Money-Multiplier Shocks[*]

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Abstract

Shocks to the M1 multiplier—in particular, shocks to the reserves/deposits ratio—played a key role in driving U.S. macroeconomic fluctuations during the interwar period, but their role in the post-WWII era has been almost uniformly negligible. The only exception are shocks to the currency/deposits ratio, which played a sizeable role for inflation and M1 velocity. By contrast, shocks to the multiplier of the non-M1 component of M2, which had been irrelevant in the interwar period, have played a significant role in driving the *nominal* side of the economy during the post-WWII period up to the collapse of Lehman Brothers, in particular during the Great Inflation episode. During either period, the multiplier of M2-M1 has been cointegrated with the short rate. The monetary base had exhibited a non-negligible amount of permanent variation during the interwar period, whereas it has been trend-stationary during the post-WWII era. In spite of the important role played by shocks to the multiplier of M2-M1 during the post-WWII period, we still detect a non-negligible role for a non-monetary permanent inflation shock, which has the natural interpretation of a disturbance originating from the progressive de-anchoring of inflation expectations which started in the mid-1960s, and their gradual re-anchoring following the beginning of the Volcker disinflation.

Keywords: Money multiplier; money demand; Lucas critique; structural VARs; unit roots; cointegration; long-run restrictions.

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1 Introduction

An enormous body of literature, dating back to Hume (1752), investigates the effects that changes in the money supply have on output and prices. Classic studies in the monetarist tradition, including Friedman and Schwartz's (1963) *Monetary History of the United States* (henceforth, *MHUS*) and Cagan (1965), go further, by decomposing the money stock into its three "proximate" determinants: the monetary base, the ratio of currency to deposits, and the ratio of reserves to deposits. Their aim was to use this decomposition as part of a "narrative" effort to pinpoint the fundamental sources of co-movement in money and other key macroeconomic variables—that is, in the language of modern econometrics, to solve the problem of identifying and estimating the effects of structural disturbances to the economy.

To review the familiar decomposition, let the monetary aggregate M be the sum of currency in circulation C and deposits D. The monetary base MB (often referred to synonymously as the stock of high-powered money), meanwhile, equals the sum of currency C and bank reserves R. Now,

$$M = C + D = \left(\frac{C+D}{C+R}\right) MB = \left(\frac{1+k}{r+k}\right) MB = m \times MB,$$

where $k = C/D$ is the currency-deposit ratio and $r = R/D$ the reserve-deposit ratio and, as indicated by the last equality, the money multiplier depends on both of these ratios.

Friedman and Schwartz (1963) and Cagan (1965) find important roles for the money multiplier and the two ratios on which it depends in their narrative histories. Most famously, Chapter 7 of Friedman and Schwartz's *MHUS* describes how, beginning in October 1930, the severe contraction characterized initially by a decline in the monetary base turned into an outright monetary and economic collapse, reflecting, first, the effects of banking panics in which customers rushed, *en masse*, to convert their bank deposits into currency, resulting in a sharp increase in k; and second, banks bolstering their liquidity positions by increasing their reserves, resulting in a rise in r. Friedman and Schwartz (1963, pp. 332-333) thus summarize:

> From August 1929 to March 1933 as a whole, the change in high-powered money alone would have produced a rise of 17.5 percent in the stock of money. The change in the deposit-currency ratio alone would have produced a decline of 37 percent; the change in the deposit-reserve ratio, a decline of 20 percent.

In this summary, we recognize in the *MHUS* a somewhat primitive form of what today we would call a "counterfactual simulation", that is, an effort to consider a set of counterfactuals in which each in a group of fundamental shocks is isolated and "killed off", so that the individual contribution of that shock to economic outcomes can be seen in isolation. To cite just one additional example, Chapter 9 of the *MHUS* describes how the Federal Reserve moved, first in July 1936 and again in January 1937 to raise reserve requirements in several steps by a total of 3 billion dollars, an amount then equal to nearly 25 per cent of the monetary base. Although they were intended by Federal Reserve officials to simply be a "precautionary measure to prevent an uncontrollable expansion of credit in the future" (*MHUS*, p. 524), Friedman and Schwartz note (p. 527) that their ultimate effect on the money multiplier, working through changes in the reserve ratio r, led the money stock to reach "an absolute peak in March" 1937 and to fall "with only minor interruption to the end of the year." Once again, in the *MHUS*, what was identified as an important, autonomous shift in the money multiplier appeared to be followed by a sharp cyclical contraction.

Despite the prominent role assigned to the money multiplier in these historical studies, and despite the obvious connections between the aims of Friedman and Schwartz (1963) and Cagan's (1965) narrative analyses and the goal of modern econometrics—namely, to learn about the structure of the economy by identifying the exogenous disturbances that drive large cyclical fluctuations in aggregate output and prices—the recent literature features no attempt, to the best of our knowledge, to build on and extend these analyses with the help of more formal, time-series methods.[1] In this paper, we aim to fill this gap in the literature. In particular, we use cointegrated structural VARs, in which fundamental disturbances are identified using long-run restrictions, to re-address the same questions posed by Friedman and Schwartz and Cagan. How important do identified shocks to the two components of the money multiplier—the currency-to-deposit and reserve-to-deposit ratios—appear to be in driving macroeconomic dynamics during the interwar period? Can an analysis based on modern time-series analysis confirm the conclusions of these classic studies? To what extent do movements in the money multiplier continue to be important in explaining movements in aggregate output and prices during the post-World War II era and, in particular, during the period of the Great Inflation of the 1970s which, after the Great Depression and before the financial crisis of 2007-08, represents the most striking period of monetary instability in a long span of United States economic history?

The availability of new econometric techniques and new data gives us the ability, not only to re-assess Friedman and Schwartz's conclusions and conjectures, but also to establish and examine a few new facts of our own. For Friedman and Schwartz and Cagan, data limitations together with the relatively primitive state of the U.S.

[1] Rasche and Johannes (1987), which estimates a set of ARIMA models for the money multiplier and its components, represents one important exception to this general observation. That study focuses, however, on developing reduced-form forecasting models that the Federal Reserve could have potentially used to better control the monetary aggregates though open-market operations that affect the monetary base according to the theories outlined, for example, by Burger (1971) or Brunner and Meltzer (1990). Rasche and Johannes make no attempt, therefore, to identify fundamental shocks to the money multipler or to trace out their effects on other macroeconomic variables.

financial system precluded any detailed analysis of the multiplier for the non-M1 components on M2. Here, we can—and do—examine both the M1 and M2-M1 multipliers separately, to ask whether their time series behavior differs and, if so, to pinpoint the reasons why. We also take advantage of information provided by the era of financial innovation that followed the Great Inflation and led to the introduction of new monetary assets including money market deposit accounts. What effect did these innovations have on the behavior of the money multiplier and its components? And did those effects spill over to impact on inflation and output as well? Finally, we ask whether purely monetary factors can explain the dynamics of inflation during and since the Great Inflation, or whether there appears to be a non-negligible role for permanent shocks of a non-monetary nature due, for example, to the de-anchoring and re-anchoring of inflationary expectations during the post-World War II period.

The remainder of this paper provides answers to all of these questions, and is organized as follows. Section 2 provides a first look at and overview of our raw data, distinguishing between the multiplier of M1 and M2-M1 and between data from the interwar period originally studied by Friedman and Schwartz and by Cagan and the more recent, post-World War II era. Section 3 uses frequency-domain methods to characterize, in a clear and comprehensive way, the shifting volatilities and cross-correlations that can be found in the series. Section 4 tests for unit roots in and cointegration between the variables that feature in our structural VARs, to help guide the models' specification. Section 5 then presents the VAR estimates and describes their implications; the impulse response functions, variance decompositions, and counterfactual simulations we report on and discuss in this key section are, in our view, the modern time-series analogs to the narrative accounts and thought experiments that run throughout the *MHUS*. Section 6 concludes, by summarizing what we've learned, both about the interwar period studied by Friedman and Schwartz and the post-World War II data from our investigation.

2 A Look at the Raw Data

2.1 The multipliers of M1 and M2-M1

Figure 1 shows, for the periods January 1919-December 1960, and 1959Q1-2016Q4, respectively, the multipliers of the M1 and M2-M1 aggregates together with a short-term monetary policy rate. Appendix A describes these data and their sources in detail. All of the data are completely standard, with the single exception that, for the post-WWII period, our measure of M1 is based on Lucas and Nicolini's (2015), which differs from the Federal Reserve's official M1 series by including Money Market Deposit Account (MMDAs) balances for the period since 1982Q2. Adding MMDAs to the standard M1 aggregate is one of the several possible adjustments which had originally been suggested by Goldfeld and Sichel (1990, pp. 314-315) in order to restore the stability of the long-run demand for M1, which had vanished around the mid-1980s.

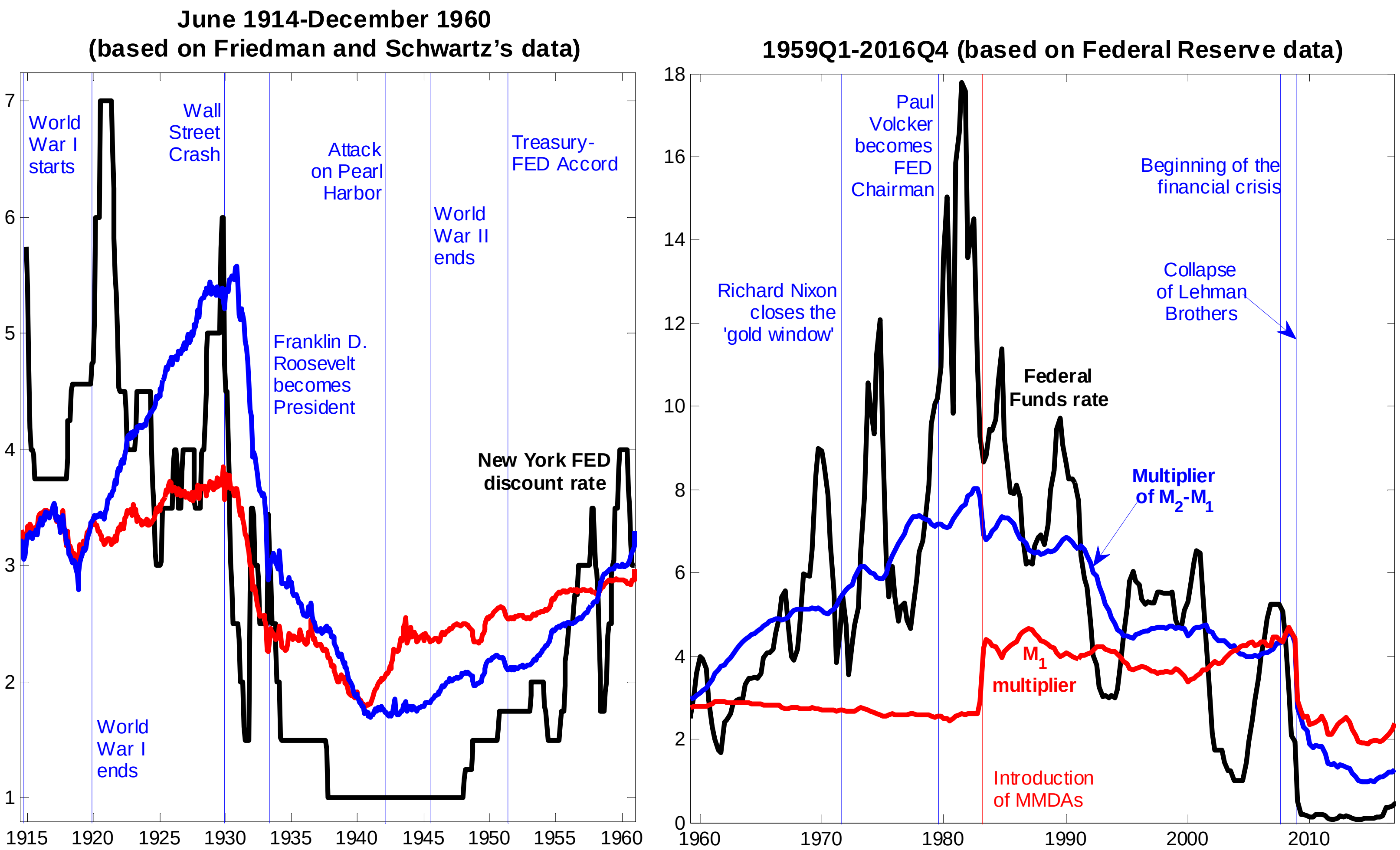

Figure 1 United States, 1914-2016: The evolution of the multipliers of M_1 and M_2-M_1

As discussed by Lucas and Nicolini (2015), the rationale for including MMDAs in M1 is that they perform an economic function similar to the more traditional 'checkable deposit' component of the Federal Reserve's official M1 series. In fact, Benati, Lucas, Nicolini, and Weber (2017; henceforth, BLNW) show that whereas—in line with, e.g., Friedman and Kuttner (1992)—based on the standard aggregate there is no evidence of a stable long-run demand for M1, evidence of cointegration between velocity and the short rate is very strong based on Lucas and Nicolini's (2015) aggregate.

During either period, the multiplier of M2-M1 had exhibited a strong positive correlation with the short rate. In fact, as we will discuss in Section 4.1, for both periods we detect strong evidence of cointegration between the two series.[2] The most natural explanation for this stylized fact has to do with permanent portfolio shifts out of (mostly) non interest-bearing M1, and into interest-bearing M2-M1, caused by permanent interest rate shocks, whatever their origin (i.e., permanent inflation shocks, or permanent shocks to the real interest rate).

The M1 multiplier, on the other hand, does not exhibit a consistent pattern across sub-periods. During the period January 1919-December 1960 it also exhibits a strong positive correlation with the short rate. It is to be noticed, however, that first, Johansen's tests do not detect cointegration between the two series (see Table $2a$); and second—and crucially—the explanation for such a correlation, in terms of direction of causality, is most likely completely different from that for the multiplier of M2-M1. In particular, the narrative account of interwar macroeconomic fluctuations provided by Friedman and Schwartz in chapters 6 to 9 of *MHUS* points towards a crucial role played by autonomous fluctuations in the M1 multiplier—caused, in turn, by exogenous disturbances to its two determinants, k and r—in driving a significant portion of business-cycle fluctuations during those years. As we will see in Section 5.1, evidence from cointegrated structural VARs provides strong support to Friedman and Schwartz's position. This implies that, e.g., the dramatic fall in the short rate during the period between the Wall Street crash and World War II should be regarded as the *consequence* of the contractionary shocks which led to an equally dramatic fall in the M1 multiplier during that period—first and foremost, the increase in the reserves/deposits ratio from about 15 per cent around the time of the Wall Street crash to a peak in excess of 47 per cent following the increase in required reserves associated with the FED's 'mistake of 1937' discussed in chapter 9 of *MHUS* (see the first panel of Figure 2). So, although during the period January 1919-December 1960 both multipliers had exhibited a strong positive correlation with the short rate, the reasons behind such superficially similar patterns are completely different. For the M1 multiplier, the direction of causality went from shocks to k and r, to fluctuations in

[2] Although, for the reasons discussed in Section 4.1, we perform our analysis by sub-sample, cointegration between the multiplier of M2-M1 and a short-term rate also holds (based on annual data) over the entire period since 1915. This result is also robust to either excluding, or including, the period since 2007, following the outbreak of the financial crisis. All of these results are available upon request.

the multiplier, to subsequent fluctuations in the economy, including movements in the short rate. For the multiplier of M2-M1, on the other hand, evidence of cointegration with the short rate suggests that its key driver were the permanent shifts in interest rates caused by shocks to the determinants of the M1 multiplier.

Turning to the period 1959Q1-2008Q3, up until the introduction of MMDAs, in 1982Q4, the M1 multiplier followed a remarkably smooth path, and exhibited, overall, comparatively little variation, fluctuating between 2.44 and 2.92 (between January 1919 and the attack on Pearl Harbor, on the other hand, it had fluctuated between 1.78 and 3.85). The natural explanation for such a smooth path up until the introduction of MMDAs is the success, on the part of U.S. policymakers, at essentially eliminating the autonomous disturbances to the currency/deposits and reserves/deposits ratios which had played such a central role during the interwar period. In their *MHUS*, Friedman and Schwartz describe how both the Federal Reserve Act of 1913, which established the Fed as a supplier of an "elastic currency" and lender of last resort, and the earlier Aldrich-Vreeland Act of 1908, which enabled banks to issue emergency currency for temporary circulation during periods of bank runs, reflected lawmakers' keen desire to remove shocks to the money multiplier as sources of monetary and economic instability. They note (p. 441), however, that in practice is was the Banking Act of 1933, which created the federal deposit insurance program, that ultimately worked best to achieve that goal:

> Federal deposit insurance attempts to solve the problem by removing the initial reason for runs: loss of confidence in the ability to convert deposits into currency. While there have been substantial changes since 1934 in the ratio of currency to deposits, there have been no radical changes in short periods like those before 1934, always the invariable hallmark of a liquidity crisis and a banking panic. And it is hard to believe that any are likely to occur in the foreseeable future.

With the benefit of decades of data compiled since the publication of the *MHUS*, we can confirm that this "foreseeable future" continued through the early 1980s. The introduction of MMDAs, however, partly changed this, by injecting additional volatility into the deposits component of M1, and therefore in the M1 multiplier, which, since 1983Q1, has fluctuated between 2.11 and 4.70.

2.2 The currency/deposits and reserves/deposits ratios

Figure 2 shows, for either of the two periods we consider, the evolution of the currency-deposit ratio k and the reserve-deposit ratio r. Evidence clearly points towards several instances in which sizable, and sometimes sudden, fluctuations in k and/or r have been associated with well-known historical events. During the period from January 1919 through December 1960 this is the case, e.g., for the dramatic increase in the currency ratio k that began, following the stock market crash, with the first wave of

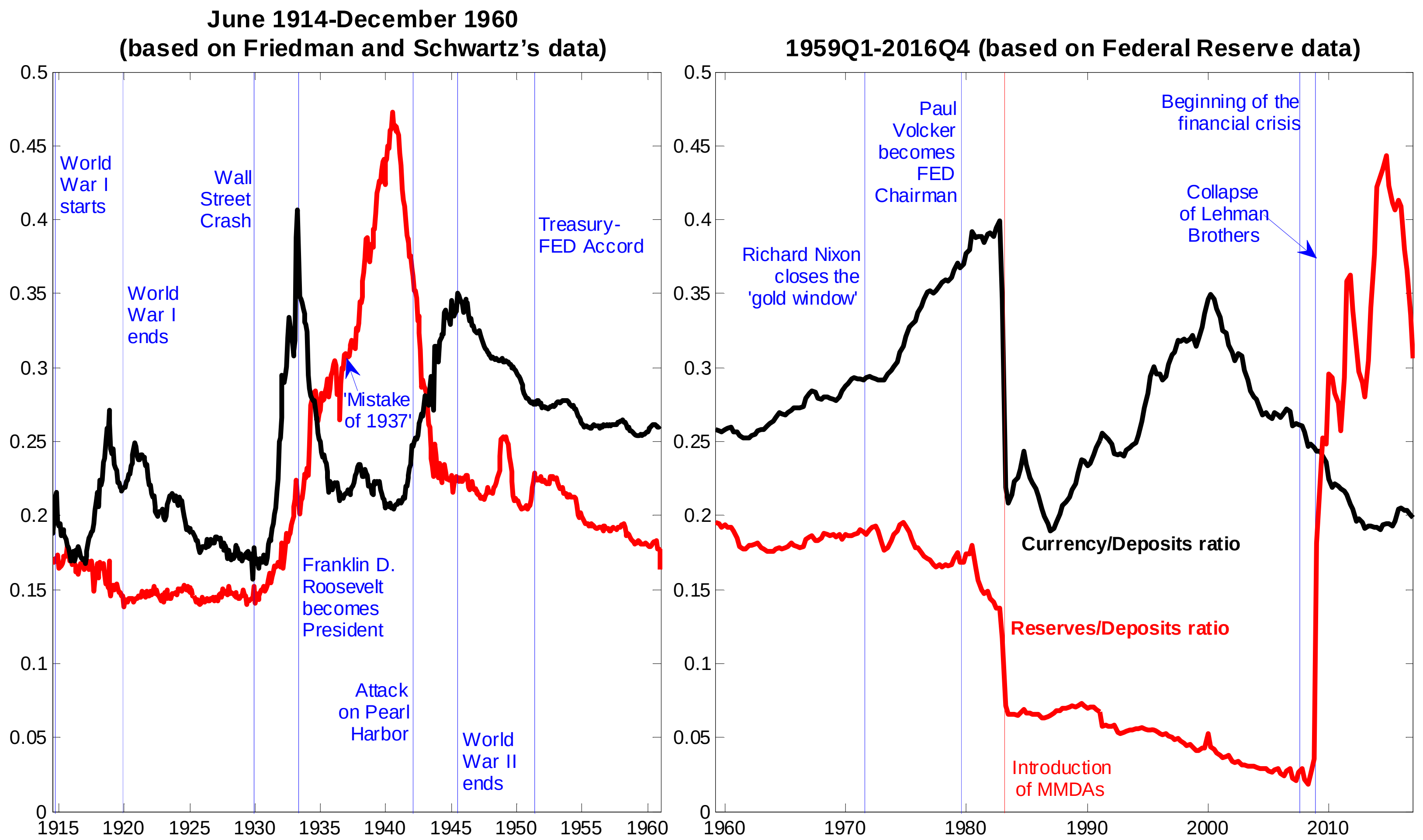

Figure 2 United States, 1914-2016: The evolution of the currency/deposits and reserves/deposits ratios

bank failures beginning in October 1930, culminating in December of that year with the collapse of the Bank of the United States. The relentless climb in k continued through subsequent waves of banking failures in 1931, 1932, and 1933, ending only after Roosevelt's banking holiday of March 1933.

On the other hand, the increase in the reserve-deposit ratio r that accompanied, but initially lagged behind, that in k went on through June 1940 according to a dramatic series of events outlined in Chapters 7 and 9 of the *MHUS*. Banks' desire to increase their holdings of reserves before the Bank Holiday of 1933 was the natural response to the series of bank runs and panics that produced the rise in k. But this accumulation or reserves continued even after k fell back towards more normal levels. As Friedman and Schwartz (p. 348) explain,

> The banks had discovered in the course of two traumatic years that neither legal reserves nor the presumed availability of a lender of last resort was of much avail in time of trouble . . . . Little wonder that they found it prudent to hold reserves that exceeded substantially the reserves they were legally required to hold.

Once the economy began to recover, many Federal Reserve officials began to worry that their monetary policy was one of excessive ease, and expressed concern, in particular, over the elevated stock of bank reserves. According to the *MHUS* (p. 520), the Federal Reserve Bank of New York, under the leadership of President George L. Harrison, played a leading role in the deliberations that followed:

> Beginning in early 1934, the Bank's staff prepared a series of internal memoranda, some circulated also to the Federal Open Market Committee, which examined the problem of excess reserves, emphasized potential dangers they raised, and considered alternative ways to control them. In the key memo (dated December 13, 1935 ...), it was concluded that open market operations would be an inefficient technique because of the size of the excess reserves and that the discount rate would be inefficient because of the absence of borrowing. Hence, the appropriate tool was a change in reserve requirements, a discontinuous policy instrument poorly suited for continuous short-term adjustments but an appropriate means of immobilizing excess reserves and thereby establishing a situation in which the flexible instrument of open market operations could be used.

Unfortunately, by raising reserves requirements sharply in July 1936 and again in January 1937, the Fed "employed too blunt an instrument too vigorously" (Friedman and Schwartz 1963, p. 526). Banks were not content to simply have some of their excess reserves re-classified as required reserves; instead, they responded to the increases in reserve requirement by accumulating still more total reserves, so as to restore excess reserves to their previous levels. The result of this policy "mistake of

1937" was yet another abrupt upward movement in the reserves ratio r, a decline in the money multiplier causing another outright monetary contraction, and a sharp economic contraction that brought recovery from the Depression to a temporary end.

As for the period 1959Q1-2008Q3, two events stand out: the introduction of MMDAs in 1982Q4, and the the introduction of Quantitative Easing (QE) during the financial crisis. During the period up to 1982Q4, the reserves/deposits ratio had been essentially flat, fluctuating between 0.137 and 0.196, whereas the currency/deposits ratio had been slowly but systematically increasing from 0.258 at the beginning of the sample, to 0.399 in 1982Q3. The introduction of MMDAs, by causing a sudden and dramatic increase in overall deposits—which more than doubled between 1982Q4 and 1983Q4—automatically produced a swift and sharp fall in both k and r, which fell, in 1983Q4, to 0.214 and 0.066 respectively. During the subsequent period, k exhibited a hump-shaped pattern, with a peak of 0.349 in 2000Q1,reaching, at the end of the sample, essentially the same value it had immediately after the introduction of MMDAs. r, on the other hand, decreased steadily until the introduction of QE, teaching an all-time minimum of 0.019 in 2008Q1, and then it skyrocketed during subsequent years, reflecting the impact on the monetary base of the Federal Reserve's asset purchases programme.

3 Evidence from Frequency-Domain Methods

The top rows of Figures 3 and 4 show, for either of the two sub-periods,[3] the business-cycle components of k, r, and of the multipliers of M1 and M2-M1, together with the business-cycle component of the logarithm of either industrial production (for the former sub-period) or real GDP *per capita* (for the latter one).[4] The bottom rows of either figure report the bootstrapped distributions of the average gain and coherence at the business-cycle frequencies of either of the four series of interest onto the real activity indicator (either industrial production, or GDP *per capita*).[5]

As previously mentioned, Friedman and Schwartz ascribe an important role to

[3]For the latter period we end the sample in 2008Q3 as the subsequent explosion in reserves—and therefore in the monetary base—associated with quantitative easing policies would render any analysis of the money multiplier meaningless.

[4]The business-cycle components have been extracted *via* the filter proposed by Christiano and Fitzgerald (2003). Following standard practice in macroeconomics, the business-cycle has been defined as comprising the set of fluctuations with periodicities between one year and a half and eight years.

[5]Cross-spectral objects have been computed based on an estimate of the spectral density matrix of the first difference of the relevant series based on the fast-Fourier transform. Smoothing of the periodograms and cross-periodograms has been implemented in the freqency domain based on a Bartlett spectral window, with the spectral bandwidth being selected automatically based on the algorithm proposed by Beltrao and Bloomfield (1987). Finally, spectral bootstrapping has been implemented *via* the procedure proposed by Berkowitz and Diebold (1998), which is a multivatiate generalization of the univariate procedure introduced by Franke and Hardle (1992).

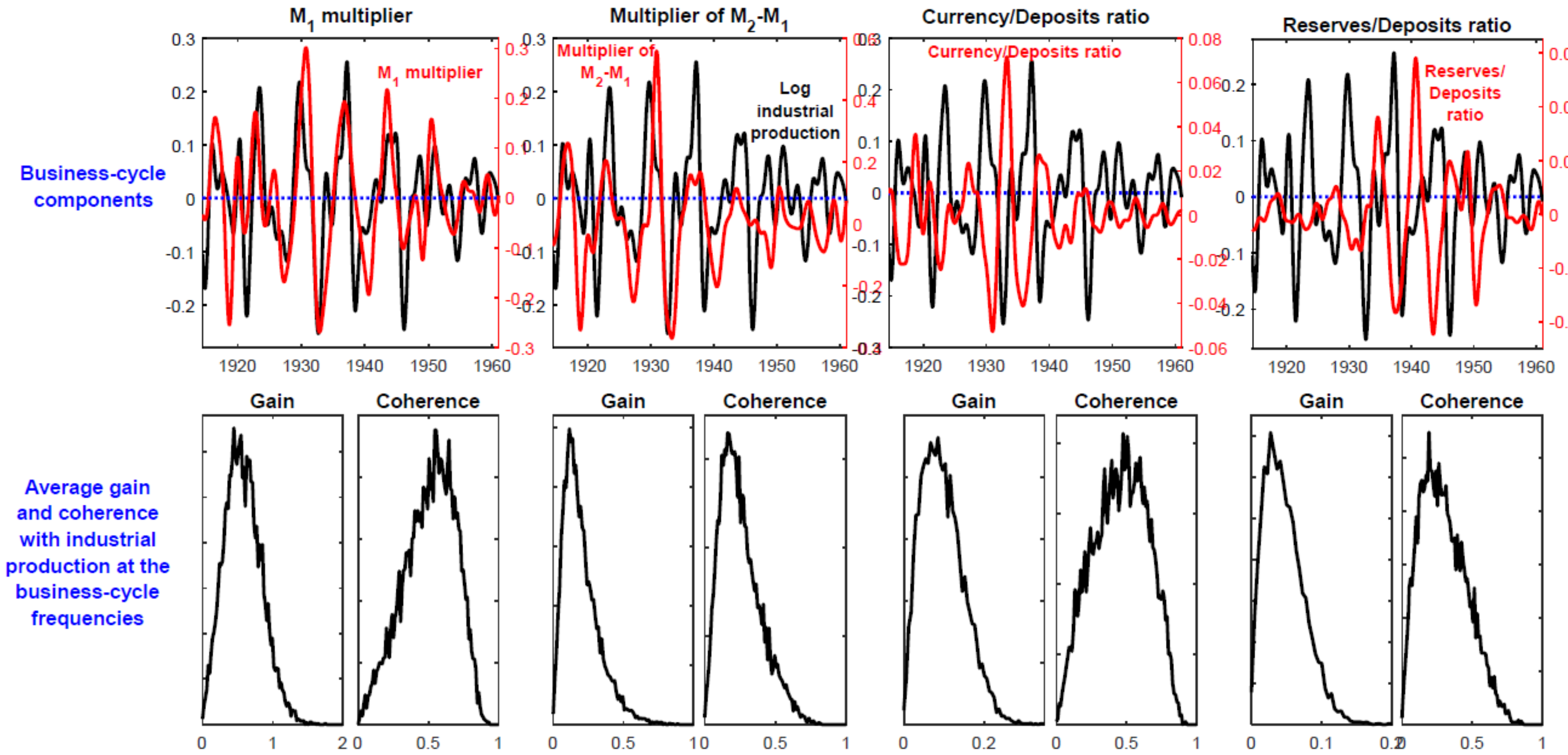

Figure 3 United States, June 1914-December 1960: Business-cycle components of log industrial production, the multipliers, and the currency/deposits and reserves/deposits ratios, and average gain and coherence at the business-cycle frequencies

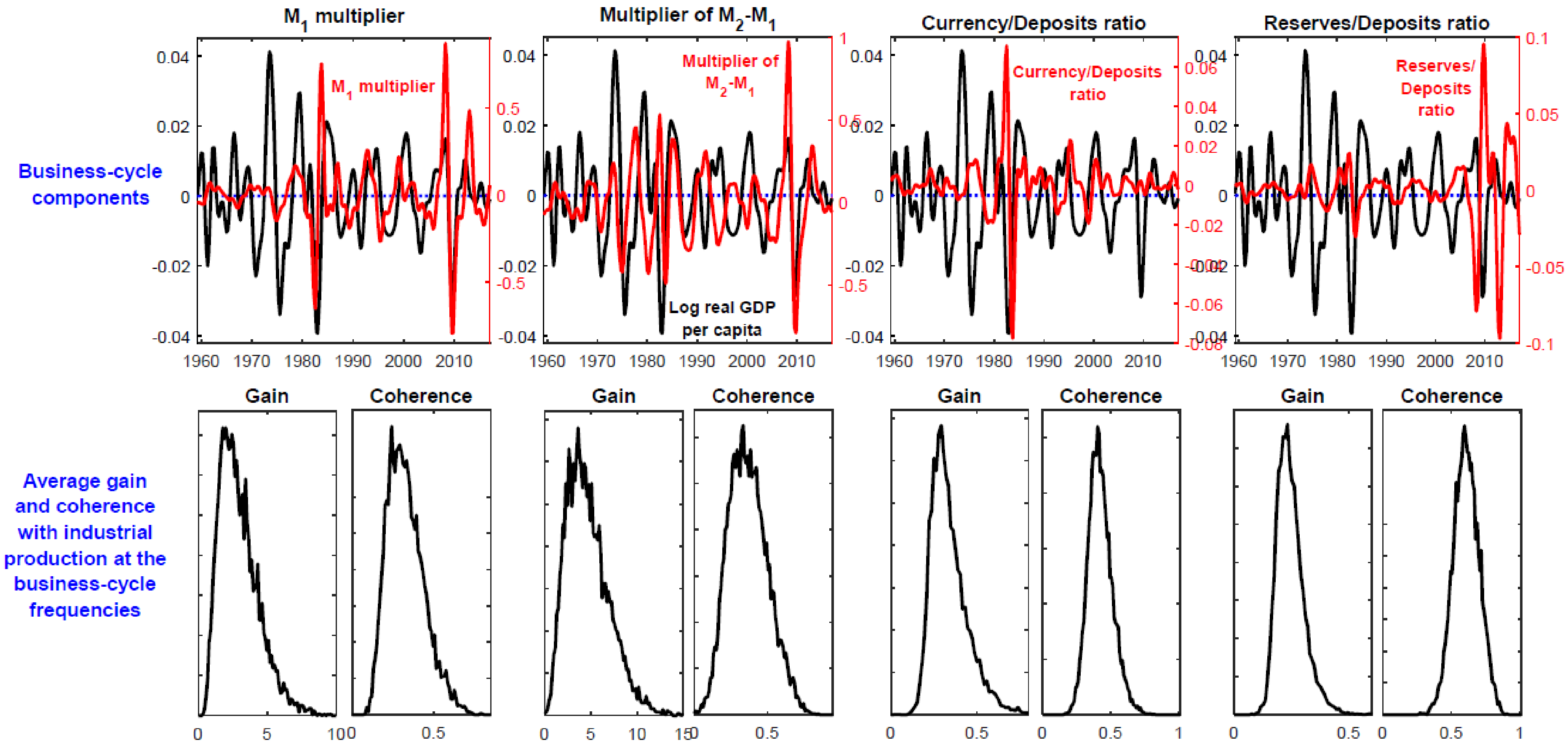

Figure 4 United States, 1959Q1-2016Q4: Business-cycle components of log industrial production, the multipliers, and the currency/deposits and reserves/deposits ratios, and average gain and coherence at the business-cycle frequencies

autonomous shifts in k and r—and therefore in the M1 multiplier—in driving macroeconomic fluctuations during the interwar period. As we will see in Section 4, our analysis confirms indeed Friedman and Schwartz's position. Intuitively, this should lead us to expect to find a strong correlation between real activity and either k, r, or the M1 multiplier at the business-cycle frequencies during this period. The evidence in Figure 3 confirms indeed this conjecture. Both k and r had exhibited a strong counter-cyclical pattern, whereas the M1 multiplier had been very strongly pro-cyclical. As for the multiplier of M2-M1, the pattern had been strongly procyclical until World War II, and it then turned mainly counter-cyclical after that. By the same token, the bootstrapped distributions of the coherence of the series of interest onto industrial production points towards a sizeable explanatory power of the former for the latter. (It is worth recalling that the coherence, which by construction is bounded between 0 and 1, is nothing but the R-squared in the regression of one variable onto the other at a specific frequency, or within a specific frequency band. By the same token, the gain is the absolute value of the slope coefficient in the same regression.) This is especially clear for k and for the M1 multiplier, whereas it is less so for r, and especially for the multiplier of M2-M1.

For the period 1959Q1-2008Q3, on the other hand, our evidence in Section 4 suggests that shocks to either k or r, and therefore to the M1 multiplier, had played a negligible role in driving macroeconomic fluctuations during those years. The evidence in Figure 4 is, under this respect, mixed. On the one hand, the relationship between the business-cycle components of either of the four series of interest, and the business-cycle component of GDP, is not nearly as strong and clear-cut as for the former period. On the other hand, however, the bootstrapped distributions of the coherences are still uniformly quite high, thus suggesting that even in the latter period k, r, and therefore the M1 multiplier still possessed non-negligible explanatory power for GDP's business-cycle fluctuations.

4 Integration and Cointegration Properties of the Data

4.1 Unit root tests

Tables 1a and 1b report, for the periods January 1919-December 1960, and 1959Q1-2008Q3, respectively, bootstrapped p-values for Elliot, Rothenberg, and Stock (1996) unit root tests for the series in our dataset.[6] (As previously mentioned, for the latter

[6]For either series, p-values have been computed by bootstrapping 10,000 times estimated ARIMA(p,1,0) processes. In all cases, the bootstrapped processes are of length equal to the series under investigation. As for the lag order, p, since, as it is well known, results from unit root tests may be sensitive to the specific lag order which is being used, for reasons of robustness we consider four alternative lag orders: p = 3, 6, 9, or 12 months for the former period, and p = 1, 2, 3, or 4 quarters for the lastter one.

Table 1a United States, January 1919-December 1960: Bootstrapped p-values for Elliot, Rothenberg, and Stock unit root tests[a]

	Lag order:			
	p=3	p=6	p=9	p=12
	In levels, without a time trend			
New York FED discount rate	0.293	0.210	0.298	0.279
High grade bond rate	0.564	0.618	0.457	0.191
BAA rate	0.508	0.506	0.369	0.150
Logarithm of $(1 + k)$	0.617	0.383	0.083	0.093
Logarithm of $(r + k)$	0.803	0.665	0.439	0.460
k	0.617	0.396	0.085	0.084
r	0.789	0.679	0.522	0.468
M1 multiplier	0.799	0.684	0.478	0.475
Multiplier of M2-M1	0.891	0.819	0.691	0.706
	In levels, with a time trend			
Log nominal M0	0.991	0.981	0.942	0.977
Log CPI	0.803	0.798	0.611	0.547
Log industrial production	0.436	0.360	0.106	0.268
Log department store sales	0.977	0.944	0.774	0.727
	In differences, without a time trend			
	p=3	p=6	p=9	p=12
Log CPI	0.000	0.000	0.001	0.000
New York FED discount rate	0.000	0.000	0.000	0.000
High grade bond rate	0.000	0.000	0.000	0.000
BAA rate	0.000	0.000	0.000	0.000
Logarithm of $(1 + k)$	0.000	0.000	0.003	0.001
Logarithm of $(r + k)$	0.000	0.000	0.023	0.022
k	0.000	0.000	0.002	0.001
r	0.000	0.000	0.016	0.018
M1 multiplier	0.000	0.001	0.069	0.082
Multiplier of M2-M1	0.000	0.000	0.017	0.033
Log nominal M0	0.000	0.000	0.012	0.004
Log industrial production	0.000	0.000	0.000	0.000
Log department store sales	0.000	0.000	0.003	0.009

[a] Based on 10,000 bootstrap replications of estimated ARIMA processes.
k = currency/deposits ratio. r = reserve/deposits ratio.

Table 1*b* United States, 1959Q1-2008Q3: Bootstrapped *p*-values for Elliot, Rothenberg, and Stock unit root tests[a]

	Lag order:			
	p=1	p=2	p=3	p=4
	In levels, without a time trend			
GDP deflator inflation	0.070	0.207	0.290	0.246
Federal Funds rate	0.232	0.195	0.197	0.139
5-year Treasury bill rate	0.535	0.555	0.515	0.498
Logarithm of $(1 + k)$	0.730	0.487	0.306	0.274
Logarithm of $(r + k)$	0.811	0.754	0.674	0.645
k	0.714	0.468	0.291	0.275
r	0.551	0.616	0.628	0.581
M_1 velocity	0.763	0.664	0.477	0.547
Multiplier of M_2-M_1	0.318	0.460	0.547	0.620
Log hours worked *per capita*	0.469	0.146	0.122	0.133
	In levels, with a time trend			
Log nominal M_1 *per capita*	0.061	0.151	0.212	0.374
Log nominal M_0 *per capita*	0.000	0.001	0.001	0.002
Log nominal M_0	0.002	0.002	0.001	0.003
Log real GDP *per capita*	0.431	0.410	0.262	0.203
Log real consumption *per capita*	0.778	0.708	0.509	0.503
Log hours worked *per capita*	0.648	0.266	0.306	0.325
	In differences, without a time trend			
	p=1	p=2	p=3	p=4
GDP deflator inflation	0.000	0.000	0.000	0.000
Federal Funds rate	0.000	0.000	0.000	0.000
5-year Treasury bill rate	0.000	0.000	0.000	0.000
Logarithm of $(1 + k)$	0.000	0.000	0.000	0.000
Logarithm of $(r + k)$	0.000	0.000	0.000	0.008
k	0.000	0.000	0.000	0.000
r	0.000	0.000	0.000	0.023
M_1 velocity	0.000	0.000	0.000	0.000
Multiplier of M_2-M_1	0.000	0.000	0.000	0.004
Log real GDP *per capita*	0.000	0.000	0.000	0.000
Log real consumption *per capita*	0.000	0.000	0.000	0.000
Log hours worked *per capita*	0.000	0.000	0.000	0.001

[a] Based on 10,000 bootstrap replications of estimated ARIMA processes.
k = currency/deposits ratio. r = reserve/deposits ratio.

period we end the sample in 2008Q3 as the subsequent explosion in reserves—and therefore in the monetary base—associated with quantitative easing policies, would render any analysis of the money multiplier meaningless.) For all series exhibiting obvious trends the tests are based on models including an intercept and a time trend.[7] These series are the logarithms of nominal M0, the CPI, industrial production, and department store sales for the former period; and of nominal M0, nominal M0 and M1 *per capita*, and real GDP and consumption *per capita* for the latter period. For all other series the tests are based on models including an intercept, but no time trend. For log hours worked *per capita* for the period 1959Q1-2008Q3—for which visual evidence on the presence or absence of a trend is not clear-cut—we report results from tests based on either model. As for the determinants of the M1 multiplier, we report results both for the levels of k and r, and for the logarithms of the numerator and denominator of the multiplier—that is: $\ln(1+k)$ and $\ln(r+k)$, respectively. The rationale for also reporting results for the two latter variables is that, in Section 5, we will identify permanent shocks to r and k by entering $\ln(1+k)$ and $\ln(r+k)$ in cointegrated VARs, and then imposing a Cholesky structure on the respective (2×2) block of the long-run impact matrix of the structural shocks. Because of this, we want to be sure that not only r and k, but also $\ln(1+k)$ and $\ln(r+k)$ are I(1).

At the 10 per cent significance level we take as our benchmark throughout the entire paper, the following results emerge from the two tables:

(*i*) inflation had been I(0) in the former period, whereas it has been I(1) in the latter one.

(*ii*) The monetary base had been I(1) in the former period, whereas it has been trend-stationary in the latter one. (The second result is robust to considering either M0, or M0 *per capita*.)

(*iii*) For all other series, the null of a unit root cannot be rejected.[8]

(*iv*) Finally, for all series, and for either period, tests in differences without a time trend strongly reject the null of a unit root. (This is crucial because a necessary condition for performing Johansen's tests is that the series under investigation do contain a unit root, but that their order of integration is not greater than one.)

Both (*i*) and (*ii*) justify our choice of performing the analysis by sub-sample, rather than for the joint sample 1919-2007 based on annual data.

4.2 Cointegration tests

Tables 2*a* and 2*b* report, for either period, results from Johansen's cointegration tests for both the 10-variables systems which will be the focus of our analysis in Section 5,

[7] The reason for including a time trend is that, as discussed e.g. by Hamilton (1994, pp. 501), the model used for unit root tests should be a meaningful one also under the alternative.

[8] For $\ln(1+k)$ and $\ln(r+k)$ for the period January 1919-December 1960, a unit root is rejected, at the 10 per cent level, based on $p = 9$ and $p = 12$ (but not based on the other two lag orders). In either case, we regard the null of a unit root as not having been convincingly rejected, and in what follows we will therefore consider either series as I(1).

and several smaller sub-systems. For the period January 1919-December 1960, the 10-variables system features the logarithms of industrial production, department store sales, M0, the CPI, $(1+k)$, and $(r+k)$; the multiplier of M2-M1; and the New York FED discount rate, Moody's BAA corporate bond yield, and the index of yields of high grade public utility bonds. For the period 1959Q1-2008Q3, on the other hand, it features the logarithms of GDP, consumption, and hours *per capita*; the logarithms of $(1+k)$ and $(r+k)$; and the multiplier of M2-M1, M1 velocity, inflation, the Federal Funds rate, and the 5-year Treasury bill rate.

Following BLNW (2017), we bootstrap the tests[9] *via* the procedure proposed by Cavaliere *et al.* (2012; henceforth, CRT). In a nutshell, CRT's procedure is based on the notion of computing critical and p-values by bootstrapping the model which is *relevant under the null hypothesis*.[10] All of the technical details can be found in CRT, which the reader is referred to. We select the VAR lag order as the maximum[11] between the lag orders chosen by the Schwartz and the Hannan-Quinn criteria[12] for the VAR in levels, for a maximum allowed lag order of $p = 12$ for the former period, and $p = 4$ for the latter one.

The following results emerge from the two tables:

(i) In line with BLNW's (2017) results for the U.S. over the entire period since 1915, we detect strong evidence of a long-run demand for M1 for either period. Specifically, for the period 1959Q1-2008Q3 we detect, as BLNW (2017), cointegration between M1 velocity and the short rate. This corresponds to the specification originally estimated by Selden (1956) and Latané (1960), which is linear in the *levels* of both series. As BLNW (2017) show, for several low-inflation countries—first and foremost, the U.S.—the data quite clearly prefer the Selden-Latané specification to the traditional 'semi-log' or 'log-log' ones. As for the former period, lack of original (i.e., non-reconstructed) nominal GDP data at a frequency higher than annual precludes us to follow the same approach. Table 2a therefore reports results for the four-variables system featuring a short rate and the logarithms of M1, the CPI, and industrial production. Based on the trace test, the null of no cointegration against the alternative of one or more cointegration vectors is very strongly rejected, with a p-value of 0.

[9] The rationale for bootstrapping critical and p-values for Johansen's tests was provided by Johansen (2002) himself, who showed how, in small samples, trace and maximum eigenvalue tests based on asymptotic critical values typically tend to perform poorly.

[10] This means that for tests of the null of no cointegration against the alternative of one or more cointegrating vectors the model which is being bootstrapped is a simple, non-cointegrated VAR in differences. For the maximum eigenvalue tests of h versus $h+1$ cointegrating vectors, on the other hand, the model which ought to be bootstrapped is the VECM estimated under the null of h cointegrating vectors.

[11] We consider the maximum between the lag orders chosen by the SIC and HQ criteria because the risk associated with selecting a lag order smaller than the true one (model mis-specification) is more serious than the one resulting from choosing a lag order greater than the true one (over-fitting).

[12] On the other hand, we do not consider the Akaike Information Criterion since, as discussed (e.g.) by Luetkepohl (1991), for systems featuring I(1) series the AIC is an inconsistent lag selection criterion, in the sense of not choosing the correct lag order asymptotically.

Table 2*a* United States, January 1919-December 1960: Results from Johansen's cointegration tests for alternative systems[a]

	Trace tests of the null of no cointegration against the alternative of h or more cointegrating vectors:			
	$h = 1$	$h = 2$	$h = 3$	$h = 4$
Baseline 10-variables system	463.621 (0.000)	311.890 (0.000)	213.786 (0.000)	131.868 (0.000)
New York FED discount rate and M1 multiplier	13.427 (0.199)			
New York FED discount rate and multiplier of M2-M1	31.223 (8.0e-4)			
New York FED discount rate and high-grade bond rate	19.708 (0.033)			
Log industrial production, log M_1, New York FED discount rate, and log CPI	75.518 (0.000)	33.588 (0.003)		
	Maximum eigenvalue tests of h versus h+1 cointegrating vectors:			
	0 versus 1	*1 versus 2*	*2 versus 3*	*3 versus 4*
Baseline 10-variables system	151.731 (0.000)	98.104 (0.000)	81.918 (0.000)	45.919 (0.216)
New York FED discount rate and M1 multiplier	12.524 (0.121)			
New York FED discount rate and multiplier of M2-M1	30.237 (1.0e-4)			
New York FED discount rate and high-grade bond rate	17.088 (0.027)			
Log industrial production, log M_1, New York FED discount rate, and log CPI	41.931 (0.002)	19.365 (0.159)		

[a] Bootstrapped p-values (in parentheses) are based on 10,000 bootstrap replications, based on Cavaliere *et al.*'s (2012) methodology.

Table 2*b* United States, 1959Q1-2008Q3: Results from Johansen's cointegration tests for alternative systems[a]

	Trace tests of the null of no cointegration against the alternative of h or more cointegrating vectors:			
	h = 1	*h = 2*	*h = 3*	*h = 4*
Baseline 10-variables system	360.293 (0.000)	268.117 (0.000)	198.429 (0.000)	147.754 (0.000)
Federal Funds rate and multiplier of M_2-M_1	25.307 (0.010)			
Federal Funds rate and 5-year Treasury bill rate	29.036 (0.001)			
Federal Funds rate and M_1 velocity	21.703 (0.031)			
Federal Funds rate and inflation	16.051 (0.117)			
Logarithms of $(1+k)$, $(r+k)$, and M_1 *per capita*	30.152 (0.097)			
Log real GDP *per capita* and log real consumption *per capita*	22.480 (0.009)			
	Maximum eigenvalue tests of h versus h+1 cointegrating vectors:			
	0 versus 1	*1 versus 2*	*2 versus 3*	*3 versus 4*
Baseline 10-variables system	92.176 (0.003)	69.687 (0.067)	50.675 (0.399)	—
Federal Funds rate and multiplier of M_2-M_1	23.086 (0.008)			
Federal Funds rate and 5-year Treasury bill rate	26.232 (0.001)			
Federal Funds rate and M_1 velocity	18.156 (0.032)			
Federal Funds rate and inflation	9.665 (0.325)			
Logarithms of $(1+k)$, $(r+k)$, and M_1 *per capita*	23.185 (0.047)			
Log real GDP *per capita* and log real consumption *per capita*	21.937 (0.005)			

[a] Bootstrapped p-values (in parentheses) are based on 10,000 bootstrap replications, based on Cavaliere *et al.*'s (2012) methodology.

The maximum eigenvalue test of one *versus* two cointegration vectors, on the other hand, does not reject the null, leading us to conclude that, in line with what we would expect *ex ante* based on economic theory, the system features one, and only one cointegration relationship, i.e., the long-run demand for M1.

(*ii*) Again, as we would expect based on theory, in either period short- and long-term nominal rates are cointegrated.

(*iii*) The same holds, in the latter period, for real GDP and consumption *per capita*.

(*iv*) Interestingly, for both periods we detect very strong evidence of cointegration between the multiplier of M2-M1 and the short-term rate. This provides statistical support to the visual impression from Figure 1 of a very strong relationship between the two series in either period. As previously discussed, the natural explanation for this pattern has to do with the permanent portfolio shifts out of (mostly) non interest-bearing M1, and into interest-bearing M2-M1, caused by permanent shocks to nominal interest rates, whatever their origin.

(*v*) In the period 1959Q1-2008Q3 inflation and the short rate have not been cointegrated. In line with King, Plosser, Stock, and Watson (1991), this suggests that, beyond permanent inflation shocks, the unit root component of nominal interest rates has also been driven by permanent shocks to the real interest rate. In what follows we do not report results for this shock because it explains uniformly minor fractions of forecast error variance for all series[13]—including the Federal Funds rate—so that the only role it plays is to introduce a 'wedge' between inflation and the Funds rate, thus preventing cointegration between the two series.

(*vi*) In line with the finding (reported in Table 1*b*) that in the period 1959Q1-2008Q3 the monetary base has been trend-stationary, we detect one cointegration vector in the trivariate system featuring the logarithms of $(1+k)$, $(r+k)$, and M1 *per capita*. Consequently, in Section 5 we will exclude the monetary base from the cointegrated system for this period.

(*vii*) Finally, turning to the 10-variables systems, we detect three cointegration vectors for the period January 1919-December 1960, and two for the period 1959Q1-2008Q3. The results for the former period are in line with those from the previously discussed tests for smaller sub-systems, which point towards cointegration between the short and the long rate; between the short rate and the multiplier of M2-M1; and between the short rate and the logarithms of M1, the CPI, and industrial production. As for the latter period, on the other hand, results based on smaller systems strongly point towards (at least) *four* cointegration relationships.[14] Before proceeding further, it is therefore necessary to address two questions: First, why might results based on the larger, and on several smaller systems produce contrasting results? And second, which of the two sets of results should be regarded as the more reliable? As for the

[13] These results are available upon request.

[14] Since M1 *per capita* does not enter the 10-variables system, cointegration between the logarithms of $(1+k)$, $(r+k)$, and M1 *per capita* is irrelevant here.

first question, a natural explanation is the small-sample problem plaguing Johansen's tests documented *via* Monte Carlo simulations by Benati (2017). In a nutshell, Benati (2017) shows that, in small-samples, the ability of Johansen's tests to detect a cointegration relationship significantly deteriorates under two empirically plausible circumstances: (a) when, in addition to a cointegration relationship, a system features one or more 'nuisance' series—i.e., series driven by permanent shocks *different* from those driving the cointegration relationship; and (b) when a system features *multiple* cointegration relationships driven by *different* permanent shocks, as implied (e.g.) by the Classical Dichotomy (this being a special case of (a)). Basic economic logic—not to mention standard economic theory—suggests that (b) is the relevant case here. In particular, under standard assumptions, the shocks driving cointegration between consumption and GDP *per capita* (essentially, neutral and investment-specific technology shocks, and shocks to labor force participation) should be orthogonal to *at least some* of the shocks driving the nominal side of the economy. Since Benati's (2017) Monte Carlo evidence shows that the addition of a *single* 'nuisance' series to a cointegration relationship causes a dramatic deterioration of the ability of Johansen's tests to detect cointegration, the contrast between the results produced by the larger, and by several smaller systems, should not be regarded as a puzzle, but should rather be expected. Further, the previous discussion suggests that, under these circumstances, the results produced by the larger system should be discounted. In particular, within the present context *three* cointegration relationships should be regarded as very highly likely:

(1) between GDP and consumption *per capita*—see, first and foremost, Cochrane (1994);

(2) between M1 velocity and the short-term rate—see in particular BLNW (2017); and

(3) between short and long rates—cointegration between nominal interest rates corresponding to different maturities is one of the most robust stylized facts in the entire field of empirical macroeconomics.

It is also important to stress that it can be trivially shown that, given an N-variables I(1) system, a cointegration relationships pertaining to a K-dimensional sub-system, with $K<N$, still exists in the larger N-variables system.[15] This implies that neither of the cointegration relationships (1)-(3)—assuming that they are truly there—can possibly 'disappear' within the 10-dimensional system.

Summing up, in what follows we will therefore proceed under the assumption that either of the 10-variables systems we use for the two sub-periods features three cointegration vectors. For the second sub-sample we will also consider, for reasons of robustness, systems with either two or four cointegration vectors. Considering two

[15] The proof is straightforward: You just take the cointegration vector pertaining to the K variables, and you augment it with N-K zeros, i.e. one zero for each of the variables excluded from the cointegration relationship. By construction, the resulting vector is indeed a cointegration vector for the larger N-variables system.

cointegration vectors is motivated by the previously discussed failure of the maximum eigenvalue test to reject the null hypothesis of two versus three cointegration vectors. Considering four, on the other hand, is motivated by (i) the results from the trace test for the 10-variables system reported in Table $2b$, and (ii) the strong evidence of cointegration between the Federal Funds rate and the multiplier of M2-M1 reported in the same table. As we discuss in Section 5.2.3, the results (which are reported in Figures A.1-A.10 in the appendix), are mostly in line with those produced by the our preferred system.

We now turn to an analysis based on cointegrated structural VARs.

5 Evidence from Cointegrated Structural VARs

5.1 The period January 1919-December 1960

We estimate the 10-variables system based on Johansen's estimator of the VECM as detailed in Hamilton (1994), imposing, in estimation, three cointegration vectors. We then identify five shocks by imposing the following restrictions on the matrix of the shocks' long-run impacts.

5.1.1 Identification

(1) We start by identifying a permanent shock to industrial production (ϵ_t^{IP}), by imposing the standard restriction that it is the only shock affecting the series in the infinite long run. Implicit in this restriction is the assumption—essentially, a formulation of the Classical Dicothomy within the present context—that nominal disturbances (in particular, monetary shocks) have no permanent impact on real activity. We regard this assumption as essentially uncontroversial. It has to be stressed, however, that empirical evidence on this issue is quite surprisingly limited, and uniformly weak.[16]

(2) Conditional on having identified ϵ_t^{IP}, we then identify four monetary shocks—a permanent shock to k (ϵ_t^k); a permanent shock to r (ϵ_t^r); a residual permanent shock to the monetary base ($\epsilon_t^{M_0}$); and a residual permanent shock to the multiplier of M2-M1 ($\epsilon_t^{M_2-M_1}$)—by imposing the following restrictions:

(i) ϵ_t^k is the only shock, beyond ϵ_t^{IP}, which is allowed to have a permanent impact on $\ln(1+k)$. Since, as we will discuss, the impact of ϵ_t^{IP} on $\ln(1+k)$ is not statistically significant an any horizon, this implies that, in fact, ϵ_t^k is the only shock driving the permanent component of k.

(ii) By the same token, we then identify ϵ_t^r as the only other shock, beyond ϵ_t^{IP} and ϵ_t^k, which is allowed to have a permanen impact on $\ln(r+k)$. Again, since the impact of ϵ_t^{IP} on $\ln(r+k)$ is not statistically significant an any horizon, this implies

[16] Benati (2015) provides evidence compatible with the Classical Dichotomy. As he stresses, however, the extent of uncertainty is uniformly substantial, so that, strictly based on empirical evidence, it is not possible to make strong statements on this issue.

that, in fact, ϵ_t^k and ϵ_t^r are the only two shocks driving the permanent component of $\ln(r+k)$. In turn, this implies that since ϵ_t^k had been previously identified in step (i), ϵ_t^r is also identified.

(iii) It is to be noticed that we are here allowing both ϵ_t^k and ϵ_t^r to have a permanent impact on the monetary base. The rationale for this is that, in the face of contractionary shocks to either k or r—and therefore contractionary shocks to the M1 multiplier—it can be reasonably expected that the Fed might try to counteract the recessionary impact on the economy by expanding the monetary base. Indeed, Friedman and Schwartz (1963, p. 192) note that the Federal Reserve Act was intended specifically to accomplish this goal:

> The Federal Reserve System was created by men whose outlook on the goals of central banking was shaped by their experience of money panics during the national banking era. The basic monetary problem seemed to them to be banking crises produced by or resulting in an attempted shift by the public from deposits to currency. In order to prevent such shifts from producing either widespread bank failures or the restriction of cash payments by banks, some means were required for converting deposits into currency without a reduction in the total of the two. This in turn required the existence of some form of currency—to be provided by the Federal Reserve note—and some means of enabling banks to convert their assets readily into such currency—to be the role of discounting.

At the same time, we also want to allow for autonomous variation in M0. The rationale for this is not only the strict conceptual one about the sheer implausibility that the monetary base might have exhibited no random, autonomous permanent variation over the sample period. Rather, the *MHUS* extensively discusses several instances in which, during those years, the base was affected by manifestly exogenous disturbances unrelated to variation in k and r.[17] The starkest example is provided by the large gold inflows, mainly from Britain, during the period of U.S. neutrality from September 1939 through November 1941, which as discussed by Friedman and Schwartz (1963, p. 551) led to a cumulative 29 percent increase in both the monetary base and broader monetary aggregates and a coincident 23 increase in the wholesale price level, translating into an inflation rate of 9 percent per year.

(iv) Finally, we identify $\epsilon_t^{M_2-M_1}$ by imposing the restriction that it is the only other shock which is allowed to have a permanent impact on the multiplier of M2-M1. As we will see, this shock played a uniformly negligible role across the board.

[17] Note, again, the similarity between Friedman and Schwartz's (1963) attempt to isolate these exogenous movements in the base through careful consideration of historical events and more contemporary approaches to econometric identification of structural shocks.

5.1.2 Characterizing the extent of uncertainty around the estimated objects

We characterize uncertainty around all of the estimated objects of interest—impulse-response functions (IRFs), fractions of forecast error variance (FEVs), and counterfactual paths obtained by killing off the shocks—by bootstrapping the estimated reduced-form cointegrated VAR as in CRT (2012), and imposing upon the bootstrapped data the same identifying restrictions we impose upon the actual data.

We now turn to discussing the evidence.

5.1.3 Evidence

Figures 5 and 6 show the IRFs to the structural shocks, and the fractions of FEV of individual series explained by either shock, together with the 16th, 84th, 5th, and 95th percentiles of the respective bootstrapped distributions, whereas Figures 7 and 8 show results from several counterfactual simulations in which we kill off either individual shocks, or, jointly, ϵ_t^k, ϵ_t^r, and $\epsilon_t^{M_0}$.

IRFs and fractions of FEV Permanent shocks to industrial production have a statistically insignificant impact on all other series at all horizons, with the single exception of department store sales, which can be thought of a proxy for consumption (in the same way as industrial production is a crude proxy for GDP). As for M0, although the point estimate of the long-run impact is positive—as we should expect—it is borderline insignificant at the one-standard deviation confidence level. It is to be noticed, however, that ϵ_t^{IP} explains a small fraction of the FEV of M0 (probably partly reflecting the imperfect approximation it provides to GDP) so that its impact on the base is necessarily imprecisely estimated.

ϵ_t^k and ϵ_t^r explain dominant fractions of the FEV of $\ln(1+k)$ and $\ln(r+k)$, respectively, thus providing reassurance that the two shocks have been precisely identified. On the other hand, they play a comparatively small role for other series, with the exception of department store sales and the CPI, for which ϵ_t^r plays a significant role, especially at horizons up to 5-6 years ahead (ϵ_t^k, on the other hand, plays a negligible role for either series at all horizons); the monetary base, for which both ϵ_t^r, and to a lesser extent ϵ_t^k, play sizeable roles, especially at long horizons; and the multiplier of M2-M1, which is largely driven by ϵ_t^r at all horizons. Finally, different from sales, neither shock is estimated to have played a sizeable role for industrial production.

ϵ_t^r leads to highly statistically significant temporary decreases in either industrial production, sales, or the CPI; to permanent decreases in both the New York FED's discount rate and the high grade bond rate, and therefore, consequently, in the multiplier of M2-M1; and to a permanent increase in the monetary base, as the FED tries to cushion the economy from the contractionary blow by expanding M0. By the same token, ϵ_t^k also leads to a permanent increase in the base, and to a permanent decrease

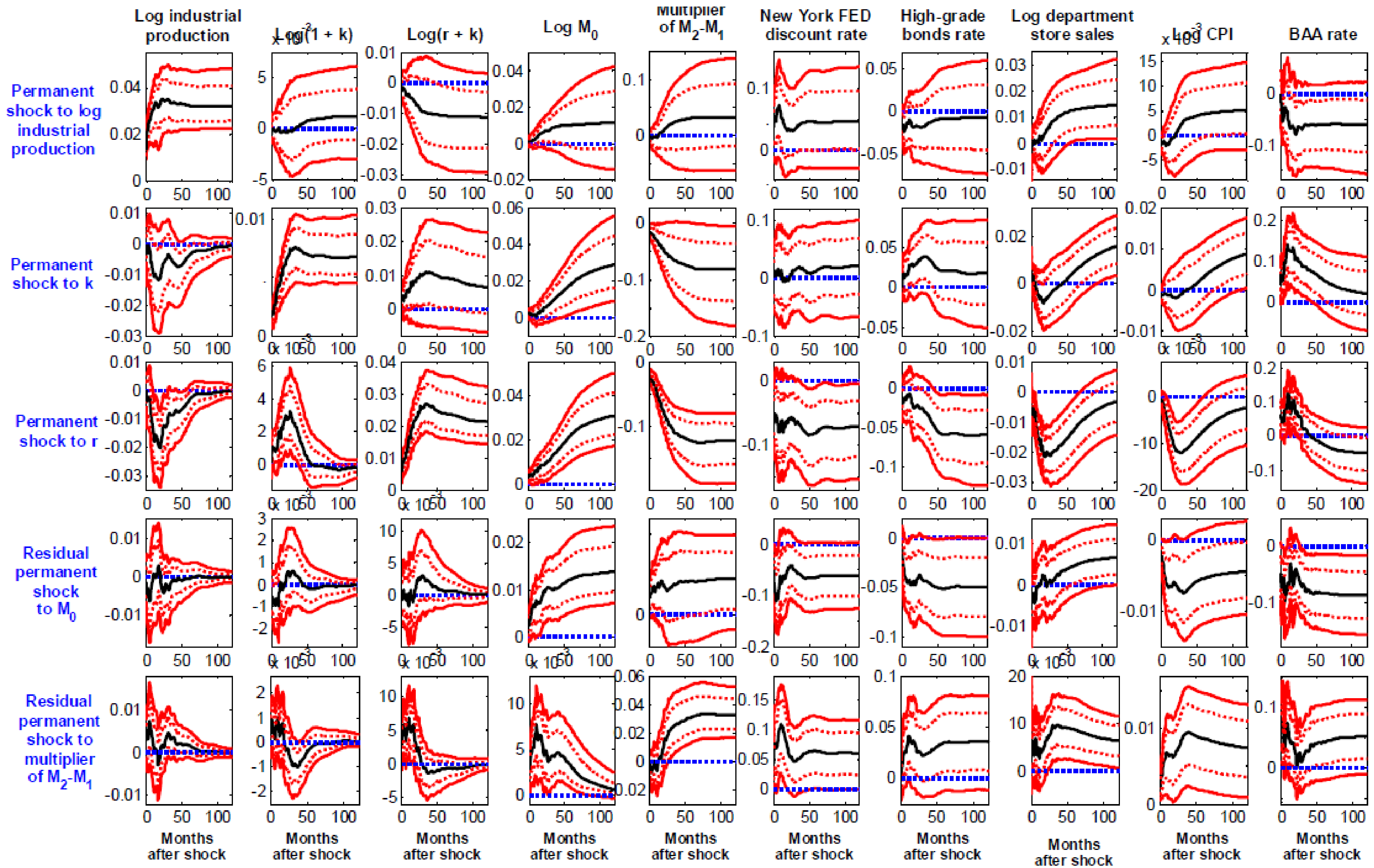

Figure 5 United States, January 1919-December 1960: Impulse-response functions to the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands

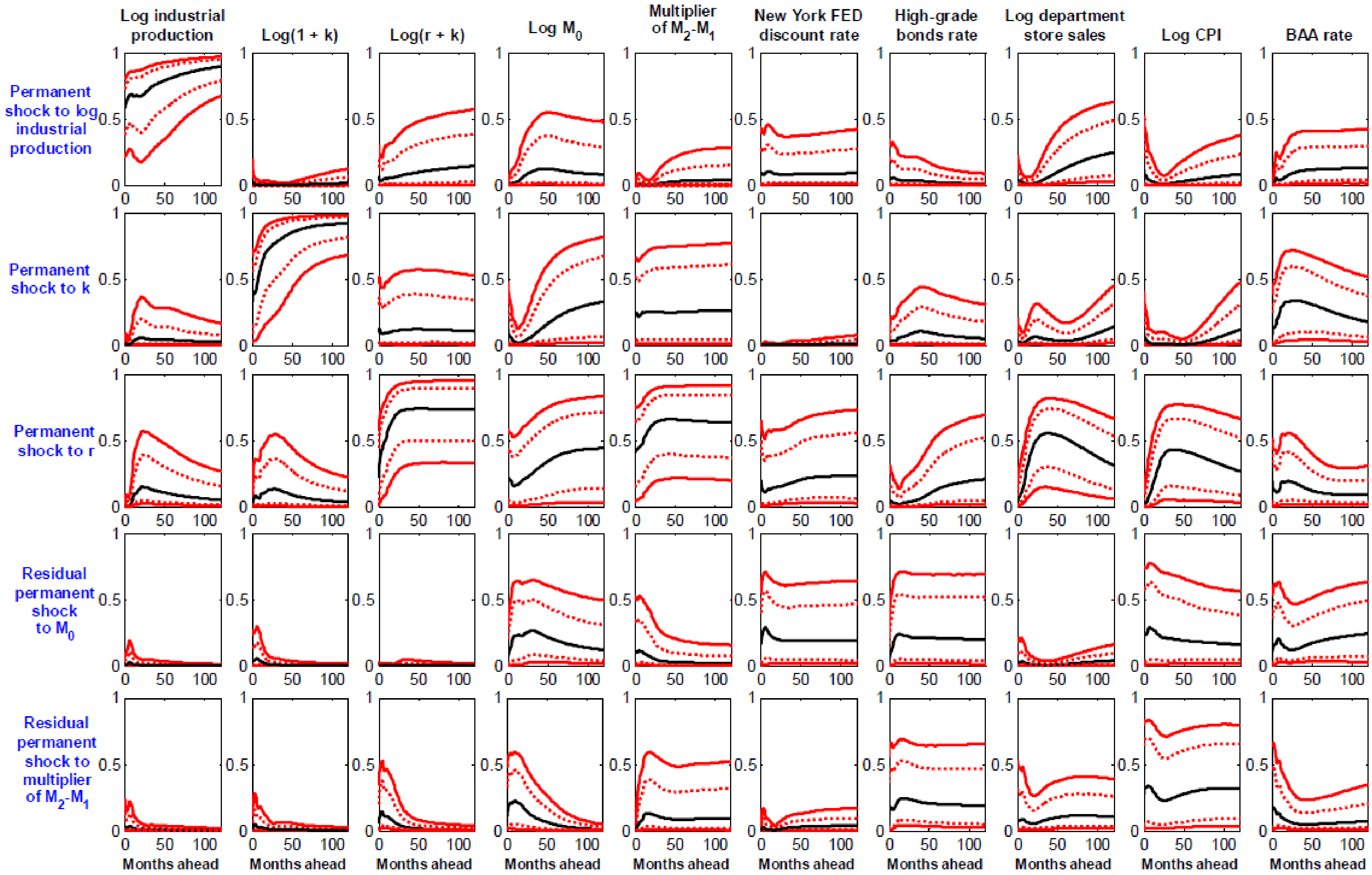

Figure 6 United States, January 1919-December 1960: Fractions of forecast error variance explained by either of the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands

in the multiplier of M2-M1, whereas its impact on interest rates is uniformly statistically insignificant. The contractionary impact on industrial production is barely significant at the one-standard deviation level for a few horizons, likely reflecting the fact that, since this shock explains little of industrial production's FEV, its impact is necessarily imprecisely estimated. The impacts on either sales or the CPI are insignificant at most horizons, but they turn positive and significant at long horizons (for the CPI the impact is borderline significant). Again, a possible explanation for these results is that since ϵ_t^k explains little of the variation of either series, correctly capturing its impact on them is problematic.

$\epsilon_t^{M_0}$ explains little of the variation of all series at all horizons, with the possible limited exception of the base, the CPI, and interest rates. The fractions of FEV for industrial production and sales, in particular, are uniformly negligible. Because of this, we should expect IRFs to be characterized by a widespread imprecision. Indeed, this is what the last row of Figure 5 shows: With the single exception of interest rates, for which the negative impacts are borderline significant, IRFs for all other series are uniformly statistically insignificant.

Finally, $\epsilon_t^{M_2-M_1}$ had played a uniformly negligible role for all series, with the possible exception of the CPI, of which, based on the point estimates, it explains between 25 and 30 per cent of the FEV at all horizons. Permanent shocks to the multiplier of M2-M1 cause, as one would expect, a statistically significant transitory increase in sales, whereas the point estimate of the impact on industrial production is positive, but the response is not statistically significant at any horizon. The impact on the CPI is, as expected, positive and statistically signficant at all horizons. The impact on interest rates is almost uniformly insignificant at all horizons. A partial exception is the New York FED discount rate, which exhibits a positive and statistically significant response at very short horizons, whereas it is borderline insignificant further out. Finally, the monetary base exhibits a positive, transitory, and strongly statistically significant increase. In the light of the transitory increase in sales documented in panel (5,8) of Figure 5, one possible interpretation of the increase in the monetary base is that FED is simply accomodating the associated increase in currency for transaction purposes: It is to be noticed that the transitory expansion is sales is not accompanied by a statistically significant fall in the currency/deposits ratio, which means that the transitory increase in purchases is associated with an increase in both currency and deposits for transaction purposes.

Counterfactual simulations The counterfactual simulations reported in Figure 7 point towards a uniformly negligible role played by ϵ_t^k, with the counterfactual paths obtained by killing off the shock being consistently not significantly different from the actual paths for all series. The obvious exception is $\ln(1+k)$, which, absent these shocks, would have been broadly flat over the entire period. ϵ_t^k also played some role for both M0 and the multiplier of M2-M1 during the years preceding Roosevelt's ascent, with the counterfactual paths for the two series being respectively higher and

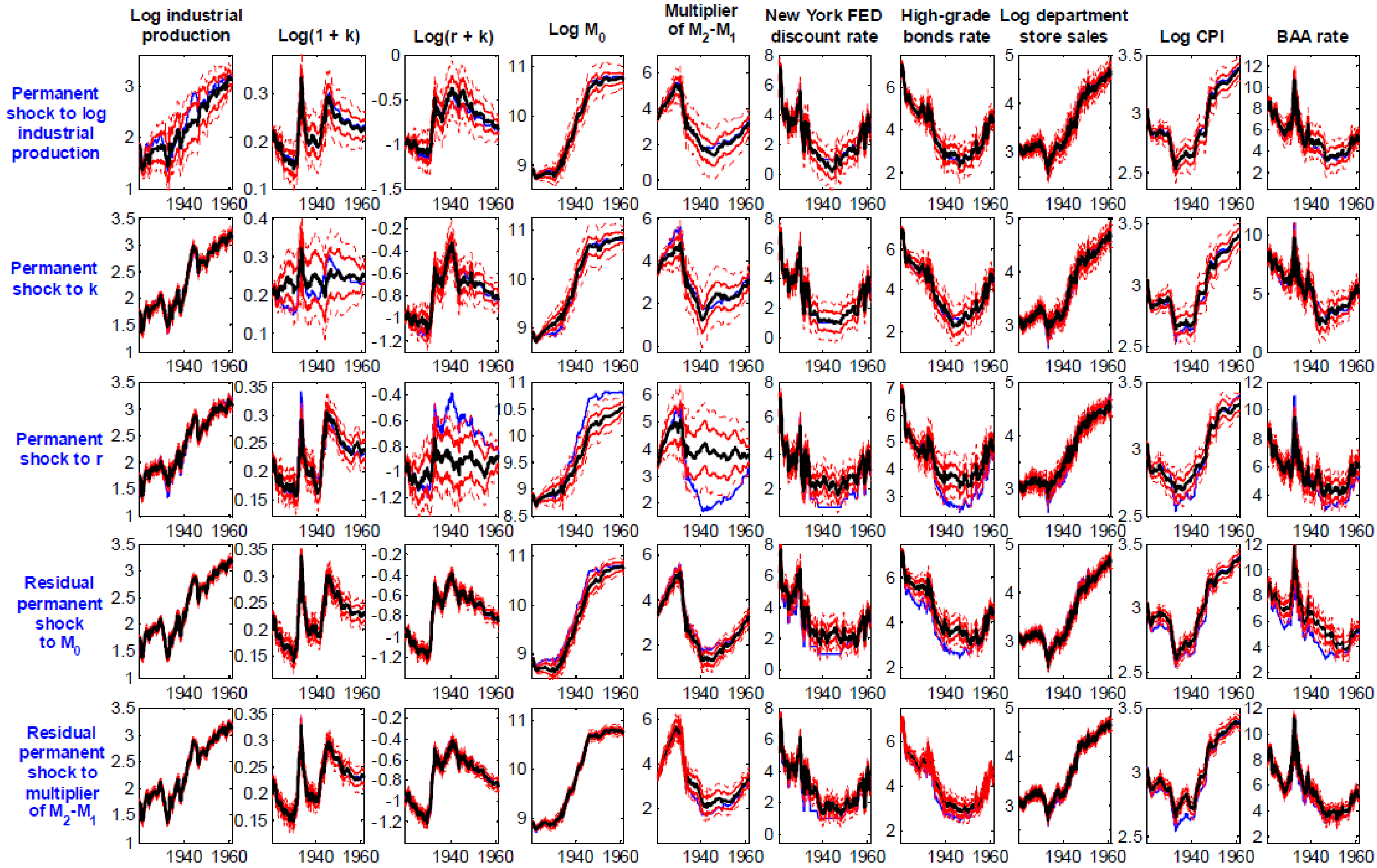

Figure 7 United States, January 1919-December 1960: Counterfactual simulations killing off the structural shocks, with 16-84 bootstrapped confidence bands

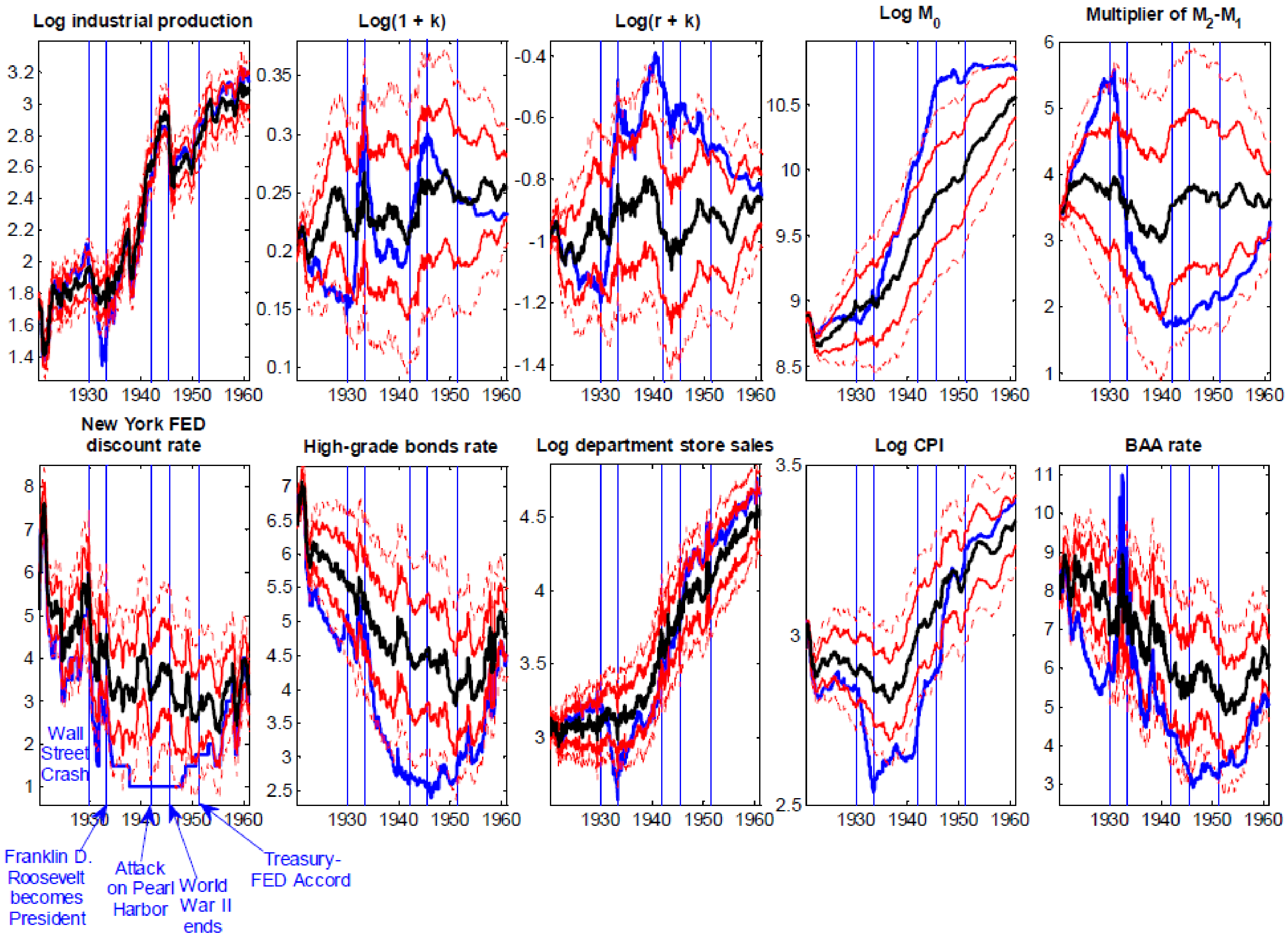

Figure 8 United States, January 1919-December 1960: Counterfactual simulations jointly killing off shocks to the currency/deposits and reserve/deposits ratios, and to the source base, with 16-84 bootstrapped confidence bands

lower than the actual ones (although the difference is never significant at the ten per cent level).

$\epsilon_t^{M_0}$ played an important role for the base itself—which, absent these shocks, would have been uniformly lower in the last part of the sample—and for nominal interest rates. In particular, the discount rate would have been uniformly higher, by about one percentage point, during most of the 1920s, and it would have been quite significantly higher, by about 1-2 percentage points, during the entire period between the Wall Street crash and the early 1950s. Evidence for both the BAA rate, and especially the high grade bond rate is even starker, with the counterfactual paths for both rates being uniformly higher than the actual, historical paths during most of the sample period, and most of the time by sizable amounts. This is especially the case for the second half of the 1920s, and for the period between Roosevelt's inauguration and the early 1950s.

These statistical findings are fully consistent with the narrative told in the *MHUS*. Friedman and Schwartz's (1963, p. 332) observe, for example, that changes in high-powered money alone would have produced a steady *rise* in the money supply, and presumably the aggregate price level itself over the four years from August 1929 through March 1933 that, instead, witnessed severe monetary and economic contraction. The tragic policy mistakes during this period manifest themselves, not so much in exogenous shocks to the monetary base but rather, the Fed's inability or unwillingness, following the death of New York Federal Reserve Bank President Benjamin Strong, to adjust the base *endogenously* that is, *in response to* larger and more fundamental shocks affecting the money multiplier.

Indeed, the second row of Figure 7 clearly highlights the important role played by disturbances to the reserves-to-deposits ratio during this sample period. Absent these shocks, $\ln(r+k)$ would have been broadly flat, since the early 1930s, and a significant portion of the dramatic increase following the Wall Street crash would have been avoided. By the same token, the discount rate would have been uniformly higher by about two percentage points during the entire period between Roosevelt's inauguration and the mid-1950s, and the same pattern holds to an even greater quantitative extent for the high grade bond rate. Interestingly, the difference between actual and counterfactual paths is significantly less marked for the BAA rate. The higher conterfactual path for nominal rates translates into a significantly higher counterfactual path for the multiplier of M2-M1 during the entire period since the early 1930s. The counterfactual path for the base would have been significantly lower during the entire period following Roosevelt's inauguration, reflecting the lack—absent ϵ_t^r—of the FED's endogenous response to these contractionary shocks. The counterfactual paths for industrial production and the CPI suggest that, absent ϵ_t^r, a significant portion of the recession and the deflation associated with the Great Depression would have been avoided. Finally, the last row of Figure 7 shows that, consistent with the last row of Figure 6, the only series whose counterfactual path would have been significantly different from the actual, historical one are the CPI, the New York FED discount rate, and the high-grade bond rate, all of which would have been, between the early 1930s and the end of the 1940s, higher than they have historically been, and by non-negligible amounts. The high-grade bond rate, in particular, would have been higher than the actual path by about 50 basis points over the entire 20-year period.

Figure 8 reports the counterfactual paths obtained by jointly killing off ϵ_t^k, ϵ_t^r and $\epsilon_t^{M_0}$. These counterfactuals aim at exploring what path the U.S. economy would have followed had disturbances to both the base, and the M1 multiplier, been absent. The evidence is quite dramatic, with the difference between counterfactual and actual paths often being, for most series, large and statistically significant. Absent these shocks, either $\ln(1+k)$, $\ln(r+k)$, or the multiplier of M2-M1 would have been broadly flat over the entire sample period; the monetary base would have been uniformly and significantly lower during the period following Roosevelt's inauguration; and interest rates would have been significantly higher over the entire sample period, often by sizeable amounts. This is especially the case for the high grade bond rate, which between Roosevelt's inauguration and the mid-1950s would have been higher by amounts sometimes in excess of 250 basis points. Crucially, the counterfactual paths for industrial production, and especially sales, clearly indicate that absent the historical combination of fundamental monetary shocks *the Great Depression would have in fact been avoided*. And the counterfactual path for the CPI clearly suggests that the deep deflation associated with the Depression would have also been avoided. All this is in line with Friedman and Schwartz's analysis in the *MHUS*; we find, as they do (pp. 300-301), that:

> The contraction is in fact a tragic testimonial to the importance of monetary forces. ...Prevention or moderation of the decline in the stock of money, let alone the substitution of monetary expansion, would have reduced the contraction's severity and almost as certainly its duration. The contraction might still have been relatively severe. But it is hardly conceivable that money income could have declined by over one-half and prices by over one-third and prices by over one-third in the course of four years if there had been no decline in the stock of money.

Also consistent with Friedman and Schwartz, we find a crucial role for shocks to the money multiplier and its components, the current-deposit and, especially in our analysis, the reserves-deposit ratio, in triggering the monetary forces behind the Great Depression. We now turn to the period 1959Q1-2009Q3.

5.2 The period 1959Q1-2008Q3

As for the former period, we estimate the 10-variables system based on Johansen's estimator of the VECM, imposing in estimation three cointegration vectors. We then identify six shocks by imposing the following restrictions on the matrix of the shocks' long-run impacts.

5.2.1 Identification, and characterization of the extent of uncertainty

(i) We start by identifying a permanent shock to hours *per capita* (ϵ_t^h), by imposing the restriction that it is the only shock affecting the series in the infinite long run.

(ii) Conditional on having identified ϵ_t^h, we then identify the permanent shock to GDP and consumption *per capita* (ϵ_t^y), by imposing the restriction that it is the only other shock affecting consumption *per capita* in the infinite long run. We focus on consumption, rather than GDP, in order to obtain a better identification of the shocks. This choice is motivated by the evidence reported, e.g., by Cochrane (1994), of consumption being, to a first approximation, the permanent component of GDP, which is an obvious time-series implication of the permanent income hypothesis under rational expectations as first outlined by Hall (1978).

(iii) Conditional on having identified ϵ_t^h and ϵ_t^y, we then identify ϵ_t^k and ϵ_t^r exactly as before. On the other hand, since M0 does not enter the VECM—because over this sample period it has been I(0)—we do not identify any residual permanent shock to the monetary base.

(iv) Conditional on having identified the first four shocks, we identify the residual shock to the multiplier of M2-M1, $\epsilon_t^{M_2-M_1}$, by imposing the restriction that it is the only other shock which is allowed to have a permanent impact on the series.

(v) Finally, following King, Plosser, Stock, and Watson (1991) we identify a residual permanent inflation shock (ϵ_t^π). A key rationale for identifying this shock is that, as the sixth column of Figure 10 shows, among the previously identified disturbances, only ϵ_t^k explains a non-negligible portion of the FEV of inflation. This implies that, in order to provide a better account of the dynamics of the permanent component of inflation, (at least) one more shock is required. Although King *et al.*'s (1991) permanent inflation shock is 'quasi-reduced-form' in nature—in the sense that it does not provide any clue about the ultimate source of such permanent variation in inflation—we regard it as sufficient for the present purposes. Since (i) as discussed, this sub-sample does not feature permanent shocks to the monetary base, and (ii) shocks to the multipliers of both M1 and M2-M1 have already been identified, a plausible interpretation of this shock is as a *non-monetary inflation shock*.[18] Under this respect, a plausible candidate is a shock to long-term inflation expectations associated with their progressive de-anchoring during the period up until the beginning of the Volcker disinflation, and their gradual re-anchoring during subsequent years.[19]

We characterize uncertainty around all estimated objects of interest as we did for the former period, by bootstrapping the estimated cointegrated VAR as in CRT (2012), and imposing upon the bootstrapped data the same identifying restrictions we impose upon the actual data.

We now turn to the evidence.

[18] We are here implicitly assuming that the non-M2 component of broader aggregates is, for practical purposes, essentially irrelevant for inflation dynamics.

[19] Evidence on the de-anchoring, and then re-anchoring of U.S. inflation expectations over the post-WWII period can be found, e.g., in Levin and Taylor (2010).

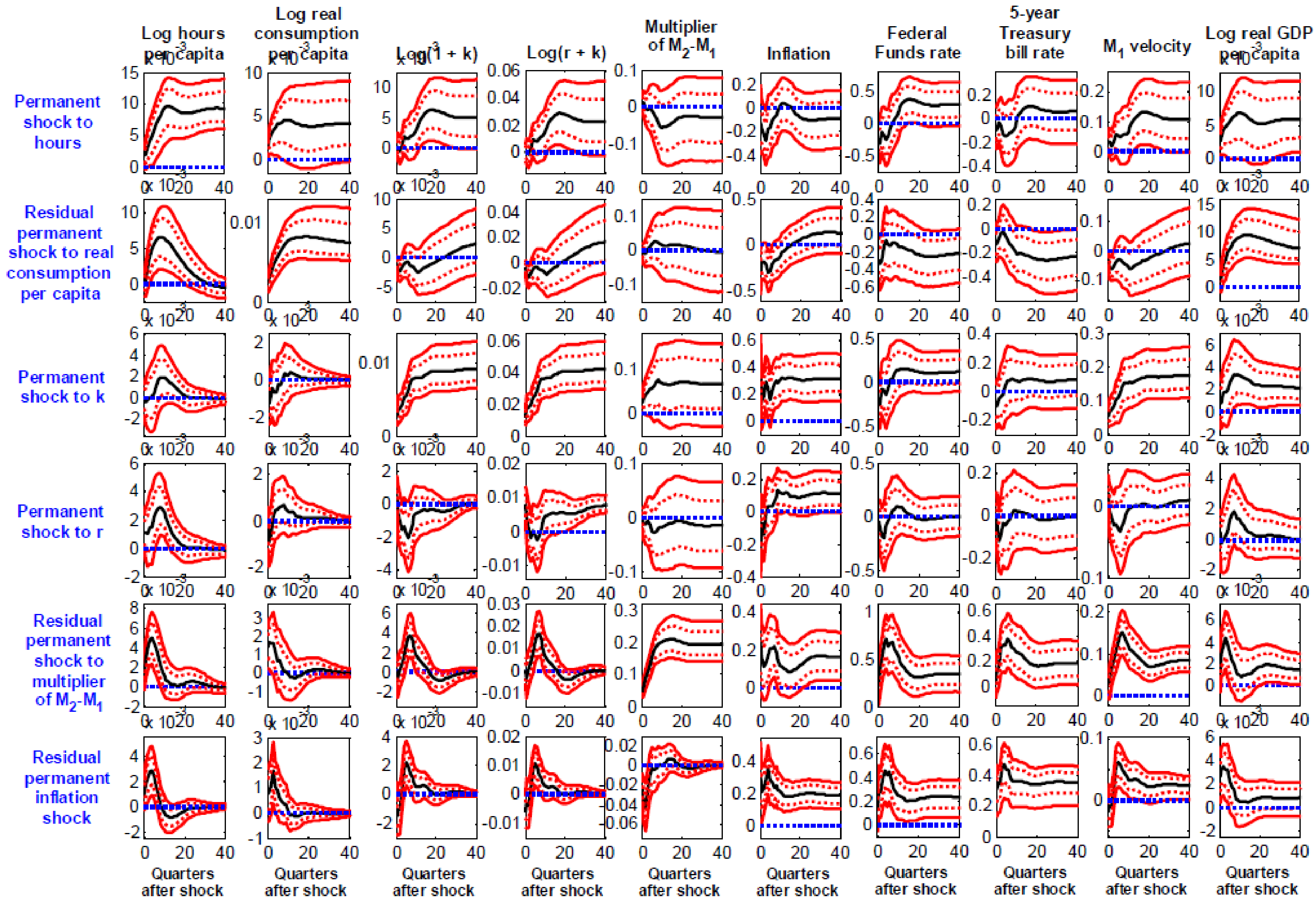

Figure 9 United States, 1959Q1-2008Q3: Impulse-response functions to the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands

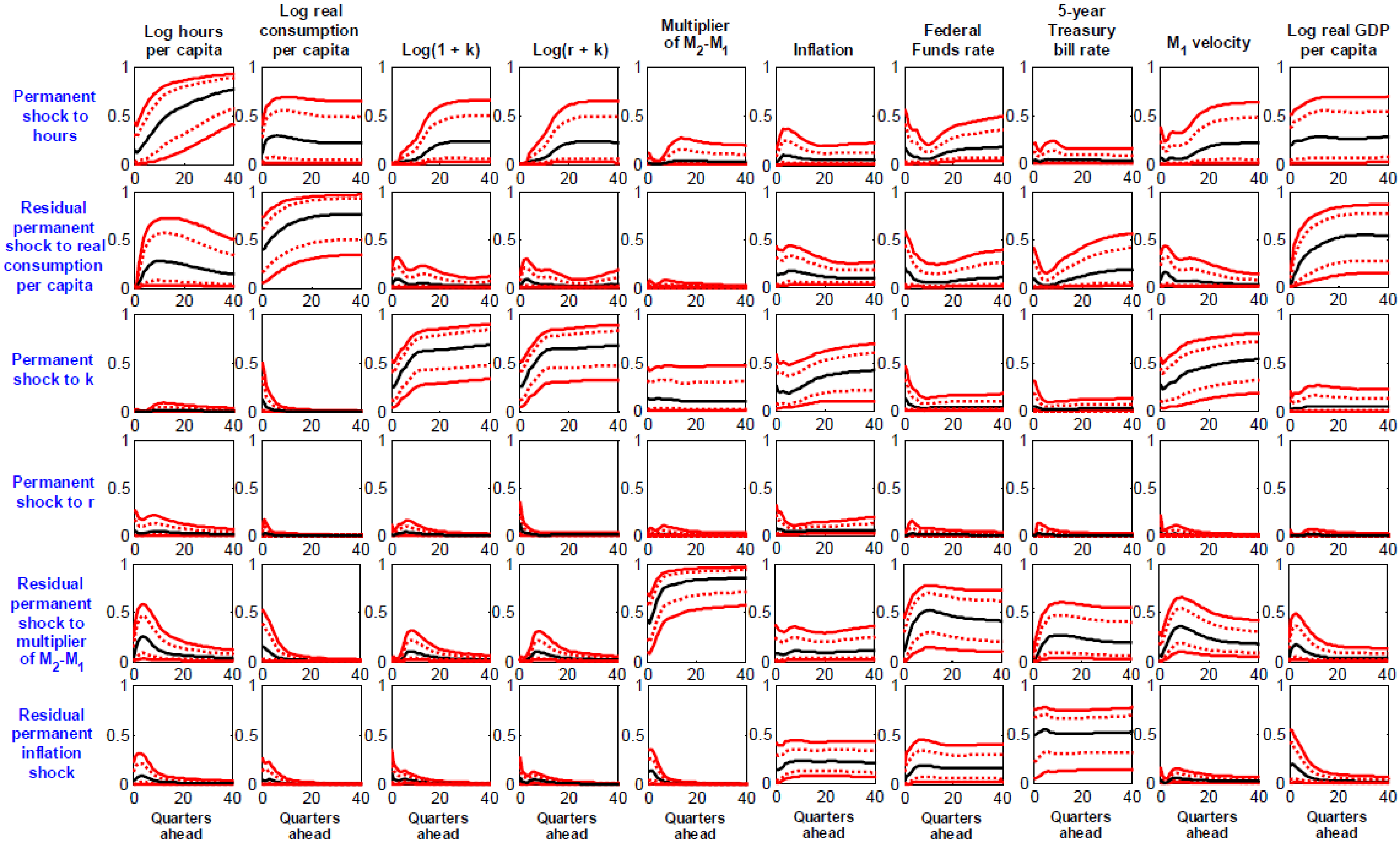

Figure 10 United States, 1959Q1-2008Q3: Fractions of forecast error variance explained by either of the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands

5.2.2 Evidence

Figures 9 and 10 show the IRFs to the five identified structural shocks, and the fractions of FEV of individual series explained by either shock, whereas Figures 11 to 13 show results from several counterfactual simulations in which we kill off either individual shocks, or, jointly, ϵ_t^k and ϵ_t^r.

IRFs and fractions of FEV Permanent shocks to hours explain the bulk of hours' fluctuations, especially at long horizons, but they are largely irrelevant for almost all other series. The notable exception are GDP and consumption, for which ϵ_t^h explain about one-fourth of the FEV at all horizons. As expected, a permanent shock to hours leads to permanent increases in both GDP and consumption (although for this latter variable the long-run impact is borderline insignificant).

Shocks to the reserves/deposits ratio are uniformly irrelevant for all series—including $\ln(r+k)$—at all horizons, with the fractions of explained FEV being consistently negligible. In the light of this, the fact that the response of hours to a positive innovation to ϵ_t^r is estimated to be, at short-horizons, *positive* and statistically significant should be put into perspective: Since ϵ_t^r explains essentially nothing of the variance of hours at any horizon, correctly capturing the impact in small samples is obviously difficult, and this result should therefore be quite heavily discounted.

Shocks to the currency/deposits ratio, on the other hand, played a non-negligible role not only for $\ln(1+k)$ and $\ln(r+k)$, but also for inflation and especially M1 velocity, explaining, at the 10-year horizon, about half of the FEV of either series. The response of GDP to ϵ_t^k is positive and statistically significant, although borderline, but, again, the fact that the fraction of explained FEV is essentially zero suggests that this result should be discounted. The same holds for hours and consumption, for which the response is insignificant at all horizons. The responses of inflation and M1 velocity—both positive, permanent, and highly statistically significant—are on the other hand problematic, because, as mentioned, ϵ_t^k explains sizeable fractions of the FEV of both series. For all other series, the responses are insignificant at all horizons.

Permanent shocks to consumption explain, as expected, the bulk of the fluctuations of consumption and GDP—in particular at the long horizons—but they are essentially irrelevant for all other series. Apart from consumption and GDP, their impact is uniformly insignificant at all horizons for all series, with the exception of hours and inflation at short horizons, and of the 5-year rate, for which the impact at long horizons is borderline insignificant. Again, in the light of the fact that these shocks explain essentially nothing of this series, this result should be discounted.

$\epsilon_t^{M_2-M_1}$ played a dominant role for the multiplier of M2-M1 and the Federal Funds rate, and a less important, but still non-negligible role for M1 velocity and the long rate. For all other series, on the other hand, the impact has been uniformly small-to-negligible. As the fifth row of Figure 9 shows, permanent shocks to the multiplier of M2-M1 cause permanent increases in inflation, the Federal Funds rate, M1 velocity and the 5-year rate, whereas the response of hours, consumption, and GDP is positive, and statistically significant at short horizons, and insignificant in the long-run (for GDP, the long-run impact is borderline insignificant).

Finally, the residual permanent inflation shock explains about one-fifth of the FEV of inflation and the Federal Funds rate, and about half of the FEV of the 5-year rate, at all horizons, whereas it plays a negligible role for all other series. The response to ϵ_t^{π} is, as expected, positive and permanent for the Federal Funds rate and the 5-year rate; it is borderline insignificant for M1 velocity; it is negative and statistically sigificant at the short horizons for the multiplier of M2-M1; and it is positive and statistically significant at the short horizons for hours, GDP, and consumption.

Counterfactual simulations The counterfactual simulations reported in Figure 11 point towards a uniformly negligible role played by either ϵ_t^y, ϵ_t^r, or ϵ_t^h for all series other than hours. Consistent with the evidence reported in Figure 10, on the other hand, killing off ϵ_t^k produces counterfactual paths which differ from the actual ones by non-negligible amounts for inflation, and especially M1 velocity. For all other series, on the other hand, the difference is negligible.

Figure 12 reports the conterfactual paths obtained by jointly killing off ϵ_t^k and ϵ_t^r. In sharp contrast to the evidence reported in Figure 8 for the former period, the impact is almost uniformly negligible: Beyond ln(1+k) and ln(r+k), the *only* other series for which the impact is not negligible is M1 velocity.

Figure 13 reports the conterfactual paths obtained by killing off $\epsilon_t^{M_2-M_1}$. Once again, the contrast with the corresponding counterfactual paths for the former period (reported in the last row of Figure 7) is, in several cases, very sharp. The counterfactual path for the multiplier of M2-M1, in particular, would have been essentially flat over the entire period, thus highlighting the dominant role played by shocks specific to this multiplier in driving its dynamics. The contrast with the evidence in panel (5,5) of Figure 7 is stark: During the former period, killing off $\epsilon_t^{M_2-M_1}$ would have not made a material difference for the path of the multiplier of M2-M1, thus reflecting the fact that, during those years, the multiplier was essentially reacting in a passive fashion to other developements in the economy. Equally sizeable is the impact for the Federal Funds rate, with the counterfactual path obtained by killing off $\epsilon_t^{M_2-M_1}$ being uniformly lower than the actual path over the entire period up to the mid-1990s, typically by about 5 percentage points or more. In particular, the impact is so large that, during two episodes in the 1970s, the counterfactual path even goes below zero.[20] Equally sizeable is the negative impact on M1 velocity, whereas the impact on the 5-year Treasury bill rate is less severe. Finally, and maybe surprisingly, the impact for inflation is clearly non-negligible—this is especially clear for the period between the mid-1980s and the end of the 1990s—but it is smaller than one might

[20]In principle, we could have avoided this undesirable feature of the counterfactual simulations in a number of different ways (e.g., by rescaling the shocks), but we have preferred to present the simple, non-manipulated results.

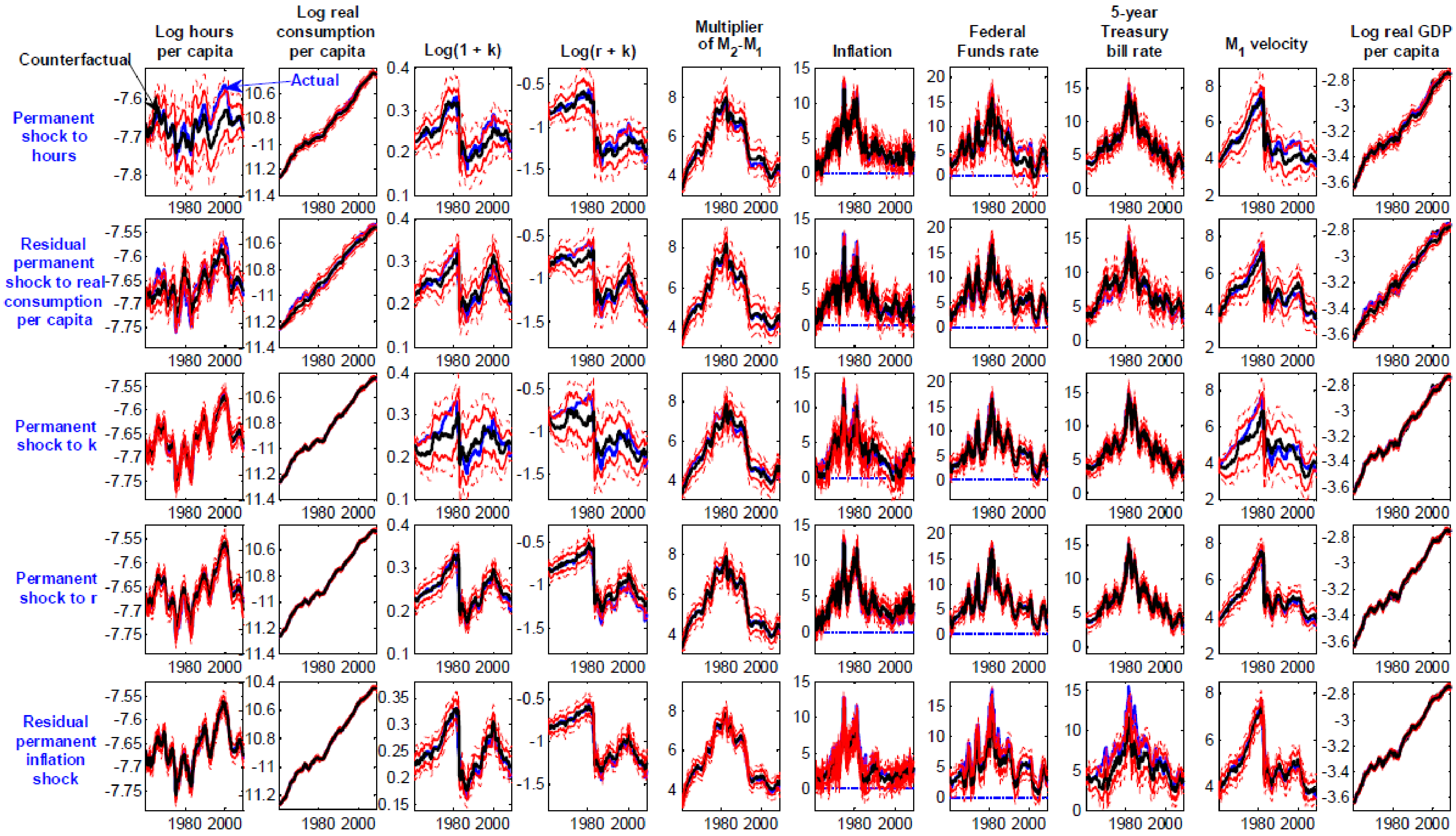

Figure 11 United States, 1959Q1-2008Q3: Counterfactual simulations killing off individual structural shocks, with 16-84 bootstrapped confidence bands

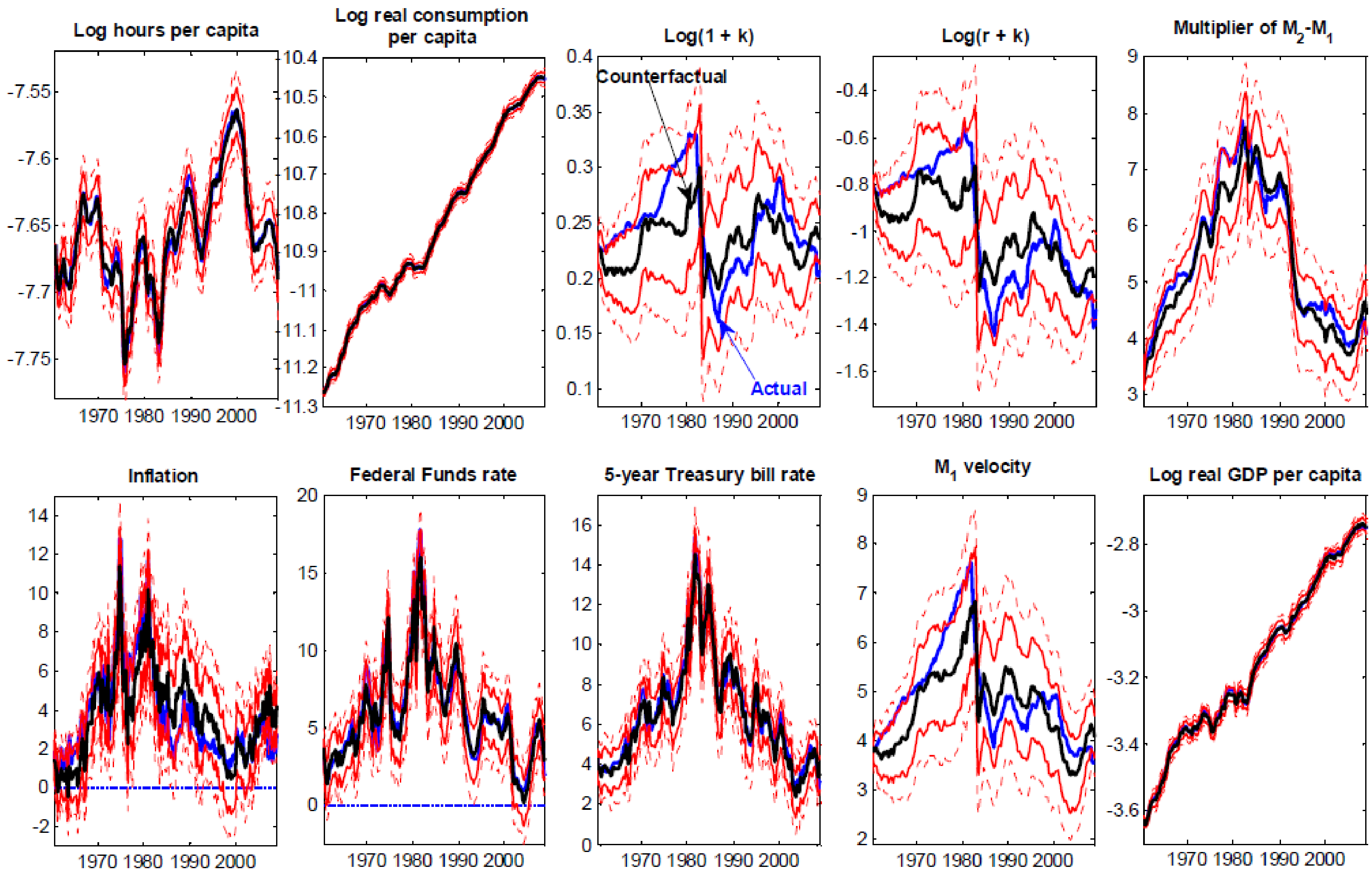

Figure 12 United States, 1959Q1-2008Q3: Counterfactual simulations jointly killing off the shocks to the M_1 multiplier, with 16-84 and 5-95 bootstrapped confidence bands

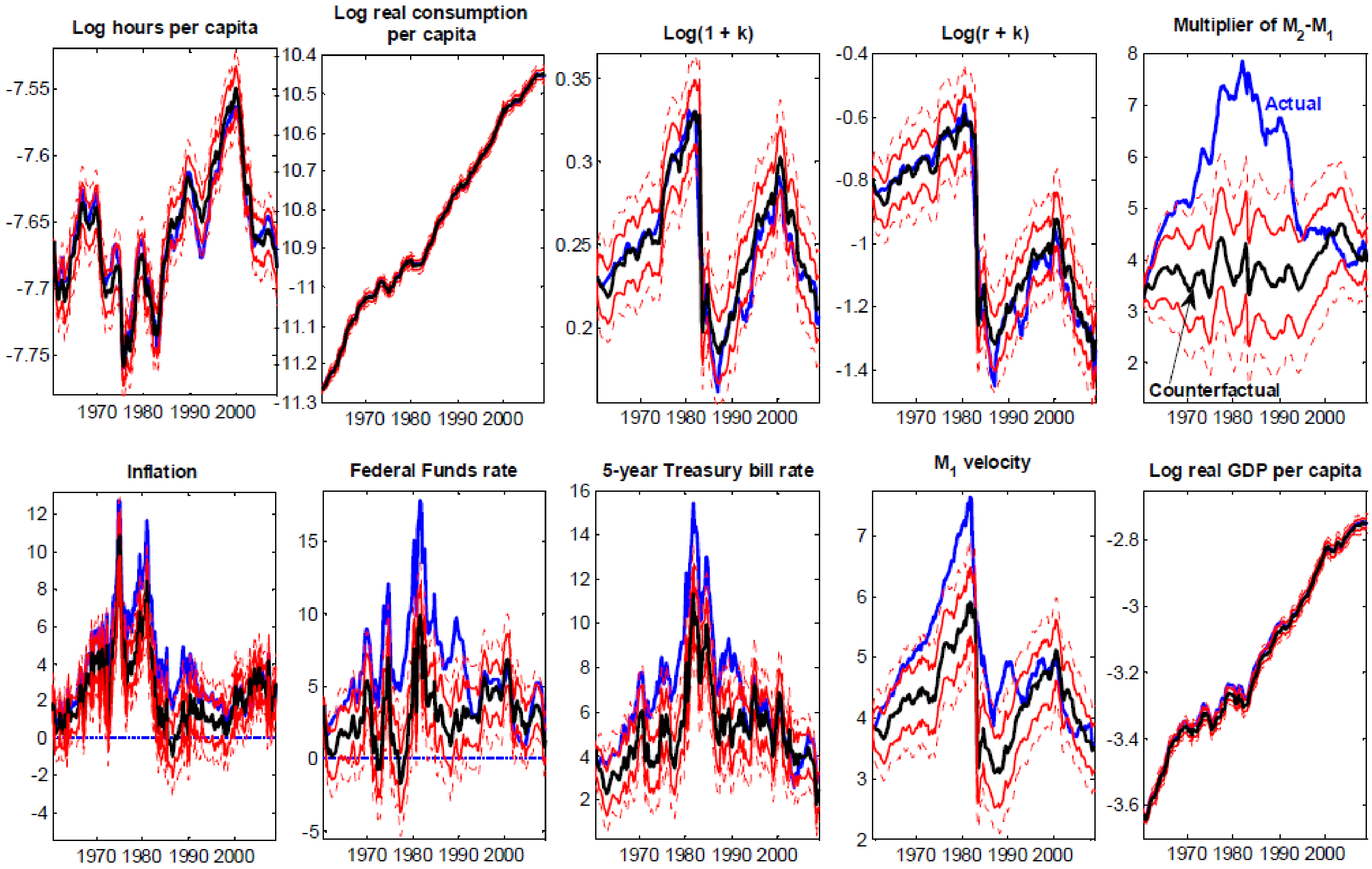

Figure 13 United States, 1959Q1-2008Q3: Counterfactual simulations jointly killing off the permanent shocks to the multiplier of M2-M1, with 16-84 and 5-95 bootstrapped confidence bands

have expected *ex ante*, in particular for the Great Inflation episode. As previously mentioned, this motivated our identification of a residual permanent inflation shock, which, as panel (6,6) of Figure 11 shows, explains about 20-25 per cent of the FEV of inflation at all horizons, and, once killed off—see panel (6,6) of Figure 11—produces a counterfactual path which is lower by a non-negligible amount.

5.2.3 Robustness to imposing either two or four cointegration vectors

Figures A.1-A.10 in the appendix report two alternative sets of results, which have been obtained by imposing either two or four cointegration vectors. Imposing two cointegration vectors produces several implausible results, e.g., statistically significant positive permanent impacts of the shock to hours on both the Federal Funds rate and the 5-year Treasury bill rate, and of the inflation shock on GDP. We interpret these results as providing validation to our choice of imposing three cointegration vectors: As discussed in Section 4.2, there are indeed very strong reasons for assuming that the system contains (at least) three cointegration vectors.

As for the system featuring four cointegration vectors, the only material difference compared to our preferred system pertains to the role played by the residual permanent inflation shock, whose role is essentially 'absorbed' by the shock to the multiplier of M2-M1: This is especially clear from a comparison of Figure A.7 with Figure 10. The main implication is that the bulk of the Great Inflation episode is now fully explained by monetary factors—i.e., shocks to the multiplier of M2-M1—with essentially no autonomous role for additional, permanent inflation shocks.

6 Conclusions

In this paper we have used cointegrated structural VARs in order to explore the dynamics of the money multiplier, focusing, in particular, on the role played by autonomous shifts in the currency/deposits and the reserves/deposits ratios, and in the multiplier of the non-M1 component of M2, in driving U.S. macroeconomic fluctuations. Shocks to the M1 multiplier—in particular, shocks to the reserves/deposits ratio—had played a key role in driving economic fluctuations during the interwar period, but their role in the post-WWII era has been almost uniformly negligible. The only exception are shocks to the currency/deposits ratio, which played a sizeable role for inflation and M1 velocity. By contrast, shocks to the multiplier of the non-M1 component of M2, which had been irrelevant in the interwar period, have played a significant role in driving the nominal side of the economy during the post-WWII period up to the collapse of Lehman Brothers, and in particular during the Great Inflation episode. During either period, the multiplier of M2-M1 has been cointegrated with the short rate. The monetary base had exhibited a non-negligible amount of permanent variation during the interwar period, whereas it has been trend-stationary during the post-WWII era. In spite of the dominant role played by shocks to the multiplier of

M2-M1 around the time the Great Inflation, we still detect a non-negligible role for a non-monetary permanent inflation shock, which has the natural interpretation of a disturbance originating from the de-anchoring of inflation expectations following the collapse of Bretton Woods.

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A The Data

A.1 Monthly series for the period January 1919-December 1960

Seasonally adjusted series for currency held by the public, demand deposits, bank reserves, and M2 are from Tables A.1 and A.2 of Friedman and Schwartz (1963). We compute high-powered (i.e., base) money as the sum of currency held by the public and bank reserves. A seasonally adjusted series for the industrial production index is from the Board of Governors of the Federal Reserve System. A seasonally adjusted series for the CPI has been constructed by linking the seasonally adjusted CPI series for all urban consumers, all items (acronym is CPIAUCSL) from the U.S. Department of Labor: Bureau of Labor Statistics, which is available since January 1947, to the CPI all items series (NBER series 04128 from NBER Historical database), which is, originally, seasonally unadjusted, and we seasonally adjusted *via* ARIMA X-12. A seasonally unadjusted series for the discount rate of the Federal Reserve Bank of New York is from the NBER Historical database (acronym is M13009USM156NNBR). The seasonally unadjusted series for Moody's seasoned Baa corporate bond yield is Moody's. A seasonally unadjusted series for the index of yields of high grade public utility bonds for United States is from the NBER Historical database (acronym is M13025USM156NNBR). A seasonally unadjusted series for department store sales is from the NBER Historical database (acronym is M06F2BUSM350NNBR), and it has been seasonally adjusted *via* ARIMA X-12.

A.2 Quarterly series for the period 1959Q1-2008Q3

A monthly seasonally adjusted M2 series is from the St. Louis FED's website (acronym is M2SL). Monthly seasonally unadjusted series for the Federal Funds rate and the 5-year Treasury bill rate are from the St. Louis FED's website (acronyms are FEDFUNDS and GS5). A monthly seasonally unadjusted series for the St. Louis Source Base (SBASENS) is from the St. Louis Fed's website. The series has been seasonally adjusted *via* ARIMA X-12 as implemented in EViews. A monthly seasonally unadjusted series for civilian non-institutional population (CNP16OV) is from the U.S. Department of Labor, Bureau of Labor Statistics. Monthly seasonally adjusted series for currency, demand deposits, and other checkable deposits (total) are from the Federal Reserve Board. The series for deposits we use in the paper has been constructed by summing up demand deposits, total other checkable deposits, and Money Market Deposits Accounts (MMDAs) discussed below. A monthly seasonally adjusted series for bank reserves has been computed as the difference between the source base and currency. All of the monthly series have been converted to the quarterly frequency by taking averages within the quarter.

A quarterly seasonally adjusted version of Lucas and Nicolini's (2015) M1 aggregate has been kindly provided by Juan-Pablo Nicolini. Specifically, the series is equal to M1SL from the St. Louis FED's website (converted to the quarterly frequency by taking averages within the quarter) until 1981Q4, and it is equal to M1SL plus MMDAs for the period 1982Q1-2012Q4. As discussed by LucasJr. and Nicolini (2015), the rationale for including MMDAs (which were introduced in 1982) into M1 is that, although they have traditionally been classified as part of the M2-M1 component, in fact, the economic function they perform is very similar to that performed by the bank deposits which are part of M1. Seasonally adjusted series for real and nominal GDP (GDPC96 and GDP, respectively) are from the U.S. Department of Commerce, Bureau of Economic Analysis. The seasonally adjusted series for real chain-weighted investment and real chain-weighted consumption of non-durables and services have been computed based on the data found in Tables 1.1.6, 1.1.6B, 1.1.6C, and 1.1.6D of the National Income and Product Accounts. Whereas real consumption pertains to non-durables and services, real investment has been computed by chain-weighting the relevant series pertaining to durable goods; private investment in structures, equipment, and residential investment; Federal national defense and non-defense gross investment; and State and local gross investment. A seasonally adjusted series for hours of all persons in the non-farm business sector (HOANBS) is from the US. Bureau of Labor Statistics. A seasonally adjusted chain-type price index series for the gross domestic product (GDPCTPI) is from the U.S. Department of Commerce: Bureau of Economic Analysis.

Appendix

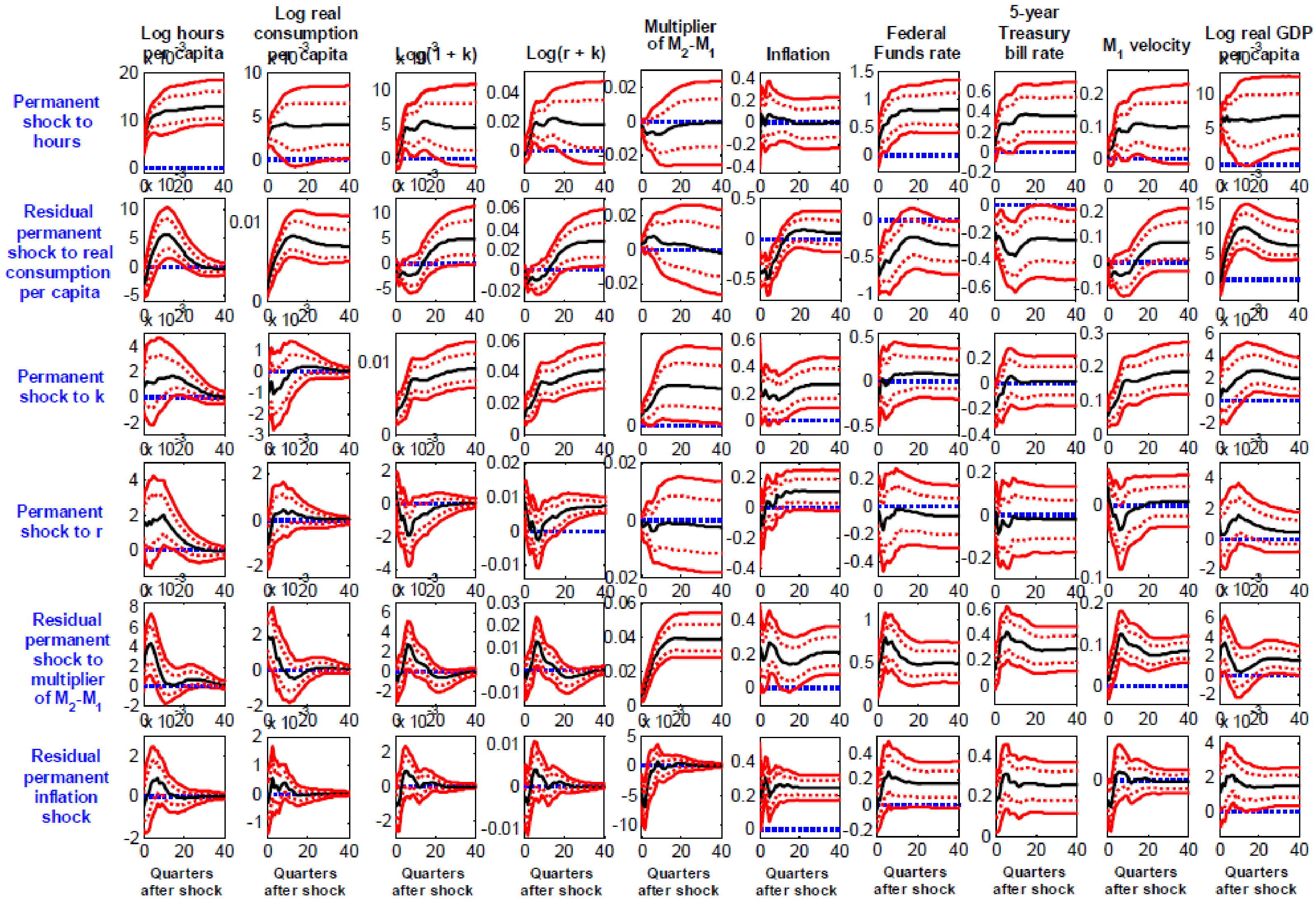

Figure A.1 United States, 1959Q1-2008Q3: Impulse-response functions to the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 2 cointegration vectors)

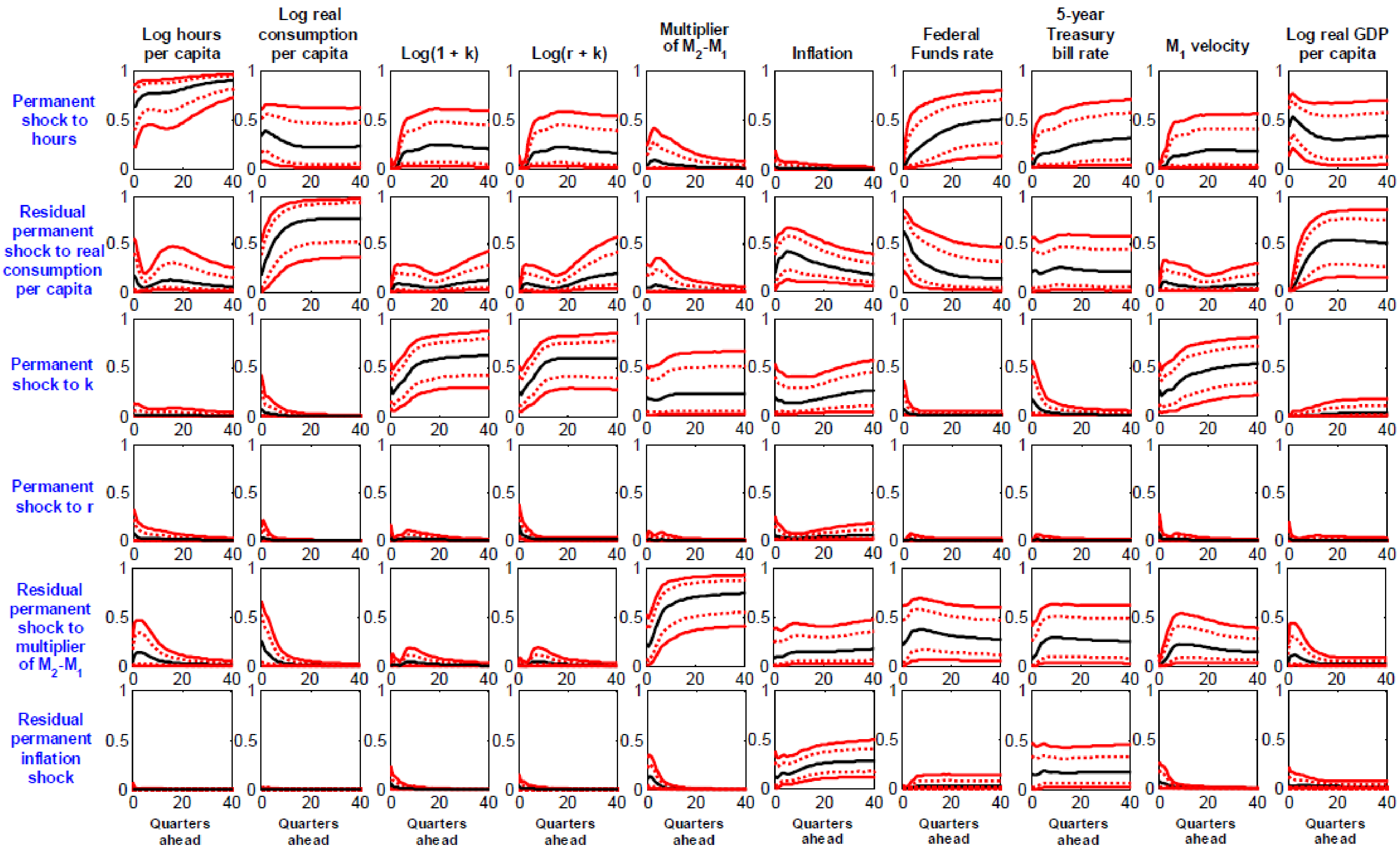

Figure A.2 United States, 1959Q1-2008Q3: Fractions of forecast error variance explained by either of the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 2 cointegration vectors)

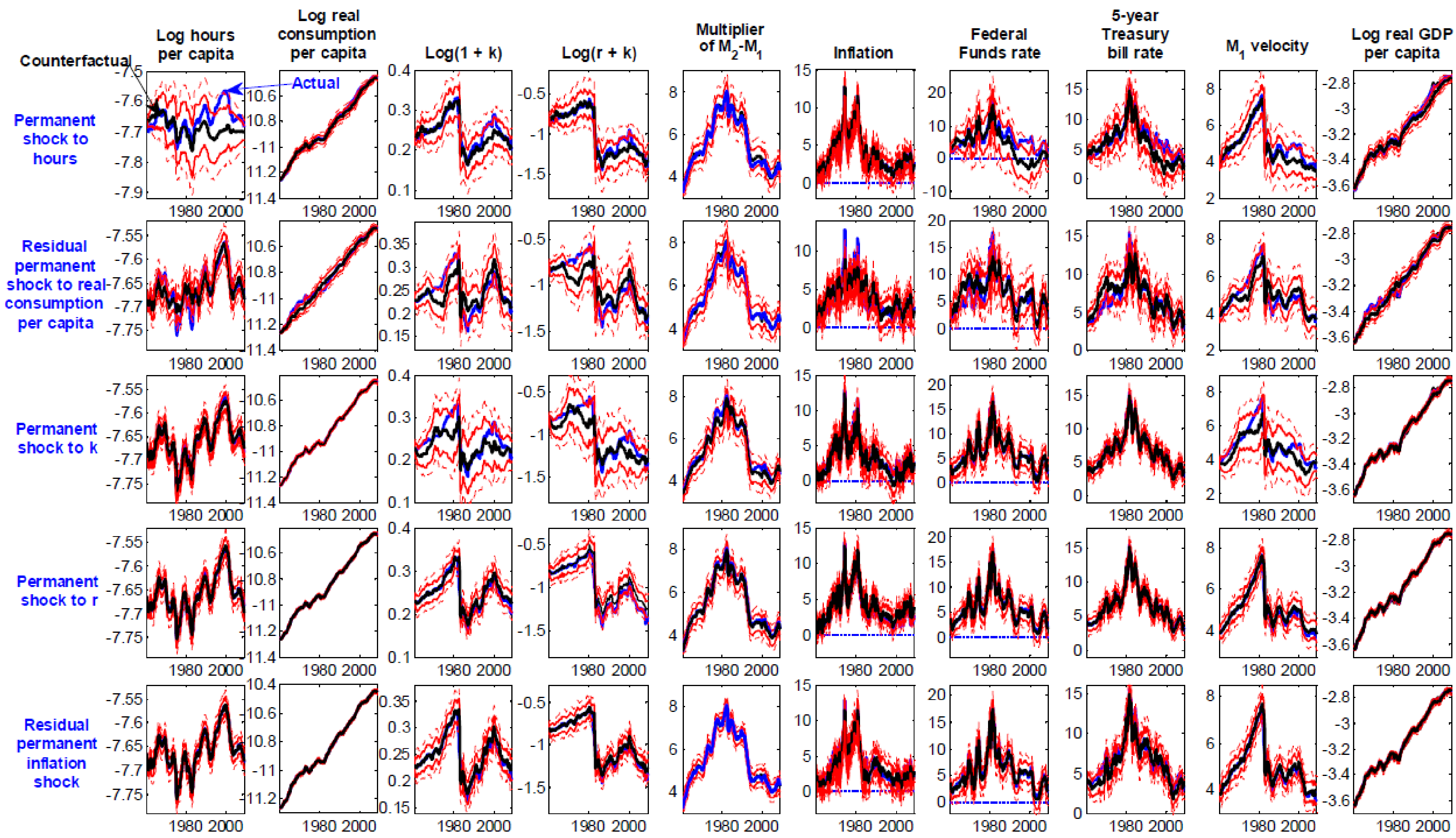

Figure A.3 United States, 1959Q1-2008Q3: Counterfactual simulations killing off the shocks to the M_1 multiplier, with 16-84 bootstrapped confidence bands (based on the model with 2 cointegration vectors)

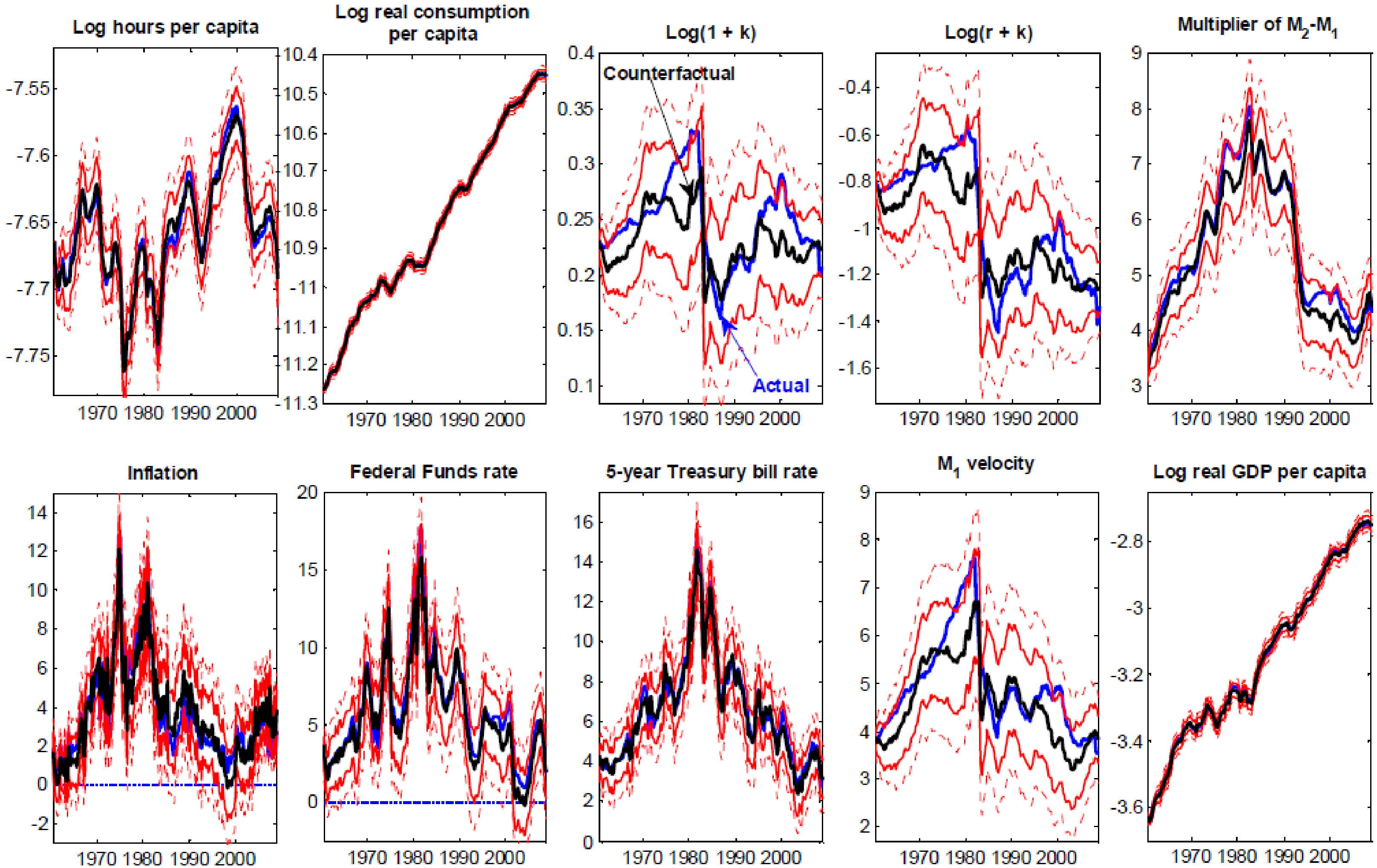

Figure A.4 United States, 1959Q1-2008Q3: Counterfactual simulations jointly killing off the shocks to the M_1 multiplier, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 2 cointegration vectors)

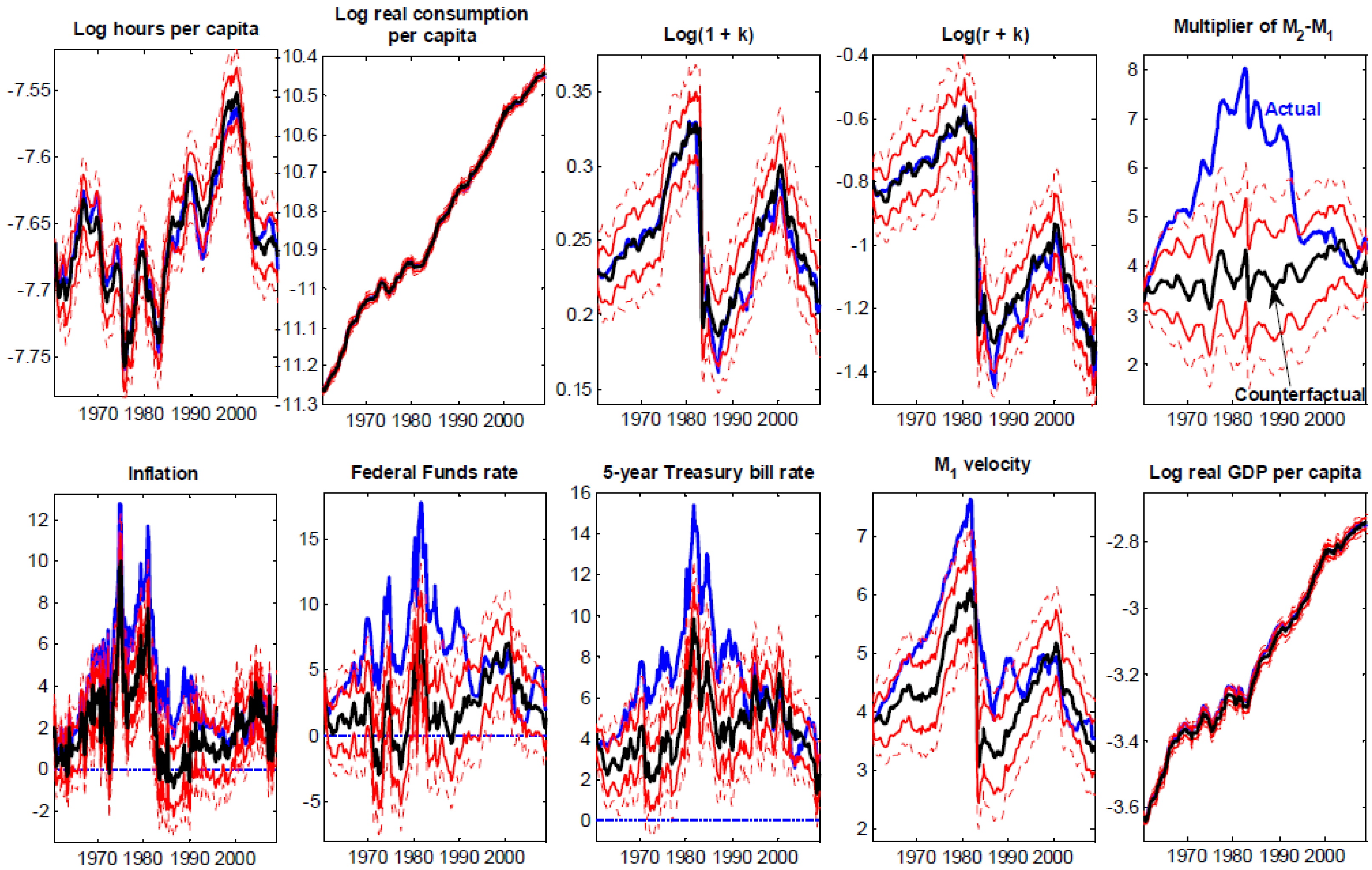

Figure A.5 United States, 1959Q1-2008Q3: Counterfactual simulations jointly killing off the permanent shocks to the multiplier of M2-M1, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 2 cointegration vectors)

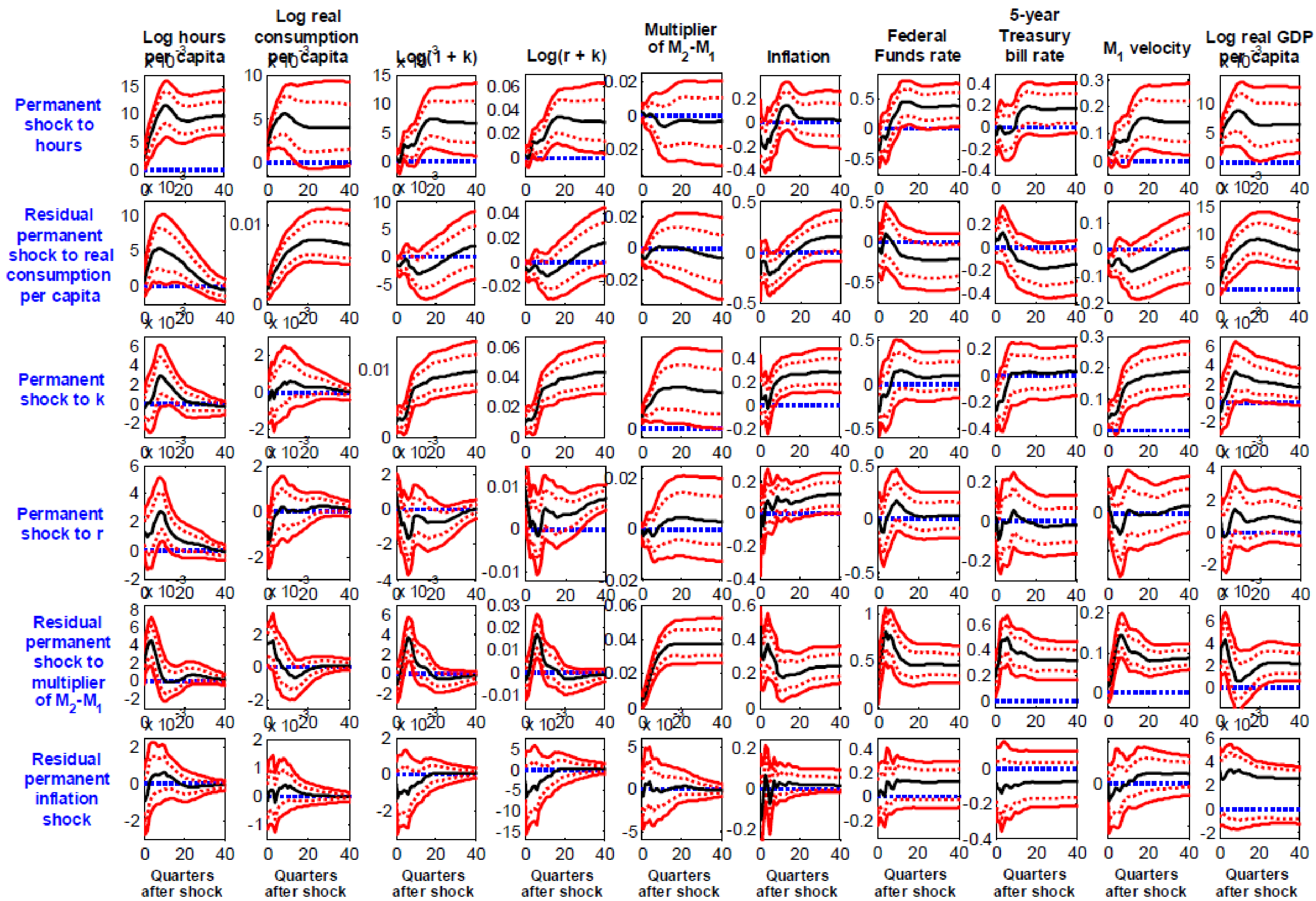

Figure A.6 United States, 1959Q1-2008Q3: Impulse-response functions to the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 4 cointegration vectors)

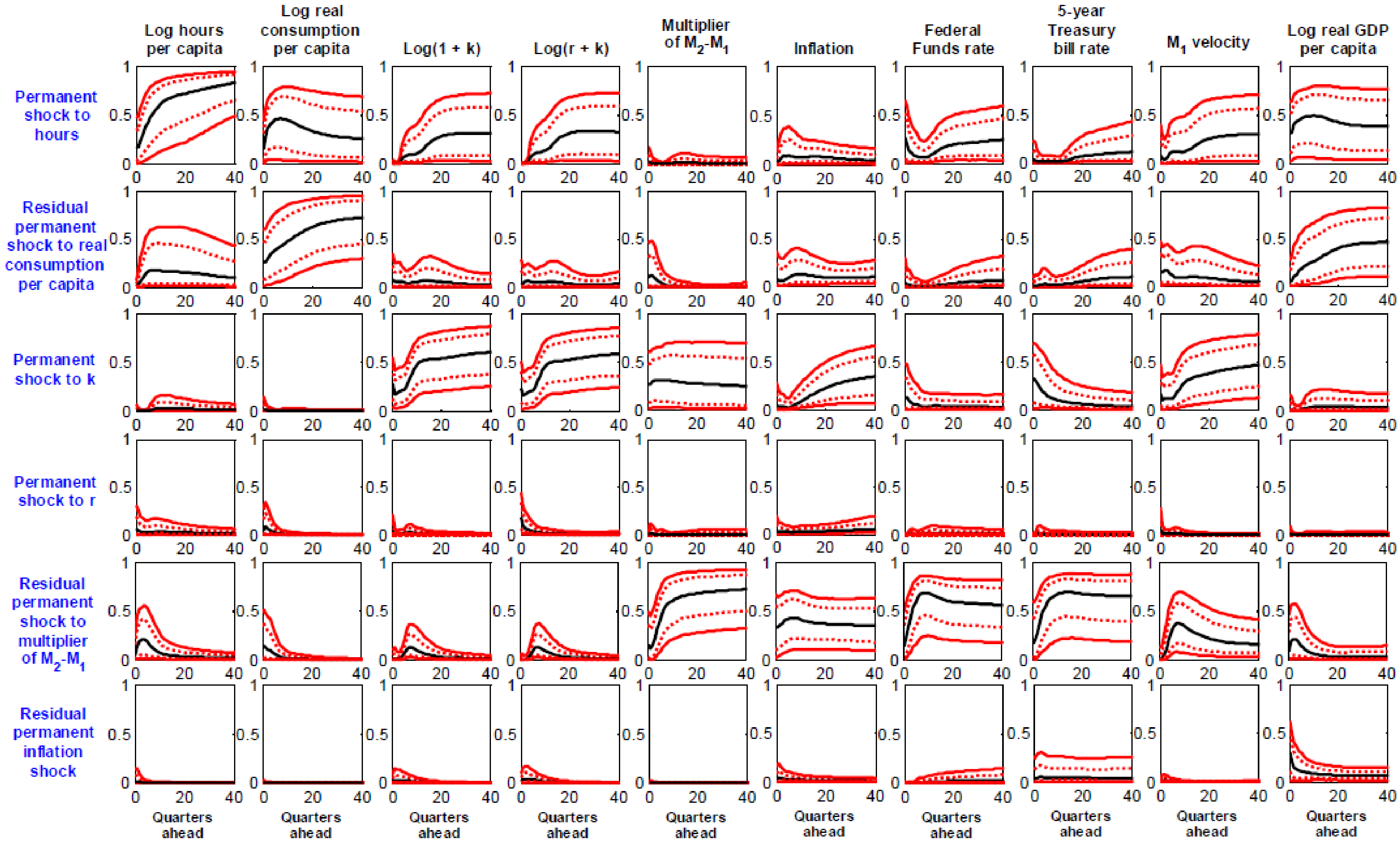

Figure A.7 United States, 1959Q1-2008Q3: Fractions of forecast error variance explained by either of the structural shocks, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 4 cointegration vectors)

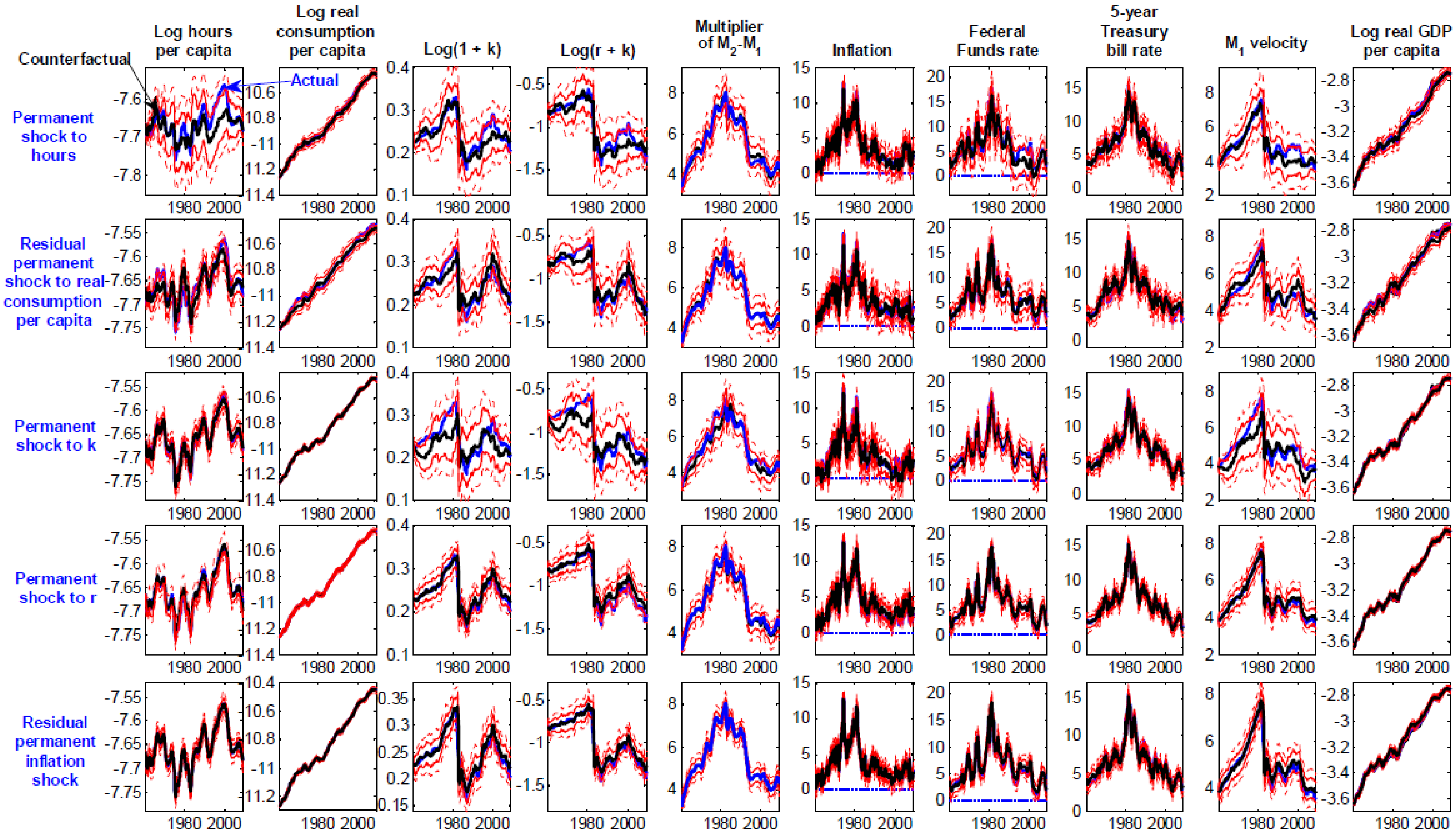

Figure A.8 United States, 1959Q1-2008Q3: Counterfactual simulations killing off the shocks to the M_1 multiplier, with 16-84 bootstrapped confidence bands (based on the model with 4 cointegration vectors)

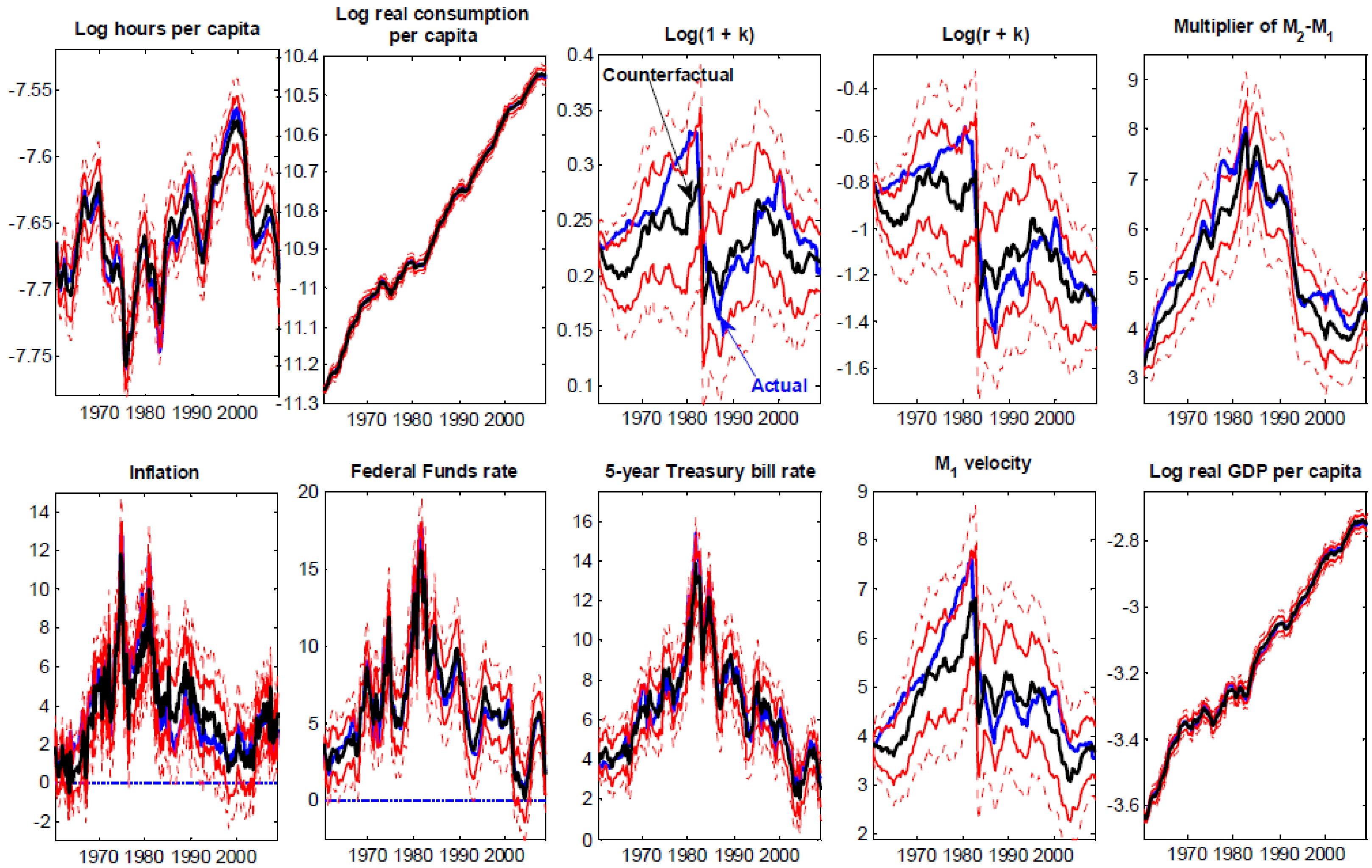

Figure A.9 United States, 1959Q1-2008Q3: Counterfactual simulations jointly killing off the shocks to the M_1 multiplier, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 4 cointegration vectors)

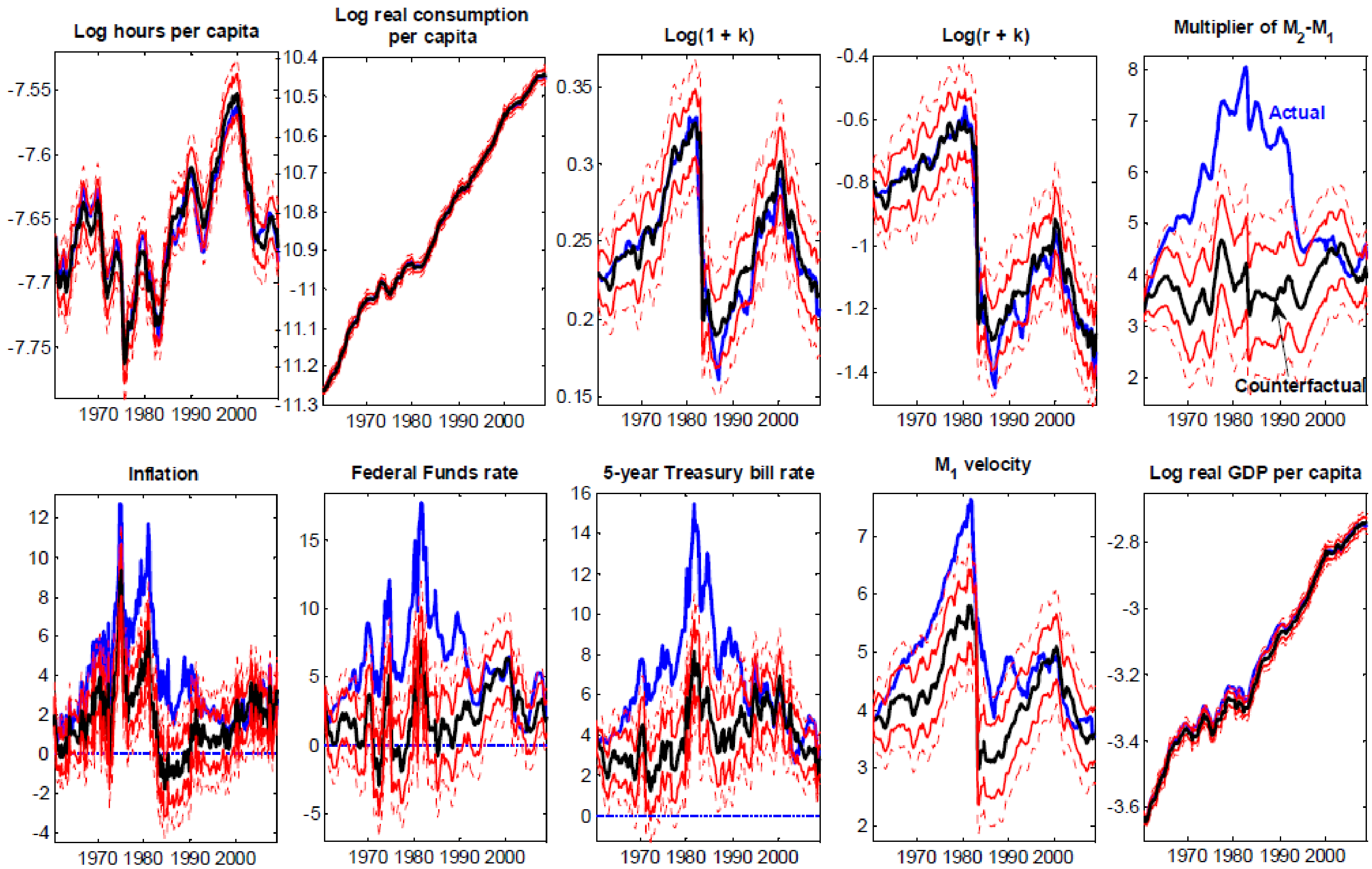

Figure A.10 United States, 1959Q1-2008Q3: Counterfactual simulations jointly killing off the permanent shocks to the multiplier of M2-M1, with 16-84 and 5-95 bootstrapped confidence bands (based on the model with 4 cointegration vectors)