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Buried in the vaults of central banks – Monetary gold hoarding and the slide into the Great Depression

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Non-technical summary

Research question

The origins of the Great Depression from 1929-33 are controversial to this day. Among economic historians, a widely-held view is that monetary forces played an important role in causing the depression. On the other hand, the macroeconometric literature has by and large found little evidence of the importance of monetary disturbances as a main cause. However, existing macroeconomic work does not incorporate essential insights from the narrative literature. This raises the question whether the conclusions drawn using formal macroeconometric methods change when taking into account in particular the workings of the international gold standard more explicitly.

Contribution

I identify monetary policy shocks in a structural macroeconometric framework and assess their role in causing the initial downturn in prices and production from 1929-31. In deliberate contrast to existing work on the depression, I take an international perspective that builds upon an appreciation of the gold standard system operating at the time. First, I employ a hand-collected monthly data set that covers a large share of the interwar world economy. Second, derived from a theoretical monetary framework, I model monetary disturbances as shocks to central bank gold demand as measured by the world gold reserve ratio. This is preferable not only on theoretical grounds to, say, interest rate measures of individual countries. It also allows me to employ narrative information to sharpen structural shock identification based on sign restrictions. I do so by imposing a single narrative sign restriction that captures a key shift in US and French monetary policy in 1928.

Results

Shocks to monetary gold demand are key in explaining the initial slide into the depression. Whereas the second phase of the collapse in output in 1931 seems to be linked to factors other than central bank policy, monetary shocks are shown to account for the overwhelming initial fall in production and prices. These findings are robust along a number of dimensions.

Nichttechnische Zusammenfassung

Forschungsfrage

Die Ursachen der Großen Depression von 1929-33 sind bis zum heutigen Tage umstritten. Unter Wirtschaftshistorikern ist die Ansicht verbreitet, dass monetäre Faktoren eine wichtige Rolle gespielt haben. Andererseits finden Studien mit makroökonometrischen Methoden kaum Anzeichen dafür, dass der Geldpolitik eine große Bedeutung zukommt. Entscheidende Erkenntnisse aus der narrativen Literatur scheinen in diesen Studien allerdings wenig Berücksichtigung zu finden. Dies wirft die Frage auf, ob die makroökonometrischen Methoden andere Ergebnisse liefern, wenn insbesondere die Rolle des internationalen Goldstandards expliziter einbezogen wird.

Beitrag

Das Forschungspapier identifiziert geldpolitische Schocks in einem makroökonometrischen Modell, um die Rolle der Zentralbanken für die Anfangsphase der Depression von 1929-31 zu untersuchen. Im bewussten Gegensatz zu bestehenden Arbeiten erfolgt die Analyse aus einer internationalen Perspektive und baut auf der Rolle des internationalen Goldstandards auf. Dazu wird zunächst ein internationaler Datensatz aus historischen Quellen zusammengestellt. Zudem werden geldpolitische Schocks als exogene Änderungen in der Goldnachfrage von Zentralbanken modelliert. Modelltheoretischen Überlegungen folgend wird die Rate der Golddeckung als entscheidender Indikator monetärer Bedingungen verwendet. Dieses Vorgehen erweist sich nicht nur als konzeptionell vorteilhaft, sondern erlaubt es auch, die Identifikation struktureller Schocks zu verbessern. Diese beruht nicht nur auf Vorzeichenrestriktionen, sondern auch auf der wichtigen Information, dass es im Sommer 1928 zu einem geldpolitischen Kurswechsel der US-amerikanischen und französischen Zentralbanken kam.

Ergebnisse

Dem Anstieg der monetären Goldnachfrage kommt eine Schlüsselrolle für die Anfangsphase der Depression zu. Während in der zweiten Phase andere Faktoren wichtiger gewesen zu sein scheinen, kann ein Großteil des Rückgangs von Preisen und Wirtschaftsleistung zu Beginn der Depression auf geldpolitische Maßnahmen zurückgeführt werden. Diese Resultate sind robust hinsichtlich einer Reihe von Modellspezifikationen.

Buried in the Vaults of Central Banks – Monetary Gold Hoarding and the Slide into the Great Depression*

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Abstract

I study whether monetary gold hoarding was the main cause of the Great Depression in a structural VAR analysis. The notion that monetary forces played an important role in bringing about the depression is well established in the narrative literature, but has more recently met some skepticism by formal macroeconometric work. In deliberate contrast to the existing macroeconometric literature, the paper i) uses a newly-assembled monthly data set of the interwar world economy, and ii) models monetary disturbances as shocks to central bank gold demand. Based on a monetary DSGE model, the world gold reserve ratio (the ratio of central bank gold holdings to monetary liabilities) is used to describe monetary conditions. This permits the use of narrative information to sharpen shock identification in a structural VAR analysis based on sign restrictions. Monetary shocks are found to have real effects and to account for a substantial part of the collapse in prices and output during the initial slide into the Great Depression.

Keywords: Great Depression, Gold Standard, Monetary Policy, Narrative Sign Restrictions
JEL Codes: E32, E42, E58, N12, N14

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1 Introduction

The modern consensus view of the Great Depression puts the disintegration of the interwar gold standard and domestic monetary policy failures at center stage to explain the world-wide fall in prices and output (Eichengreen and Sachs, 1985; Hamilton, 1987; Bernanke and James, 1991; Eichengreen, 1992). In particular, one strand of the literature emphasizes excessive competition for gold by central banks in the late 1920s (Johnson, 1997; Irwin, 2012; Sumner, 2015). Countries with large and growing monetary gold reserves, most notably the US and France, were reluctant to inflate their currencies but hoarded the gold instead. This policy forced other countries, notably Britain, to likewise tighten monetary conditions to defend their tumbling reserves. In a gold standard system, this increased demand for monetary gold meant that the world price level in terms of gold had to fall. This deflation, so the narrative goes, led to the unprecedented collapse in output and employment.

However, whereas this essentially monetary account of the depression is well established in the narrative literature, formal empirical work (reviewed in Section 2.2) has been more skeptical.[1] In this paper, I provide formal macroeconometric evidence for the view that monetary factors, in the guise of central bank gold hoarding, were a primary cause of the initial slide into the Great Depression. I argue that the inability of the existing VAR literature to verify the importance of monetary factors in part stems from its neglect to incorporate essential insights about how the interwar global monetary system operated. This is true in two main ways, both of which motivate key elements of the empirical analysis in this paper.

First, the macroeconometric literature predominantly focuses on the experience of individual countries, in particular the US economy. This is despite the fact that it is well understood that from a theoretical standpoint it is not sufficient to look at monetary conditions of even large countries in isolation. Instead, in an international gold standard system national price levels are determined in world markets and each country controls domestic prices only to the extent it influences world monetary conditions (Frenkel, 1971; McCloskey and Zecher, 1976, 1984). This line of reasoning is largely absent from the existing macroeconometric work but is explicitly accounted for in the empirical analysis in this paper. More specifically, I adopt an international perspective and assemble a dataset of the interwar world economy that contains monthly time series information of twelve countries, covering roughly 60% of world output. This allows me to capture worldwide – instead of focusing on domestic – monetary conditions, in line with the narrative literature.

Second, recent macroeconometric work on the depression predominantly uses money supply and/or interest rate measures to describe monetary policy and to identify structural monetary shocks. While this is a standard approach in the study of more modern

[1] In a survey article, Evans et al. (2004, p.1) conclude that "[f]rom the voluminous literature using vector autoregression (VAR) techniques, the empirical results offer no consensus that monetary policy was the main cause of the Great Depression."

economies, it can be argued to obfuscate developments in world gold markets that are key determinants of monetary conditions in an international gold standard economy from a theoretical standpoint. Consequently, these have played a prominent role in the monetary narrative of the depression but again are absent from existing macroeconometric work. A further contribution of this paper is to address these considerations on two fronts. First, regarding the *measurement* of world monetary policy in general and central bank gold demand in particular, I use the world gold reserve ratio, the ratio of central bank gold holdings to monetary liabilities, as the main monetary variable of interest. Second, this choice has implications for the *identification* of structural monetary shocks. Specifically, it allows me to enrich the common approach of using sign restrictions with the so-called narrative approach by employing narrative sign restriction techniques developed by Antolin-Diaz and Rubio-Ramirez (2018). Notably, both the choice of the gold reserve ratio as a useful monetary policy measure and the identifying sign restrictions are derived formally from a gold standard DSGE model prior to their being used in the empirical VAR analysis.

The main results of the paper can be summarized as follows. Monetary policy shocks, as measured by exogenous innovations in the world gold reserve ratio, have significant real effects in the interwar period. More importantly, monetary shocks account for a substantial part of the decline in world prices and production in 1929-31, in contrast to much of the earlier macroeconometric literature. These results continue to hold when explicitly taking into account various other explanations often given in the literature, like the stock market crash of October 1929 and non-monetary effects of financial frictions. The findings are robust along multiple lines, particularly regarding shock identification, and confirm a predominantly monetary account of the initial slide into the Great Depression.

The paper is structured as follows. In order to motivate the empirical analysis, Section 2 first describes the modern 'consensus view' on the causes of the Great Depression in a brief literature review, and lays out the 'gold hoarding view' explicitly modeled in this paper. Section 2.2 contrasts this with the results of existing econometric work. Part 3 then sets out to motivate the main pillars that the subsequent empirical analysis rests on. Specifically, Section 3.1 develops a monetary DSGE model in order to gain an understanding of how monetary forces operate in a gold standard economy. In particular, I use the model to derive both the gold reserve ratio as the main monetary policy measure and at the same time inform the identifying assumptions used in the empirical model. Section 3.2 then describes key events in the run-up to the depression that are used to sharpen the structural identification of monetary policy shocks in the VAR analysis. The latter is conducted in part 4, which starts off by describing the data and model (4.1), before presenting results (4.2). Section 4.3 presents additional results and addresses robustness considerations, before part 5 concludes.

2 Literature Review

2.1 The 'Consensus View' Today: A Monetary Origin

Ever since its onset in 1929, various explanations for the Great Depression have been advanced in the literature, many of them non-monetary.[2] While some of them are widely considered to be important – and several will be addressed in the empirical analysis in Section 4 –, the notion that the depressions' origins are to be found in monetary factors has come to represent what has been termed a 'consensus view'.[3]

Beginning with Friedman and Schwartz's (1963) re-exploration of the monetary origins view, the initial focus was on panic-induced declines of the money supply in the US, where the Fed had already deliberately tightened monetary policy to curb a stock market boom in 1929. Choudhri and Kochin (1980) and Eichengreen and Sachs (1985) then initiated an internationalization of the monetary view. They not only focused less on the US economy but also put the role of the international gold standard as a source of propagation at center stage. The authors show for nine and ten countries, respectively, that those economies which left gold earlier also recovered more quickly. Bernanke and James (1991, p.44) extend these findings to 24 countries, and conclude that "it seems reasonable to accept the idea that the worldwide deflation of the early 1930s was the result of a monetary contraction transmitted through the international gold standard". In a similar vein, Eichengreen (1992) discusses in detail how the altered institutional nature of the gold standard in the post-WWI financial system contributed to international financial instability in the interwar period. And finally, Eichengreen (2002) summarizes the consensus notion that points to an interaction of gold-standard-induced instability in some, and misguided domestic monetary policies in other countries as the main source of the depression.

In order to motivate the empirical analysis in part 4, closer attention is paid to a particular line of argument of the consensus view sketched above – that of a tightening of monetary policy by an increased demand for monetary gold as the main initial cause of the dislocation. As will be developed more fully in Section 3.1.2, this increased gold demand can be observed as rising gold reserve ratios and is deflationary in an international gold standard. This is the main thesis in Johnson (1997) and Sumner's (2015) recent account of the initial causes of the Great Depression, and is largely in line with the contemporary analysis by monetary economists Ralph Hawtrey and Gustav Cassel.[4] Both of them had warned already in the 1920s that with more and more countries rejoining the gold standard after its abandonment in WWI, competition for the existing monetary gold would drive

[2]Among the most prominent are (i) an autonomous drop in consumption (Temin, 1976; Harrison and Weder, 2006), (ii) technology shocks (Kehoe and Prescott, 2002), (iii) wealth losses and uncertainty effects due to the stock market crash (Mishkin, 1978; Romer, 1990), (iv) non-monetary financial frictions (Bernanke, 1983; Calomiris 1993), and (v) protectionism (Crucini and Kahn, 1996).

[3]For a use of this term see e.g. Eichengreen, (2002, p.1), Tavlas (2011, p.566), and Irwin (2014, p.200).

[4]For a more detailed account see Batchelder and Glasner (2013) and Irwin (2014).

up its value, implying a falling price level under the gold standard.[5] Hawtrey and Cassel therefore urged monetary authorities to cooperatively use foreign exchange as reserves to back part of their note issue. And indeed, this arrangement of a gold exchange standard worked for some time. However, it broke down soon after France rejoined gold.

Hetzel (2002, p.12) describes how, after experiencing high inflation rates from 1924-26, France readopted the gold standard in 1926. However, as Hamilton (1987, pp.146-47) notes, fiscal reform and increased public confidence in the franc proved the French currency to be under-, while sterling was overvalued (Bordo et al., 2002, p.4). Under fixed parities in terms of gold, the corresponding excess demand for francs meant a large-scale accumulation of foreign exchange reserves, most importantly sterling and US dollar, at the Bank of France.

When the Bank in 1928 started to convert these reserves into gold,[6] confidence in other countries' parities, particularly the British, eroded. This in turn gave rise to an ever stronger competition for monetary gold, which more and more substituted foreign exchange reserves of central banks.[7] Irwin (2012, pp.18-23) describes the institutional details in France at the time. Specifically, legislation passed in mid-1928 prohibited the Bank of France from accumulating any more foreign exchange reserves. Moreover, as will be explained in more detail in Section 3, the new law effectively necessitated an ever-increasing gold backing to satisfy the high demand for cash among the French population. In addition to the direct gold purchases by the Bank of France, this indirectly led to gold flows into central bank coffers (Eichengreen, 1986). Gardner (1932, p.58) observes that of the increase of $2 billion in central bank gold reserves from 1926 to 1930, an "outstanding" nearly three-quarters were taken by France. This led Cassel (1930) to comment that "[i]t is especially remarkable that the Bank of France has consistently and quite unnecessarily acquired enormous amounts of gold without troubling in the least about the consequences which such a procedure was bound to have on the gold supply of the rest of the world."[8]

Around the same time, in mid-1928, the Fed, too, tightened policy. Following a period of monetary ease and explicit cooperation with the Bank of England to relieve pressure from Britain, the Fed reversed course to curb domestic stock market speculation. Amid the

[5]This is not to say that Hawtrey and Cassel were the only economists who voiced concerns at the time. For instance, Keynes (1929, p. 776) in January 1929 warned that a "difficult, and even a dangerous, situation is developing (...). There may not be enough gold in the world to allow all the central banks to feel comfortable at the same time." Similar concerns can be found in Gardner (1932). Tavlas (2011) has an account of similar warnings by the two contemporary economists William Foster and Waddill Catchings.

[6]Accominotti (2009) analyzes the reserve management of the Bank of France from 1928 onward and identifies capital loss considerations as the main driving force of changes in the portfolio composition of the Bank away from foreign exchange and towards gold.

[7]According to Eichengreen and Temin (2000, p.200), "[t]he share of foreign exchange in global monetary reserves fell from 37 per cent at the end of 1928 to a mere 11 per cent by the end of 1931."

[8]French gold hoarding even grew in intensity in 1931. According to Gardner (1932, p.64), while world gold reserves increased by USD 275 million, French reserves soared by twice that amount: "France not only took all the new gold, but drew down the stocks of other countries by an equivalent amount", leaving Hawtrey (1931, p.208) to cynically assert that "I do not know why France, with one-ninth the national income of the United States, should need half the amount of gold." Later, Hawtrey (1932, p.38) concluded that "the French absorption of gold in the period from January 1929 to May 1931 was in fact one of the most powerful causes of the world depression."

effective departure from power of Benjamin Strong, its foremost monetary policy maker and architect of the earlier cooperative stance towards Britain, the Fed hiked discount rates. Moreover, like the Bank of France, the Fed began to increase its note issue with more and more inflowing gold. It is this contemporaneous shift in gold policies in France and the US, described in more detail in Section 3.2.2, that will be used to sharpen structural identification in the VAR analysis in part 4. Cassel (1931, p.12) observed these developments with great concern and lamented that "the gold thus accumulated [since mid-1928] has not been used for any purpose, but has simply been buried in the vaults of the central banks."

While world monetary conditions clearly tightened in mid-1928, it was not until later in 1929 that central bank gold hoarding gained in intensity when Britain was forced to abandon its easy monetary stance. Amid large outflows, Britain's monetary gold stock fell below the £150 million mark recommended in the Cunliffe Committee report in mid-1929 and the Bank of England intervened. It, too, raised discount rates and increased its gold reserve ratio in the later months of 1929. This "simultaneous adoption of tight money policies in the United States, France, and Britain", in the words of Sumner (2015, p.49) "made worldwide deflation almost inevitable".

As mentioned, this gold demand view as an essentially monetary account has found its way into the mainstream narrative of the depression.[9] However, the macroeconometric literature on the depression is much more skeptical towards a predominantly monetary interpretation, as discussed next.

2.2 Recent VAR Empirics: New Skepticism Towards the Monetary Explanation

Ever since the seminal work of Sims (1980b), structural vector autoregressive (VAR) models have become standard tools in empirical macroeconomics. Whereas initial findings by Sims (1980a) are supportive of a largely monetary explanation, much of the more recent VAR-based work makes for much more skepticism towards the importance of monetary factors in explaining the initial slide into the Great Depression.

Burbidge and Harrison (1985) find for the US in the years 1929-31 that their VAR forecasts improve little when adding monetary disturbances. Although in their model monetary factors are more important for the later depression years, the authors interpret their findings as evidence against them having caused the initial slide into the depression. In a similar fashion, Fackler and Parker (1994) report that shocks associated with consumer sentiment and business failures account for the majority of the initial contraction, whereas monetary innovations become more important only 1931 onward. Again based on a historical decomposition exercise, Cecchetti and Karras (1994) reach similar conclusions with respect to the role of collapsing consumer demand, although they regard monetary

[9]See e.g. Eichengreen (1986, p.57), Hamilton (1987, p.147), and Eichengreen and Temin (2000, pp.200, 205), Bordo et al. (2002, pp.3-4), Bordo (2006, p.6).

causes to be of roughly equal importance. Estimating a Bayesian VAR model, Sims (1998) finds that innovations in the discount rate and M1 hardly contribute to explaining output and price level behavior. Likewise, Ritschl and Woitek (2000) estimate a Bayesian VAR and analyze forecasts out-of-sample. They do not find that either interest rate or monetary aggregate innovations are useful in predicting “anything more than a very mild recession” (p.20). In contrast, a model including real variables like building permits and various measures from the steel industry reveals that these more accurately forecast the decline in output. Finally, Amir-Ahmadi and Ritschl (2009) employ a Bayesian factor-augmented VAR model with a large number of time series to avoid having to use imperfect aggregate interwar data. Using the sign-restriction approach of Amir-Ahmadi and Uhlig (2015), they find that monetary policy (as measured by five different interest rates and monetary aggregates) had only a limited impact on real variables. They conclude (p.3) that their results "caution against a predominantly monetary interpretation of the Great Depression."

At this stage it is worth emphasizing that all the above studies focus on the US economy and measure the stance of monetary policy via interest rates and/or monetary aggregates.[10] This is certainly in the spirit of Friedman and Schwartz's (1963) classical account of the depression, but seems somewhat surprising in light of the path the rest of the literature has taken since. This understanding will inform the empirical strategy adopted in this paper, as explained in the following.

3 Empirical Strategy

This section develops the empirical strategy employed in the subsequent VAR analysis and explains how, and why, it differs from the existing macroeconometric literature on the depression. First, Section 3.1 develops some theoretical predictions. It begins by discussing the tension between the US-centric analysis in recent VAR work on the one hand, and the international focus in the narrative literature on the other. It traces this tension back to the implicitly assumed adjustment mechanism and the degree of monetary autonomy in a gold standard system. Then, Section 3.1.2 lays the groundwork for the measurement of monetary policy and monetary shocks within the VAR model. This is done with the help of a monetary DSGE model that formalizes the effects of central bank gold demand and derives the gold reserve ratio as a measure of monetary policy in a gold standard economy. Section 3.1.3 then enlarges the model to account for a variety of other variables and shocks.

[10] There are a few VAR-based studies on non-US economies (see e.g. Mattesini and Quintieri, 1997, on Italy) but to my knowledge there is only one study that models the Great Depression period in a multi-country framework, namely Almunia et al. (2010). However, these authors use annual data, and are primarily interested in the fiscal policy response to the depression, not in what caused it. In addition, they employ a panel VAR merely in order to increase the number of observations, but not in an attempt to study either cross-country spillovers or world monetary conditions. To the best of my knowledge, only Irwin's (2012) study is international in nature, focuses on gold and does point to a monetary origin of the depression. However, it employs traditional econometric techniques and does not identify structural shocks.

Following these theoretical considerations, Section 3.2 first summarizes structural shock identification via sign restrictions from simulated model impulse responses. Moreover, it features a discussion of events that can plausibly be described as exogenous innovations in the stance of monetary policy. This narrative information from outside the model is then used to sharpen identification of monetary policy shocks from the set of traditional sign restrictions.

3.1 Theoretical predictions

3.1.1 Monetary Autonomy in an International Gold Standard

As laid out in Section 2, one major way in which the macroeconometric literature differs from the work by economic historians lies in its almost exlusive focus on the US economy. This can at least partly be traced back to influential work of Friedman and Schwartz (1963) which many of the mentioned papers reference. Notably, Friedman and Schwartz (1963) quite explicitly base their analysis on the theory of the price-specie-flow mechanism (Bordo, 1984, p.86). According to this traditional theory of adjustment, gold flows out of one country cause a contraction in the national money supply and consequently the price level. This improves the country's competitiveness and external balance, reversing or neutralizing the gold outflows. Importantly, under this view individual monetary authorities have a relatively large degree of control over domestic monetary variables. Consequently, analyzing national monetary policies separately, as is done in the macroeconometric literature, makes some intuitive sense.

This approach, however, stands in contrast to a theory based on the monetary approach to balance of payment adjustments in a gold standard system. According to this alternative view, international adjustment is not (and cannot primarily be) achieved via shifts in relative price levels as these are tightly constrained by international arbitrage. Instead, adjustment is accomplished via changes in spending that restore some desired portion of money holdings in asset portfolios. This view has not only been shown to be theoretically more plausible than the original price-specie-flow mechanism (Samuelson, 1980), but also to better fit empirical facts on how the gold standard functioned in practice (Frenkel, 1971; McCloskey and Zecher, 1976; Dick and Floyd, 1991).[11] It consequently informed much of the internationalization of the narrative literature in the 1980s and 90s. If it was hardly possible for an individual central bank to systematically vary its country's price level independently from the rest of the world via changes in domestic money supplies – just as it is difficult to do so for a region within a country –, the analysis had to be expanded to the level of the system as a whole. If prices fall "sharply in terms of gold all over the world", in the words of Sumner (2015), "[i]t makes no sense to explain that sort

[11] For a history of thought on the gold standard adjustment mechanism see Bordo (1984, pp.83-91), who also cites Williamson (1961), Triffin (1964) and Johnson (1972) as proponents of the monetary approach to balance of payment adjustment, which McCloskey and Zecher (1976) build upon.

of phenomenon solely by looking at the money supply of a single country."

Instead, under the gold standard the price level by definition reflects the (inverse) value of gold. And since the value of gold is equalized across all countries, changes in national price levels follow from the *combined* actions of all central banks that jointly determine the international value of gold. It follows that each central bank controls domestic prices only to the extent that it contributes to the value of gold in international markets via gold demand policy. While this appreciation is largely absent from the existing macroeconometric literature, it explicitly informs the empirical analysis in this paper. This raises the question of how (global) gold demand policy can be measured and what its relation is to other measures of the stance of monetary policy. These considerations are discussed next.

3.1.2 Measurement of Monetary Policy in a Gold Standard Model

A second difference between the narrative and the macroeconometric literature concerns the measurement of monetary policy. In order to address this issue, this section develops a formal monetary framework that builds upon the gold standard model of Goodfriend (1988). Notably, the modeling approach reflects the understanding laid out before that monetary conditions in each country can only be controlled to the extent that an individual monetary authority affects world monetary conditions. Against this background, the approach intentionally abstracts from modeling individual countries. Instead, it is primarily concerned with formalizing aggregate monetary conditions in an international gold standard system.

A Simple Model to Guide Intuition Consider a simple model with three assets that a representative consumer can invest in: government bonds, currency and gold. The latter two yield utility. The government uses part of the exogenous stock of gold to back its supply of currency with a certain fraction of monetary gold, and stands ready to exchange gold into currency at a fixed exchange rate.

A representative household maximizes expected utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, M_t/P_t, G_t^p) \tag{1}$$

where I assume the utility function to be additively separable in consumption C_t, real money balances M_t/P_t and private gold holdings G_t^p:

$$U(C_t, M_t/P_t, G_t^p) = \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{(\frac{M_t}{P_t})^{1-\phi}}{1-\phi} + \frac{(G_t^p)^{1-\kappa}}{1-\kappa} \tag{2}$$

Maximization is subject to the budget constraint

$$C_t + \frac{M_t}{P_t} + \frac{P_t^g G_t^p}{P_t} + \frac{B_t}{P_t} + T_t = Y_t + \frac{M_{t-1}}{P_t} + \frac{B_{t-1}^p R_t}{P_t} + \frac{P_t^g G_{t-1}^p}{P_t}, \tag{3}$$

where R_t is the one-period interest rate on riskless government bond holdings B_t^p, T_t are real lump-sum taxes, P_t^g is the price of gold in terms of currency, and Y_t are available real resources.

The first-order conditions with respect to C_t, B_t, M_t and G_t^p read, respectively,

$$\varrho_t = C_t^{-\sigma} \tag{4}$$

$$\frac{\varrho_t}{P_t} = \beta R_t \mathbb{E}_t \frac{\varrho_{t+1}}{P_{t+1}} \tag{5}$$

$$\frac{\varrho_t}{P_t} = \beta \mathbb{E}_t \frac{\varrho_{t+1}}{P_{t+1}} + \left(\frac{M_t}{P_t}\right)^{-\phi} \frac{1}{P_t} \tag{6}$$

$$\frac{\varrho_t P_t^g}{P_t} = \beta \mathbb{E}_t \frac{\varrho_{t+1} P_{t+1}^g}{P_{t+1}} + \left(G_t^p\right)^{-\kappa}, \tag{7}$$

in which ϱ_t is the Lagrange multiplier on the budget constraint. These conditions, together with transversality conditions, determine the demand side of the model.

For simplicity, in this baseline version of the model, I abstract from production. Instead, in the tradition of Lucas (1978), resources are exogenous but non-storable. With a fixed aggregate stock of gold G, the gold market clearing condition reads

$$G = G_t^m + G_t^p \tag{8}$$

Government policy, next to issuing bonds B_t and levying lump-sum taxes T_t, comprises the choice of two variables: the money supply M_t and monetary gold holdings G_t^m. As I am interested in the analysis of a monetary economy under a gold standard, I assume that the government commits to exchanging a fixed amount of gold into a unit of currency. In other words, the price of gold in terms of money is fixed:

$$P_t^g = P^g. \tag{9}$$

In addition, the money supply is backed by monetary gold holdings in some proportion:

$$\lambda_t = P^g G_t^m / M_t, \tag{10}$$

where λ_t is the *gold reserve ratio*, and the gap between M_t and $P^g G_t^m$ on the central bank balance sheet is filled by central bank bond holdings: $B_t^m = M_t - P^g G_t^m$.

The gold reserve ratio λ_t will be used to describe the monetary stance in the empirical analysis. In order to justify this choice, it is now worth shedding some light on the monetary transmission mechanism in the model, from which three key points will emerge. First, in a gold standard economy, the central bank affects the price level via gold demand policy. Specifically, any increase in the demand for gold (absent corresponding increases in its supply) raises its value relative to goods and services. As this cannot materialize in an increase in the money price of gold, it has to materialize in a decline of the general price level. Second, the demand for gold by the central bank, and hence the stance of monetary policy, can be described by the gold reserve ratio. Third, adjustments of short-term interest rates or monetary aggregates can best be thought of as merely *implementing* a certain level of monetary gold demand. Finally, I will offer some practical considerations that speak in favor of using the gold reserve ratio empirically.

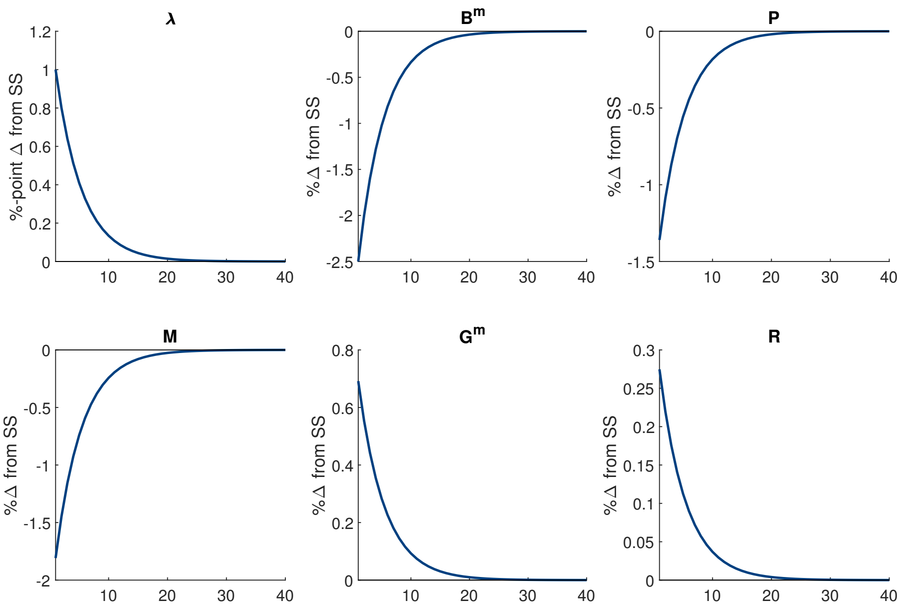
The gold reserve ratio as a measure of the monetary stance It is easy to grasp price level determination in an economy where gold is the only money. Household demand and the exogenous supply give rise to an equilibrium value of gold. Owing to gold's role as the medium of account, by definition the value of gold is the (inverse of the) price level. Central banks can conduct monetary policy, *i.e.* control the price level, by gold demand policy: taking some of the gold and putting it in its vault, say, will make gold more scarce, increase its value and depress the overall price level.

In a gold *standard* economy, where monetary gold merely backs the issue of cash, nothing fundamental changes. The central bank commits to redeem holders of notes in gold using a fixed conversion rate, equivalent to equation (9).[12] However, also in this environment, monetary policy is conducted by regulating monetary gold demand: the central bank can lower the price level by putting – for each outstanding banknote – a larger share of the exogenous gold supply in its vault. This will increase the gold reserve ratio and, just as before, will raise gold's value and depress prices. Similarly, if the central bank decided to lower – for each gold coin in its vault – the amount of money in circulation, this, too, would lead to a rise in the gold reserve ratio and a fall in prices. The reason lies in the central bank's commitment to still exchange one banknote for a certain amount of gold: with money now being more scarce but with its nominal value fixed, the central bank effectively increases the real value of the gold in its vault. Households have an incentive to exchange their private gold, which they hold for non-monetary reasons, at the central bank gold window for currency. Monetary gold holdings at the central bank will increase and prices fall, until the rebuilt amount of money in circulation suffices to support a certain level of nominal spending determined in general equilibrium.

This analysis shows that, in a gold standard economy, changes in the gold reserve ratio measure changes in monetary gold demand and the stance of monetary policy. In particular, focusing only on the outstanding amount of money is not enough, neither is focusing only on the amount of monetary gold. By fixing the gold price of money, or equivalently the money price of gold, there are effectively two units of account. Excess demand for, or supply of, either will spill over to the other. Instead, the ratio of monetary gold to currency, the gold reserve ratio, will indicate the actual stance of monetary policy.

[12] As banknotes offer higher liquidity services, they are used as medium of exchange. Goods and bond prices could either still be denominated in terms of gold, with the gold price of money being fixed, or in terms of money, with the money price of gold fixed.

Figure 1: IRFs to a monetary policy shock in the gold standard model



Note. Impulse responses to a monetary gold demand (= contractionary monetary policy) shock, in the form of an exogenous increase in the gold reserve ratio λ, in the simple endowment gold standard model. The calibration is described in Table 2 in Appendix A.1.

Implementation of monetary policy in a gold standard economy. Central banks in the interwar period regularly referred to the discount rate (or their outstanding monetary liabilities) as their immediate instrument to steer monetary conditions. In light of the discussion above, it is instructive to use the simple model setup laid out so far to shed light on the gold reserve ratio and its relation to such monetary instruments.

For this purpose, consider Figure 1 which depicts impulse responses to a contractionary monetary policy shock in the form of an increase in the gold reserve ratio λ.[13] First and foremost, the figure shows what was discussed above: a rise in λ leads to a fall in the price level. However, the figure also makes clear that the short-term interest rate has to rise, which makes (one-period) bonds relatively attractive compared to money and private gold holdings. Households trade their gold for money at the central bank gold window and at the same time the central bank withdraws money from circulation by selling bonds to households. With prices at a lower level, households are content with a smaller amount of money in circulation, while the central bank holds more monetary gold.

This analysis shows that adjustments in the stance of monetary policy generally require changes in monetary instruments. Whether the central bank initiates the adjustment via an interest rate hike (leaving its balance sheet unchanged), by directly selling bonds for gold (an asset swap, leaving the monetary base unchanged), or by conducting open mar-

[13]Details on the model calibration are, in the interest of space, relegated to Appendix A.1. While Appendix A.2 features a discussion on the objectives and targets of monetary policy, for the current purposes I may assume that the monetary authority – absent any shocks – fixes the gold reserve ratio and therefore adheres to the 'rules of the game': $\lambda_t = \lambda + \epsilon_t^G$, where ϵ_t^G is an autoregressive shock to monetary gold holdings used to illustrate the effects of a contractionary monetary policy shock.

ket operations (a balance sheet contraction, leaving the monetary gold stock unchanged), is immaterial as long as it lets the other respective variables respond in a manner that implements the increase in the gold reserve ratio.

Practical considerations. Another reason why thinking of monetary policy in the form of the gold reserve ratio, instead of interest rates, seems desirable has to do with the international context of the empirical analysis to follow. While central banks in practice did use their discount rates to attract or let loose of monetary gold, the main determinant of gold flows was not the level of discount rates *per se* but the interest spreads between countries. If, say, the Bank of England increases its discount rate in order to attract gold from the US, but the interest spread in favor of the US remains sizable, the British central bank might fail to induce much gold flow at all. Similarly, it is not clear how, say, a discount rate cut in France and a contemporaneous discount rate hike in the US (as for instance in February 1928) affects world monetary conditions. Indeed, a generalization to an international context of the discussion above makes clear that the net effect will depend on what happens to the world gold reserve ratio. As a consequence, by weighing individual countries' gold cover ratios by their central banks' amount of monetary gold, I follow Sumner (2015) and can easily construct a world gold reserve ratio that can be used in the empirical analysis as a measure of the world monetary stance.[14]

To summarize, using the gold reserve ratio as the main monetary variable of interest is not only more directly linked to the paper's narrative about monetary gold demand. It can also be argued to be preferable on theoretical grounds and to have more suitable aggregation properties.[15] Finally, it will come in handy when adding narrative information to improve shock identification, as I describe in Section 3.2.2.

3.1.3 Enlarging the Model to Account for Other Shocks

In order to address a variety of different explanations for the Great Depression in both the narrative and macroeconometric literature, this section enlarges the simple DSGE model and derives a full set of impact restrictions for the subsequent VAR analysis. I introduce production via capital and labor, as well as various frictions, such as wage stickiness, investment adjustment costs and financial frictions in the spirit of Bernanke et al. (1999).[16]

[14] A final, related, reason for the choice of the gold reserve ratio has to do with France. The Bank of France increased discount rates repeatedly before France's rejoining gold in 1926. However, the period of a substantial increase in the French gold reserve ratio from 1928-31 is actually characterized by repeated and consistent declines in the discount rate. This break in the equivalence of gold reserve and discount rate adjustments was mainly due to the special monetary conditions in France in the interwar period characterized by a persistent excess demand for currency, see Eichengreen (1986, pp.66-68), Gardner (1932, p.61) and Irwin (2012, p.20) on these. Using changes in interest rates to describe adjustments in the stance of monetary policy then seems particularly misleading in the case of France.

[15] See Sumner (2015, chapter 13) for a related discussion.

[16] As these additional features are standard in, in the interest of space, more details on the model are relegated to Appendix A.2.

These additions allow to account for a rich set of variables to be used for shock differentiation. Specifically, I consider two additional shocks. These are meant to capture a variety of potential causes of the Great Depression other than a monetary tightening via the hoarding of monetary gold. First, an *aggregate demand* (AD) shock is supposed to capture the notion that an autonomous drop in consumption (Temin, 1976) or the stock market crash (Mishkin, 1978, Romer, 1990) initiated the depression and made prices and output fall in tandem. In addition, I address the view that non-monetary financial frictions from a collapsing banking system dramatically increased financing costs of firms as captured by the risk spread employed in Bernanke (1983). I model this shock as an exogenous change in capital quality.[17] Second, I capture the notion of an *aggregate supply* (AS) shock as changes to the production capacity of the interwar economy (Kehoe and Prescott, 2002). In the model, this shock is implemented as a standard technology shock.

Figure 2 shows impulse responses to the three considered shocks in the larger model to a set of key macroeconomic and financial variables. In order to ensure a robust empirical identification of shocks from these responses, I allow for uncertainty in two respects: first, I vary certain key parameters by drawing uniformly from plausible parameter ranges, producing uncertainty bands around the estimated impulse responses (Canova and Paustian, 2011).[18] Second, I account for uncertainty with respect to the monetary reaction function. In a "classical" regime, the gold cover ratio is not allowed to respond on impact to either aggregate demand or supply shocks. This could be justified with a reference to lags in the response of monetary authorities and in the implementation process through discount rate changes. It could also reflect a strict adherence to the 'rules of the game', *i.e.* to keeping the gold reserve ratio constant. In a different regime, the gold reserve ratio responds positively to increases in the wholesale price index (WPI) (*i.e*, to positive aggregate demand and negative aggregate supply shocks). This notion would hold under price level targeting.[19]

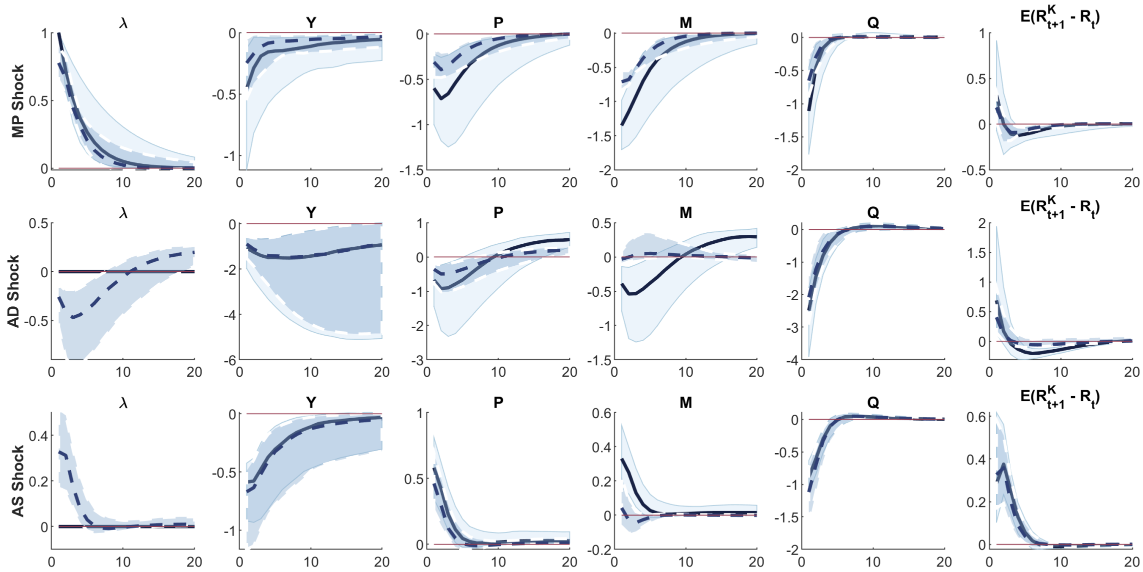
The enlarged model offers the following key predictions: output, the price level, money holdings and asset prices decline following a contractionary monetary shock, whereas no clear prediction can be made regarding the excess financing premium. Aggregate demand shocks cause a fall in output, prices and asset valuations as well as an increase in financing spreads, but no unambiguous response of money holdings. Moreover, the central bank lowers the gold reserve ratio under an assumed price level targeting regime. Finally, the aggregate supply shock leads to a fall in output and asset prices, but an increase in the price level and interest spreads. Again no clear prediction can be made with respect to money holdings, and the central bank increases the gold reserve ratio to dampen the increase in

[17] This shock is used for instance in Gertler and Karadi (2011) to produce a contemporaneous fall in production, the price level and stock prices and an increase in risk spreads to describe the behavior of the US economy during and after the Great Financial Crisis. I prefer the capital quality shock to a "preference shock" to the consumption-savings decision, which is also often used to produce crises, as the latter is not associated with a fall in asset prices or an increase in risk premia.

[18] I thank a referee for suggesting this approach. Details are described in Appendix A.2.

[19] See footnote 46 for a discussion.

Figure 2: IRFs in the medium-scale model used to derive sign restrictions



Note. Impulse responses to contractionary shocks in the medium-scale gold standard model. Shaded areas denote 95% confidence bands stemming from parameter uncertainty following Canova and Paustian (2011). Solid lines and lighter areas assume a "classical" monetary regime in which the central keeps the gold reserve ratio constant. Dashed lines and darker areas assume that the central bank stabilizes the price level by varying the gold reserve ratio. Responses in percentage point (λ, $E(R^K_{t+1} - R_t)$) or percent deviations (all others). The calibration is described in Table 3 in Appendix A.2.

prices when assuming a price level target.

3.2 Empirical Shock Identification

This section describes the shock identification used in the structural VAR analysis. As discussed, one source of information stems from the theoretical monetary model. Whereas early macroeconometric contributions relied on imposing a (usually recursive) ordering in the responses of the variables in the model to identify structural shocks, the approach adopted here relies on the imposition of restrictions on the signs of impulse responses functions.[20] Such an approach not only has the advantage that it imposes much weaker restrictions than traditional recursive identification schemes but also that these restrictions can be more rigorously derived from economic theory, such as those in Figure 2.

However, the parsimonious approach of using sign restrictions comes at the cost of often fairly large sets of structural impulse responses, sometimes to the point that little economic inference can be drawn from them. In addition, they might entail implications for the role of some shocks at certain points in time that are at odds with the established understanding of that period in the narrative literature. Against this background, I follow Antolin-Diaz and Rubio-Ramirez (2018) who enrich traditional sign restriction identification by employing external narrative information on certain key events. More specifically, Antolin-Diaz and Rubio-Ramirez (2018) require that for certain points in time the contribution

[20]See Faust (1998) and Uhlig (2005) for early contributions.

of a particular shock to the unexpected change in some endogenous variable be of some (relative) size. In other words, restrictions are not only imposed on the signs of impulse responses. Instead they are imposed also on the historical decomposition at certain key dates in accordance with the prevalent understanding of these dates in the literature. These *narrative sign restrictions* are therefore a way to incorporate external information without the need for an instrument time series and seem especially well suited to be applied to the Great Depression given its rich narrative account developed over many decades.[21] In Section 3.2.2, I therefore describe two key events that – given the choice of the gold reserve ratio as the monetary variable of interest – can be summarized by one single narrative sign restriction which is used to sharpen shock identification.

3.2.1 Traditional Sign Restrictions

Table 1 summarizes the sign restrictions derived from the monetary DSGE model. I consider two identification schemes: a simple one that identifies the monetary shock as parsimoniously as possible and in particular does not impose monetary non-neutrality, as in Figure 1; and a full set of restrictions based on Figure 2.[22] All restrictions are imposed only on impact.[23]

Table 1: Sign restrictions used in the VAR analysis

	simple	full identification		
	MP	**MP**	**AD**	**AS**
Gold reserve ratio (λ)	+	+	0	
Output (Y)		–	–	–
Prices (P)	–	–	–	+
Money (M)	–	–		
Asset price (Q)		–	–	–
Spread ($\mathbb{E}R^K - R$)			+	+

Note. Sign restrictions for contractionary shocks in the VAR. Restrictions are derived from the simple monetary gold standard model (*simple*, based on Figure 1) and medium-scale business cycle gold standard model (*full identification*, based on Figure 2). Restrictions are imposed only impact in period 0.

In order to fully differentiate the monetary from the aggregate demand shock, I need

[21] Indeed, the so-called narrative approach to shock identification can be argued to have originated in the study of the depression in that Romer and Romer (1989) coined the term in their critical assessment of the exogeneity of various key events identified by Friedman and Schwartz (1963).

[22] I thank a referee for suggesting to add the full set of restrictions implied by the DSGE model.

[23] The number of periods for which the sign restrictions are imposed turns out not to matter much.

to make an assumption about the response of the gold reserve ratio.[24] In line with the discussion in Section 3.1.2, one plausible case could be a non-response if central banks are collectively committed to the *rules of the game* and keep the gold reserve ratio constant. The implied zero restriction to aggregate demand shocks is chosen here as a benchmark case.[25]

3.2.2 Adding Narrative Information

As laid out earlier, I enrich the traditional sign restriction scheme by employing narrative information from outside the model in order to sharpen identification. In keeping with this paper's focus on the gold hoarding view in an international context I will focus on a key shift in the stance of monetary policy in the US and France, the two countries with very large monetary gold holdings. Conveniently, these two events can be summarized in a single narrative sign restriction. In the following, I justify this restriction by invoking events in mid-1928 and their assessment by various scholars as exogenous shifts in policy.

France. As mentioned in Section 2.1, France experienced high rates of inflation in 1924-26 but then pegged the franc to gold at an undervalued exchange rate. With the franc tied to gold, the Bank of France had to engage in large-scale foreign exchange interventions in order to prevent the appreciation of its currency. Irwin (2012, p.19) describes how the Bank offset the inflationary impact, but then increasingly sold its foreign exchange holdings (in particular British pounds and US dollars) for gold. When officials at the Bank of England complained about this practice, an agreement was reached that had the Bank of France temporarily stabilize its sterling holdings.

This relatively accommodative stance in French policy came to a halt when the so-called *Monetary Law* took effect on June 25, 1928. The law constrained French monetary policy in various important respects. Chief among them was the prohibition of engaging in the purchase of foreign exchange, which meant that the Bank could henceforth only acquire monetary gold to stabilize its undervalued exchange rate. Therefore, instead of continuing the brief period of accommodation of world monetary conditions, the law tied the hands of the Bank of France and prevented the use of its foreign exchange reserves to alleviate the drain of monetary gold, especially from Britain. At the same time, due to the particularities of French demand for cash,[26] gold continued to flow into France. Critics

[24]To see that, consider for instance a negative aggregate demand and a contractionary monetary policy shock. Both of these are identified as causing a fall in prices, output and asset valuations. As all additional restrictions of these two shocks refer to two distinct sets of variables, in the absence of additional assumptions, certain draws of impulse responses could in principle satisfy the restrictions of both shocks.

[25]Notably, this baseline specification is not meant as a realistic portrayal of the monetary policy reaction function in the interwar years but merely chosen to ensure shock differentiation. I discuss alternative assumptions in Section 4.3.

[26]Again, see Eichengreen (1986, pp.66-68), Gardner (1932, p.61) and Irwin (2012, p.20) on these. In particular, the French public wanted to increase its holdings of cash. To do so, it restricted its spending in order for the French economy to run current-account surpluses. The resulting gold inflows were necessary, given the Monetary Law, to back the issuance of cash.

observed that the Bank could in principle offset these gold flows by reducing its gold reserve ratio to ease monetary conditions in France. However, the Monetary Law prevented this from happening as well, as it required a backing of central bank liabilities by gold of at least 35%. In addition, the law prescribed that new currency issue had to be backed one-for-one by gold. With a gold reserve ratio of less than one, this effectively meant that any increase in the monetary base was accompanied by a rise in gold backing. The taking effect of the Monetary Law can then directly be tied to the steady rise of the French gold reserve ratio in the months and years to follow.

United States. Whereas the period of a more accommodative policy stance in France before mid-1928 was only reluctantly implemented, the Fed under the leadership of Benjamin Strong had eased monetary conditions in 1927 with the express purpose of supporting Britain's monetary gold holdings. But just like its counterpart in France, also the Fed sharply reversed course in mid-1928. As Sumner (1991, p.389) puts it: "By June 1928, the fact that the U.S. had exported almost $500 million in gold, and the perception that speculation in the stock market boom had become excessive, resulted in the Federal Reserve shifting to a contractionary policy." Although this shift was implemented via discount rate hikes that started already in late May 1928, it was not before July when the US discount rate exceeded the one set by the Bank of England. The sensitivity of gold flows to the US-UK discount rate spread is evidenced in Sumner (2015). He quotes the New York Times' expectation that the direction of gold flows would change rapidly in the face of rumors of a Fed tightening in June 1928.[27] While these gold inflows into the US could have been reversed, and could have eased pressure on Britain, the Fed sterilized the inflows, *i.e.,* did not have its gold reserve ratio fall further (Meltzer, 2004, p.140).

There is some indication that this shift in US monetary policy can be tied to the illness and later death of New York Fed Governor Strong. Friedman and Schwartz (1963) make much of Strong's departure as a key event in their account of the depression, as have other scholars.[28] Strong's easing policies were not only implemented against some resistance within the Fed but also sparked public opposition.[29] Friedman and Schwartz (1963) and Meltzer (2004) describe the power struggle within the Fed between the New York Bank under Strong and the Board. Strong was chiefly concerned with international

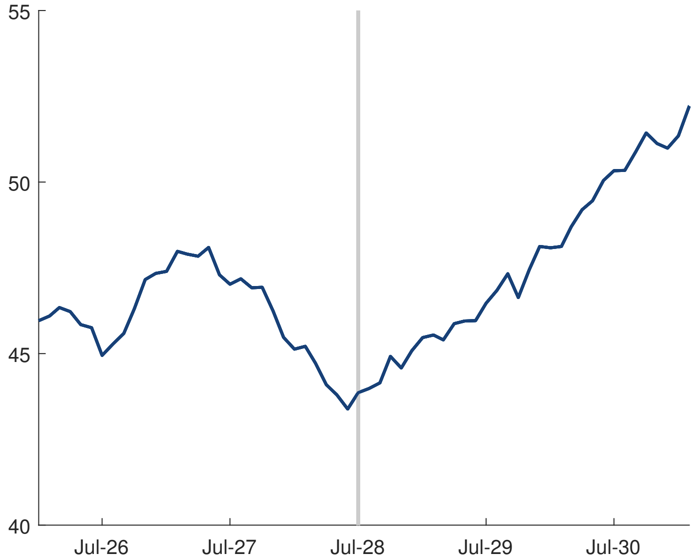
[27] Also Crabbe (1989, p.432) stresses the importance of the US-UK short-term interest rate spread for gold flows between the two countries. The Fed itself, too, recognized and publicly discussed the shift in its policy in mid-1928. In its January 1930 Monthly Bulletin (p.1) it credits the "firm money conditions that have come to prevail in the United States" with "arresting the outflow of gold" that had occurred before the policy shift.

[28] Friedman and Schwartz focus in particular on the lack of leadership within the Fed in the early 1930s. Hetzel (1985, p.3) calls Strong's death a "key event". Fisher (1934, p. 151) was convincend that "if [Strong] had lived and his policies had been continued, we might have had the stock market crash in a milder form, but after the crash there would not have been the great industrial depression."

[29] Most notably is the so-called Chicago Controversy when the Federal Reserve Bank of Chicago resisted the discount rate reductions in August 1927 but was overruled by the Board in September (Meltzer, 2004). These events led the Chicago Tribune to publicly demand Strong's resignation.

cooperation and domestic price level stability. The Board, in contrast, was worried about speculative excess that had supposedly resulted in inflated stock market prices, which could be tamed by a tightening of monetary policy. It is therefore worth mentioning that Strong's effective departure from power came about just around mid-1928, months before his death in October. Strong's health severely declined in Spring 1928 and, as Bernanke (2002) notes, "with it, his influence in the Federal Reserve System."[30] To be sure, it remains unclear just how important Strong's departure as the dominant figure within the Fed was for the change in US policy.[31] Friedman and Schwartz's (1963, p.414) evaluation that the "shift in the locus of power almost surely would not have occurred when it did if Strong had lived" may add to the exogeneity of the events in mid-1928. For the purposes here it may suffice to adopt Bernanke's (2002) view that "this period represents a tightening in monetary policy not related to the current state of output and prices – a monetary policy 'innovation', in today's statistical jargon."

Figure 3: World gold reserve ratio around 1928



Note. World gold reserve ratio computed as described in Sections 4.1 and Appendix A.4. The vertical line denotes the date of Narrative Sign Restriction 1.

The events described above are clearly visible in Figure 3, which shows the evolution of the world gold reserve ratio. The cooperative policy stance by the Fed, and to some extent the Bank of France, shows up as a decline in the ratio throughout 1927. While the reserve ratio continued to decline in June, there is a clear break in the trend in July 1928 as a

[30] Klein (2001, p.146) describes how Strong, ill and exhausted, sailed for France in May 1928, and, upon advice of his doctor, had to "give up all work if he wished to live". He then "grudgingly made plans to resign". Meltzer (2004, p.232) reports that he returned from Europe only in August but "was too ill to resume his duties."

[31] Batchelder and Glasner (2013, p.3) see a clear and direct connection and write: "Despite calls for another rate hike, Strong kept the discount rate at 4 percent until ill health forced his retirement in February 1928. Strong's successor, his deputy William Harrison, acceded to the increasingly urgent demands for action to quell the stock market boom, raising the discount rate to 5 percent soon after replacing Strong."

result of the shifts in US and French policy.[32] Given my choice of the gold reserve ratio as the primary monetary variable in the VAR, I can therefore conveniently summarize the two key events in US and French monetary policy in one single narrative sign restriction as follows.

Narrative Sign Restriction 1. *There was a contractionary monetary policy shock in July 1928 and this shock was the most important driver of the unexpected movement in the world gold reserve ratio in this month.*[33]

Before moving on to the empirical analysis, one may note that Narrative Sign Restriction (NSR) 1 does not involve any of the main outcome variables of interest – prices and production – but only the monetary variable itself. Further, in no way does NSR 1 involve the period under investigation – the initial slide into the depression. It merely represents a clear shift in world monetary conditions towards a tightening, and in doing so sharpens identification of shocks to monetary conditions.

4 Empirical Analysis

With the measurement of monetary conditions and identification of shocks in place, this section features the main empirical analysis. Subsection 4.1 contains a description of the employed dataset and VAR model. In the interest of space, more technical details regarding the VAR, structural identification and the construction of the data series are relegated to the appendix. Subsection 4.2 then describes the results in the form of impulse responses, historical and forecast error variance decompositions. Finally, Section 4.3 features additional results and various robustness checks.

4.1 Data and Model

Data. The dataset contains monthly time series from 1922 to 1936 for twelve countries covering roughly 60% of world output at the sample start.[34] The countries covered are the United States, the United Kingdom, Austria, Canada, Finland, France, Germany, Japan, the Netherlands, Norway, Poland and Sweden. The choice of countries is mostly based on data availability. In addition, care was taken so as to include countries from various

[32] Incidentally, Eichengreen (1992, pp.12-13) summarizes the simultaneous shift to hard money policies in both the US and France as well: "(...) U.S. lending was curtailed in the summer of 1928 as a result of increasingly stringent Federal Reserve monetary policy. Inauspiciously, the monetary contraction in the United States coincided with a massive flow of gold to France, where monetary policy was tight for independent reasons." He then goes on to stress how these shifts led to the adoption of contractionary policies in other countries as well, notably in Britain, as described in Section 2.1.

[33] Antolin-Diaz and Rubio-Ramirez (2018) call this a narrative sign restriction of the weaker "Type A". This is in contrast to the stronger "Type B" restriction under which the shock in question is responsible for a larger share of the unexpected movement in a variable than the sum of all other shocks (*i.e.*, it is the *overwhelming* instead of the *most important* driver).

[34] The share of world output is calculated based on estimates contained in the Maddison Historical Statistics dataset, available at `https://www.rug.nl/ggdc/historicaldevelopment/maddison/`.

geographical regions as well as covering the three 'blocs' ('gold', 'Sterling' and 'foreign exchange') that made up the interwar gold standard system as identified in the literature. The raw data is partly hand-collected from a multitude of historical sources and is described in detail in Appendix A.4.

In line with the monetary DSGE model, the baseline VAR contains six macroeconomic and financial variables: the gold reserve ratio (derived from central bank gold holdings and monetary liabilites), industrial production, wholesale prices, money holdings, a stock market index, and a risk spread describing lending rates of US corporate borrowers relative to long-term government bonds. Additionally, I have information on employment and nominal wages that is used for robustness purposes. As the analysis is concerned with the entire international interwar monetary system, the time series used in the VAR are meant to proxy world counterparts. For that purpose I construct aggregate measures for all variables from the individual country data series. In the case of the gold reserve ratio this is done as a weighted average following Sumner (2015).[35] This reflects the discussion in Section 3.1.2 on the relative merits of indicators of the stance of monetary policy in that the gold reserve ratio can be easily aggregated, with weights accurately reflecting each country's importance in world monetary gold demand.

For the other variables in the dataset, aggregation is performed via factor analysis. This reflects two considerations. First, regarding the stock market indices, wages and measures of the money supply, the precise definitions vary from country to country such that it is *a priori* unclear how to average them. This is even more the case for measures of employment, which, due to data availability, in some countries comprise unemployment rates, whereas in others indices of occupational activity are used. Employing factor analysis represents a convenient way to summarize information from these different types of variables that still capture the same underlying economic concept. Second, the goal is to measure a latent world counterpart of production, prices, asset valuations *etc.*, the precise task that factor analysis is designed for in the first place. With these considerations in mind, for each variable its aggregate world measure is simply the first principle-component factor of the individual country-specific time series. This one factor explains around 50% to 90% of the underlying normalized series, depending on the variable.

Notwithstanding the issues outlined above, as an alternative to using factor analysis I also consider weighted averages of the country-specific series, where the weights are derived from estimated interpolated nominal GDP series.[36] The resulting aggregate time series, using both methods, are depicted in Figure 9. Differences for industrial production, stock prices and especially wholesale prices are small, larger differences can be seen for money

[35] Note, however, that in comparison to Sumner the time series are longer, a somewhat different set of countries is used and the reserve ratio is calculated using also central bank deposits, not just currency in circulation, when available.

[36] These are again based on the Maddison Historical Statistics dataset.

holdings and wages.[37]

Model and Estimation. I estimate a 6-variable monthly VAR with $p = 12$ lags:

$$\mathbf{y}_t = \mathbf{k} + \mathbf{B}_1\mathbf{y}_{t-1} + ... + \mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \tag{11}$$

where $\mathbf{y}_t$ is a vector of endogenous variables, $\mathbf{u}_t$ is a vector of residuals, $\mathbf{B}_\mathbf{l}$ are coefficient matrices, and $\mathbf{k}$ is a vector of constants. Structural shock identification is achieved via traditional and narrative sign restrictions, as described in Section 3.

Given the relatively short time sample, the estimation is done using Bayesian methods. In particular, I assume a multivariate normal distribution for the regression coefficients, and an inverse Wishart distribution for the covariance matrix of the error term. I employ standard "Minnesota"-type priors (as in Litterman, 1986), where in the baseline case I assume prior random-walk behavior of all variables in the system with the exception of the risk spread. In a robustness exercise I estimate the model in first differences and consequently set the corresponding parameters to zero, as in Banbura et al. (2010). The hyperparameter controling the overall tightness of the Minnesota prior is determined optimally in the spirit of hierarchical modelling as in Giannone et al. (2015). More details on the model estimation are given in Appendix A.3.

4.2 Results

I begin the discussion of the results with the most parsimonious identification scheme in order to study real effects of monetary shocks. The analysis revolves around impulse responses and historical decompositions. Additionally, I discuss the role of NSR 1 via monetary shock distributions at key dates. Afterwards, I impose the full set of restrictions in order to analyze relative shock contributions, again in the form of historical as well as forecast error variance decompositions.

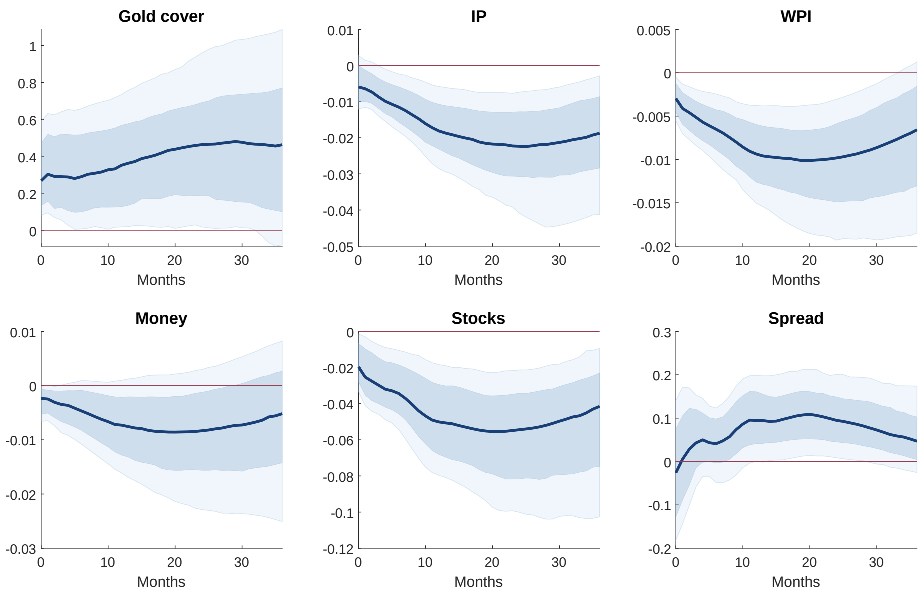
4.2.1 Parsimonious Specification: Real Effects of Monetary Shocks

Impulse responses. Figure 4 shows impulse responses to a contractionary monetary policy shock using the parsimonious shock identification scheme where no restrictions are imposed on real and financial variables. The persistent increase of the gold reserve ratio leads to a decline of prices on impact by assumption, in line with the reasoning laid out in Section 3.1.2: an increase in the demand of gold increases its value, which – given its role of unit of account – materializes as a fall in the general price level. Indeed, it turns out to have significant effects for more than two years in the VAR model. There, an increase in the gold reserve ratio by roughly half a percentage point leads to a peak decline of prices of roughly one percent at the point-wise median. More importantly, despite the absence of an impact

[37] More details on the construction of the aggregate series as well as sources and descriptions of the individual raw data can be found in Appendix A.4.

restriction, real activity is also negatively affected. The effects on industrial production are similarly statistically significant but quantitatively even more pronounced, with a peak response of roughly two and a half percent. These results point to the importance of nominal frictions in the interwar world economy in that a substantial part of the monetary shock materializes as a decline in economic activity, rather than prices. Stock market valuations show a similar yet quantitatively even larger decline, corroborating the view that monetary shocks might have played a role in bringing down stock prices. The risk spread increases as well, although statistically so only after several months. Again, this result fits the view that monetary innovations could have caused, or worsened, financial distress.

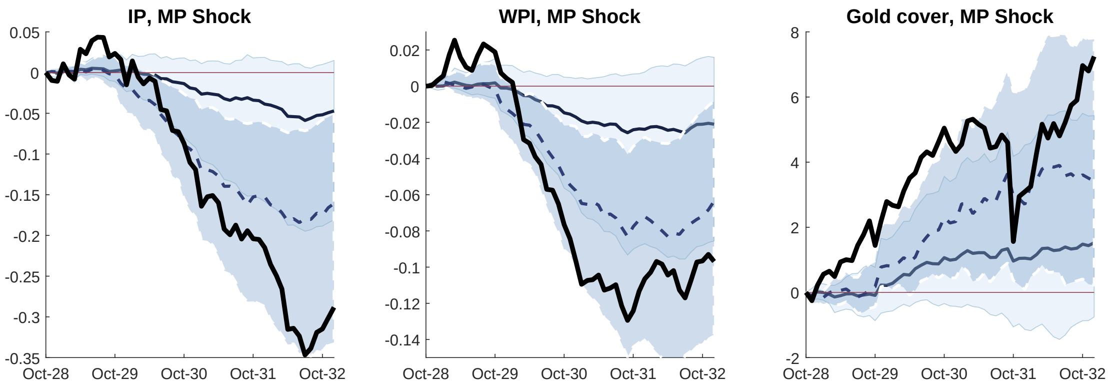
Figure 4: IRFs to a monetary policy shock in the VAR model with simple identification restrictions



Note. Impulse responses to a contractionary monetary policy shock. Shock identification via sign restrictions according to the simple set of restrictions in Table 1 and NSR 1. Solid lines denote point-wise median IRFs, dark (light) shaded areas denote 68% (90%) credible sets.

Historical decomposition. The impulse responses functions depicted in Figure 4 show average responses of prices and production to monetary shocks over the whole sample period. More insightful for the question at hand, however, is to examine the impact of gold hoarding in a particular time period – the initial slide into the depression. One way to do that is to conduct a historical decomposition analysis. In this exercise, a model prediction is contrasted with the actual data, giving rise to a forecast gap. This original forecast is then amended by feeding in structural shocks of interest to see if the forecast gap narrows. This would be the case if indeed these shocks, in the period under consideration, are responsible for the departure of the actual variables from the original forecast. Insofar, for the question at hand, the extent to which monetary shocks can account for these deviations is a measure of the importance of monetary gold hoarding as a cause of the depression.

Figure 5: Historical decomposition in the VAR model with simple identification restrictions

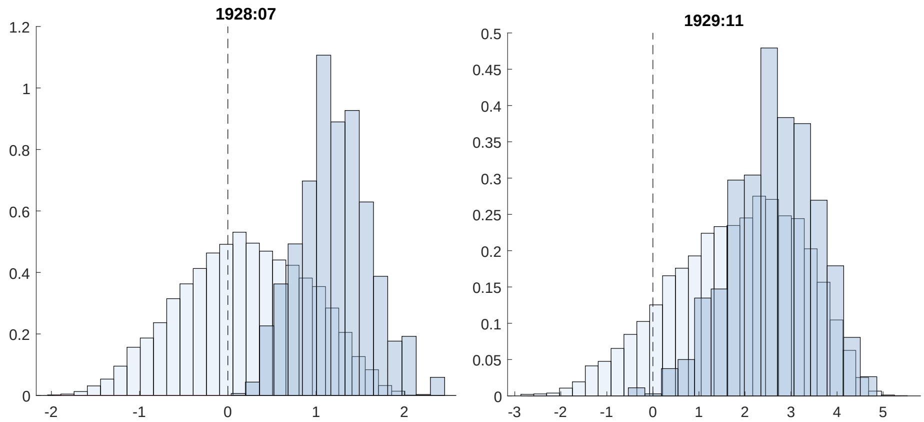


Note. Historical decompositions showing deviations of the respective variable from a model forecast beginning in October 1928: without shock (thick solid lines) and with monetary policy shock identified according to the simple set of restrictions in Table 1 (solid lines, light areas), and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

Figure 5 shows the results of such an exercise for industrial production, prices and the gold reserve ratio. The thick solid lines represent deviations of the data from the model forecast starting in October 1928, roughly one year before the beginning of the depression, while the dashed line incorporates structural monetary policy shocks as identified by traditional and narrative sign restrictions. In order to gauge the role of the narrative information, the thin solid lines repeat this exercise when omitting NSR 1. During most of 1929, deviations are relatively small and wholesale prices as well as industrial production even increase somewhat relative to the model forecast. Only with the onset of October 1929 there is a persistent and steep fall in both variables. As indicated by the dashed lines, this sharp decline is accounted for to a large degree by the identified monetary policy shock. Especially in the case of industrial production, the model forecast amended by the gold hoarding shock follows the observed unexpected change closely up to around one year into the depression in October 1930. Subsequently, the contribution of the monetary shock flattens out, implying that there were no large additional contractionary impulses from central bank gold hoarding for some time. Only at the beginning of 1932 there is another, albeit smaller, tightening according to the structural model.

These dynamics are also clearly visible in the third panel showing the historical decomposition of the gold reserve ratio. Notably, there is some variation in gold backing also during the end of 1928 to mid-1929 but this is not accounted for by exogenous monetary shocks. In line with the results for prices and production, this changes after October 1929 when the gold hoarding shock accounts for most of the increase in the gold reserve ratio for roughly one year. Again in line with the results discussed so far, the contribution then flattens out and there is even a short-lived decline in the gold reserve ratio.[38] Only by the beginning of 1932 does central bank gold hoarding again contribute to the observed rise in the gold reserve ratio.

Figure 6: Distribution of structural monetary shock at key dates in the VAR with simple identification restrictions



Note. Monetary shock distribution in July 1928 (left) and November 1929 (right). Shock identification according to the simple set of restrictions in Table 1 (light bars), and additionally NSR 1 (dark bars).

These findings are remarkably in line with the analysis in Sumner (2015). According to his narrative, the initial slump up to the fall of 1930 was largely caused by central bank gold hoarding after which other deflationary forces became more prominent.[39] Indeed, in Figure 5 there is another steep unexpected decline in industrial production in October and November of 1931, which is not well explained by the identified monetary shock. Instead it might be associated with the wide-spread banking panics, chiefly in the United States. In that sense then the failure of the monetary shock to account for this second decline in production actually speaks to the quality of the simple identification scheme, which is supposed to narrowly identify exogenous innovations in central bank gold hoarding rather than monetary or non-monetary financial shocks more broadly.

The role of Narrative Sign Restriction 1. In Figure 5, much of the explanatory power of monetary shocks in accounting for the decline in prices and output hinges on NSR 1. This can be seen from the differences between the thin solid and dashed lines. As discussed in Section 3.2.2, July 1928 marks a clear break in the trend of the gold reserve ratio, but there is no single large innovation or outlier in the series. It is hence worthwhile

[38]This is associated with Britain (and parts of the so-called Sterling bloc) leaving the gold standard in the fall of 1931.

[39]Chief among these was currency hoarding after the onset of the first American and European banking crises. This was accommodated somewhat, in particular by the Fed, but to an insufficient degree. For some time, in the Summer of 1931, also private gold hoarding contributed to the deflation according to Sumner (2015), reflecting the fear of devaluation of major currencies against gold.

to shine some more light on the role of the narrative information in guiding shock identification. To that end, Figure 6 shows the posterior distribution of structural monetary shocks with and without assuming NSR 1. The left panel depicts these distributions at the date of the restriction, July 1928. In the baseline case, the shocks are distributed roughly symmetrically around zero, *i.e.* the model regards a monetary easing almost as likely as a monetary tightening. In contrast, the narrative restriction excludes any stimulative monetary shocks and shifts the probability mass to the right. The model now considers a substantial monetary contraction of a one-and-a-half percentage point increase in the gold reserve ratio as most likely. Interestingly, this additional information has implications for the beginning of the downturn in 1929. Although NSR 1 refers to only one month in mid-1928, the right panel of Figure 6 shows that by imposing the additional restriction, the posterior distribution also shifts to the right for November 1929, a month with large falls in production and stock prices at the beginning of the depression.[40]

4.2.2 Full Set of Restrictions: Relative Shock Contributions

The simple identification scheme employed above is useful to provide evidence of monetary non-neutrality and points to a potentially important role of central bank gold hoarding in bringing about the initial slide into the depression. However, as the ultimate goal is to quantify the contribution of monetary factors relative to other explanations given in the literature, I now consider the full set of theoretical impact restrictions derived from the medium-scale monetary model in Table 1.

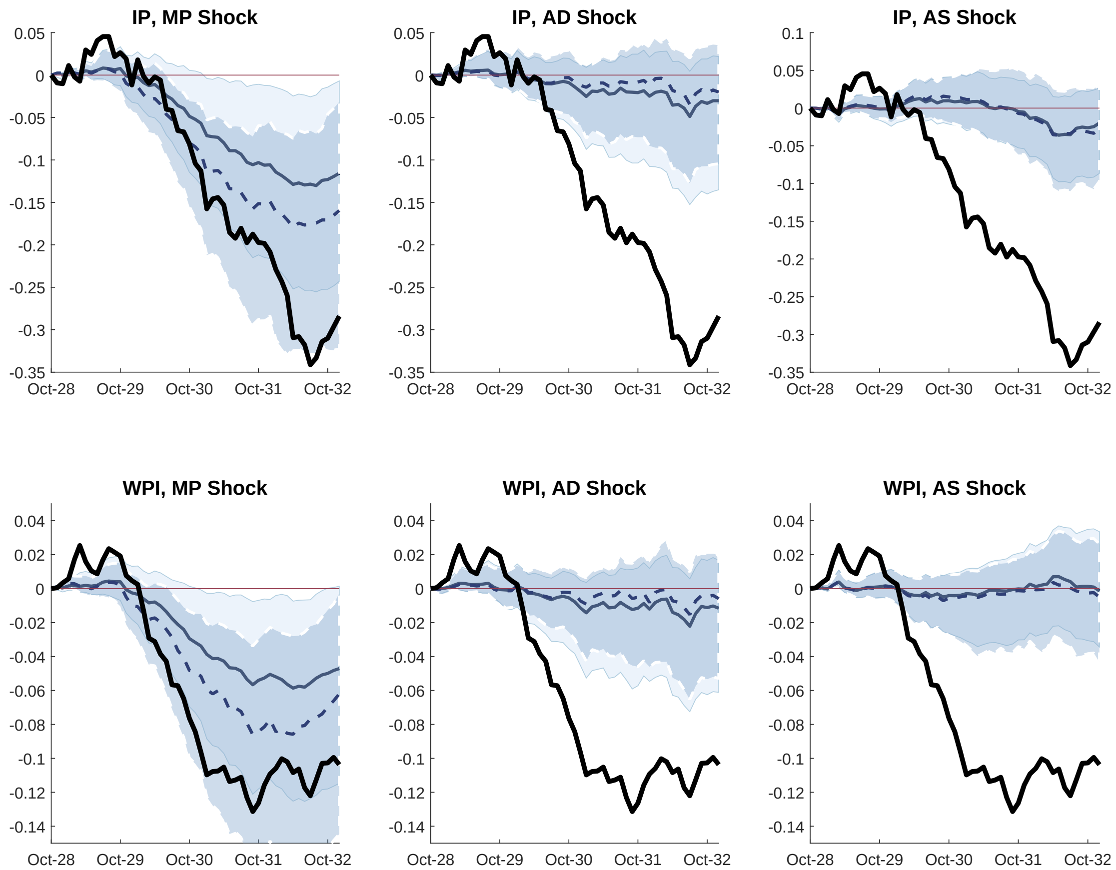
Figure 7 depicts results for the historical decomposition analysis in the larger model. The graphs show the decomposition of industrial production in the first and wholesale prices in the second row, while each column reports the respective contribution of the monetary policy, aggregate demand and aggregate supply shocks, respectively. It first becomes apparent that none of the two latter shocks account for a large share of the unexpected decline of prices and production. One may note that this is despite the fact that a (negative) aggregate demand shock is identified as causing a fall not only in output and prices but also an increase in the risk spread and a decline in the stock market, which is often associated with having caused, or at least substantially worsened, the fall in spending.[41]

More importantly, shocks to monetary policy still explain the overwhelming part of the fall in prices and production during the first one to two years of the slump. Moreover, there is still a visible flattening of the monetary contribution after 1930, in line with the discussion above, when other contractionary forces became more prominent. In particular, the gold hoarding shock again does not account well for the second unexpected sharp decline

[40] This is visible in the third panel in Figure 5 as well: whereas the traditional sign restrictions perceive only a modest monetary contraction, the model with narrative information registers a much larger tightening beginning in November 1929.

[41] See Romer (1990) and Mishkin (1978). Section 4.3 revisits this point.

Figure 7: Historical decomposition in the VAR model with full set of identifying restrictions



Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by traditional sign restrictions as in Table 1 (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

in production, most likely associated with the wide-spread banking panics after October 1931 (Bernanke, 1983).[42] In that sense the shock identification schemes differentiates well monetary gold hoarding from other monetary shocks and non-monetary financial shocks.

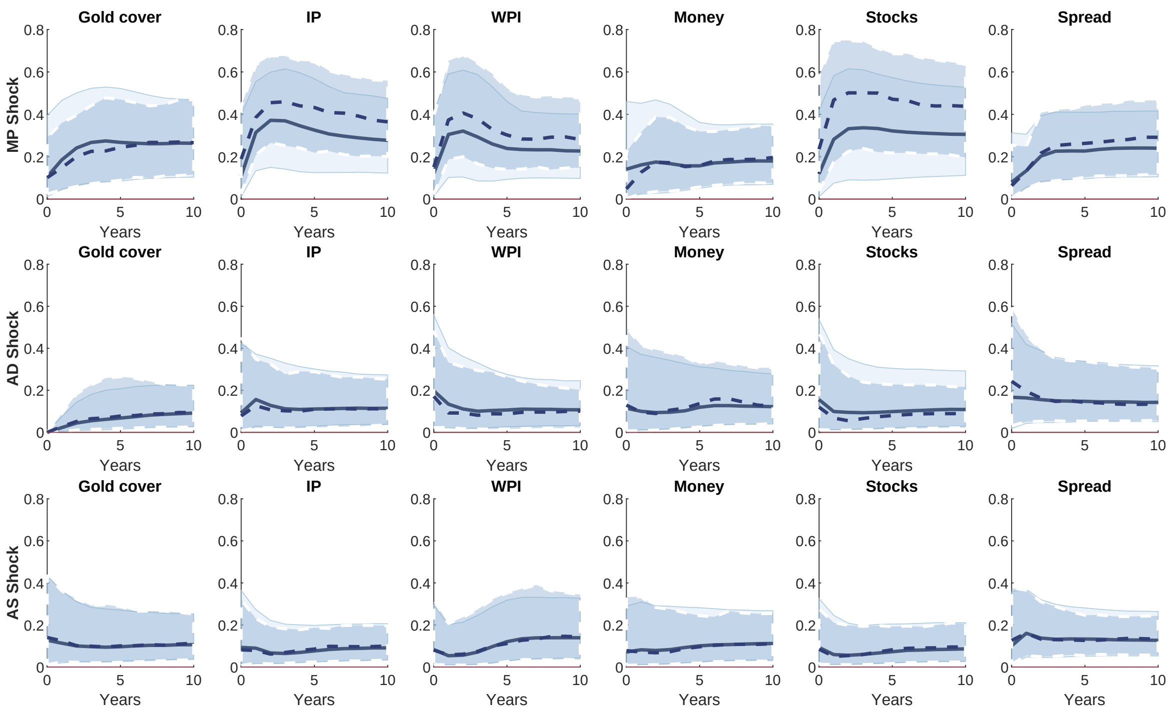
Notably, compared to the simple identification scheme, NSR 1 plays a smaller role in bringing about these results. This can again be seen from comparing the dashed and thin solid lines in Figure 7. One interpretation of these results is that additional exogenous narrative information can to some extent be substituted for by imposing tighter traditional restrictions, such that monetary shocks have real effects. Still, even with these stronger traditional assumptions, imposing NSR 1 does help to identify the shock generally and lets the model associate a larger share of the fall in economic activity and prices to changes in monetary policy.

These more pronounced effects when imposing NSR 1 can also be observed in Figure 8. It reports forecast error variance decompositions (FEVD), a measure of the relative

[42] Whether or not the initial monetary contraction also caused the run on banks – for instance through nominal debt contracts that could not be honored anymore in the face of persistently falling nominal income – is certainly possible but not addressed explicitly in the analysis here.

importance of a particular shock for the variation of the endogenous variables over the whole sample period. Overall, the two non-monetary shocks likely account for roughly equal shares of 10 to 20 percent of most variables according to the traditional sign restrictions, whereas the shares are somewhat higher for the identified monetary shock. However, the posterior probability of the contribution of the monetary shocks to industrial production, wholesale and stock prices is elevated when imposing NSR 1. Interestingly, this is not the case for the gold reserve ratio and money holdings, most likely because the monetary shock is the only one imposing a response to these variables from the outset.

Figure 8: FEVD in the VAR model with full identifying restrictions



Note. Forecast error variance decomposition in the VAR model. Shock identification based on the full set of traditional sign restrictions as in Table 1 (solid lines, light areas) and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

4.3 Additional Results and Robustness Checks

This section presents additional results to address various concerns with respect to shock identification, model specification and variable measurement. For brevity, I here mostly focus on the results for the historical decomposition analysis.[43]

Sign restriction periods, variable choice and measurement. Results do not change materially when altering the number of periods for which the sign restrictions are imposed. Swapping industrial production for an employment index (Figure 11 in Appendix A.5)

[43]For completeness, Figure 10 shows impulse responses in the model with full identifying restrictions. Results hardly differ from Figure 4.

delivers a somewhat more pronounced increase in the first half of 1929 but the subsequent downturn is similarly well explained by monetary forces as before. Even a second decline in 1932 can be observed, which is, in line with the baseline results, not well accounted for by the monetary shock. Using the employment index in the place of stock market prices hardly changes results, as does swapping money holdings with a nominal wage index.

With regards to variable transformations, there could be concerns with respect to the role of initial conditions in VARs in levels with high variable persistence (Giannone et al., 2019). To alleviate these concerns, I re-estimate the model with all trend variables in first differences and afterwards cumulate the resulting historical decompositions. Figure 12 shows that results are essentially identical to those with the VAR estimated in levels. Figure 13 repeats this exercise but uses GDP-weighted aggregates instead of those computed via factor analysis. Also in this case results look similar, with NSR 1 playing a somewhat smaller role.

Country and time samples. As is described in detail in Appendix A.4, since not for all countries in the sample all variables are available from 1922 onward, the aggregate time series used in the VAR reflect information of a subset of countries for the period of 1922:01 to 1924:12. Although care has been taken to avoid any breaks in the aggregate series, one might still be interested if the results are altered when the sample begins in 1925. Reassuringly, this is not the case (Figure 14). In addition, an earlier version of this paper was based around a smaller set of countries, where most variables were computed from data for Canada, France, the Netherlands, Sweden, the United Kingdom and the United States. The fact that for all of these countries data from 1922 was available for most of the main variables and that results were very similar to the ones presented here, should further alleviate concerns regarding time and country samples.

Finally, there could be concerns with respect to the end of the time sample. With the US devaluing the dollar against gold in April 1933 and several other countries abandoning the gold standard altogether in the early 1930s,[44] one might question whether the gold cover ratio for the later sample period is a useful variable to describe monetary conditions. In addition, a violent change in the monetary regime might bring about structural breaks that could obfuscate parameter estimates. I address these concerns by re-estimating the model using only data until the end of 1932. Results show that the contribution of the monetary shock is only somewhat smaller in the later parts of the depression and is hardly changed in the period until 1931 (Figure 15). The relative contributions of aggregate demand and supply shocks are almost unaffected.

Dropping additional sign restrictions on the monetary shock. As discussed in Section 3.1.2, the full set of identifying restrictions specifies output and stock prices to respond to monetary shocks in a manner implied by standard assumptions of nominal

[44] See Bernanke and James (1991, p.37) for an overview.

frictions. Figure 16 depicts results for the case when I identify monetary shocks alongside of demand and supply shocks but identify the former using the more parsimonious sets of restrictions by omitting output and stock market responses. Even under these substantially less strict assumptions, the contribution of monetary shocks looks similar to before.[45] What is more, the analysis confirms the notion that imposing stricter traditional sign restrictions can to some extent substitute for the additional narrative restriction, in that the differences between the thin solid and dashed lines are more pronounced than before.

Shock differentiation and monetary reaction functions. In Table 1, I assume a zero response of the gold reserve ratio to aggregate demand shocks. As discussed, this is not meant as a realistic portrayal of the monetary reaction function in the interwar years but is necessary in order to avoid any potential overlap with the identified monetary shock. Here, I consider alternatives to this assumption. First, Figure 17 show that results are almost unchanged when the gold reserve ratio is assumed to fall in response to a decline in the price level, *e.g.* as stemming from contractionary aggregate demand or stimulative supply shocks. This notion would hold under price level targeting and a similar restriction was recently used by Arias et al. (2019) in order to sharpen identification of US monetary policy shocks in post-WWII data. Whereas in their case the underlying assumption – that the monetary authorities follow the Taylor principle – seems perhaps more justified, the case can be made that central banks in the interwar period at least to some extent set their monetary instruments with domestic business cycle conditions in mind.[46] Further, rather than specifying a non-response of the gold reserve ratio, I impose a zero restriction of money holdings to demand shocks in Figure 18, which again leaves results essentially unchanged. Finally, not specifying any response – such that the sets of shocks are not necessarily entirely distinct, as is done *e.g.* in Amir-Ahmadi and Ritschl (2009) – if anything increases the contribution attributed to the monetary shock further.

Narrative sign restrictions on the stock market decline. As described in Section 2, Mishkin (1978) and Romer (1990) express the view that an exogenous collapse in the stock

[45] Results in this case are somewhat weaker when using GDP-weighted aggregates instead of aggregates based on factor analysis.

[46] The clearest case of this notion can be found in the case of Sweden, which officially adopted an explicit price level target after leaving gold in 1931, see Berg and Jonung (1999). Although in the case of the US economy there never was an explicit price level target, there was indeed an attempt to introduce just that into the Federal Reserve Act in 1926. As described in detail in Hetzel (1985, p.3) and Meltzer (2004), the so-called Strong bill (after Representative James G. Strong) envisaged that "[a]ll of the powers of the Federal Reserve System shall be used for promoting stability in the price level". While Governor Benjamin Strong, whose importance for US interwar monetary policy is attested to in Section 3.2.2, rejected the rules-based character of the bill, he did perceive price level stability as the central goal of Fed policy. This is evidenced in his testimony in the Strong Hearings, which Hetzel (1985, p.7) quotes: "I personally think that the administration of the Federal reserve system since the reaction of 1921 has been just as nearly directed as reasonably human wisdom could direct it toward that very object [of stabilizing the price level]." Finally, Simmons (1996, p.428) studies the determinants of discount rates and open market operations of 15 central banks between 1925 and 1938 in a regression analysis and concludes that "central banks clearly were conducting their monetary policies in a way that countered business cycle pressures."

market might have depressed consumer spending and prices. This notion was accounted for already in the baseline identification scheme in Table 1 in that a negative aggregate demand shock was identified as causing also the stock market to decline. A more direct way of addressing this non-monetary hypothesis would be to incorporate it in an additional narrative sign restriction as follows.

Narrative Sign Restriction 2. *There was a negative aggregate demand shock in November 1929 and this shock was the most important driver of the unexpected movement in world stock markets in this month.*[47]

One may note that Narrative Sign Restriction 2 is a substantially stronger assumption than Narrative Sign Restriction 1. It may still be useful to employ it here, however. This is the case not only in order to more directly address the notion in Romer (1990) but also to showcase that even such a strong narrative sign restriction in favor of a non-monetary account of the depression does not substantially alter the conclusions drawn so far. Indeed, Figure 19 shows that results for the initial downturn are hardly changed when additionally imposing Narrative Sign Restriction 2: the monetary policy shock is still clearly the most important driver. Only in late 1931 and 1932, the aggregate demand shock accounts for a substantially larger share of the decline in both prices and production compared to the baseline specification. Interestingly, this is the case although Narrative Sign Restriction 2 specifically involves the period of the initial downturn rather than later parts of the depression. This is line with the findings throughout that specifying a narrative restriction does not merely mechanically change the interpretation of the period involved, but can also substantially alter structural inference of chronologically distinct episodes.

5 Conclusion

The notion that its causes lie in monetary disturbances has found its way into the modern consensus view of the Great Depression. In particular, there is agreement among economic historians "that the gold standard was a key element – if not the key element – in the collapse of the world economy" (Eichengreen and Temin, 2000, pp.184-85). At the same time, much of the recent macroeconometric literature is more skeptical towards a mainly monetary account but has largely ignored the role of the gold standard in the interwar world economy. Accordingly, Evans et al. (2004, p.21) note that "[t]he inability of the VAR literature to reliably verify" the importance of monetary factors in bringing about the depression, indicates that "the identification of monetary policy during this period remains elusive."

It is with these considerations in mind that this paper conserves, and adds to, the econometric rigor of the existing macroeconometric literature, but explicitly identifies monetary

[47] While the largest drop in various stock market indices occurred in late October 1929, most of the decline shows up in the monthly data in the November observation.

policy differently along multiple dimensions. First, the paper relies on the world gold reserve ratio as the main variable of interest to model the monetary policy stance. This notion reflects a particular strand of the monetary origins view, contemporarily put forth by Ralph Hawtrey and Gustav Cassel and more recently by Johnson (1997), Irwin (2014) and Sumner (2015). According to this view, it was mainly central bank gold hoarding, particularly by France and the US, that initiated the slide into the Great Depression. Second, the paper internationalizes the analysis by employing a hand-collected monthly data set comprising time series information of twelve countries covering roughly 60% of world output. This is again explicitly in contrast to past macroeconometric work but reflects the trajectory the narrative literature on the depression has taken since the seminal, but US-centric, account by Friedman and Schwartz (1963). Finally, my choice of the gold reserve ratio as the main monetary variable allows me to explicitly incorporate insights from that rich narrative literature on the depression in the VAR model. I do so by summarizing plausibly exogenous shifts in policy in a single narrative sign restriction in order to sharpen shock identification.

I find that monetary policy shocks in the form of exogenous increases in the world gold reserve ratio have real effects in the interwar world economy. More importantly, a historical decomposition analysis suggests that shocks to monetary gold hoarding are key in explaining the initial slide into the depression. Whereas the second phase of the collapse in output in 1931 seems to be linked to factors other than central bank policy, monetary shocks are shown to account for the overwhelming initial fall in production and prices. These findings are robust along a large number of dimensions, including shock identification, VAR specifications as well as country and time sample under consideration. The results are in line with recent evidence from DSGE modeling of the depression.[48] They lend support to the gold hoarding view as well as more broadly to the notion that monetary factors played an important role in bringing about the Great Depression.

[48] See Pensieroso and Restout (2018) who use a two-country DSGE model of the interwar gold standard and, in line with this paper, use the gold reserve ratio as a measure of monetary policy. They, too, find that the initial contraction of output and prices from 1929 to 1930 was overwhelmingly caused by monetary forces.

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A Appendix

A.1 Details on the Small-Scale Gold Standard Model

The model parameters of the small-scale model are shown in Table 2 and are calibrated with values common in the literature. Parameters relating to the utility from money and gold holdings are informed by values set by Jacobson et al. (2016), who also employ Goodfriend's (1988) model.

Table 2: Parameter calibration in the small gold standard model

Parameter	Description	Value
β	Discount factor	0.99
α	Capital share in production	0.33
σ	Coefficient of relative risk aversion	1
η	Inverse Frisch labor elasticity	0.5
δ	Capital depreciation rate	0.023
ϕ	Utility parameter for money holdings	60
κ	Utility parameter for gold holdings	100
P^g	Price of gold in terms of currency	1
ρ_λ	Interest rate smoothing parameter	0.8
σ^λ	Std. dev. of monetary policy shock	0.01

A.2 Details on the Medium-Scale Gold Standard Business Cycle Model

In the following, I briefly lay out the additional features added to the simple gold standard asset pricing model. Subsequently I describe the model calibration and list the equilibrium equations. As the setup and model frictions are fairly standard, I omit detailed derivations of the equilibrium conditions for the sake of brevity.

A.2.1 Adding business cycle features

Adding production. As I am mainly interested in the question whether empirically identified monetary shocks can explain the downturn in real economic activity in the onset of the depression, the simple asset pricing model is augmented by a production sector. This will enable me to show that monetary shocks can have sizeable real effects under reasonable calibrations. It is also useful in order to study productivity shocks ("aggregate supply shocks") as an alternative non-monetary explanation to the depression, as brought forward by for instance Kehoe and Prescott (2002). Empirically, real output is proxied by a measure of world industrial production.

Adding wage stickiness. In order to induce real effects of monetary shocks, I add a nominal friction to the model. Whereas prices are assumed to be entirely flexible, nominal wages are subject to a Calvo-type friction as in Erceg et al. (2000b). This model feature is meant to address the view in Eichengreen and Temin (2000, pp.183-84, 193-94), Erceg et al. (2000a), and Sumner (2015) that a high degree of wage stickiness in the 1920s and 30s was an important transmission mechanism of falling prices to declining real activity. The empirical analysis in some robustness specifications features a measure of employment and a nominal wage index in order to account for this notion.

Adding investment adjustment costs. Assuming costly adjustment of investment produces a meaningful role for the price of capital, which is meant to proxy the stock market. The latter plays an important role in prominent non-monetary accounts of the depression, as in Mishkin (1978) and Romer (1990). I therefore add a measure of world stock markets in the empirical analysis and link it to a non-monetary shock, namely a shock to capital quality that has prices and output move in the same direction ("aggregate demand shock").

Adding financial frictions. One of the most well-known non-monetary accounts of the Great Depression is Bernanke's (1983) notion that the financial stress during the downturn interrupted financial intermediation and increased borrowing costs even for relatively safe debtors. This view has culminated in the development of the financial accelerator framework in Bernanke et al. (1999), in which borrower leverage determines their financing conditions. Adding this feature to the model gives rise to a countercyclical risk premium that spikes in the face of contractionary shocks, thereby reinforcing their impact. Adding an empirical measure of this risk spread to the VAR plays a role in differentiating monetary from non-monetary financial channels.

A.2.2 Monetary policy regimes

One can distinguish at least two plausible monetary regimes. Under the *classical gold standard* the gold reserve ratio is fixed:

$$\lambda_t = \lambda \tag{12}$$

This amounts to following the 'rules of the game' under which central banks let domestic variables adjust in response to the in- or outflow of monetary gold.[49] However, the central bank(s) could also commit to follow other objectives, say in the form of a strict *price level target*:

$$P_t = P \tag{13}$$

[49] This policy regime was followed relatively closely by the Bank of England in the pre-WW1 gold standard system which is generally associated with a larger degree of stability of monetary conditions.

One can summarize the choice of monetary policy regime by the following expression:

$$\lambda_t = \rho_\lambda \lambda_{t-1} + (1 - \rho_\lambda)\Big[\varphi_\lambda(\lambda_t - \lambda) + \varphi_P(P_t - P)\Big] + \epsilon_t^\lambda, \tag{14}$$

which is reminiscent of monetary rules in the spirit of Taylor (1993) with the exception that the latter is usually cast in the form of a nominal interest rate instrument. The choice of regime then amounts to choosing the response coefficients φ_λ and φ_P. In Figure 2, I remain agnostic about the precise monetary regime and use two different calibrations in the illustrative impulse response analysis, namely $[\varphi_\lambda = \infty,\ \varphi_P = 0]$ and $[\varphi_\lambda = 0,\ \varphi_P = 1.5]$. The former represents a strict adherence to the 'rules of the game' and the latter is meant to denote a relatively mild price level targeting regime.

A.2.3 Calibration

A realistic calibration of the medium-scale model is complicated by the lower level of scholarly understanding of interwar business cycles compared to modern economies. As indicated in the main text, I therefore follow Canova and Paustian (2011) and account for parameter uncertainty by uniformly drawing from plausible ranges of values for various parameters. I base the support of each parameter on standard values in the business cycle literature and take care to include relatively broad ranges of lower and higher values, reflecting the increased uncertainty. Table 3 reports the chosen parameter values and ranges. The confidence bands in Figure 2 are based on 100 draws.

Table 3: Parameter calibration in the medium-scale business cycle gold standard model

Parameter	Description	Value/Support
β	Discount factor	0.99
P^g	Price of gold in terms of currency	1
ρ_ν	Persistence of preference shock	0.7
σ^ω	Standard deviation of entrepreneur shock	0.217
σ^A	Std. dev. of technology shock	0.01
σ^λ	Std. dev. of monetary policy shock	0.01
α	Capital share in production	[0.2, 0.5]
δ	Capital depreciation rate	[0.02, 0.04]
σ	Coefficient of relative risk aversion	[0.8, 2]
ϕ_w	Calvo parameter of wage stickiness	[0, 0.9]
ϵ_w	Elasticity of substitution of labor services	[4, 10]
η_i	Investment adjustment cost parameter	[1.0, 2.2]
ϕ	Utility parameter for money holdings	[40, 80]
κ	Utility parameter for gold holdings	[70, 130]
η	Inverse Frisch labor elasticity	[0.7, 2.9]
ψ	Labor disutility parameter	[1.5, 3.5]
μ	Verification cost of entrepreneur default	[0.1, 0.4]
θ^e	Survival prob. of entrepreneurs	[0.95, 0.99]
ζ_w^e	Wage indexation	[0.2, 0.6]
ρ_A	Persistence of technology shock	[0.5, 0.95]
ρ_λ	Persistence of monetary policy shock	[0.5, 0.9]
ρ_ξ	Persistence of capital quality shock	[0.8 0.95]

A.2.4 Equilibrium equations of medium-scale gold standard model

$$\varrho_t = C_t^{-\sigma} e^{\nu_t} \tag{15}$$

$$1 = \beta R_{t+1} \mathbb{E}_t \frac{\varrho_{t+1}}{\varrho_t} \frac{P_t}{P_{t+1}} \tag{16}$$

$$Y_t = e^{\xi_t} K_t^\alpha (e^{A_t} N_t)^{1-\alpha} \tag{17}$$

$$A_t = \rho^A A_{t-1} + \epsilon_t^A \tag{18}$$

$$\nu_t = \rho^\nu \nu_{t-1} + \epsilon_t^\nu \tag{19}$$

$$\upsilon_t = \rho^\upsilon \upsilon_{t-1} + \epsilon_t^\upsilon \tag{20}$$

$$Q_t = 1 + \frac{\eta_i}{2}\left[\frac{I_t}{I_{t-1} - 1}\right]^2 + \eta_i \left[\frac{I_t}{I_{t-1} - 1}\right] \frac{I_t}{I_{t-1}} - \beta \mathbb{E}_t \frac{\varrho_t}{\varrho_{t+1}} \eta_i \left[\frac{I_{t+1}}{I_t - 1}\right]\left[\frac{I_{t+1}}{I_t}\right]^2 \tag{21}$$

$$C_t + I_t = Y_t \tag{22}$$

$$R_t^K = \frac{\alpha \frac{Y_t}{K_t} + (1-\delta)Q_t}{Q_{t-1}} e^{\xi_t} \tag{23}$$

$$K_{t+1} = I_t + (1-\delta)K_t e^{\xi_t} \tag{24}$$

$$w_t = (1-\alpha)K_t^{\alpha}(e^{A_t})^{1-\alpha}(N_t)^{-\alpha} \tag{25}$$

$$w_t^{\#} = \frac{\epsilon^w}{\epsilon^w - 1}\frac{f_t^1}{f_t^2} \tag{26}$$

$$f_t^1 = e^{\nu_t}\psi\Big[\frac{w_t}{w_t^{\#}}\Big]^{1+\eta^w} N_t^{1+\eta^w} + \mathbb{E}_t\phi^w\beta(1+infl_t)^{-\zeta^w\epsilon^w(1+\eta^w)}(1+infl_{t+1})^{\epsilon^w(1+\eta^w)}\Big[\frac{w_{t+1}^{\#}}{w_t^{\#}}\Big]^{\epsilon^w(1+\eta^w)} f_{t+1}^1 \tag{27}$$

$$f_t^2 = e^{\nu_t}C_t^{-\sigma}\Big[\frac{w_t}{w_t^{\#}}\Big]^{\epsilon^w} N_t + \mathbb{E}_t\phi^w\beta(1+infl_t)^{\zeta^w(1-\epsilon^w)}(1+infl_{t+1})^{\epsilon^w-1}\Big[\frac{w_{t+1}^{\#}}{w_t^{\#}}\Big]^{\epsilon^w} f_{t+1}^2 \tag{28}$$

$$w_t^{1-\epsilon^w} = (1-\phi^w)(w_t^{\#})^{1-\epsilon^w} + (1+infl_{t-1})^{\zeta^w(1-\zeta^w)}(1+infl_t)^{\epsilon^w-1}\phi^w(w_{t-1})^{1-\epsilon^w} \tag{29}$$

$$W_t = w_t/P_t \tag{30}$$

$$1 + infl_t = P_t/P_{t-1} \tag{31}$$

$$\frac{\varrho_t}{P_t} = \beta\mathbb{E}_t\frac{\varrho_{t+1}}{P_{t+1}} + \Big(\frac{M_t}{P_t}\Big)^{-\phi} \tag{32}$$

$$\frac{\varrho_t P^g}{P_t} = \beta\mathbb{E}_t\frac{\varrho_{t+1}P^g}{P_{t+1}} + \Big(G_t^p\Big)^{-\kappa} \tag{33}$$

$$G = G_t^m + G_t^p \tag{34}$$

$$\lambda_t = P^g G_t^m / M_t \tag{35}$$

$$\lambda_t = \rho^{\lambda}\lambda_{t-1} + \epsilon_t^{\lambda} \tag{36}$$

$$\mathbb{E}_t R_{t+1}^K(1-\Gamma(\bar{\omega}_{t+1})) + \frac{\Gamma'(\bar{\omega}_{t+1})}{\Gamma'(\bar{\omega}_{t+1}) - \mu G'(\bar{\omega}_{t+1})}[R_{t+1}^K(\Gamma(\bar{\omega}_{t+1})) - \mu G(\bar{\omega}_{t+1})) - R_t P_t/P_{t+1}] = 0 \tag{37}$$

$$R_t^K[\Gamma(\bar{\omega}_t) - \mu G(\bar{\omega}_t)] = R_t\frac{P_{t-1}}{P_t}\frac{\phi_{t-1}^e - 1}{\phi_{t-1}^e} \tag{38}$$

$$N_{t+1}^e = \theta^e\Big[Q_t K_t R_t^K(1-\mu G(\bar{\omega}_t)) - R_t\frac{P_t}{P_{t+1}}(Q_t K_t - N_t^e)\Big] + startup^e \tag{39}$$

$$\bar{\omega}_t = R_t^L\frac{Q_{t-1}K_{t-1} - N_{t-1}^e}{R_t^K Q_{t-1}K_{t-1}} \tag{40}$$

$$\Gamma(\bar{\omega}_t) = \bar{\omega}_t(1-F(\bar{\omega}_t)) + G(\bar{\omega}_t) \tag{41}$$

$$\Gamma'(\bar{\omega}_t) = 1 - F(\bar{\omega}_t) \tag{42}$$

$$\mu G'(\bar{\omega}_t) = \mu\bar{\omega}_t F'(\bar{\omega}_t) \tag{43}$$

$$F(\bar{\omega}_t) = \Phi((\sigma^W)^{-1}(log(\bar{\omega}_t) - \mu^W)) \tag{44}$$

$$F'(\bar{\omega}_t) = \phi(log(\bar{\omega}_t), \mu^W, \sigma^W)/\bar{\omega}_t \tag{45}$$

$$\phi^e_t = \frac{Q_t K_t}{N^e_t} \tag{46}$$

$$spread_t = \mathbb{E}_t \frac{R^K_{t+1}}{R_t} \frac{P_t}{P_{t+1}} \tag{47}$$

$$G(\bar{\omega}_t) = -\Phi\left(\frac{\mu^W - log(\bar{\omega}_t)}{\sigma^W} + \sigma^W\right) \tag{48}$$

A.3 VAR Model and Structural Identification

The structural VAR can be written as

$$\mathbf{A}_0\mathbf{y}_t = \mathbf{k} + \mathbf{A}_1\mathbf{y}_{t-1} + ... + \mathbf{A}_p\mathbf{y}_{t-p} + \epsilon_t, \quad \epsilon_t \sim \mathcal{N}(\mathbf{0}, \mathbf{I}), \tag{49}$$

where $\mathbf{y}_t$ is an $(n \times 1)$ vector of endogenous variables, and $\mathbf{k}$ is a vector of constants. The corresponding reduced-form VAR is:

$$\mathbf{y}_t = \mathbf{c} + \mathbf{B}_1\mathbf{y}_{t-1} + ... + \mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \quad \mathbf{u}_t \sim \mathcal{N}(\mathbf{0}, \mathbf{\Sigma}), \tag{50}$$

with $\mathbf{c} = \mathbf{A}_0^{-1}\mathbf{k}$, $\mathbf{B}_l = \mathbf{A}_0^{-1}\mathbf{A}_l$ and $\mathbf{u}_t = \mathbf{A}_0^{-1}\epsilon_t$. One can collect the structural parameters $\mathbf{\Theta} = (\mathbf{A}_0, \mathbf{A}_+)$ with $\mathbf{A}_+ = [\mathbf{A}_1, ..., \mathbf{A}_p, \mathbf{c}]$.

Identification. Impulse response functions (IRFs) are defined recursively as

$$\begin{aligned} \mathbf{L}_0(\mathbf{\Theta}) &= \mathbf{A}_0^{-1} \\ \mathbf{L}_k(\Theta) &= \sum_{l=1}^{h}(\mathbf{A}_0^{-1}\mathbf{A}_l)\mathbf{L}_{h-l}(\mathbf{\Theta}), \text{ for } 1 \leq h \leq p \\ \mathbf{L}_k(\Theta) &= \sum_{l=1}^{p}(\mathbf{A}_0^{-1}\mathbf{A}_l)\mathbf{L}_{h-l}(\mathbf{\Theta}), \text{ for } p < h < \infty \end{aligned} \tag{51}$$

and give, in row i and column j the response of i-th variable to the j-th structural shock at horizon h. Next to impulse responses I heavily rely on historical decompositions (HDs). Following the notation in Antolin-Diaz and Rubio-Ramirez (2018) these are defined as

$$\mathbf{H}_{i,j,t,t+h}(\mathbf{\Theta}, \epsilon_{\mathbf{t}}, ..., \epsilon_{t+h}) = \sum_{l=0}^{h} \mathbf{e}'_{i,n}\mathbf{L}_l(\Theta)\mathbf{e}_{j,n}\mathbf{e}'_{j,n}\epsilon_{t+h-l}, \tag{52}$$

where $\mathbf{e}_{j,n}$ is the j-th column of $\mathbf{I}_n$ with $1 \leq i, j \leq n$ and for $h \geq 0$. $\mathbf{H}_{i,j,t,t+h}$ then gives the contribution of the j-th shock to the observed unexpected change in the i-th variable in periods t to $t + h$. Structural shocks are retrieved as

$$\epsilon_{\mathbf{t}}(\mathbf{\Theta}) = \mathbf{A}_0\mathbf{y}_t - \mathbf{A}_+\mathbf{x}_t, \tag{53}$$

with $\mathbf{x}_t = [\mathbf{1}, \mathbf{y}_{t-1}, ..., \mathbf{y}_{t-p}]$.

Both impulse response functions and historical decompositions require identification of structural shocks. A traditional sign restriction procedure starts with some orthogonalization of the residual covariance matrix, for instance from a Cholesky decomposition: $\mathbb{E}\mathbf{u_t}\mathbf{u_t'} = \mathbf{\Sigma} = (\mathbf{A_0^{-1}})'\mathbf{A_0^{-1}}$ where $\mathbf{\Sigma}_\epsilon$ is normalized to $\mathbf{I}_n$. Via rotation, new sets of orthogonal structural shocks are then found via $\epsilon_t^* = \mathbf{Q}\epsilon_t$, where $\mathbf{Q}'\mathbf{Q} = \mathbf{Q}\mathbf{Q}' = \mathbf{I}_n$. Draws are retained if corresponding impulse responses satisfy the sign restrictions imposed by the researcher, and discarded otherwise. While there are various methods of obtaining Q, for efficiency reasons a Householder transformation is used in the form of QR decompositions as in Rubio-Ramirez et al. (2010).

In addition to these traditional sign restrictions, Antolin-Diaz and Rubio-Ramirez (2018) develop narrative sign restrictions on both impulse responses and historical decompositions. Draws are then retained only if they satisfy, in addition to the traditional sign restrictions, certain conditions on particular dates. These are, in the context of this paper, summarized in NSR 1 (and in Narrative Sign Restriction 2, which is used additionally in Section 4.3). For instance, in the terminology used so far, NSR 1 can be written as:

$$|\mathbf{H}_{\lambda,MP,1928:07}(\mathbf{\Theta}, \epsilon_{1928:07}(\mathbf{\Theta}))| > max_{j\neq MP} > max_{j\neq MP}|\mathbf{H}_{\lambda,j,1928:07}(\mathbf{\Theta}, \epsilon_{1928:07}(\mathbf{\Theta}))| \quad (54)$$

Bayesian inference. As is common, I specify a multivariate normal distribution for the regression coefficients, and an inverse Wishart distribution for the covariance matrix of the error term:

$$\mathbf{\Sigma} \sim \mathcal{IW}(\underline{\mathbf{S}}, \underline{\nu}), \quad (55)$$

$$\mathbf{B}|\mathbf{\Sigma} \sim \mathcal{N}(\underline{\mathbf{B}}, \mathbf{\Sigma} \otimes \underline{\mathbf{\Omega}}). \quad (56)$$

$\mathbf{B} = vec([\mathbf{c}, \mathbf{B}_1, ..., \mathbf{B}_p]')$ are the stacked coefficient matrices and $\underline{\mathbf{S}}$, $\underline{\nu}$, $\underline{\mathbf{B}}$ and $\underline{\mathbf{\Omega}}$ are hyperparameters. Specifically, $\underline{\mathbf{S}}$ and $\underline{\nu}$ are, respectively, the scale matrix and the degrees of freedom of the prior inverse Wishart distribution. As is standard, I specify $\underline{\mathbf{S}}$ as a diagonal matrix with entries σ_i^2 equal to the residual variance of the regression of each variable onto its own first lag. The degrees of freedom are set to $\underline{\nu} = n + 2$ so as to ensure that the prior variances of the coefficient matrices exist and $\mathbb{E}(\mathbf{B}) = \underline{\mathbf{B}}$ and $\mathbb{V}ar(\mathbf{B}) = \underline{\mathbf{S}} \otimes \underline{\mathbf{\Omega}}$.

I use a standard "Minnesota"-type prior in the spirit of Litterman (1986). Specifically, their first two moments are:

$$\mathbb{E}[(\mathbf{B_l})_{\mathbf{i,j}}|\mathbf{\Sigma}] = \begin{cases} \delta_i & i = j, l = 1 \\ 0 & \text{otherwise} \end{cases} \quad (57)$$

$$\mathbb{V}ar[(\mathbf{B_l})_{\mathbf{i,j}}|\mathbf{\Sigma}] = \begin{cases} \frac{\lambda^2}{l^2} & i = j, \forall l \\ \frac{\lambda^2}{l^2}\frac{\Sigma_{i,i}}{\sigma_j^2} & i \neq j, \forall l \end{cases} \quad (58)$$

where $(\mathbf{B_l})_{\mathbf{i,j}}$ is the response of variable i to variable j at lag l and $\delta_i = 1$, implying random-walk behavior of the underlying time series in the baseline specification. In a robustness exercise I estimate the model in first differences and consequently set the corresponding parameters to zero, as in Banbura et al. (2010).[50] As is common, I formalize the idea that more recent lags of a variable tend to be more informative by specifying l^2 in the variance

[50] An exception is the risk spread where the parameter to set to zero throughout.

entries, with $l = 0.2$. Hence, equation (58) ensures a decaying variance of parameters for more distant lags. The hyperparameter λ controls the overall tightness of the Minnesota prior and is determined optimally in the spirit of hierarchical modelling as in Giannone et al. (2015).

Also for the implementation of the narrative sign restrictions I adopt Bayesian methods as described in Antolin-Diaz and Rubio-Ramirez (2018).[51] In doing so, a complication arises relative to the case of traditional sign restrictions in that narrative sign restrictions depend not only on the structural parameters (as traditional sign restrictions do) but also on the structural shocks. This implies that, while traditional sign restrictions truncate the prior, narrative sign restrictions truncate the likelihood function. Antolin-Diaz and Rubio-Ramirez (2018) then show that this truncated likelihood function can be written as the non-truncated one, re-weighted with weights inversely proportional to the probability of satisfying the restriction.

Start by defining a function g_h that maps the data and structural parameters into structural shocks: $\epsilon_t = g_h(\mathbf{y}_t, \mathbf{x}_t, \mathbf{\Theta})$, $1 \leq t \leq T$. Then the generic restriction $\phi(\mathbf{\Theta}, \epsilon^\nu) > 0$ can be written as

$$\tilde{\phi}(\mathbf{\Theta}, \mathbf{y}^\nu, \mathbf{x}^\nu) = \phi(\mathbf{\Theta}, g_h(\mathbf{y}_{t_1}, \mathbf{x}_{t_1}, \mathbf{\Theta}), ..., g_h(\mathbf{y}_{t_\nu}, \mathbf{x}_{t_\nu}, \mathbf{\Theta})) > 0, \tag{59}$$

with ν representing the period(s) for which the restriction(s) is/are imposed. Further, define $(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})$ as the so-called reduced-form orthogonal parameterization. Using the Cholesky decomposition $h(\mathbf{\Sigma})$ of the covariance matrix $\mathbf{\Sigma}$ one can write the following mapping between $(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})$ and the set of structural parameters $\mathbf{\Theta}$ as $f_h(\mathbf{\Theta}) = (\mathbf{A}_0^{-1}\mathbf{A}_+$, $(\mathbf{A}_0^{-1})'\mathbf{A}_0^{-1}$, $h((\mathbf{A}_0^{-1})'\mathbf{A}_0^{-1}\mathbf{A}_0)$, with $\mathbf{A}_0^{-1}\mathbf{A}_+ = \mathbf{B}$, $(\mathbf{A}_0^{-1})'\mathbf{A}_0^{-1} = \mathbf{\Sigma}$ and $h((\mathbf{A}_0^{-1})'\mathbf{A}_0^{-1}\mathbf{A}_0) = \mathbf{Q}$, such that the inverse is:

$$f_h^{-1}(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}) = (\underbrace{h(\mathbf{\Sigma})^{-1}\mathbf{Q}}_{\mathbf{A}_0}, \underbrace{\mathbf{B}h(\mathbf{\Sigma})^{-1}\mathbf{Q}}_{\mathbf{A}_+}). \tag{60}$$

The generic restriction (59) can then be expressed as

$$\Phi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \mathbf{y}^\nu, \mathbf{x}^\nu) = \tilde{\phi}(f_h^{-1}(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}), \mathbf{y}^\nu, \mathbf{x}^\nu) > 0. \tag{61}$$

Antolin-Diaz and Rubio-Ramirez (2018) then go on to show that the truncated likelihood is

$$\pi(\mathbf{y}^T | \mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \Phi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \mathbf{y}^\nu, \mathbf{x}^\nu) > \mathbf{0}) = \frac{[\Phi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \mathbf{y}^\nu, \mathbf{x}^\nu) > 0]\pi(\mathbf{y}^T | \mathbf{B}, \mathbf{\Sigma})}{\omega(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})}, \tag{62}$$

where $\omega(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})$ is the probability of satisfying the restriction, and $\pi(\mathbf{y}^T | \mathbf{B}, \mathbf{\Sigma})$ is the

[51] I thank Juan Antolin-Diaz and Juan Rubio-Ramirez for providing me with their narrative sign restriction codes.

un-truncated likelihood. They go on to show that the generic posterior encompassing both traditional ($\Gamma(f_h^{-1}(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})) > 0$) and narrative ($\Phi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \mathbf{y}^\nu, \mathbf{x}^\nu) > 0$) sign restrictions $\pi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}|\mathbf{y}^T, \Gamma(f_h^{-1}(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})) > 0, \Phi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \mathbf{y}^\nu, \mathbf{x}^\nu) > 0)$ is proportional to

$$[\Gamma(f_h^{-1}(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})) > 0]\frac{[\Phi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \mathbf{y}^\nu, \mathbf{x}^\nu) > 0]\pi(\mathbf{y}^T|\mathbf{B}, \mathbf{\Sigma})}{\omega(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})}\pi(\mathbf{B}, \mathbf{\Sigma}). \quad (63)$$

Choosing uniform-inverse Wishart priors for $(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})$ then results in an algorithm that draws independently from the uniform-inverse Wishart posterior of $(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})$ and checks for the traditional and narrative sign restrictions. However, draws are not automatically accepted if they satisfy the narrative restrictions as is implicit in the truncated likelihood above. Instead, M structural shocks ϵ^ν are drawn from a standard normal distribution and the (inverse) importance weight $\omega(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})$ is approximated by the share of the M draws that satisfy the narrative restriction $\Phi(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q}, \mathbf{y}^\nu, \mathbf{x}^\nu) > 0$. This procedure implies that draws satisfying the narrative restriction are down-weighted to ensure that posterior draws are actually normal-inverse Wishart.

A.4 Data

Data description. Table 4 provides an overview of the availability of each variable for all countries in the dataset, the sources and definitions of which are reported in Table 5. The data is taken from a large number of sources including the Monthly Statistical Bulletin of the League of Nations, the Monthly Bulletin of the Federal Reserve Board of Governors, Jan Tinbergen's International Abstract of Economic Statistics, the NBER Macrohistory Database, and the interwar macroeconomic dataset compiled by Albers (2018). The three main variables – the gold reserve ratio (constructed from central bank gold holdings and liabilities), wholesale prices and a production series – are available for almost all twelve countries.[52] The same is true for stock market indices. Employment and wage data as well as monetary aggregates are covered to a somewhat lesser degree, while I use a risk spread only for the United States. All variables with the exception of the risk spread have been seasonally adjusted where necessary.[53] Occasional individual missing values have been linearly interpolated.

Aggregate measure of the gold reserve ratio. As explained in the main text, the world gold reserve ratio is computed as a weighted average following Sumner (2015). This reflects the discussion in Section 3.1.2 on the relative merits of indicators of the stance of monetary policy in that the gold reserve ratio can be easily aggregated, with weights accurately reflecting each country's importance in world monetary gold demand. The raw data is obtained from a variety of sources given in Table 5. Regarding central bank liabilities, some effort was spent to not only include currency in circulation, but also other sight liabilities. While currency was generally the largest category of liabilities, for some countries there was a non-negligible share of deposits, in some cases more than one third of total liabilities. As weights I use each country's gold holdings, expressed in US dollars, as a share of all countries' monetary gold in the sample.[54] Also, although Italy is not in the sample, data on gold holdings and central bank liabilities are available from the Board of Governors as well. As Italy held a non-negligible amount of gold, I also include it in

[52] Wholesale prices are available for Finland as well but are excluded from the sample as they represent an outlier in that they exhibit a sharp increase in December 1931, which would also show up in the aggregate world time series. In addition, Canada did not have a central bank until 1935 and I do not include Canada for the calculation of the gold reserve ratio. At any rate, however, Canadian banks did not hold more than 1% of world monetary gold reserves, the resulting measure of the world gold reserve ratio would be almost unaffected by adding Canada.

[53] An F test on seasonal dummies was performed. Seasonal adjustment was done whenever the p value of this test was below 0.1.

[54] As an alternative, I compute weights based on USD gold holdings published in the Banking and Monetary Statistics 1914-41 by the Federal Reserve Board of Governors. These statistics contain gold holdings for all countries in the sample. However, as the data is available in monthly frequency starting in mid-1928 and in annual frequency before, in this case I linearly interpolate the weights before 1928. This introduces smoothing to the weights but the effect is small in that the relative gold holdings did not move dramatically within a given year in that period. Consequently, the weights are similar to those I compute based on the gold raw data series. The resulting aggregate gold reserve ratio is depicted with dashed lines in Figure 9. Reassuringly, when I use this alternative ratio I get results very similar to those reported in the main text.

the calculation of the world gold reserve ratio. Doing so results in a coverage of world gold holdings of more than 75% at the beginning of the sample in 1922.

One final issue with the computation of the world gold reserve ratio arises from devaluations. The most striking example of that is the US which devalued the US dollar against gold in the Spring of 1933. As the US dollar lost roughly 40% if its value against gold, central bank gold holdings – expressed in US dollars – relative to liabilities jumped up the same amount essentially overnight. In the context of the model in Section 3.1.2, P^g, assumed fixed, increased by 40%. Such a strong increase in the measured gold reserve ratio would amount to a substantial observed tightening of monetary policy. This is despite the fact that the devaluation is generally understood to have been a substantial easing of monetary policy that broke the "golden fetters" of the gold standard and set the stage for the recovery from the Great Depression.[55] As the resulting break in the data series therefore would obfuscate what the gold reserve ratio is supposed to measure, I remove breaks from devaluation by indexing. While this approach is not without its downsides,[56] it is the least problematic in that it preserves the usefulness of the gold reserve ratio in two ways. First, it avoids breaks in the series generally; and second, it does not attribute these breaks to a strong tightening of policy that did not in fact take place.

Table 4: Countries and variables in the dataset

	CB gold	CB liab.	WPI	IP	Money	Stocks	Emp.	Wages	Spread
Austria	(✓)	(✓)	✓	(✓)		(✓)			
Canada			✓	✓	✓	✓	✓		
Finland	(✓)	(✓)		(✓)		(✓)			
France	✓	✓	✓	✓	(✓)	✓	✓		
Germany	✓	(✓)	(✓)	(✓)		(✓)	(✓)	(✓)	
Japan	(✓)	(✓)	✓	✓	✓	✓	(✓)	✓	
Netherl.	✓	✓	✓	(✓)		✓	✓		
Norway	✓	✓	✓	✓	✓	✓			
Poland	(✓)	(✓)	✓	(✓)	(✓)	(✓)	(✓)	(✓)	
Sweden	✓	✓	✓	✓	(✓)	✓	✓		
UK	✓	✓	✓	✓	✓	✓	✓		
US	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note. CB gold stands for central bank gold holdings, *CB liab.* for central bank liabilities (notes in circulation + deposits), *Emp.* for measures of (un)employment. Black checkmarks denote data availability from 1922:01 to 1936:12. Checkmarks in grey denote data availability starting in 1924:02 (in case of central bank gold holdings and liabilities) or 1925:01 (for all other variables).

Aggregate measures of all other variables. All other variables are computed as the first factor of the respective country group, as outlined and motivated in the main text.

[55] See for instance Eichengreen (1992). For a somewhat oppsing view, which stresses the importance of fiscal space (as opposed to monetary factors) from devaluation, see Jacobson et al. (2016).

[56] To the extent that devaluation came with monetary easing, this is not captured by the measure.

All individual data series are normalized before the factor analysis is performed. Despite the large number of countries in the sample and the heterogeneity with respect to their size and level of development, I generally find that the first factor can explain a sizable share of variation of the underlying time series. This share varies from close to 50% for industrial production and the monetary aggregate to 90% for wholesale prices. Even the employment aggregate explains close to 80% of the underlying variation in spite of the fact that for some countries I use unemployment rates and for others employment indices. This speaks to the usefulness of factor analysis to compute aggregates in addition to the considerations outlined in Section 4.1.

As depicted in Table 4, for some countries where data is generally available, sometimes the series starts only in 1925. I deal with this issue as follows. First, I compute the first factor for all countries for which the series is available for the full sample. I then do the same for the full set of countries starting in 1925. As a third step, I append the first data series to the second by indexing it to the latter's level of 1925. This procedure avoids any jumps in the resulting data series and uses information from all the countries where available. This procedure also ensures that the first three years of data (1922:01-1924:12) do not have to be dropped, which would make the dataset even shorter.[57]

The resulting time series are by construction normalized around zero and generally lie between -2 and 2. In order to be able to interpret the data series quantitatively, I re-normalize them according to their respective US counterpart, before taking logs.[58] This procedure ensures that absolute changes of the measures can be conveniently interpreted approximately as percent changes of the respective US variable.[59]

[57] I address concerns that having the resulting time series include information from a time-varying set of countries might introduce unobserved breaks in Section 4.3. In there, I do shorten the time sample to begin in 1925 and find my results to still hold.

[58] An exception is the employment measure, which I re-normalize with respect to its UK counterpart, since the US one is an unemployment rate, not an employment index.

[59] The choice of the US is somewhat arbitrary but useful in that the quantitative dynamics of US variables are more familiar than those of the smaller countries in the sample. Changing the country relative to which the aggregate series are standardized hardly affects results.

Table 5: Data sources and definitions

	Central bank gold		Central bank liabilities	
	Description	Source	Description	Source
Austria	Oesterreichische Nationalbank gold holdings	Federal Reserve Bulletin, various issues	Oesterreichische Nationalbank currency in circulation + deposits	Federal Reserve Bulletin, various issues
Canada				
Finland	Bank of Finland gold holdings	Federal Reserve Bulletin, various issues	Bank of Finland currency in circulation + deposits	Federal Reserve Bulletin, various issues
France	Bank of France gold reserves	League of Nations, Monthly Statistical Bulletin; Statistisches Reichsamt, Statistisches Jahrbuch	Bank of France notes in circulation + total deposits	Federal Reserve Bulletin, various issues
Germany	Reichsbank gold holdings	League of Nations, Monthly Statistical Bulletin, various issues; Statistisches Reichsamt, Statistisches Jahrbuch	Reichsbank notes in circulation	Albers (2018)
Japan	Bank of Japan gold holdings	Federal Reserve Bulletin, various issues, Albers (2018)	Bank of Japan notes in circulation + deposits	Federal Reserve Bulletin, various issues, Albers (2018)
Netherlands	Nederlandsche Bank gold reserves	League of Nations, Monthly Statistical Bulletin; Statistisches Reichsamt, Statistisches Jahrbuch	Nederlandsche Bank notes in circulation	League of Nations, Monthly Statistical Bulletin; Statistisches Reichsamt, Statistisches Jahrbuch
Norway	Norges Bank gold holdings	Klovland, Monetary aggregates in Norway 1819-2003	Norges Bank M0	Klovland, Monetary aggregates in Norway 1819-2003
Poland	Bank of Poland gold holdings	Albers (2018)	Bank of Poland notes in circulation + deposits	Albers (2018)
Sweden	Riksbank gold reserves	League of Nations, Monthly Statistical Bulletin; Statistisches Reichsamt, Statistisches Jahrbuch	Riksbank notes in circulation	League of Nations, Monthly Statistical Bulletin; Statistisches Reichsamt, Statistisches Jahrbuch
UK	Bank of England gold reserves	League of Nations, Monthly Statistical Bulletin; Statistisches Reichsamt, Statistisches Jahrbuch	Monetary base (cash in circulation, till money of banks, bank deposits at BoE)	Capie and Webber (1985), Table I.(1), p.54ff.
US	Monetary gold stock	NBER, m14076b	High-powered money	Friedman and Schwartz (1963), Table B-3, p.799ff.

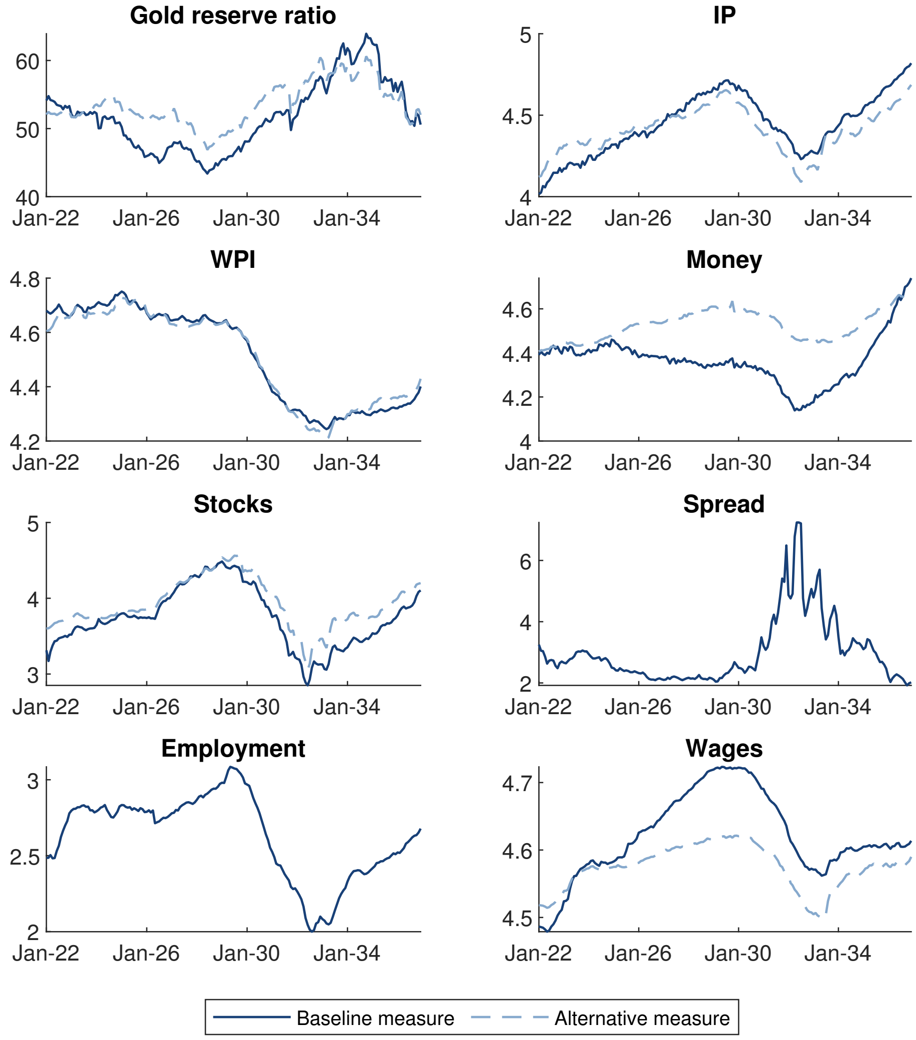
	WPI		IP	
	Description	Source	Description	Source
Austria	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Monthly GDP estimate from first principle component of a multitude of time series	Albers (2018)
Canada	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Industrial production index	Tinbergen, International abstract of economic statistics
Finland			Monthly GDP estimate from first principle component of a multitude of time series	Albers (2018)
France	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Industrial production index	Tinbergen, International abstract of economic statistics
Germany	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Monthly GDP estimate from first principle component of a multitude of time series	Albers (2018)
Japan	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Industrial production index	Tinbergen, International abstract of economic statistics
Netherlands	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Monthly GDP estimate from first principle component of a multitude of time series	Albers (2018)
Norway	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Industrial production index	Klovland, Measuring trends and cycles in industrial production in Norway 1896-1948, Table A6
Poland	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Monthly GDP estimate from first principle component of a multitude of time series	Albers (2018)
Sweden	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Industrial production index	Statistisches Reichsamt, Statistisches Jahrbuch
UK	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Industrial production index	Mitchell et al. (2012)
US	Wholesale price index	League of Nations, Monthly Statistical Bulletin, various issues	Industrial production index	NBER, m01175

	Money		Stocks	
	Description	Source	Description	Source
Austria			Stock prices of 35 industrial shares	Albers (2018)
Canada	Demand deposits of chartered banks	Tinbergen, International abstract of economic statistics	Stock prices of common stocks	Tinbergen, International abstract of economic statistics
Finland			Share price index	Albers (2018)
France	Deposits at 4 large commercial banks	Tinbergen, International abstract of economic statistics	SGT stock index at Paris Bourse	Hautcoeur and Petit-Koñczyk
Germany			Stock price index	Statistisches Reichsamt
Japan	Commercial bank deposits	Tinbergen, International abstract of economic statistics	Average price of 50 industrial shares	Tinbergen, International abstract of economic statistics
Netherlands			General stock market index	Tinbergen, International abstract of economic statistics
Norway	M1	Klovland, Monetary aggregates in Norway 1819-2003	Stock price index	Klovland, Historical stock price indices in Norway 1914-2003, Table A1
Poland	Joint-stock bank deposits	Albers (2018)	Stock market general index	Albers (2018)
Sweden	Commercial bank domestic deposits	Albers (2018)	Riksbank index all shares	Tinbergen, International abstract of economic statistics
UK	M1	Capie and Webber (1985), Table I.(2), p.65ff.	Industrial share price index	Tinbergen, International abstract of economic statistics
US	Adjusted demand deposits of all commercial banks + currency held by the public	NBER, m14174	S&P500	Robert Shiller

	Employment		Wages	
	Description	Source	Description	Source
Austria	Unemployed workers receiving benefits	Tinbergen, International abstract of economic statistics		
Canada	Employment index	Tinbergen, International abstract of economic statistics		
Finland				
France	Coefficient of placement index (ratio of placements to unfilled applications)	NBER, m08024a		
Germany	Employment index (self assembled based on unemployment rate among trade union members)	Tinbergen, International abstract of economic statistics; League of Nations statistical bulletin, various issues	Hourly wages in 17 occupations	Albers (2018)
Japan			Effective wages of industrial workers	Albers (2018)
Netherlands	Unemployment among trade unioners, general index	Tinbergen, International abstract of economic statistics		
Norway				
Poland	Employment in mining and manufacturing	Albers (2018)	Nominal wage index	Albers (2018)
Sweden	Unemployment of trade unioners	Tinbergen, International abstract of economic statistics		
UK	Insured workers unemployed	NBER, m08002ab		
US	Employment index based on number of employed workers in production	NBER, m08010	Index of Composite Wages	NBER, m08061c

	Risk spread	
	Description	Source
US	Spread between AAA bond yield and Moody's Baa corporate bond yield	FRED (NBER, m13033a, BAA)

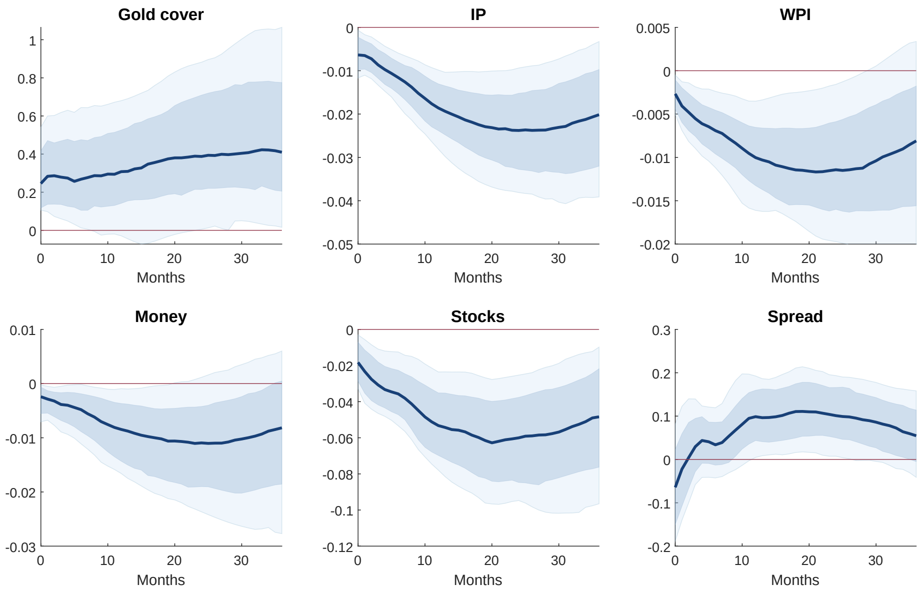
Figure 9: Final data series employed in the VAR analysis



Note. Final time series used in the VAR analysis. These are computed from individual-country data series as described in Section A.4. For macroeconomic and financial variables, baseline measures refer to aggregates based on factor analysis, alternative measures are constructed as weighted averages with weights reflecting nominal GDP. Baseline measure for the gold reserve ratio uses gold weights from country-specific sources, the alternative measure uses weights from the Banking and Monetary Statistics of the Federal Reserve Board. Employment and the risk spread do not feature alternative measures due to heterogenous country-specific variables and lack of data availability, respectively.

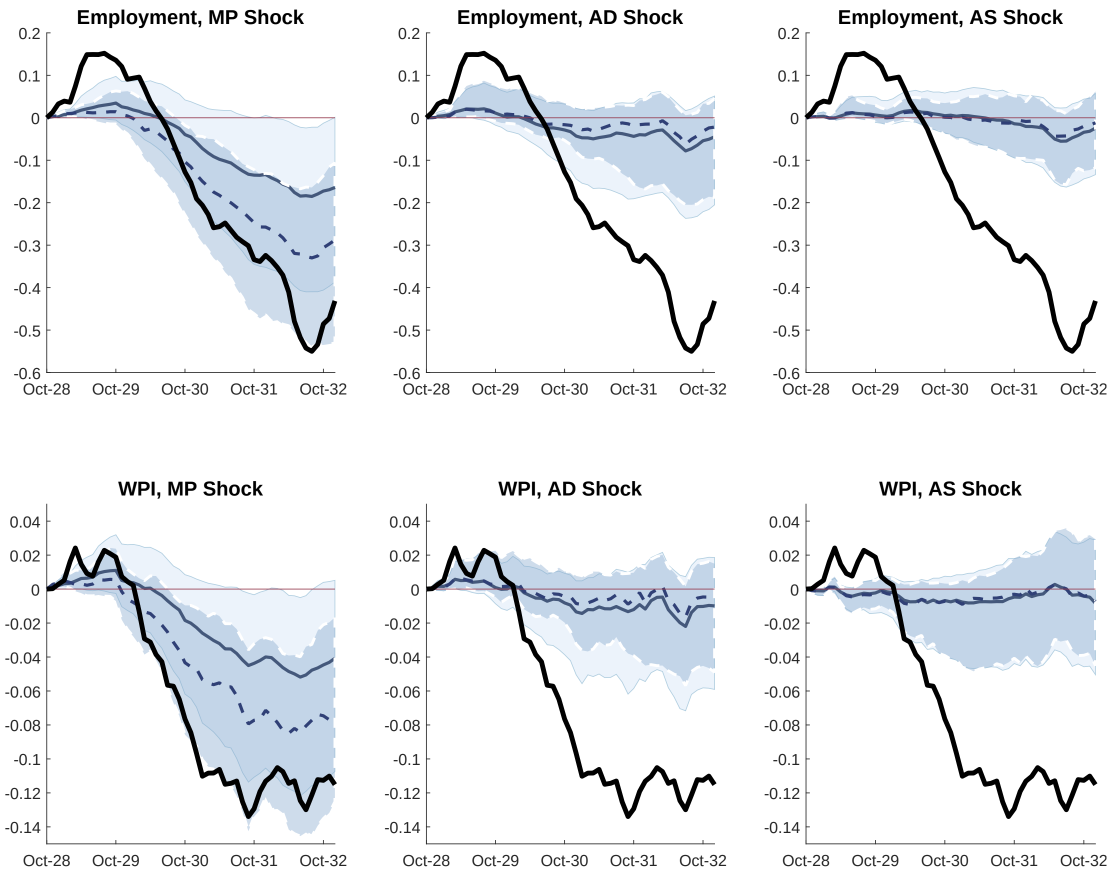
A.5 Additional VAR Results and Robustness Checks

Figure 10: IRFs to a monetary policy shock in the VAR with full restrictions



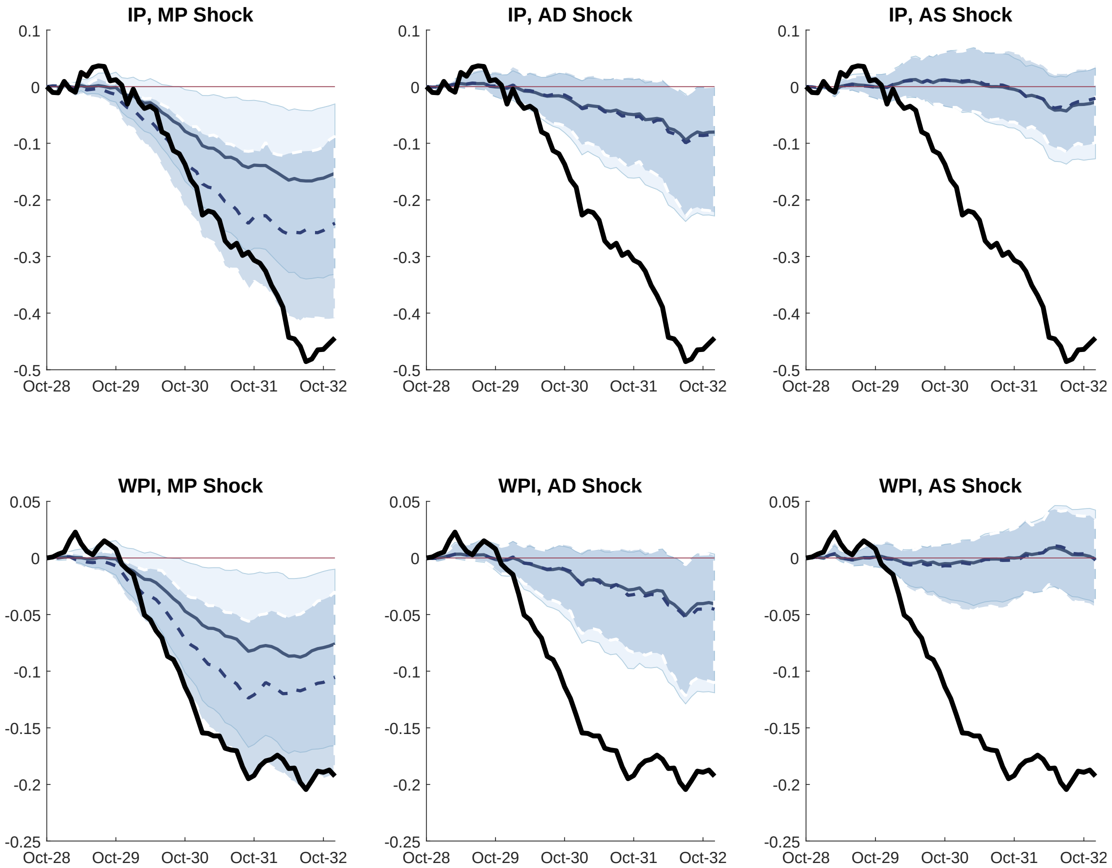
Note. Impulse responses to a contractionary monetary policy shock. Shock identification via sign restrictions according to the full set of restrictions in Table 1 and NSR 1. Solid lines denote point-wise median IRFs, dark (light) shaded areas denote 68% (90%) credible sets.

Figure 11: Robustness: Historical decomposition in a model, with employment instead of industrial production



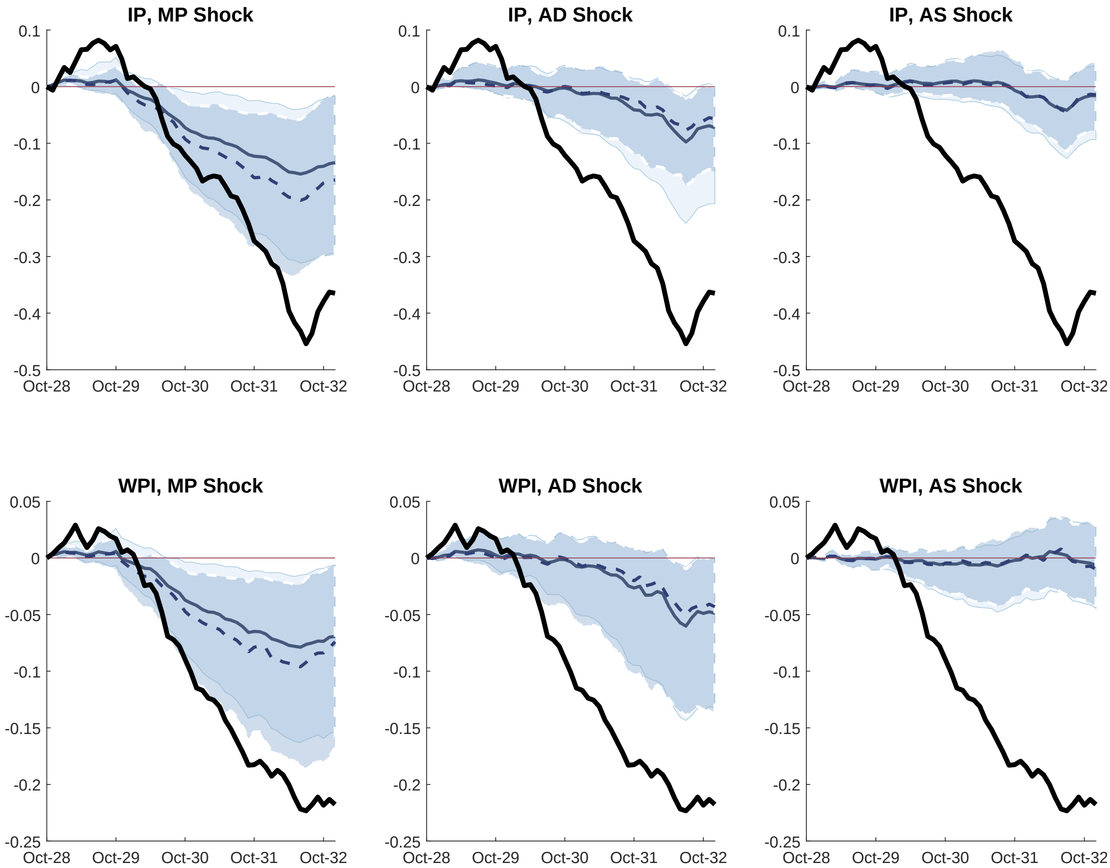
Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions as in Table 1 (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

Figure 12: Robustness: Historical decomposition in the VAR model with trending variables in first differences



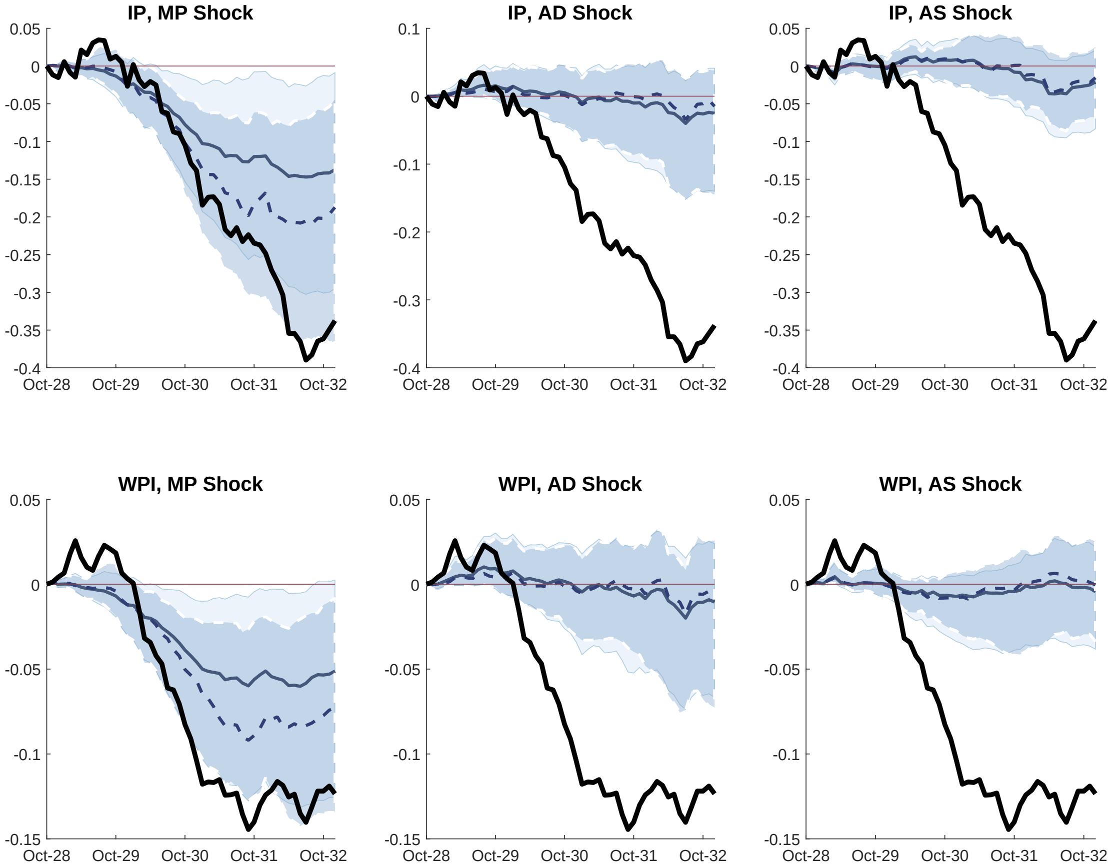
Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions as in Table 1 (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

Figure 13: Robustness: Historical decomposition in the VAR with GDP-weighted aggregates and trending variables in first differences



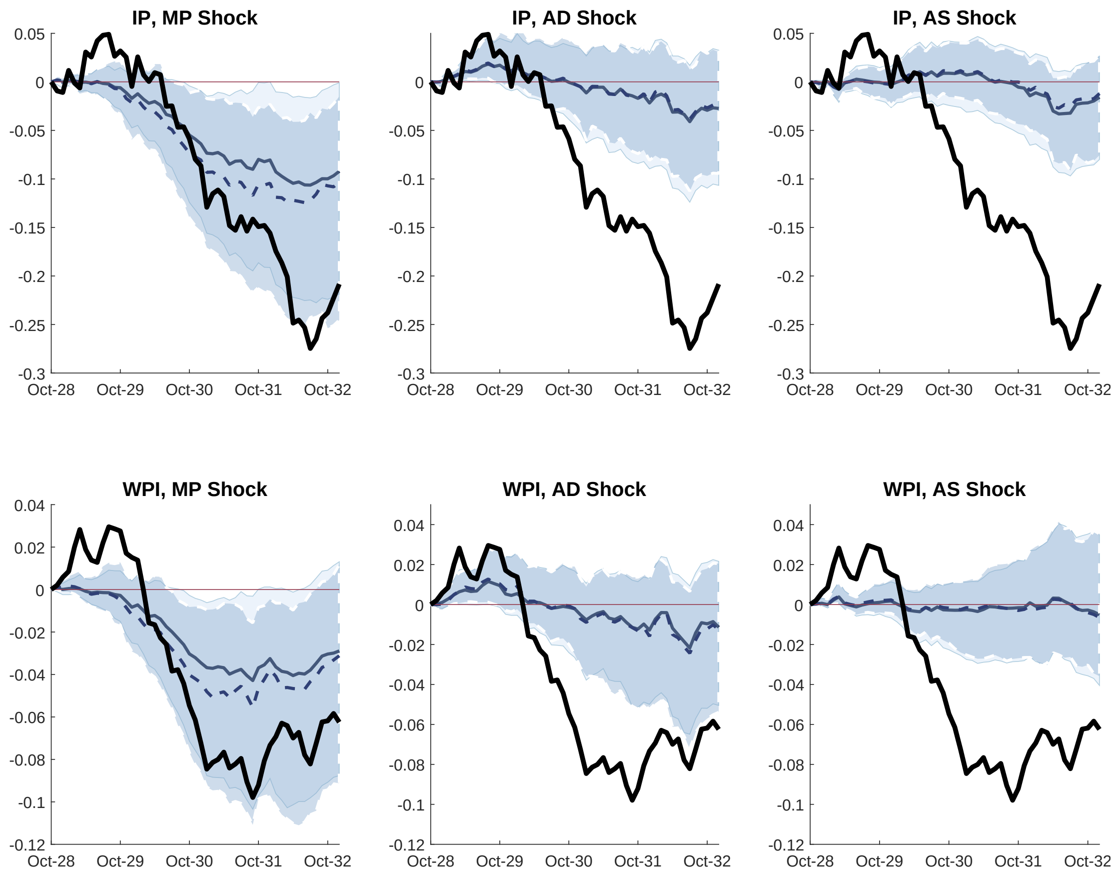
Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions as in Table 1 (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

Figure 14: Robustness: Historical decomposition, sample start in 1925



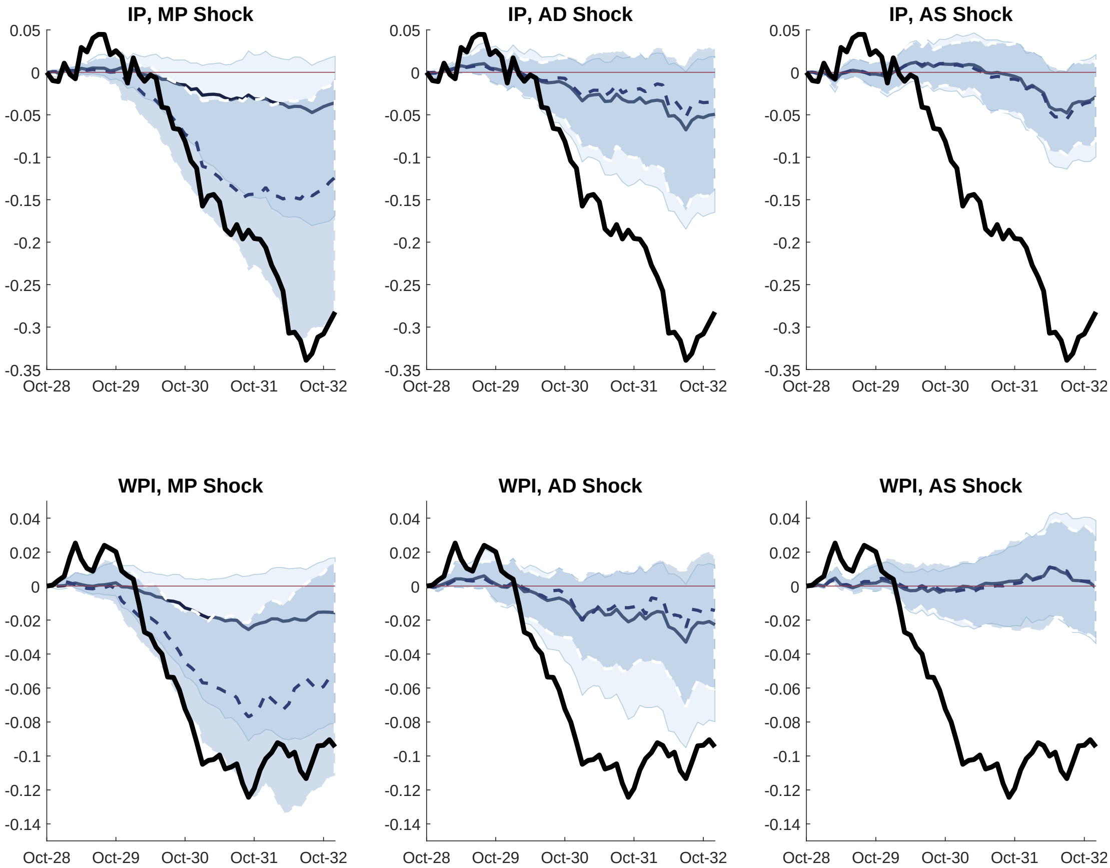
Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions as in Table 1 (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

Figure 15: Robustness: Historical decomposition, sample end in 1932



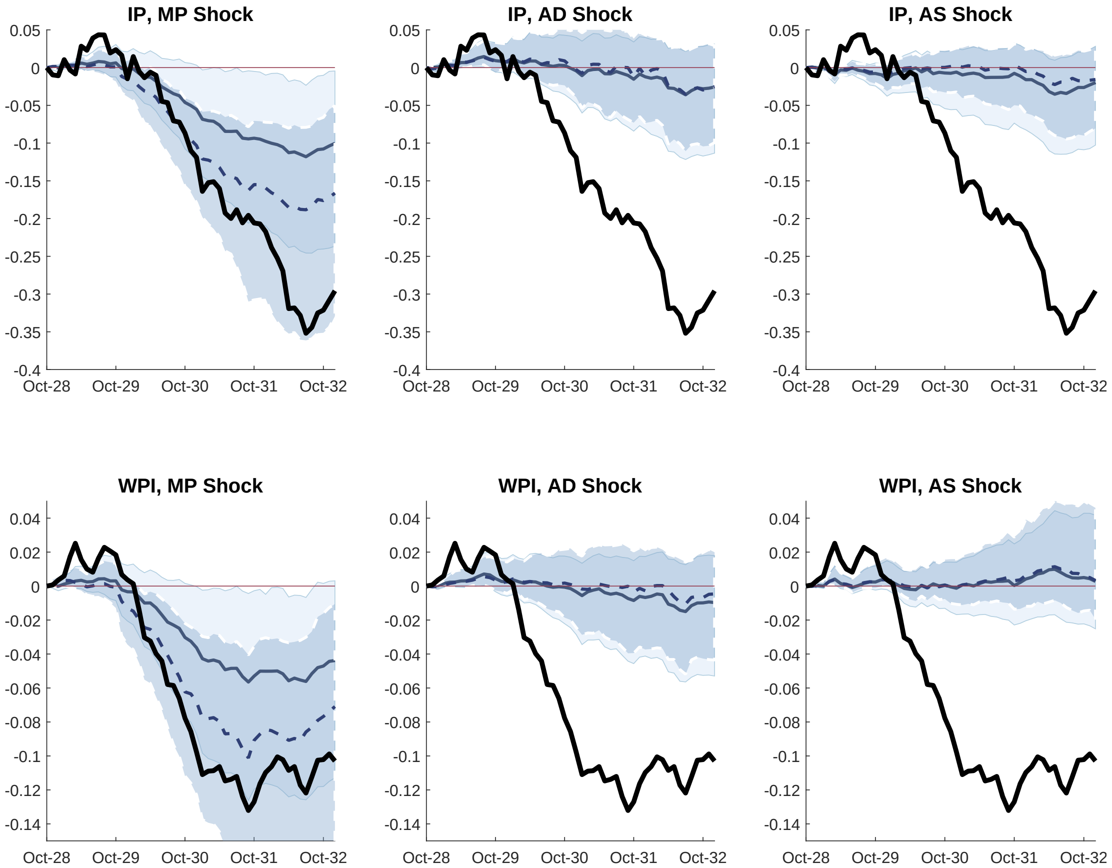
Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions as in Table 1 (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). Shaded areas denote 68% credible sets.

Figure 16: Robustness: Historical decomposition, omitting output and stock price sign restrictions for monetary policy shock



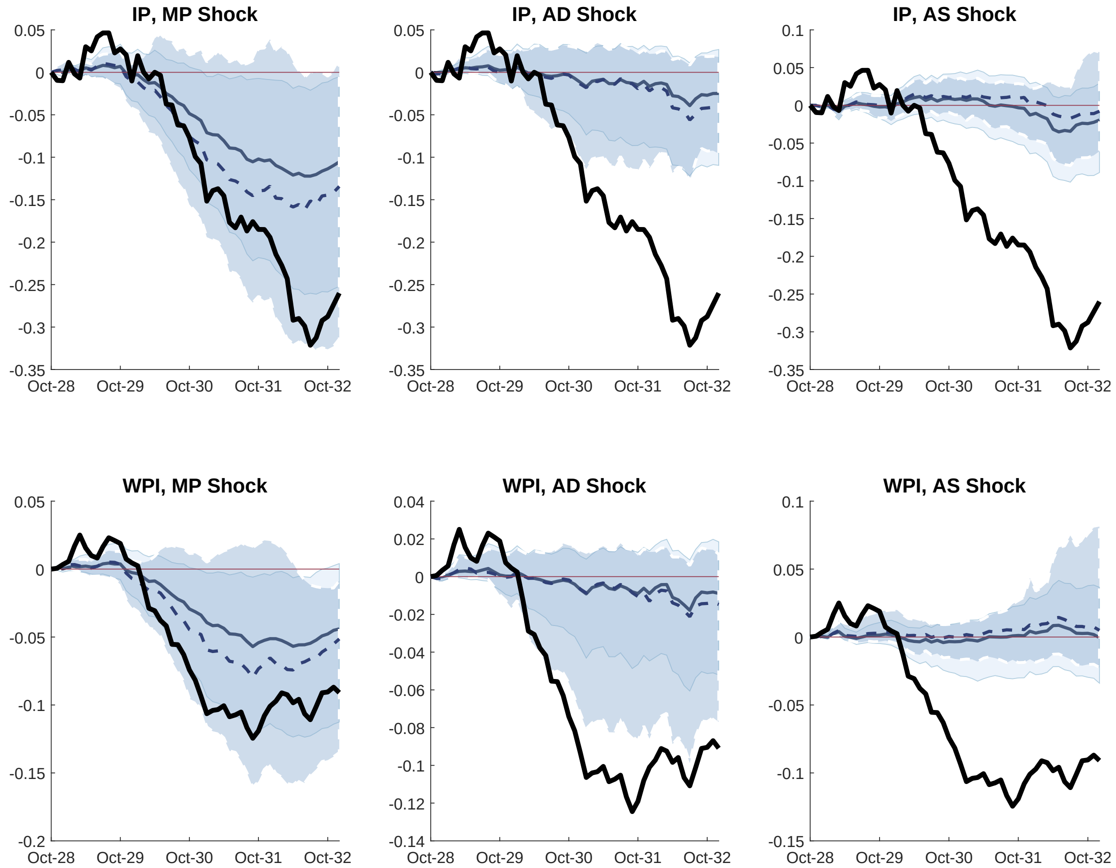
Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by the simple set of traditional sign restriction as in Table 1 (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas) Other shocks identified according to the full set of traditional sign restrictions. Shaded areas denote 68% credible sets.

Figure 17: Robustness: Historical decomposition, price level targeting instead of zero restriction of gold cover to AD shock



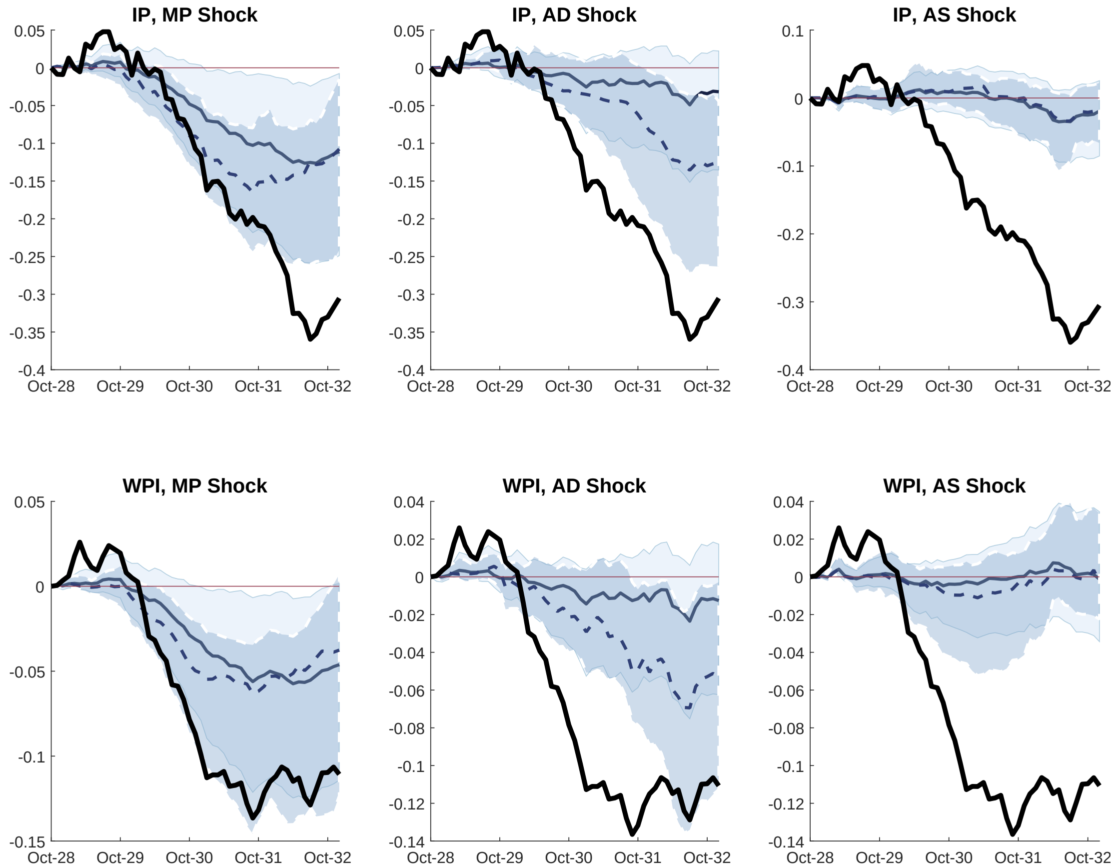
Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). No zero restriction of the gold reserve ratio to AD shocks is imposed. Instead the gold reserve ratio responds positively to positive demand and negative supply shocks ("price level targeting"). Shaded areas denote 68% credible sets.

Figure 18: Robustness: Historical decomposition, assuming zero response of money instead of gold cover to AD shock



Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions (solid line, light areas) and additionally NSR 1 (dashed lines, dark areas). Zero response to AD shock is imposed on money holdings instead of the gold reserve ratio. Shaded areas denote 68% credible sets.

Figure 19: Robustness: Historical decomposition in the 6-variable VAR model with additionally Narrative Sign Restriction 2



Note. Historical decompositions in the 6-variable VAR(12) showing deviations of the respective variable from a model forecast in October 1928: without shock (thick solid lines) and with monetary policy shock identified by full set of traditional sign restrictions as in Table 1 (solid line, light areas) and additionally NSR 1 and Narrative Sign Restriction 2 (dashed lines, dark areas). Shaded areas denote 68% credible sets.