 1931
	After England's departure from gold	13th of Sep. 1931	7th of Nov. 1931
	Winter 1932 crisis	13th of Dec. 1931	6th of Feb. 1932
	Second Chicago panic	19th of Jun. 1932	20th of Aug. 1932
	Winter 1933 crisis	18th of Dec. 1933	4th of Mar. 1933

Notes: Wicker (1996) also identifies small and local banking crises, which he calls mini-panics. However, these crises are not listed in the table.

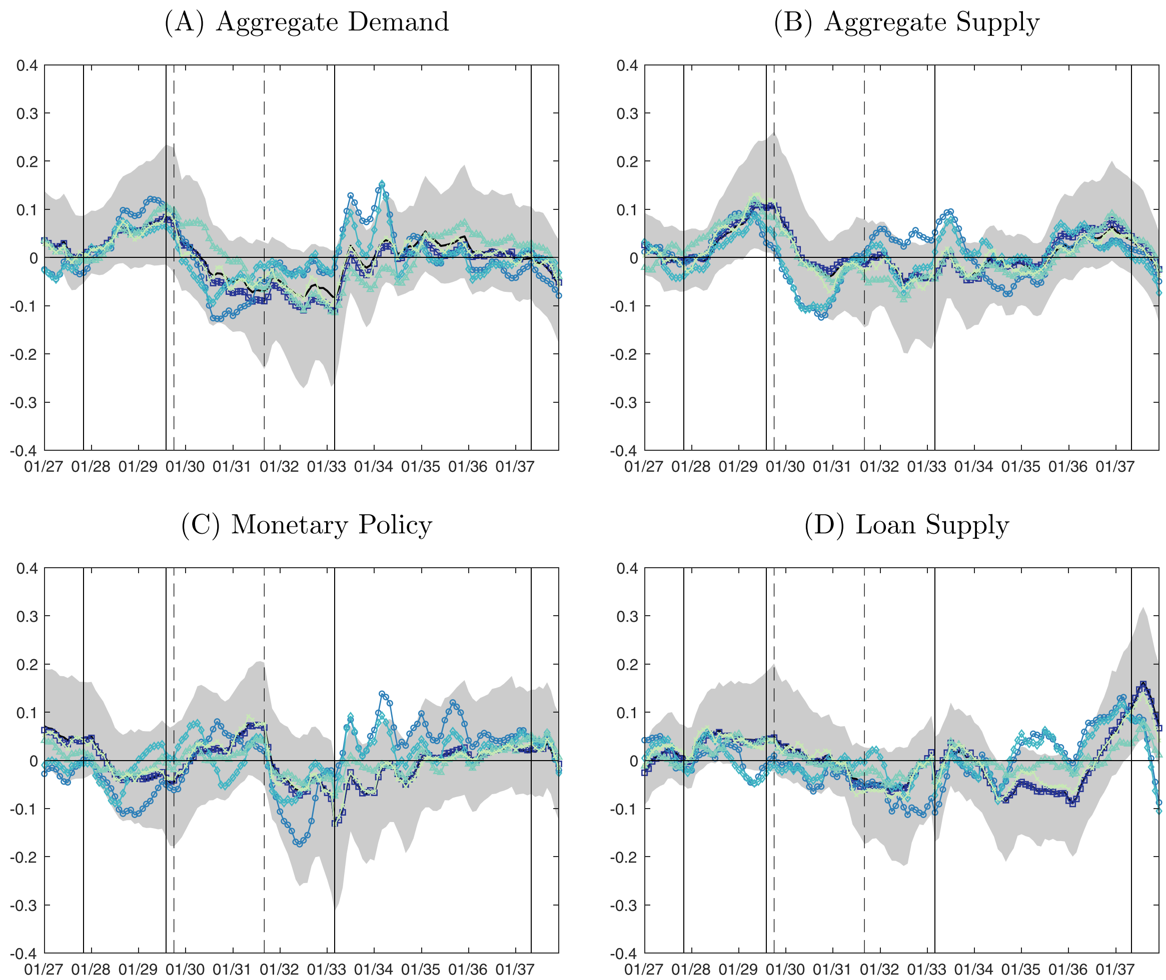

Fig. 10. Robustness checks IV: historical decomposition of industrial production (1927:1–1937:12).

loan supply shocks contributed considerably to output dynamics between 1931 and 1933. The negative output effects associated with loan supply shocks intensified after the early waves of bank failures and by the end of 1931, loan supply shocks accounted for roughly 40% of the combined effects of the identified shocks. This finding is consistent with the view that the banking crises contributed to the economic downturn through a process of financial disintermediation as argued by Bernanke (1983). Furthermore, our results show that economic activity during the Great Depression was driven by shocks of multiple origins and that the quantitative contributions of the these shocks vary over the course of the Great Depression. Thus, a complete description of the Great Depression requires a holistic view of the contribution of different shocks over the period (see also Cecchetti and Karras, 1994; Fackler and Parker, 1994).

That said, we do not want to overstate our results. Our findings have to be interpreted conditional on the validity of restrictions that we impose to characterize the shocks. While it is generally considered to be an advantage of sign restrictions over alternative identification approaches that only rather uncontroversial assumptions are required in many cases (Uhlig, 2017), this is not necessarily the case for the 1930s. Since the economy operated rather differently than a modern economy during the Great Depression, our identifying assumptions are in many cases not based on standard relationships used in modern macroeconomics, but were chosen to match the economic and institutional environment of the 1930s. Nevertheless, these assumptions cannot be tested and their validity can be debated. And since our results have to be interpreted conditional on these assumptions, caution is required.

This is especially true for the characterization of monetary policy. To address this issue we report result obtained with alternative restrictions used for the identification of monetary policy. And although these additional analyses substantiate our main conclusions, it has to be kept in mind that models based on different sets of restrictions cannot be compared statistically and that they rely on rather different assumptions about the behavior of the Fed during the 1930s, which also complicates the comparison.

Another caveat is that our data are subject to measurement error, especially since data availability is limited. The data series for deposits of failed banks, for instance, had to be interpolated due to a lack of data with an appropriate frequency. Moreover, we can only include Fed member banks, which means that our banking sector related variables are only an imperfect proxy for banking activity. While we are able to support our results with a number of robustness checks, these robustness checks rely on repeated estimations.

Finally, there are several interesting avenues for future research. First, although our characterization of loan supply shocks is fairly general, extending the framework to capture loan supply dynamics in an even broader sense, especially incorporating quantity rationing, as discussed in Section 1, is an interesting direction for future research. Second, extending the framework to incorporate narrative sign restrictions appears as a promising approach to use detailed historical information for the identification of shocks (Amir-Ahmadi et al., 2020). Third, although our results can give a sense of when a specific type of shocks was more relevant during the Great Depression, a better understanding of this time-variation would provide important additional insights about the underlying mechanisms and outcomes.

Appendix A. Additional tables and figures

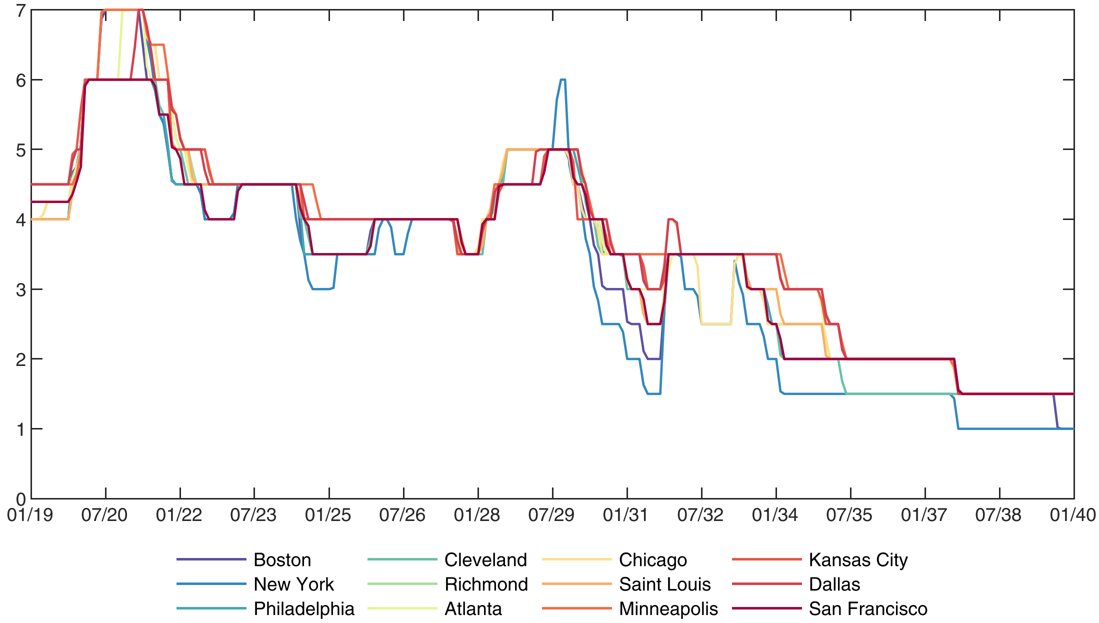

Fig. A.1. Federal Reserve Banks' district specific discount rates.

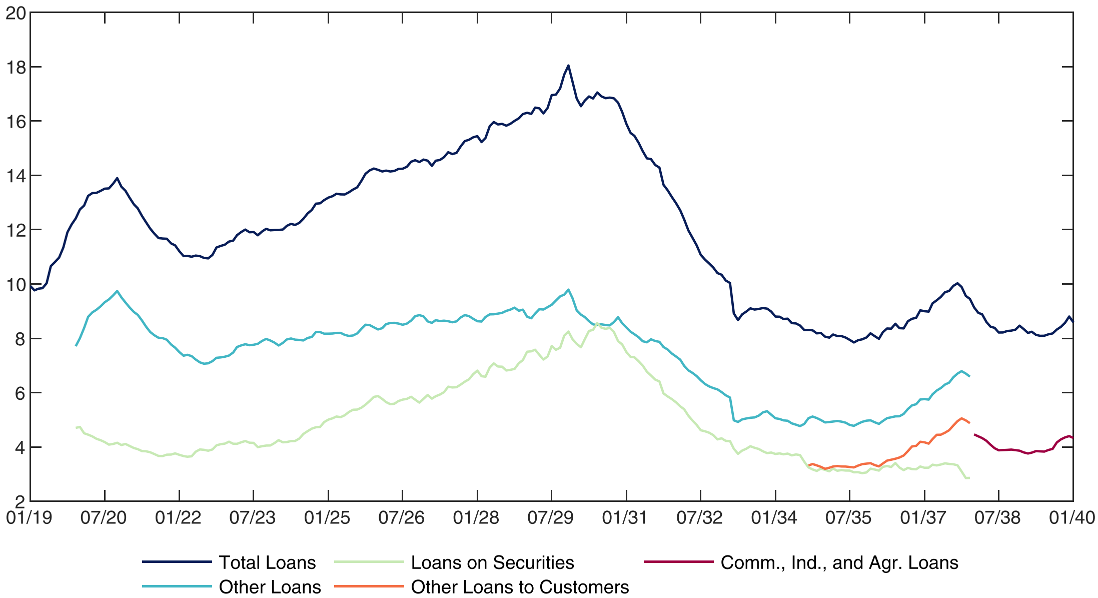

Fig. A.2. Loan categories (1919:1–1941:1).

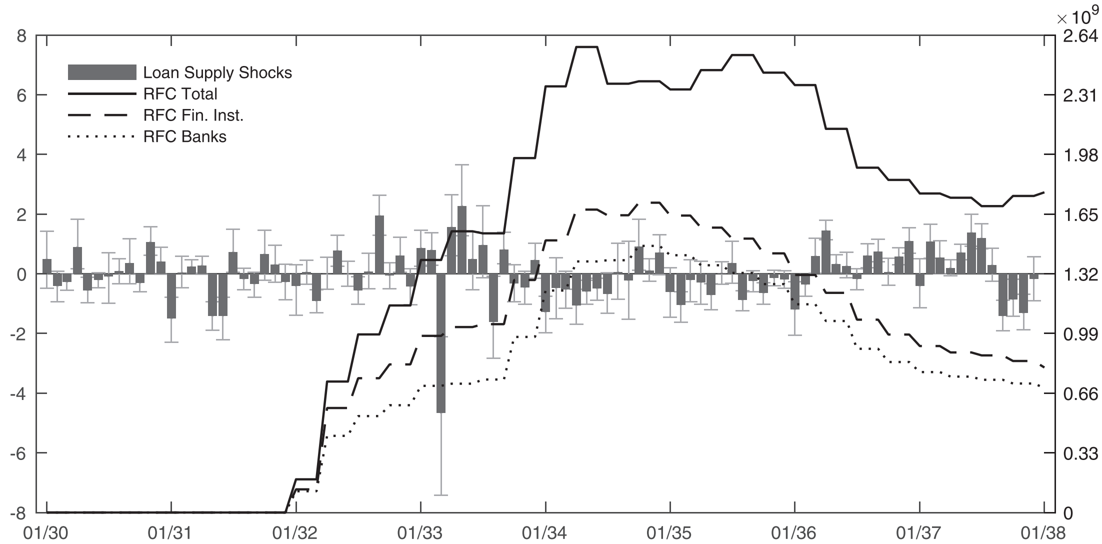

Fig. A.3. Identified loan supply shocks and RFC loans and investments (1930:1–1938:1).

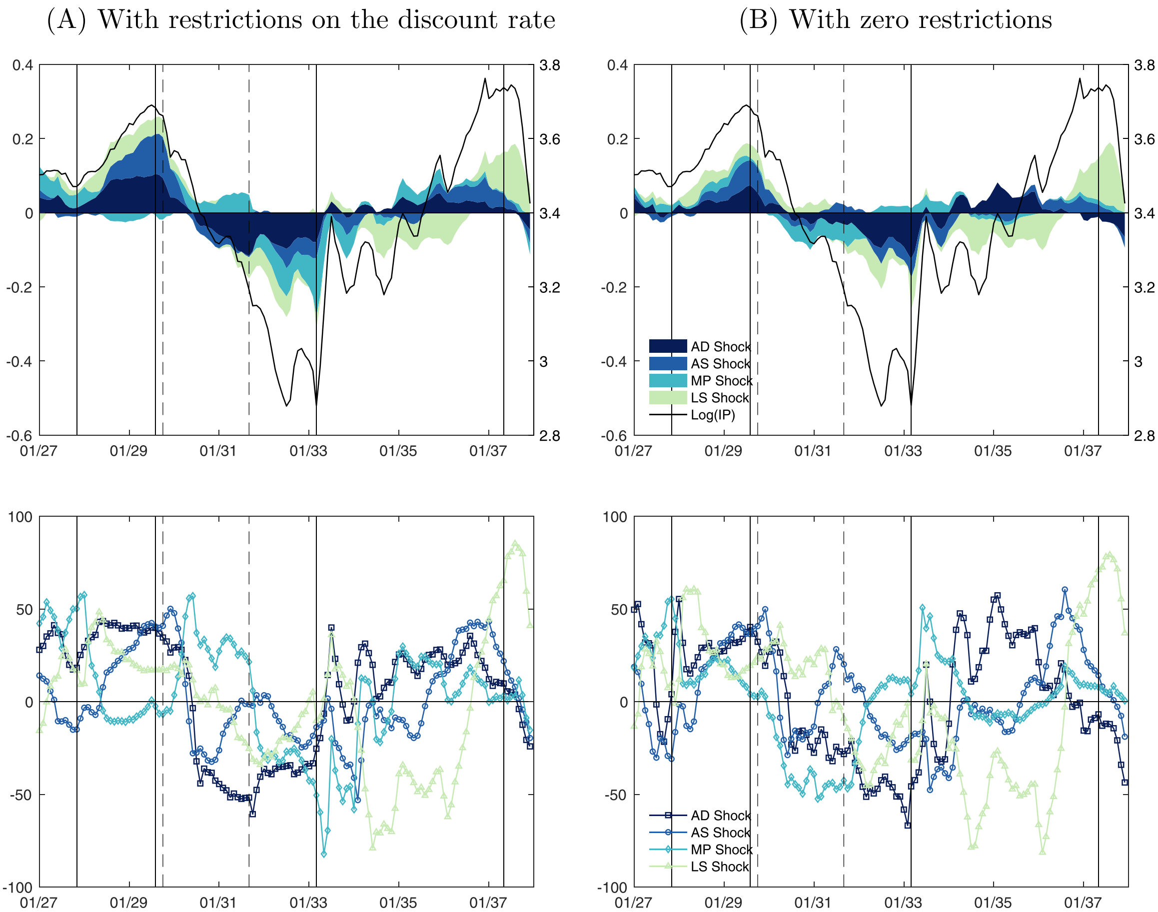

Fig. A.4. Alternative identification of monetary policy: historical decomposition of industrial production (stacked and relative; 1927:1–1937:12).

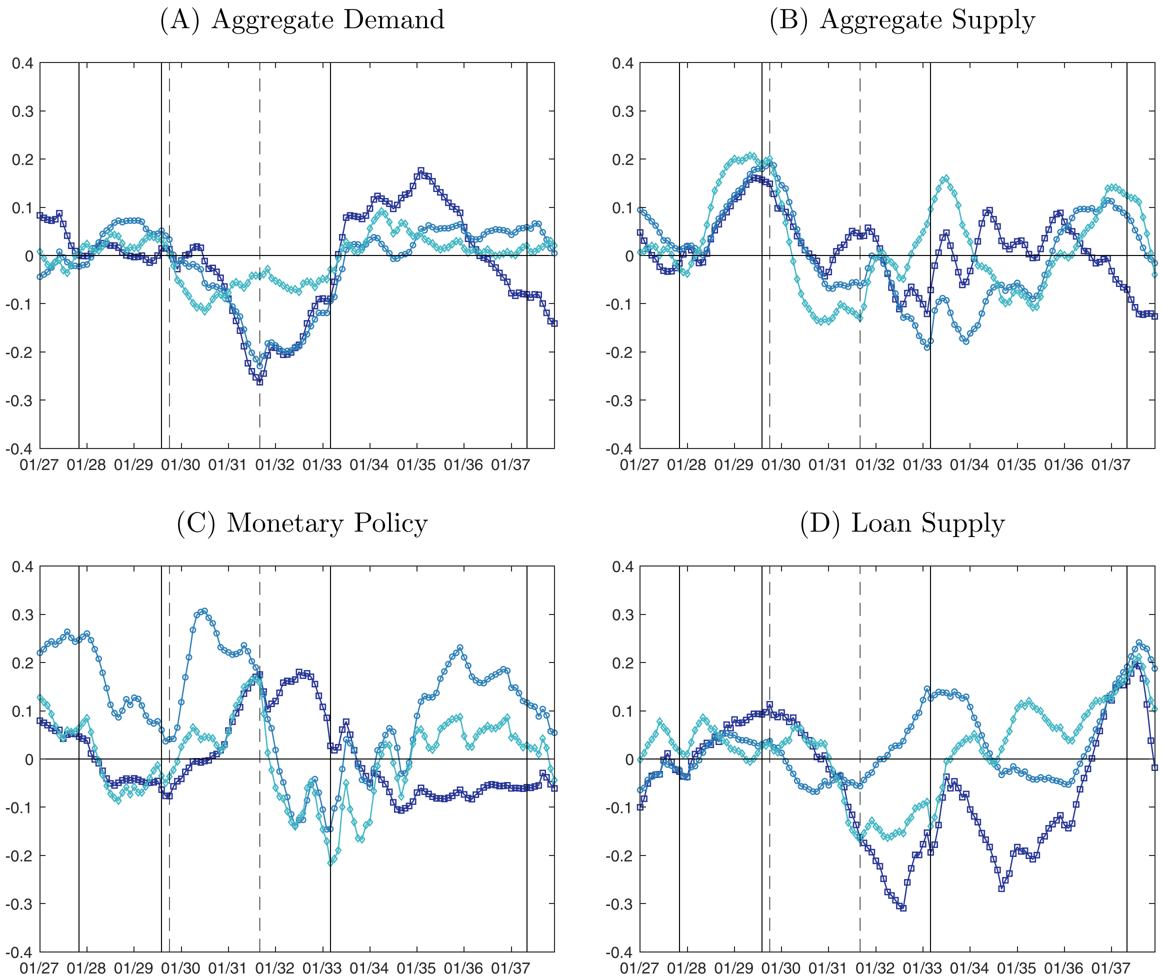

Fig. A.5. Historical decomposition of industrial production (median target models, 1927:1–1937:12).

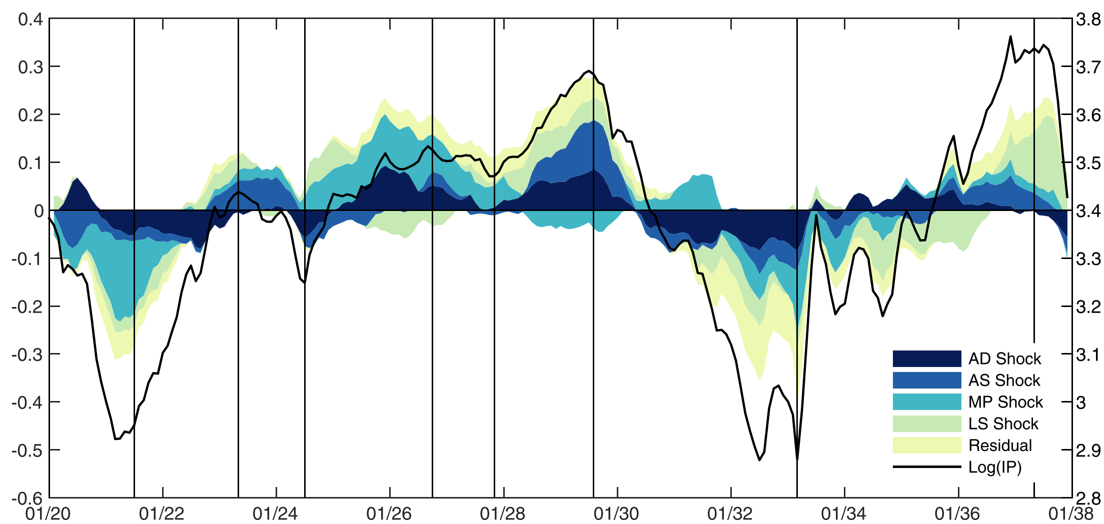

Fig. A.6. Stacked historical decomposition of industrial production (1920:1–1937:12).

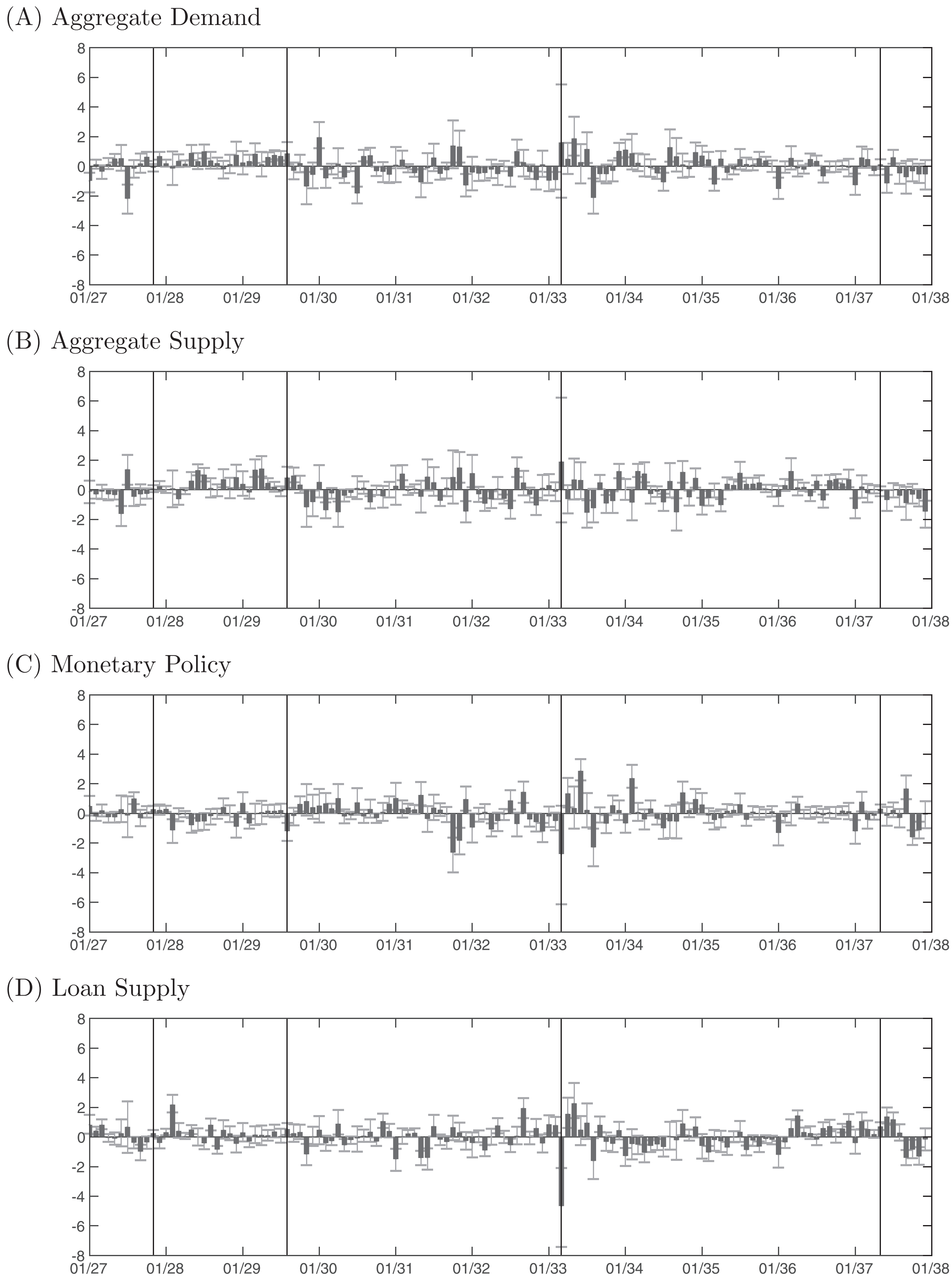

Fig. A.7. Identified structural shocks (1927:1–1937:12).

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