The Effect of News Shocks and Monetary Policy*

Luca Gambetti[†]
Collegio Carlo Alberto,
Università di Torino and BGSE

Christoph Görtz[‡]
University of Birmingham

Dimitris Korobilis[§]
University of Glasgow

John D. Tsoukalas[¶]
University of Glasgow

Francesco Zanetti[‖]
University of Oxford

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Abstract

A VAR model estimated on U.S. data before and after 1980 documents systematic differences in the response of short- and long-term interest rates, corporate bond spreads and durable spending to news TFP shocks. Interest rates across the maturity spectrum broadly increase in the pre-1980s and broadly decline in the post-1980s. Corporate bond spreads decline significantly, and durable spending rises significantly in the post-1980 period while the opposite short-run response is observed in the pre-1980 period. Measuring expectations of future monetary policy rates conditional on a news shock suggests that the Federal Reserve has adopted a restrictive stance before the 1980s with the goal of retaining control over inflation while adopting a neutral/accommodative stance in the post-1980 period.

Keywords: News shocks, Business cycles, VAR models.

JEL Classification: E20, E32, E43, E52

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[†]Collegio Carlo Alberto, Università di Torino, Piazza Arbarello 8, 10122 Torino, Italy. Tel: +39 011-670-5270, email: luca.gambetti@carloalberto.org.

[‡]Department of Economics, University House, Birmingham, B15 2TT, U.K.

[§]Adam Smith Business School, Gilbert Scott Building, Glasgow, G12 8QQ, U.K., email: Dimitris.Korobilis@glasgow.ac.uk.

[¶]Adam Smith Business School, Gilbert Scott Building, Glasgow, G12 8QQ, U.K.

[‖]Department of Economics, Manor Road, Oxford, OX1 3UQ, U.K.

1 Introduction

The effect of anticipated changes in future total factor productivity (TFP) — the so-called "news shocks" — on current macroeconomic outcomes has spurred considerable research interest over the past few years. Several studies find that news shocks exert strong influence on expectations about future economic conditions and thus lead to sizable changes in current economic activity.[1] This paper establishes new empirical facts about changes in the transmission and propagation of news shocks over time and finds that they are tightly linked to systematic changes in the conduct of monetary policy.

To isolate differences in the effect of news shocks across time, we estimate a vector autoregression (VAR) model on two subsamples of U.S. data, before and after 1980. We apply the identification approach in Forni et al. (2014), whereby a TFP news shock best anticipates TFP in the long run without changing current TFP.[2] We find that responses of nominal short- and long-term interest rates to a news TFP shock exhibit a sign reversal between subperiods. A positive news TFP shock is associated with a delayed *rise* in short- and long-term nominal interest rates before the 1980s. In contrast, the same shock is associated with a *fall* in these same rates after the 1980s. We investigate whether these sharp sign reversals in the response of nominal rates are related to systematic differences in the conduct of monetary policy using the Expectation Hypothesis as our organizing framework. The Expectation Hypothesis postulates that long-term interest rates are approximated by an expectation component derived from the weighted average of current and future short-term interest rates plus an error component that encapsulates risk premia. The expectation component provides a powerful reading on the conduct of monetary policy and expectations about the full range of future policy rates. We find that the sign reversals are echoed by similar shifts in the response

[1] See Beaudry and Portier (2014) and references therein for a comprehensive review of the literature.
[2] In section 2, we discuss the relationship of our identification method with alternative approaches.

of the *expectations component* in the term structure of policy yields inferred from the Expectation Hypothesis. The VAR model shows that the expectations component of long-term rates rises persistently in response to the anticipated increase in TFP in the pre-1980 period and declines persistently in the post-1980 period. These findings are robust to alternative maturities of bond yields and consistently point to substantial changes in the systematic response of monetary policy to anticipated changes in TFP before and after the 1980s.

We find that the systematic changes in the response of policy yields are mirrored by macroeconomic aggregates. Economic activity, hours worked, investment and consumer durable spending decline on impact and closely track movements in observed TFP in the pre-1980 period, whereas they sharply increase on impact and anticipate the future rise in TFP several years ahead in the post-1980 period. These findings are consistent with the logic of the standard Euler equation, where the entire path of real interest rates is inversely related to spending decisions, especially for investment and durables spending. Corporate bond spreads, which proxy financial conditions, rise somewhat in the first subperiod and decline in the second subperiod, consistent with the effect of the news shock on real activity.[3]

What is the explanation for these systematic differences in the response of policy rates and the consequent changes in the propagation of news shocks across a wide range of economic variables? An array of influential research shows that anchoring inflation expectations helps the central bank stabilize current inflation without requiring sharp adjustments in the policy rate.[4] To the extent that large and persistent movements in inflation cannot occur without substantial changes in monetary policy, we can glean information about variations in the conduct of monetary policy from the differences

[3]See Gilchrist and Zakrajsek (2012) for a treatment of financial conditions and the relation with corporate bond spreads. See Görtz et al. (2021), and Görtz and Tsoukalas (2017) for a discussion of the critical role of financial markets for the propagation of news shocks.

[4]See Gertler et al. (1999), Svensson (2010) and references therein.

in the responses of inflation and inflation expectations to anticipated changes in TFP. The reaction of inflation expectations to the TFP news shock is significantly different between subsamples even though the TFP news shock produces a similar impact decline in actual inflation in both subsamples. In the first subsample, inflation expectations increase despite a decline in actual inflation. The rise in inflation expectations coincides with a delayed increase in economic activity generated by the news shock. In contrast, in the second subsample, the decline in expected inflation resembles the fall in actual inflation, despite an immediate and strong increase in economic activity. Evidently, the increase in real activity triggered by the TFP news shock feeds into higher inflation expectations in the first subperiod but not the second subperiod.

The stark change in the response of expected inflation and policy yields across maturities is timed with important changes in the remit of U.S. monetary policy. Policy rates in the pre-1980s closely track economic activity as a result of the "lean-against-the-wind" stance of chairman William McChensey Martin who presided over most of this period (1951-1970). During this time, the Fed was concerned that expansionary movements in economic activity may generate a sharp rise in inflation given the limited influence over inflation expectations. By contrast, in the post-1980s, the Fed received a dual mandate to achieve maximum employment, stable prices, and moderate long-term interest rates, becoming legally liable to maintain stable inflation.[5] Under the chairmanships of Volcker, Greenspan, Bernanke and Yellen (1979-2018), the Fed effectively anchors inflation expectations, remaining unconcerned that good news about productivity may generate inflationary pressures — even though they stimulate economic activity on impact. Our results endorse this intuition: the news TFP shock is associated

[5]See the Federal Reserve Act (ch. 6, 38 Stat. 251, enacted December 23, 1913, 12 U.S.C. ch. 3). In 1977, Congress amended the Federal Reserve Act, directing the Board of Governors of the Federal Reserve System and the Federal Open Market Committee to "...maintain long run growth of the monetary and credit aggregates commensurate with the economy's long run potential to increase production, so as to promote effectively the goals of maximum employment, stable prices and moderate long-term interest rates." See Goodfriend and King (2005) for an economic account of the new monetary policy framework.

with a persistent and mild fall in inflation expectations. The response of the Fed, in contrast to the first subperiod, is not to restrict the immediate rise in economic activity in the aftermath of the news shock by raising the policy rate. Our findings are consistent with these systematic changes in the conduct of monetary policy over time. Thus, post-1980s evidence suggests that the Fed allowed the nominal interest rate to decline in a quest to curb the fall in actual inflation since it was able to credibly and effectively manage inflation expectations.[6]

Our analysis relates to the literature on news shocks which shows that anticipated movements in future TFP have an important effect on current macroeconomic fluctuations.[7] In particular, our paper builds on the work by Kurmann and Otrok (2013), Cascaldi-Garcia (2017) and Kurmann and Otrok (2017) who document a tight relationship between news shocks and the term structure of interest rates. However, our study is the first to detect temporal variation in the effect of TFP news shocks and to establish that these differences are related to changes in the conduct of monetary policy over time. In this respect, our analysis also contributes to the large body of research on the time variation in the effect of exogenous shocks on macroeconomic outcomes. Benati (2004) and Bianchi et al. (2009) detect important time variation in economic performance related to changes in the monetary policy framework across time. Mumtaz and Surico (2012) show global changes in the persistence and level of inflation since the 1980s that can be explained by changes in the conduct of monetary policy and the onset of globalization. Gambetti and Gali (2009) estimate important changes in the co-movements among output, hours and productivity over the postwar period. Liu et al. (2017) find sharp differences in the effect of monetary policy shocks across alternative regimes of monetary policy. Gali et al. (2003) identify a shock that moves productivity

[6] An influential study by Gertler et al. (1999) shows that monetary policy can effectively influence the economy by managing inflation expectations in addition to using changes in the policy rate.

[7] See for example Beaudry and Portier (2004), Karnizova (2010), Milani (2011), Barsky and Sims (2011), Schmitt-Grohe and Uribe (2012), Gunn and Johri (2013), Ben Zeev and Khan (2015), Kamber et al. (2017), Görtz and Tsoukalas (2017), Chan et al. (2018) and Görtz et al. (2020).

in the long run and find results consistent with ours: in the Volker-Greenspan period (1982Q3-1998Q3) hours worked and GDP rise much faster in response to the identified shock than in a pre-Volcker sample (1954Q1-1979Q2). In fact, in the latter sample, as documented in this paper, they find the impact response of hours to be negative before it rises in the long run. Also the decline (rise) of the nominal interest rate and the decline (insignificant response) in inflation Gali et al. (2003) document for the pre-Volker (Volker-Greenspan) subsample is consistent with our findings. In identifying a shock that moves productivity in the long run, Gali et al. (2003) are agnostic about whether the shock is anticipated or unanticipated. It is notable though, that that they find for both subsamples productivity not to move on impact, which suggests they capture anticipated technology shocks to a certain degree. The methodology applied in our paper explicitly identifies both, anticipated and news technology shocks.

Finally, our results also relate to the large literature on the effect of monetary policy for macroeconomic fluctuations. Influential studies by Gertler et al. (1999), Ireland (2000, 2003, 2007), Boivin and Giannoni (2006), Castelnuovo (2012) and several other studies show that the effect of exogenous shocks on the economy depends on the stance of monetary policy. Our analysis provides novel empirical evidence on the critical role of monetary policy for the propagation of anticipated changes in TFP on the economy, which is consistent with variation in the remit of U.S. monetary policy over the postwar period.

The remainder of the paper is organized as follows. Section 2 presents data and lays out the VAR model and the identification strategy. Section 3 discusses new facts on the propagation of news shocks over time as well as investigates the sources of systematic differences in the response of interest rates and macroeconomic indicators. Section 4 concludes.

2 Data and the VAR model

This section describes the data, subperiods and identification methodology.

Data. We estimate the VAR model using quarterly U.S. data for the period 1954:Q3−2018:Q3. We examine several different VAR specifications with the aim of establishing robust and comprehensive facts about the response of a host of measures of economic activity, interest rates, prices, financial and survey indicators to TFP news shocks. A key input is an observable measure of TFP. We use the aggregate TFP measure in Fernald (2012), which is based on the growth accounting methodology in Basu et al. (2006) and corrects for unobserved capacity utilization that is critical to accurately estimate TFP in the data. In addition to standard macro indicators used in previous studies — namely, output, consumption, investment, and hours worked — we incorporate information from three nominal measures of long-term rates, specifically one- five- and ten-year government bond yields. We include inflation expectations using the expected one-year-ahead inflation from the Michigan survey. We also use personal consumption expenditures on durables and the Michigan survey expectations and buying intention on durables and vehicles. Appendix A provides details on the data and time series construction. To estimate the model, we apply four lags with a Minnesota prior and compute confidence bands by drawing from the posterior. Appendix B provides details on the specification of the prior.

Subperiods. A large number of studies has detected a significant change in the dynamic properties of several U.S. macroeconomic variables before and after the mid-1980s. Moreover, a fundamental change in Federal Reserve policy is widely believed to have occurred soon after Paul Volcker's appointment as chairman in August 1979. and monetary policy has become more responsive to movements in inflation in the post-1980 period.[8] Consistent with the findings in the literature, the full sample period is

[8]See Taylor (1993), Clarida et al. (2000) and references therein.

divided into two disjointed subsamples: the first runs from 1954:Q3 through 1979:Q2 and corresponds to the chairmanships of Martin and Burns (and a very short tenure of Mitchell), and the second runs from 1982:Q3 through 2018:Q3, corresponding to the chairmanships of Volcker, Greenspan, Bernanke and Yellen as well as the first two quarters under Powell.[9]

Identification methodology. To identify the TFP news shock, we adopt the identification scheme in Forni et al. (2014), and assume that the news shock does not change TFP on impact and has maximal impact on TFP in the long run (at the 40-quarter horizon).[10]

3 Results

Figures 1 and 2 display the impulse response functions (IRFs) to a positive TFP news shock for the pre- and post-1980 period, respectively. They focus on the IRFs of TFP, three activity variables, inflation (as measured from the GDP deflator), the five-year bond yield and the three-month T-bill rate.[11]

The *short-run* response of the two real activity variables — namely, output, and hours worked — shows a marked difference between subperiods. The impact response of hours

[9] We remove the period 1979:Q3-1982:Q2 from our analysis because of unusual operating procedures that were effective during that episode. Bernanke and Mihov (1998) provide formal evidence on the idiosyncracy of that period.

[10] Our identification methodology is closely related to alternatives suggested by Barsky and Sims (2011), Neville et al. (2014) and Kurmann and Sims (2017). In Appendix E we discuss these and show robustness of our results.

[11] We find a zero impact response of TFP to the news shock by construction and a gradual increase to a permanently higher level that captures a permanent diffusion process of technology anticipated by agents in the economy. This dynamic response is consistent with the original idea of a gradual diffusion of news shock and corroborates the assessments of the TFP response to a news shock outlined in Beaudry and Portier (2014). The long-run increase in TFP in response to the news shock is approximately 1 percent in both subperiods. The observation that the response of TFP in the long run to the news shock is nearly identical across subperiods, is important for the analysis. We interpret the dynamic response of TFP to the news shock and the strong quantitative similarity in the medium (beyond the 20-quarter horizon) to long run across subperiods as compelling evidence that our identification scheme effectively and consistently identifies TFP news shocks between subperiods.

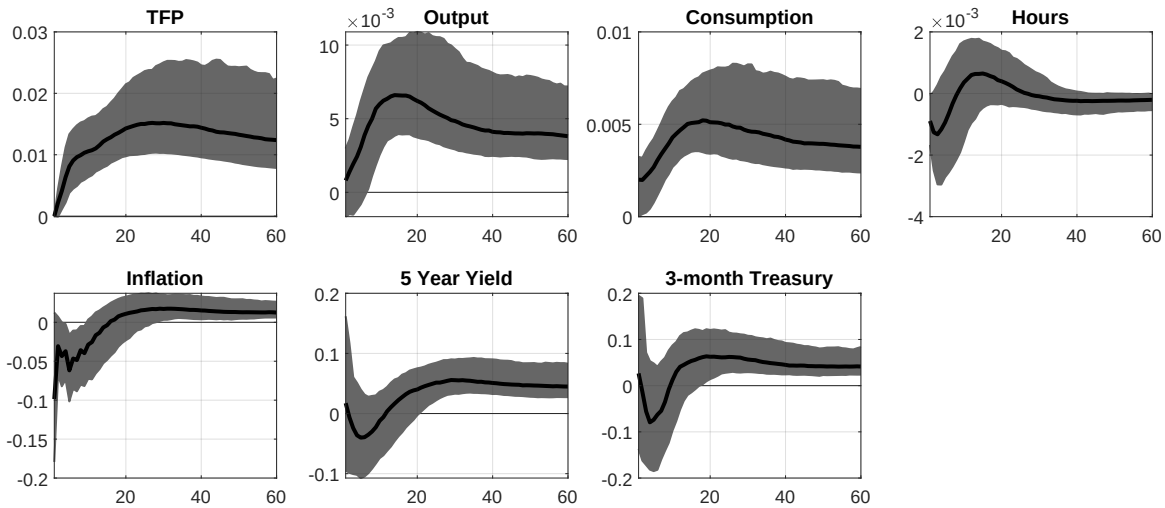

Figure 1: First sample (1954:Q3-1979:Q2). The solid line is the median estimated impulse response (in percent) to a positive TFP news shock from a seven variable VAR featuring TFP, output, consumption, hours, inflation, 5-year bond yield and 3-month T-bill rate estimated with 4 lags. Shaded areas indicate the 16% and 84% confidence bands.

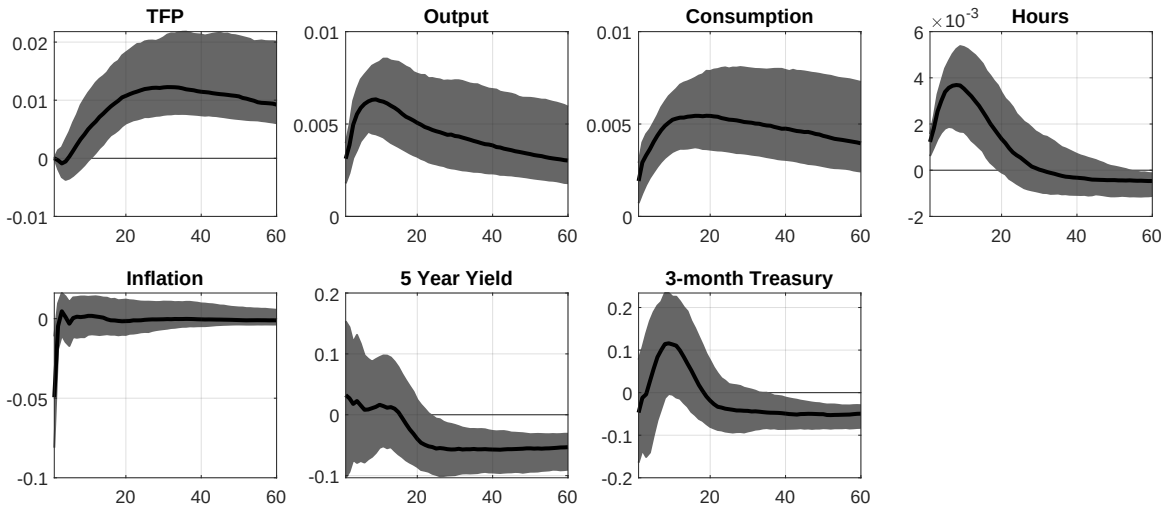

Figure 2: Second sample (1982:Q3-2018:Q3). The solid line is the median estimated impulse response (in percent) to a positive TFP news shock from a seven variable VAR featuring TFP, output, consumption, hours, inflation, 5-year bond yield and 3-month T-bill rate estimated with 4 lags. Shaded areas indicate the 16% and 84% confidence bands.

is negative in the first sample while it is positive in the second subsample. The impact response of output varies significantly between subperiods, being insignificantly different from zero in the first subsample and significantly positive in the second subsample. The response of consumption, measured by consumption expenditures in non-durables and services, is broadly similar across the two subperiods. But important to our analysis, as we illustrate below in this section, the short-run response of private investment and consumer durables differs significantly across subsamples. These differences account, at least qualitatively, for the different short-run output responses to the news TFP observed across the two subperiods. The short-run response of inflation is negative in both subperiods. However, inflation picks up and becomes mildly positive at approximately the three-year horizon in the first subperiod whereas it quickly returns to zero in the second subperiod. The timing in the rise of inflation during the first sample coincides with the strong increase in output and hours in that subsample. The fall in inflation in the second subperiod is in line with conventional wisdom: namely, inflation is forward looking and mimics the fall in real marginal costs brought about the future increase in TFP. This finding generalizes and corroborates the results in Barsky et al. (2015) and Christiano et al. (2010) that also detect a strong disinflationary effect of news shocks. However, the behavior of inflation in the first subperiod is difficult to square with this view since the increase in inflation occurs at a time when TFP is already approaching the new higher long-run level that in principle stimulates a reduction in inflation. We discuss this issue in more detail when we examine and contrast the behavior of realized inflation with expectations of inflation. The transitional dynamics of variables differ across subperiods. In the first subperiod, output and hours worked closely track the path of TFP beyond the very short run. In contrast, in the second subperiod, the same variables swiftly respond on impact in the anticipation of the foreseen increase in TFP, even though the latter begins to increase only after about two years. Overall, responses of macro aggregates in the second subperiod are consistent with the expansionary effect

of TFP news shocks, as articulated in Beaudry and Portier (2006).

Long- and short-term interest rates. The comparison across subperiods pinpoints some striking and systematic differences in the responses of short- and long-term interest rates that is indicative of important differences in the conduct of monetary policy between subperiods. Figures 1 and 2 display responses to the three-month Treasury bill rate and the five-year government bond yield. In the pre-1980 period, the response in the short-term nominal interest rate tracks the reaction of output closely; that is, it is statistically indifferent from zero for the initial 16 quarters, gradually rising and becoming significantly positive thereafter. Importantly, the peak response in the nominal rate coincides with the peak in the responses of output and hours. The response of the long-term nominal interest rate is similar to the reaction of the short-term nominal interest rate; that is, it is not statistically different from zero for the first 20 quarters and then significantly rises and remains elevated thereafter. In contrast, in the post-1980 period, the response of the short-term nominal interest rate is negative and becomes significant from approximately the 30-quarter horizon. The response of the long-term nominal interest rate is negative and statistically significant after the first 25 quarters.

To investigate whether alternative maturities of short- and long-term rates exhibit similar differences across subperiods, Figures 3 and 4 display IRFs of several short- and long-term rates to a positive TFP news shock for the pre- and post-1980 periods, respectively. The responses are generated from VAR specifications where we condition the analysis on the same set of variables as those displayed in Figures 1 and 2, but where we replace the five-year yield with either the one-year or 10-year yield, and where we replace the three-month Treasury bill rate with the Fed funds rate. The responses of the one-year, five-year and 10-year yields are consistent with each other in each sub-sample. Figure 3 shows that in the first subperiod, long-term interest rates exhibit a significant rise after approximately 20 quarters. In the first subsample, the response of the long-term rates mimics the response of the short rates to a great extent, suggesting that

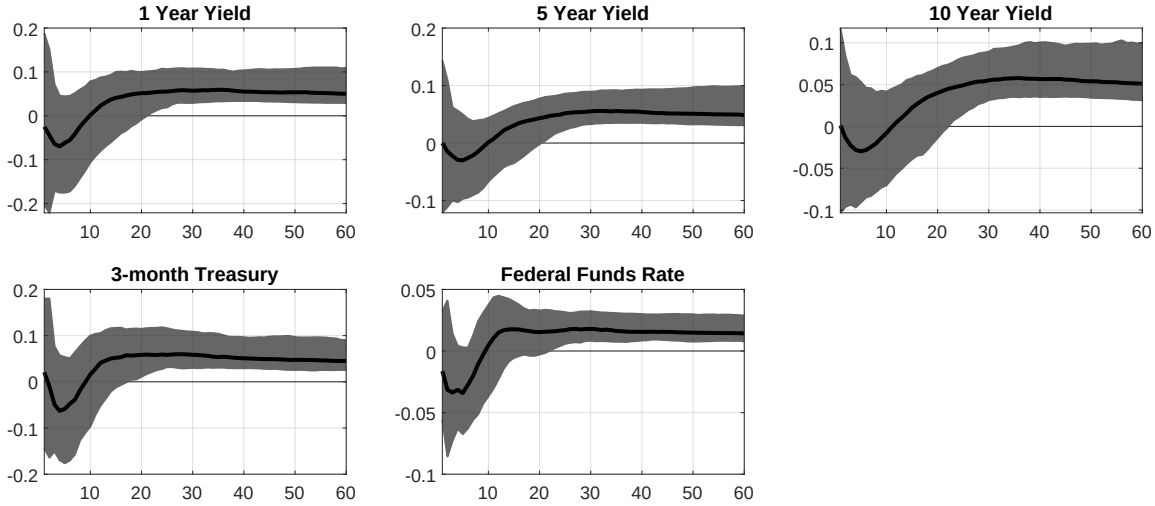

Figure 3: First sample (1954:Q3-1979:Q2)—long- and short-term rates. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

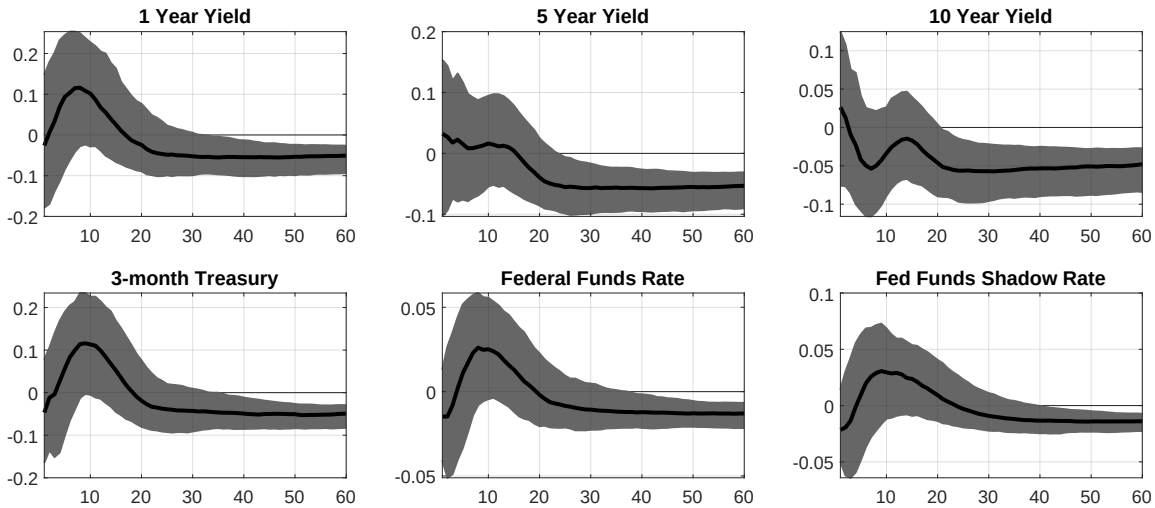

Figure 4: Second sample (1982:Q3-2018:Q3)—long- and short-term rates. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

bond markets expect short rates to stay persistently elevated. The response of short-term interest rates suggests a restrictive stance adopted by the Fed, which, as explained above, coincides with the pick-up in real activity documented in Figure 1. Figure 4 in contrast suggests a distinctively different pattern in the responses of long- and short-term interest rates. Both short and long rates exhibit a decline beyond the short run following the news TFP shock. The short-term rates captured in the three-month T-bill and the Fed funds rate exhibit initially an insignificant response, followed by a decline that is statistically significant. Also when considering the Wu-Xia Fed Funds Shadow Rate — which differs from the Fed funds rate between 2008Q4 and 2015Q4 — the same pattern can be observed.[12] Overall, the responses of short- and long-term rates in the second period is consistent with a short-run neutral interest rate that becomes progressively more accommodative (or looser) policy stance.

Expectation Hypothesis of interest rates. The VAR results point to systematic changes in a number of different maturity interest rates and changes in the reaction of macroeconomic variables — namely, output and hours worked — to TFP news shocks. To investigate whether differences in the responses of interest rates with different maturities reflect systematic changes in the conduct of monetary policy, we assess the reaction of the *expectations component* of the long-term interest rate using the Expectation Hypothesis of interest rates.

We use the Expectations Hypothesis (EH) to produce a measure of the expected future conduct of monetary policy. The EH postulates that long-term interest rates are proxied by a weighted average of current and future short-term interest rates. This metric provides a powerful reading on expectations about the whole range of future policy rates and therefore conveys a broad appraisal on the overall expected stance of

[12] Wu and Xia compute a short term nominal interest rate for the period December 16, 2008, to December 15, 2015, when the Federal Open Market Committee set the target range for the Federal Funds rate at 0 to 25 basis points. At all other times in our sample, the series for the shadow rate coincides with the Federal Funds rate. We show in Appendix D that our results are roust also when the second subsample excludes the financial crisis (1982Q3-2008Q3).

monetary policy. We compute a synthetic ten-year long rate from the EH as the weighted sum of present and expected short-term interest rates. Specifically,

$$i_t^{40} = i_t + \frac{1}{40}\sum_{j=0}^{39}\Big[(1-\frac{j}{40})E(\Delta i_{t+j}|Y_t)\Big], \tag{1}$$

where $E(\Delta i_{t+j}|Y_t)$ is the future expected path of interest rates as implied by the VAR model, based on the information set Y_t, where we use the three-month T-bill as our measure of the short-term rate.[13] Equation (1) is only approximate since there are deviations between the actual and synthetic ten-year rates which are captured by the term premium. The term premium is calculated as the difference between the observed 10-year, long-term interest rate and the corresponding 10-year, long-term rate computed from the EH (denoted LEH) (i.e., term premium = 10-year rate − LEH). Examining the behavior of the LEH allows us to establish the extent to which the observed actual response of long-term rates to the news shock is driven by movements in the systematic conduct of monetary policy.

Figures 5 and 6 display the short- and long-term rates as well as the LEH. Consistent with results on short- and long-term interest rates displayed in Figures 3 and 4, the response of the systematic component of the long-term rate, LEH, differs significantly across the two subperiods. The VAR model shows that the LEH component rises persistently in response to the anticipated increase in TFP in the pre-1980 period. In contrast, the LEH component declines persistently in response to the same anticipated TFP increase in the post-1980 period.[14] These distinctive differences in the systematic policy component of the long-term interest rate indicate the role of monetary policy in

[13]Results are robust also when we compute a synthetic long rate based on the five-year long rate. Our findings are also robust to using the Federal Funds rate instead of the three-month T-bill as a measure of the short-term rate. An appendix that details these results is available upon request.

[14]For both subsamples we find the term premium to be insignificant for almost all horizons, most notably in the long run. Hence, movements in the term premium cannot account for the persistent differential movements of long-term rates in response to news shocks across subsamples. Results are available upon request

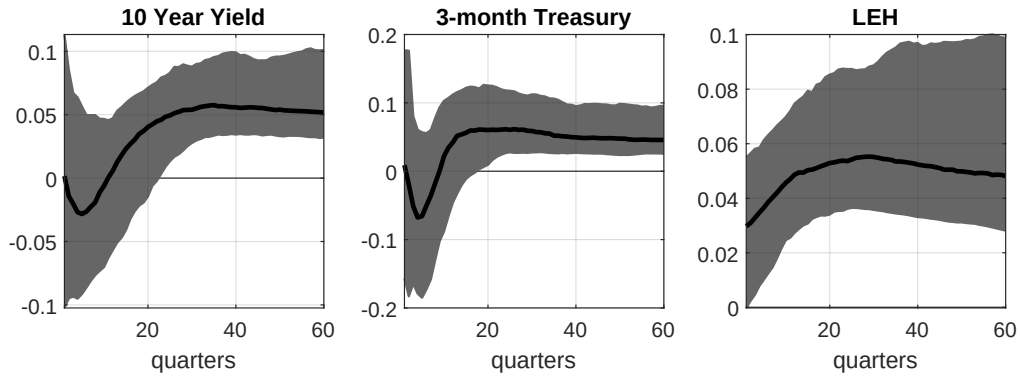

Figure 5: First sample (1954:Q3-1979:Q2)–decomposition of interest rates. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

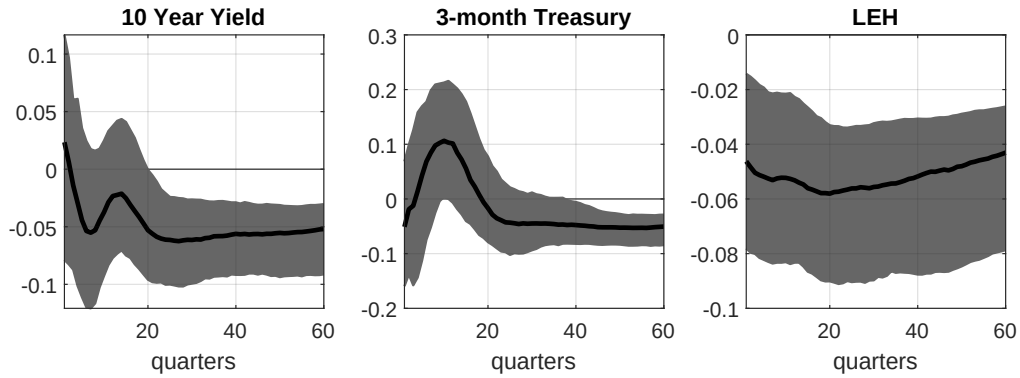

Figure 6: Second sample (1982:Q3-2018:Q3)–decomposition of interest rates. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

the different propagation of the TFP news shock.

Real interest rates, durables spending and financial variables. The analysis shows that systematic changes in the response of policy yields are echoed by changes in the response of real interest rates and real and financial variables to news shocks between subperiods. Figures 7 and 8 display IRFs to private domestic investment, consumer durables, the three-month (realized) real interest rate (computed as the three-month Treasury bill rate minus actual inflation) and the BAA-AAA corporate bond spread in the first and second sample, respectively. Private domestic investment includes spending of consumer durables. However, we plot the IRF of the latter separately to highlight the different response of this component of consumption relative to the non-durables component of consumption shown in Figures 1 and 2.

The responses of private domestic investment and corporate spread are obtained from a VAR specification conditioned on the same information as the one in Figures 1 and 2, except that we drop the five-year yield and the three-month Treasury bill rate and replace them with the aforementioned variables. The responses of consumer durables and real interest rate are generated in the same fashion. Several findings are worth noting. In the first subperiod, the impact responses of private investment and consumer durables are significantly negative. These responses eventually turn positive and display a path similar to the activity indicators shown in Figure 1. In contrast, in the second subperiod, the impact responses of the same activity variables are strongly positive. In the first subperiod, the response of the real interest rate is positive for almost 20 quarters before it returns to zero. In the second subperiod, in contrast, while initially the median response is positive (though insignificant), it becomes negative from approximately 20 quarters onwards. The response of the real interest rate in the two subperiods is consistent with the reaction of the short-term nominal interest rate shown in Figures 1 and 2. The path of the real rate indicates a restrictive policy stance in the first subperiod and a neutral and ultimately looser policy stance in the second subperiod. Finally, in the first

subperiod, the impact response of the corporate bond spread is positive, suggesting an initial tightening of financial conditions in the corporate debt market. In the second subperiod, the response of the corporate spread is significantly negative, suggesting a relaxation of financial conditions. Models with a role for financial frictions predict this type of negative correlation between investment and credit spreads.[15]

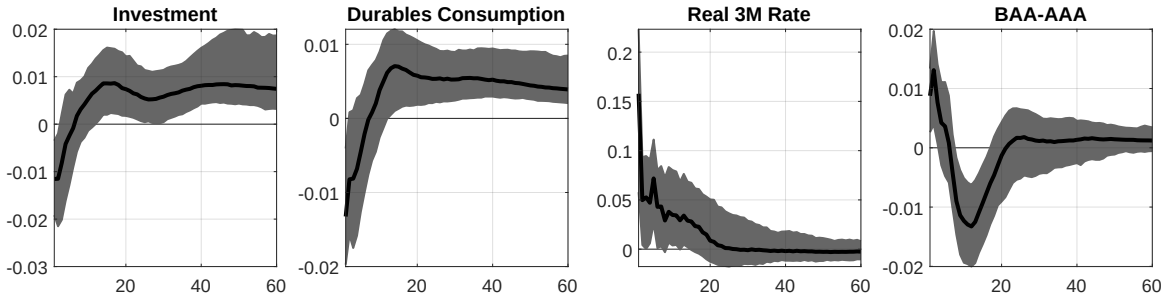

Figure 7: First sample (1954:Q3-1979:Q2). The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

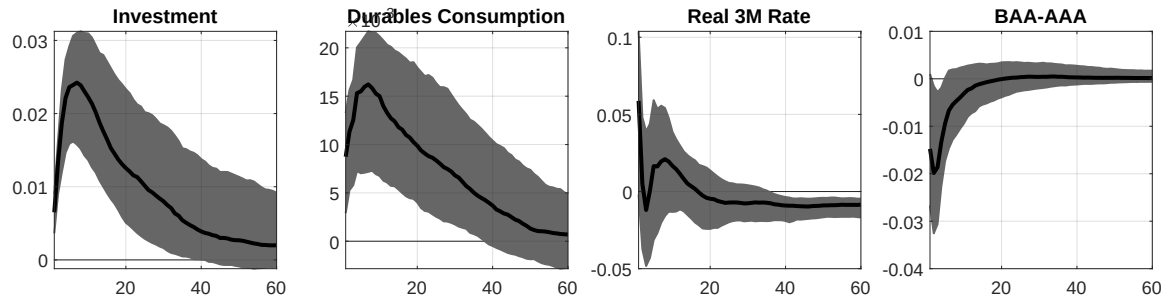

Figure 8: Second sample (1982:Q3-2018:Q3). The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

One important finding is the role of leading indicator of the corporate bond market in the second subperiod. Corporate bonds immediately internalize the rise in future TFP and the profitability of new investment spending by easing financial conditions quickly.

[15]See e.g. Gilchrist and Zakrajek (2012), Faust et al. (2013) and Görtz et al. (2021) and references therein.

This leading reaction of the corporate bond market fails to occur in the first subsample. If anything, financial markets play a very limited role in the short-run propagation of the news shock. Quantitatively, the negative response of the corporate spread in the second subsample is significantly stronger compared to the response in the first subsample (when the latter eventually declines). Similarly, the peak response of private investment is significantly stronger in the second subsample compared to the peak response in the first subsample (which occurs later). The last two observations corroborate the potentially important role played by financial markets for the propagation of the news shock in the second subsample. In Appendix C, we also examine the behavior of several indicators from the Michigan survey and Tobin's Q. The survey indicators relate to consumers' perceptions about buying conditions of durables and vehicles, as well as the widely used five-year ahead consumer confidence. The responses of these indicators are consistent with the differential responses of investment and durables, namely that they rise immediately and significantly in the second subperiod, signalling good times ahead, but are insignificantly different from zero in the first subperiod.

Inflation expectations and monetary policy. What can explain these systematic differences in the conduct of monetary policy and the consequent changes in propagation across real and financial variables? A central finding in modern macroeconomics is that monetary policy exerts a strong influence on inflation expectations and that central banks may use this channel to anchor inflation expectations to stabilize the economy (see Gertler et al. (1999) and references therein). By anchoring inflation expectations, the monetary authority retains control on current inflation without having to aggressively adjust the policy rate. These theoretical insights provide a powerful metric to measure systematic variations in the conduct of monetary policy across subperiods. To the extent that large and persistent movements in inflation cannot occur without substantial changes in monetary policy, we can glean information about variations in the conduct of monetary policy from the differences in the responses of inflation and inflation

expectations to anticipated changes in TFP.

Figures 9 and 10 show the responses of current inflation and expected inflation — measured by the one-year-ahead inflation expectations from the Michigan Survey of Consumers — to the TFP news shock before and after 1980, respectively.[16] It also displays the IRFs of activity indicators and the Fed Funds rate. Two observations stand out. First, the responses of inflation expectations across the two subperiods are remarkably different. In the first subperiod, inflation expectations exhibit a decline in the short run similarly, although smaller in magnitude, to the decline in realised inflation. However, shortly after this decline, inflation expectations rise, suggesting that the public expects inflation to rise. Interestingly, the rise in inflation expectations occurs while realized inflation is still declining (at the 10-quarter horizon). The rise in inflation expectations coincides with the peak in economic activity, which occurs at the 10-quarter horizon. Inflation expectations remain consistently high thereafter; as long as activity remains strong (see the response of output), consumers expect higher inflation, and anticipate permanently higher expected inflation despite the economic boom subsides in the long run. This finding involves a concurrent increase in TFP, which could, other things being equal, keep inflationary pressures in check. In contrast, in the second subperiod, expected inflation shows a small and persistent decline that returns to the initial state gradually while the actual inflation response has returned to zero by around the one-year horizon. In the second subperiod, inflation expectations are decoupled from the boom in economic activity, which is large in the aftermath of the TFP shock. Evidently, in the second subperiod, future growth in TFP is perceived as being disinflationary.

Changes in the conduct of monetary policy. To better understand these markedly different results across subperiods, it is valuable to relate the findings to the

[16]The Michigan Survey provides the data on inflation expectations from 1960Q1 so that we had to limit our first subsample to this start date.

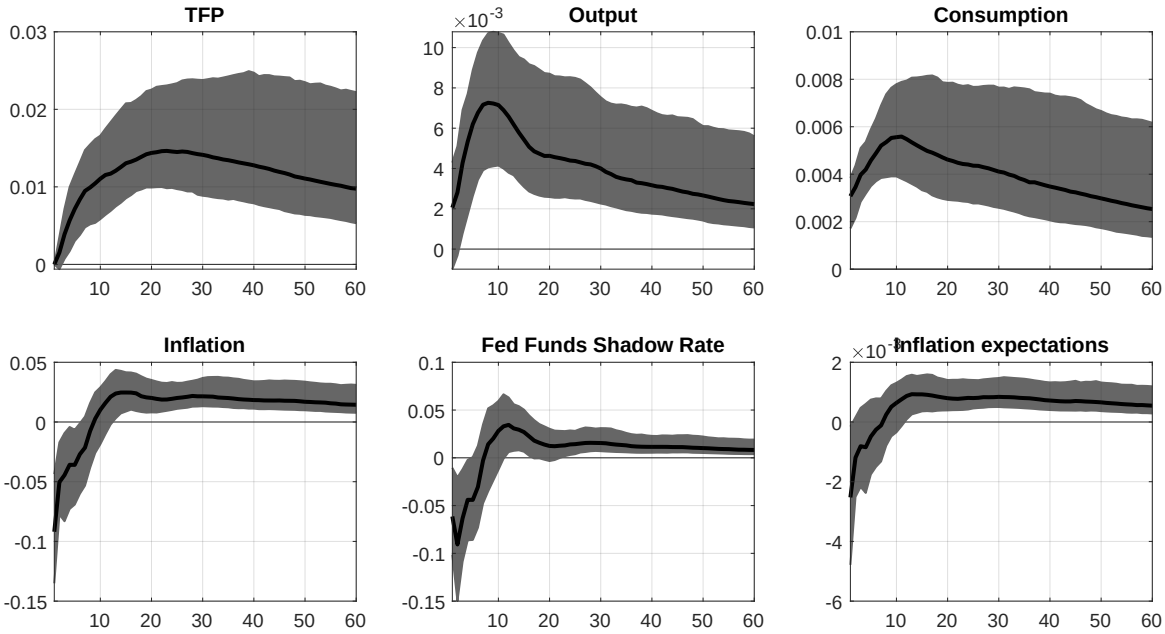

Figure 9: First sample (1960:Q1-1979:Q2). The solid line is the median estimated impulse response (in percent) to a positive TFP news shock from a seven variable VAR featuring TFP, output, consumption, inflation, Fed Funds shadow rate, and one-year-ahead Michigan inflation expectations estimated with four lags. Shaded areas indicate the 16% and 84% confidence bands.

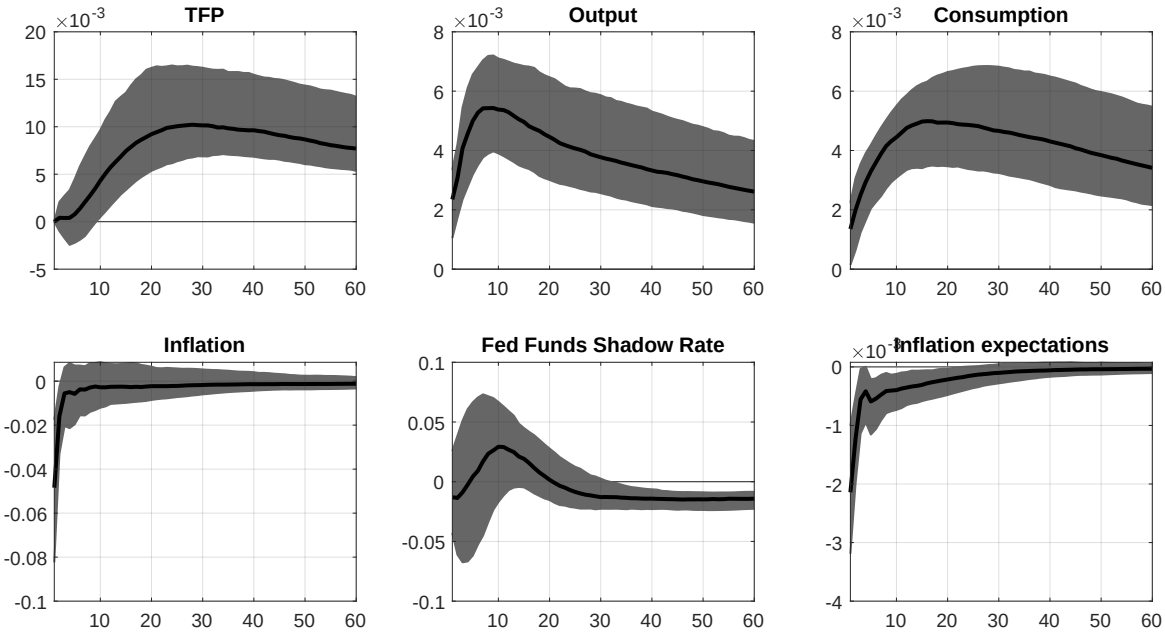

Figure 10: Second sample (1982:Q3-2018:Q3). The solid line is the median estimated impulse response (in percent) to a positive TFP news shock from a seven variable VAR featuring TFP, output, consumption, inflation, Fed Funds shadow rate, and one-year-ahead Michigan inflation expectations estimated with four lags. Shaded areas indicate the 16% and 84% confidence bands.

broader historical context of the conduct of monetary policy in the United States. The first subperiod broadly coincides with the term of governor William McChesney Martin, chairman of the Board of Governors of the Federal Reserve from April 1951 to January 1970. During this period, the Fed used independence gained with the Treasury-Fed Accord to begin a new regime for monetary policy, which chairman Martin described as "leaning against the wind." During this period, the FOMC began to use systematic changes in short-term interest rates to counteract changes in economic activity with the aim to stabilize the economy. In the policy regime pre-1980s, changes in short-term interest rates would be sharp enough to avert positive inflation premia in bond rates and upward pressures in inflation. The immediate raise in policy rates in response to an increase in real activity during the first subsample clearly indicates a monetary policy consistent with the lean-against-the-wind approach by chairman Martin.[17] The conduct of monetary policy changes considerably in the second subsample. In August 1979, with the appointment of Paul Volcker as chairman of the Board of Governors of the Federal Reserve System, the Fed received a dual mandate to achieve maximum employment, stable prices and moderate long-term interest rates, becoming legally liable to maintain stable inflation.[18] This commitment enabled the Fed to effectively anchor inflation expectations in the post-1980 period, facilitating a protracted disinflationary period in the U.S. economy (see Goodfriend and King (2005)).[19] Consistent with the VAR results in the post-1980s, the Fed allowed the nominal interest rate to decline in a quest to curb the fall in inflation since the Fed was able to credibly and effectively

[17] As chairman, Martin was known for his tight money policies and anti-inflation bias. He emphasized the importance of statistics over economic theory and also pushed for flexibility and discretion in the Fed's policymaking. In 1956, he famously described the Fed's purpose to Congress as "leaning against the winds of deflation or inflation, whichever way they are blowing." See the chronicle of the Fed's history at: http://www.federalreservehistory.org/Events/DetailView/63, http://www.federalreservehistory.org/People/DetailView/113 and http://www.federalreservehistory.org/Period/PrintView/12.

[18] The U.S. Congress introduced a dual mandate to promote maximum sustainable employment and price stability with the Federal Reserve Act of 1977.

[19] An array of studies supports this interpretation of monetary policy stance. See, for example, Gertler et al. (1999), Ireland (2007), Debortoli and Lakdawala (2016) and references therein.

manage inflation expectations to restrain the rise in current inflation without having to increase the policy rate.

4 Conclusion

This paper documents significant changes in the effect of TFP news shocks on macroeconomic variables before and after 1980. Short- and long-term nominal interest rates exhibit a sign reversal in response to a news TFP shock before and after 1980. Using the Expectations Hypothesis, which conveys a broad appraisal on the overall expected stance of monetary policy, we document that the sign reversal also is echoed in the reversal of the response in the term structure of expected policy rates across subperiods. Specifically, the expectations component of long-term rates rises persistently in response to the anticipated increase in TFP in the pre-1980 period, and it declines persistently in the post-1980 period, suggesting a restrictive (accommodative) monetary policy stance in the pre-1980 (post-1980) period in response to the news TFP shock. Several activity variables also differ in their responses to the news shock across subperiods.

The analysis suggests that the different responses of macroeconomic aggregates to news shocks between subperiods are related to sharp changes in the conduct of monetary policy. Systematic policy changes are reflected by the ineffectiveness of the Fed to anchor inflation expectations in the pre-1980 period and the subsequent strong objective to achieve stable inflation in the post-1980 period that leads to a powerful anchoring of inflation expectations. Thus, the Fed's weak influence over the formation of expectations in the first subperiod leads to a tightening of monetary policy in response to any initial increase in economic activity in response to news shock. In contrast, the Fed adopts a looser monetary policy in the second subperiod since it can credibly and effectively manage inflation expectations to restrain the rise in inflation that results from the increase in real activity generated by the news shock.

Our study offers several interesting directions for future research. It would certainly be valuable to develop structural models to study the interaction between the formation of expectations and systematic changes in the conduct of monetary policy, which is a central finding of our analysis. Such models should incorporate imperfect common knowledge of economic agents that recent studies find capable of generating a reversal in the response of the economy to aggregate disturbances.[20] Disperse information is also a critical feature to include in the model since it may interact with monetary policy to explain changes in the propagation of anticipated news shocks, as Melosi (2014) shows for the propagation of monetary and technology shocks. These important extensions remain open to future research.

[20]See Melosi (2016) and references therein for a recent discussion of the issues.

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Online Appendix

A Data Sources and Time Series Construction

Table 1 provides an overview of the data used in the analysis. Below we describe in detail all of the data transformations we made to construct the dataset for the estimation of the VAR model. We take the data series for aggregate utilization adjusted TFP to estimate the VARs from John Fernald's website ($www.frbsf.org/economic-research/economists/jfernald/quarterly\_tfp.xls$), as described in Fernald (2012).

Real and nominal variables. Consumption (in current prices) is defined as the sum of personal consumption expenditures on services and personal consumption expenditures on non-durable goods. The time series for real consumption is constructed as follows. First, we compute the shares of services and non-durable goods in total (current price) consumption. Then, total real consumption growth is obtained as the chained weighted (using the nominal shares above) growth rate of real services and growth rate of real non-durable goods. Using the growth rate of real consumption, we construct a series for real consumption using 2005 as the base year. The consumption deflator is calculated as the ratio of nominal over real consumption. In the VAR model, we use the log change in the GDP deflator as our inflation measure; however results are nearly identical when we use the consumption deflator or CPI inflation. Analogously, we construct a time series for the investment deflator using series for (current price) personal consumption expenditures on durable goods and gross private domestic investment and chain weight to arrive at the real aggregate. Real output is GDP expressed in consumption units by dividing current price GDP with the consumption deflator.

The hourly wage is defined as total compensation per hour. Dividing this series by the consumption deflator yields the real-wage rate. Hours worked is given by hours of all persons in the non-farm business sector. All series described above are expressed in

per capita terms using the series of non-institutional population, age 16 and above.

The BAA-AAA spread. The spread is obtained from the Federal Reserve Bank of St. Louis' online database FRED ($https://fred.stlouisfed.org.$).

Tobin's Q. Tobin's Q is the ration of market to book value for the Dow Jones Industrial Average. This definition is taken directly from Welsh and Goyal (2008), "A Comprehensive Look at The Empirical Performance of Equity Premium Prediction," Review of Financial Studies, 21.

Wu-Xia shadow rate. The Wu-Xia shadow federal funds rate is based on a model by Cynthia Wu and Fan Dora Xia and is obtained from the Federal Reserve Bank of Atlanta ($https://www.frbatlanta.org/cqer/research/shadow_rate.aspx$).

Table 1: Time Series used in the empirical analysis

Time Series Description	Units	Code	Source
Gross domestic product	CP, SA, billion $	GDP	BEA
Gross Private Domestic Investment	CP, SA, billion $	GPDI	BEA
Real Gross Private Domestic Investment	CVM, SA, billion $	GPDIC1	BEA
Personal Consumption Exp.: Durable Goods	CP, SA, billion $	PCDG	BEA
Real Personal Consumption Exp.: Durable Goods	CVM, SA, billion $	PCDGCC96	BEA
Personal Consumption Expenditures: Services	CP, SA, billion $	PCESV	BEA
Real Personal Consumption Expenditures: Services	CVM, SA, billion $	PCESVC96	BEA
Personal Consumption Exp.: Nondurable Goods	CP, SA, billion $	PCND	BEA
Real Personal Consumption Exp.: Nondurable Goods	CVM, SA, billion $	PCNDGC96	BEA
Civilian Noninstitutional Population	NSA, 1000s	CNP160V	BLS
Non-farm Business Sector: Compensation Per Hour	SA, Index 2005=100	COMPNFB	BLS
Non-farm Business Sector: Hours of All Persons	SA, Index 2005=100	HOANBS	BLS
Effective Federal Funds Rate	NSA, percent	FEDFUNDS	BG
3 Month Treasury Bill Rate	NSA	T-Bill	St. Louis FED FRED
1 Year, 5 Year, 10 Year government bond Yields	NSA		Fed Board
All Employees	SA	B-1	BLS
Average Weekly Hours	SA	B-7	BLS
E5Y Confidence Indicator		Table 29	Michigan Survey
Buy Intentions Durables		Table 35	Michigan Survey
Buy Intentions Vehicles 1 Year ahead		Table 37	Michigan Survey
1 Year ahead Inflation Expectations		Table 32	Michigan Survey
BAA-AAA corporate spread			St. Louis FED FRED

CP = current prices, CVM = chained volume measures (2005 Dollars), SA = seasonally adjusted, NSA = not seasonally adjusted. BEA = U.S. Department of Commerce: Bureau of Economic Analysis, BLS = U.S. Department of Labor: Bureau of Labor Statistics and BG = Board of Governors of the Federal Reserve System, IEC = Federal Financial Institutions Examination Council, FRB = Federal Reserve Board.

B Specification for the Minnesota prior in the VAR

Assume the simple VAR(p) model

$$y_t = v + A_1 y_{t-1} + ... + A_p y_{t-p} + \varepsilon_t, \tag{2}$$

where y_t is a $n \times 1$ vector of variables, and $\varepsilon_t \sim N(0, \Sigma)$ with Σ the covariance matrix. The prior for the VAR coefficients $A = \left[v, A_1', ..., A_p'\right]'$ is of the form

$$vec(A) \sim N\left(\underline{\beta}, \underline{V}\right),$$

where $\underline{\beta}$ is one for variables that are in log-levels, and zero for rate variables (inflation, short and long interest rates). The prior variance $\underline{V}$ is diagonal with elements,

$$\underline{V}_{i,jj} = \begin{cases} \frac{\underline{a}_1}{p^2} \text{ for coefficients on own lags} \\ \frac{\underline{a}_2 \sigma_{ii}}{p^2 \sigma_{jj}} \text{ for coefficients on lags of variable } j \neq i \\ \underline{a}_3 \sigma_{ii} \text{ for intercepts} \end{cases} \tag{3}$$

where, p denotes the number of lags. Here σ_{ii} is the residual variance from the unrestricted p-lag univariate autoregression for variable i. The degree of shrinkage depends on the hyperparameters $\underline{a}_1, \underline{a}_2, \underline{a}_3$. We set $\underline{a}_3 = 100$, and we select $\underline{a}_1, \underline{a}_2$ by specifying a wide grid of possible values.[21] We take all possible pairs of $\underline{a}_1$ and $\underline{a}_2$ on these grids, thus, estimating 1540 models with varying degrees of prior informativeness. The optimal shrinkage pair for $\underline{a}_1$ and $\underline{a}_2$ is the one that maximizes the in-sample fit of the VAR, as measured by the Bayesian Information Criterion. The covariance matrix has a diffuse prior of the form $p(\Sigma) \propto |\Sigma|^{-(n+1)/2}$.

[21] The grids of values we use are: $\underline{a}_1$ = (1e-5,2e-5,3e-5,4e-5,5e-5,6e-5,7e-5,8e-5,9e-5,1e-4,2e-4,3e-4,4e-4,5e-4,6e-4,7e-4,8e-4,9e-4,0.001,0.002,0.003,0.004,0.005,0.006,0.007,0.008,0.009,0.01,0.02,0.03,0.04,0.05,0.06,0.07,0.08,0.09,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,2,3,4,5,6,7,8,9,10),
$\underline{a}_2$ = (0.01,0.02,0.03,0.04,0.05,0.06,0.07,0.08,0.09,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,2,3,4,5,6,7,8,9,10).

C Forward-looking variables

Do responses to forward-looking variables across the two sub-samples show any systematic change related to the variation in the responses of series of economic activity and interest rates? Figures 11 and 12 show the responses of several expectation indicators from the Michigan Survey of Consumers and Tobin's Q.[22] Tobin's Q refers to the ratio of market value to book value of companies in the Dow Jones Industrial average, and it is a key forward-looking measure of how financial markets assess profitability in modern investment theory. The first forward looking variable we examine from the Michigan Survey is consumer confidence (E5Y). In the first subperiod, the response of E5Y is insignificant. In the second subperiod, in contrast, it is strongly and persistently positive, suggesting confidence about expansionary prospects of the economy. This response is interesting as it coincides with a delayed rise in TFP (not shown here). We examine the behavior of two other confidence indicators from the Michigan survey that are highly representative of the consumers' perception about future economic conditions, namely buying conditions for consumer durables and buying conditions for vehicles. In the first subperiod, none of the responses of buying conditions for consumer durables or vehicles is significantly different from zero. By contrast, in the second subperiod, the responses are strongly positive and significant on impact, suggesting that consumers perceive good times ahead. The response of Tobin's Q also is quite different quantitatively across subperiods. Tobin's Q is a key summary statistic for private investment spending because it incorporates future expectations about corporate profitability and captures how the stock market values capital of the corporate sector. The response of Tobin's Q in the first subperiod is insignificant. By contrast, the response in the second subperiod is

[22] Data availability requires us to restrict the first or second subsample for this exercise. The variables from the Michigan Survey of Consumers are only available from 1960Q1. When these variables are included in the VAR, we restrict the first subsample to 1960:Q1-1979:Q2. Tobin's Q is available only until 2017Q4. When this variable is included in the VAR we restrict the second subsample to 1982:Q3-2017:Q4, while the first subsample remains the same as in the main body of the paper (1954:Q3-1979:Q2).

significant on impact and remains positive for more than 20 quarters.

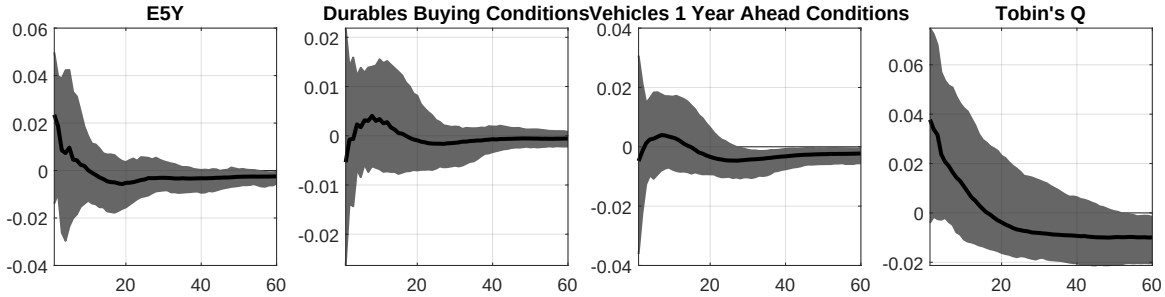

Figure 11: First sample. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock from a VAR featuring TFP, output, consumption, hours, inflation and one of the shown variables at a time. Shaded areas indicate the 16% and 84% confidence bands.

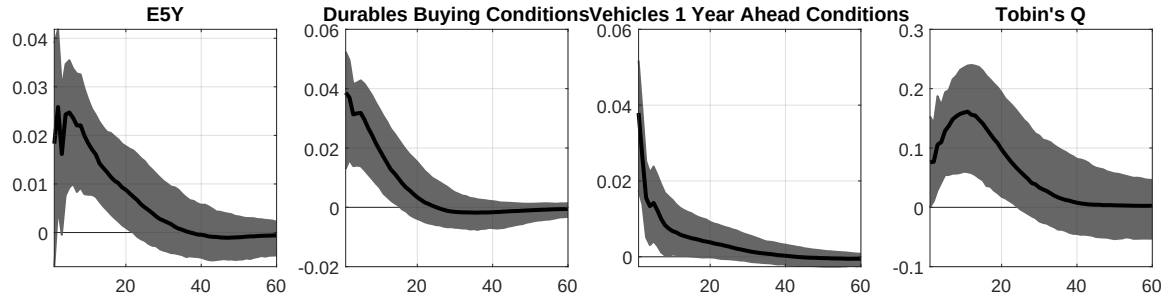

Figure 12: Second sample. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock from a VAR featuring TFP, output, consumption, hours, inflation and one of the shown variables at a time. Shaded areas indicate the 16% and 84% confidence bands.

D Excluding the Great Recession

During November 2008 the Federal Reserve launched QE1 and in December 2008 the Federal Open Market Committee set the target range for the federal funds rate at 0 to 25 basis points. This section evaluates whether our results for the second subsample are robust also when we exclude times of unconventional monetary policy and a federal funds rate at the zero lower bound. Figure 13 shows short- and long-term rates for

a 1982Q3-2008Q3 subsample. The responses are generated from VAR specifications featuring TFP, output, consumption, inflation, one of the yields, and the three month treasury. In response to the TFP news shock, the one, five and ten year yields as well as the 3-month treasury rate decline which is consistent with the evidence for the longer second subsample shown in the main body of the paper.

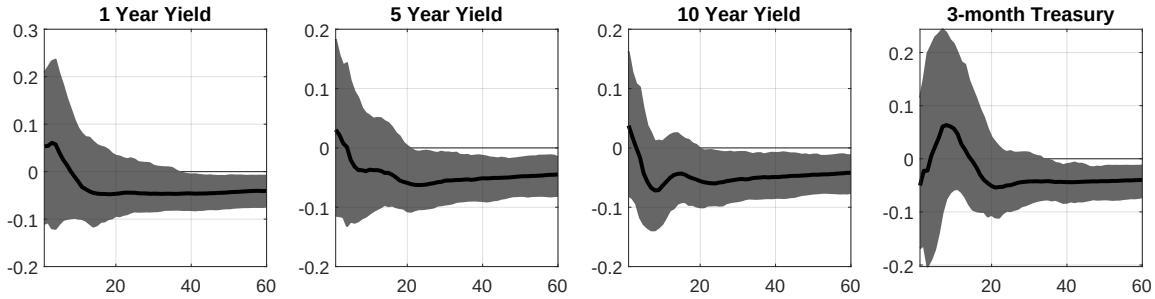

Figure 13: Alternative second sample (1982:Q3-2008:Q3). The solid line is the median estimated impulse response (in percent) to a positive TFP news. Shaded areas indicate the 16% and 84% confidence bands.

E Alternative News Shock Identification

Section 2 outlines that the shock identification scheme (based on Forni et al. (2014)) used in the main body, imposes that the news shock does not move TFP on impact but maximizes the effect on TFP in the long run. This section documents robustness of our results to two closely related alternative shock identifications suggested in the literature.[23] Shown responses are generated from VAR specifications where we condition the analysis on the same set of variables as those displayed in Figures 1 and 2, but where we replace the long- and short-term rates.

[23]Barsky and Sims (2011) propose a third alternative identification strategy that considers all shocks that are orthogonal to the innovation in current productivity. Among these, they select the shock that maximally explains a weighted average of future levels of productivity from horizons h to H. As such, the identification is closely related to the one of Neville et al. (2014) which we discuss in detail below. Results based on Neville et al. (2014) and Barsky and Sims (2011) are almost identical and are for the latter available upon request.

Alternative shock identification I. We explore the robustness of our results using the alternative approach proposed by Neville et al. (2014), which identifies the news shock as the shock that maximizes the fraction of variance explained in TFP at a specific long but finite horizon h. Both, this identification scheme and the one employed in the main body impose a no-impact restriction on TFP. Figures 14 and 15 show our results are robust when using this alternative news shock identification (setting h=40 quarters). In the first subsample short- and long-run rates rise while in the second subsample they fall. These results are qualitatively and quantitatively very similar to the results reported in the paper using Forni et al. (2014).

Alternative shock identification II. Kurmann and Sims (2017) suggest an identification that differs from the alternative identification I by the fact that it doesn't impose a zero impact restriction on TFP. Hence, it identifies the shock that explains the maximum variance of TFP at the long-run horizon h. Figures 16 and 17 show our results are qualitatively and quantitatively robust when using this alternative news shock identification (setting h=40 quarters). In the first subsample short- and long-run rates rise while in the second subsample they fall.[24]

[24]Impulse responses are still consistent with the ones documented in the main body when setting h to 60 or 80 quarters. Results are available upon request.

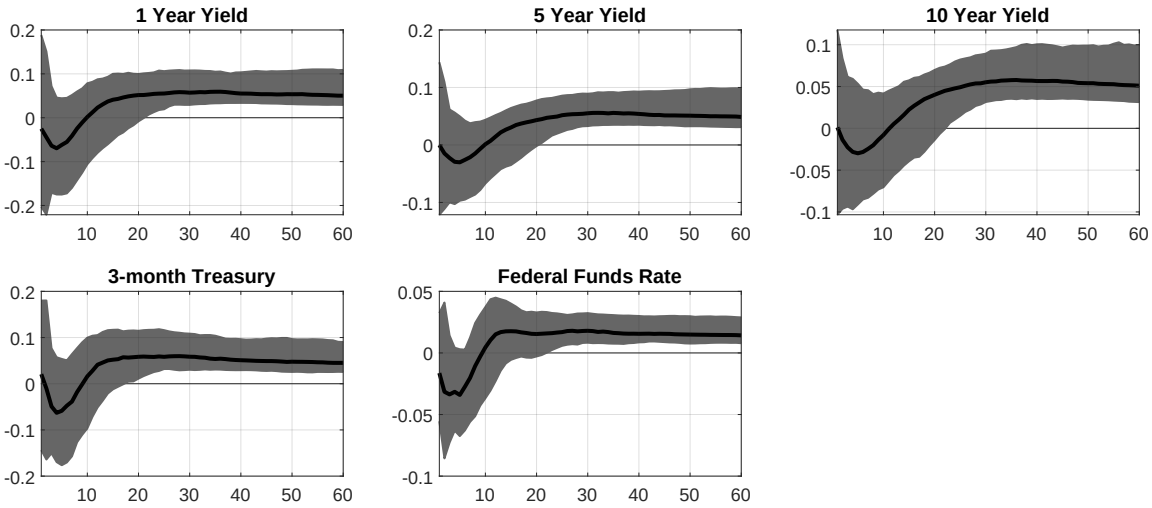

Figure 14: First sample (1954:Q3-1979:Q2)—long- and short-term rates. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Alternative shock identification I. Shaded areas indicate the 16% and 84% confidence bands.

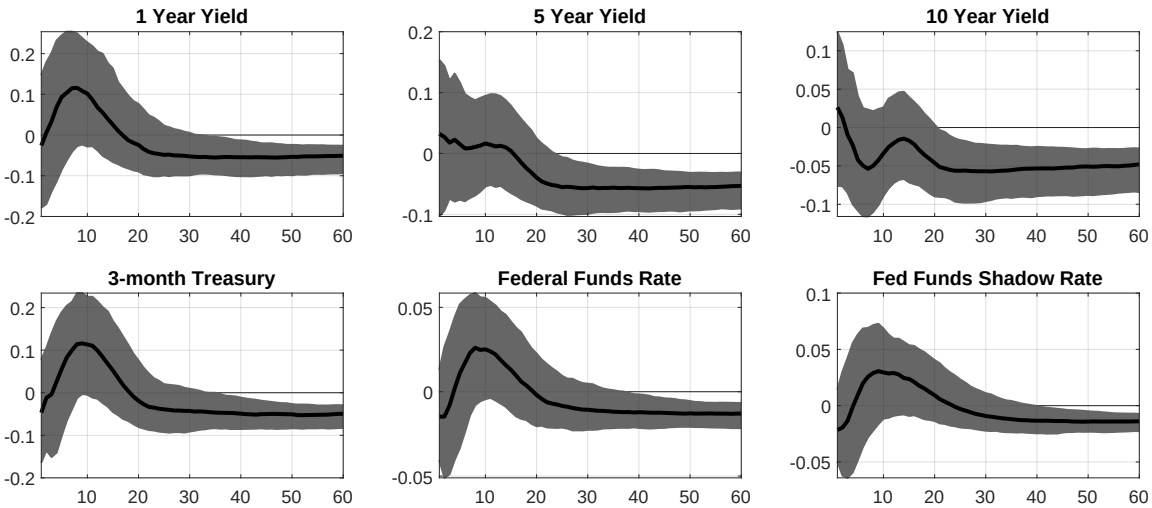

Figure 15: Second sample (1982:Q3-2018:Q3)—long- and short-term rates. Alternative shock identification I. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

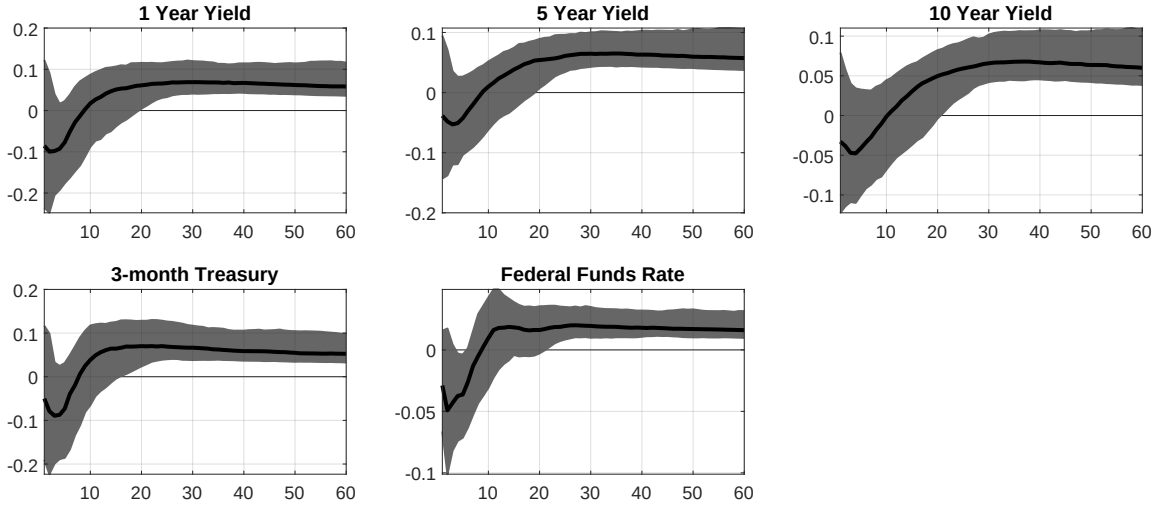

Figure 16: First sample (1954:Q3-1979:Q2)—long- and short-term rates. Alternative shock identification II. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.

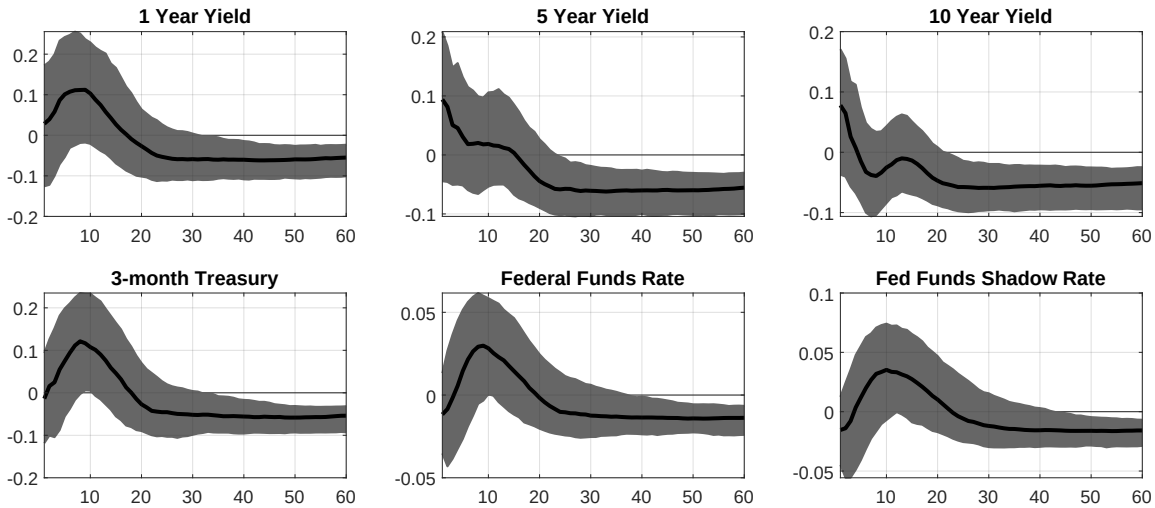

Figure 17: Second sample (1982:Q3-2018:Q3)—long- and short-term rates. Alternative shock identification II. The solid line is the median estimated impulse response (in percent) to a positive TFP news shock. Shaded areas indicate the 16% and 84% confidence bands.