Online Appendixes to Missing Disinflation and Missing Inflation: A VAR Perspective*

Elena Bobeica and Marek Jarociński
European Central Bank

*Author e-mails: elena.bobeica@ecb.int and marek.jarocinski@ecb.int.

Appendix A. Data and Sources

Table A1. Euro-Area Data Sources and Definitions

Variable	Source	Definition
Price Index		
HICP	Eurostat, ECB	Harmonized index of consumer prices, seasonally adjusted
Domestic Real Activity Variables		
Real GDP	Eurostat	Chain-linked volume, calendar and seasonally adjusted
Real Consumption	Eurostat	Chain-linked volume, calendar and seasonally adjusted
Real Investment	Eurostat	Chain-linked volume, calendar and seasonally adjusted
Total Employment	Eurostat	Persons, calendar and seasonally adjusted data
Unemployment Rate	Eurostat	Standardized unemployment rate, seasonally adjusted
Capacity Utilization	BIS	Sector covered: manufacturing
Consumer Confidence	European Commission	Survey indicator, seasonally adjusted, balance of responses
Purchasing Managers' Index (PMI)	Markit	Survey indicator, seasonally adjusted
External Variables		
Rest-of-the-World Real GDP	National sources, IMF, OECD, authors' calculations	Euro-area real GDP index was extracted from the world GDP index using the euro-area share in world GDP (expressed in PPP)
Price of Oil in USD	Bloomberg	Brent crude oil price in U.S. dollars

(*continued*)

Table A1. (Continued)

Variable	Source	Definition
	External Variables	
Price of Non-energy Commodities	OECD	Prices of raw materials, total index excluding energy (U.S. dollars)
Nominal Effective Exchange Rate	ECB	Nominal effective exchange rate vis-à-vis nineteen trading partners
USD/EUR Exchange Rate	ECB	Exchange rate against euro, spot (mid)
U.S. Real GDP	BIS	Chain-linked volume, calendar and seasonally adjusted
U.S. Consumer Prices	BIS	Consumer price index, seasonally adjusted
Federal Funds Rate	BIS	Daily and monthly average
	Financial Variables and Uncertainty	
Short-Term Interest Rate	ECB, AWM	EONIA, historical close, average of observations through period. Available since 1999, back-linked using data from the Area Wide Model (AWM) database
Two-Year Government Bond Spread	ECB	Two-year government benchmark bond yield minus EONIA
Ten-Year Government Bond Spread	ECB	Ten-year government benchmark bond yield minus EONIA

(*continued*)

Table A1. (Continued)

Variable	Source	Definition
Financial Variables and Uncertainty		
Mortgage Bank Lending Spread	National sources, Eurostat, ECB	Loans to households for house purchase, weighted average of the rates for the euro-area Big 5 (weights based on nominal GDP) minus EONIA
GM Corporate Credit Spread	Gilchrist and Mojon (2017)	The difference between the corporate bond yields and the yield of a German bund zero-coupon bond of the same maturity, aggregated acoss individual bonds from Germany, France, Italy, and Spain
GM Bank Credit Spread	Gilchrist and Mojon (2017)	As above, but only for bank bonds
VSTOXX	Bloomberg	Thirty-day implied volatility of the EURO STOXX 50, average, before 2000:Q2 replaced with the U.S VIX
Economic Policy Uncertainty Index	Baker, Bloom, and Davis (2016)	European News Index

Notes: The world GDP index was constructed as follows. Starting in 1995, quarterly national accounts data from individual national sources were used for countries covering around 93 percent of world GDP. For the remaining countries, the annual data provided by the World Economic Outlook database (WEO) was interpolated. The interpolation does not affect the aggregate world GDP, as the share of these countries is relatively small. The aggregation of individual data has been done using the annual PPP weights of each country provided by IMF WEO, and a fixed base index was constructed (2005 = 100). Before 1995, a large set of individual country data is either not available or not reliable. In order to back-link the world GDP index for the pre-1995 period, the annual world output data provided by WEO were interpolated using the quarterly data for real output of OECD countries. This ensures that the annual growth rate of world GDP is in line with the IMF estimate and the infra-annual dynamics is given by developments in countries covering a large share of world GDP.

Table A2. U.S. Data Sources and Definitions

Variable	Source	Definition
	Price Index	
CPI	BIS	Consumer price index, seasonally adjusted
	Real Activity Variables	
Real GDP	BIS	Chain-linked volume, calendar and seasonally adjusted
Real Consumption	BIS	Chain-linked volume, calendar and seasonally adjusted
Real Investment	BIS	Chain-linked volume, calendar and seasonally adjusted
Total Employment	BIS	Thousands of persons, seasonally adjusted
Unemployment Rate	BIS	Seasonally adjusted
Capacity Utilization	BIS	Sector covered: manufacturing
Consumer Confidence	Bloomberg	Conference Board Consumer Confidence, seasonally adjusted
Purchasing Managers' Index (PMI)	Bloomberg	U.S. Chicago Purchasing Managers Index, seasonally adjusted

(*continued*)

Table A2. (Continued)

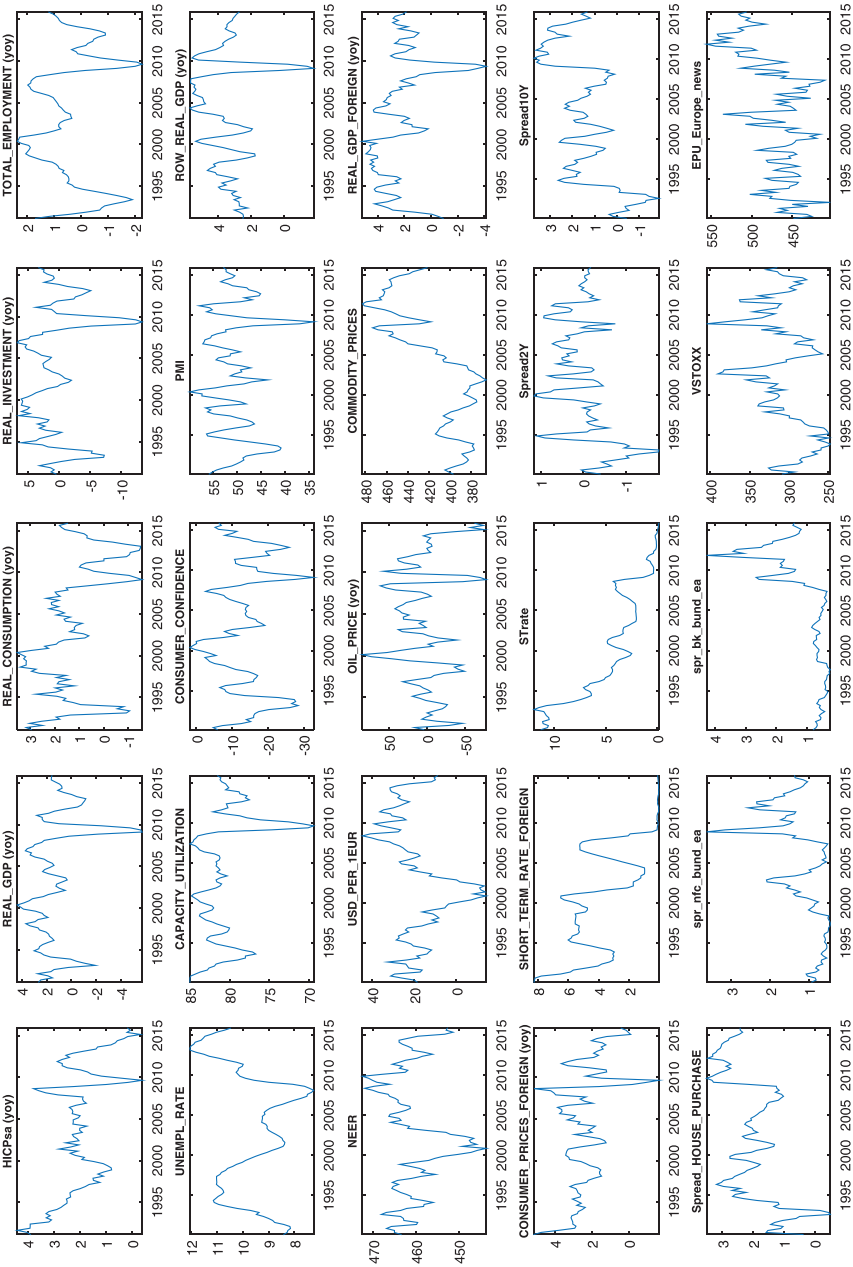
Variable	Source	Definition
	External Variables	
Rest-of-the-World Real GDP	National sources, IMF, OECD, authors' calculations	U.S. real GDP index was extracted from the world GDP index using the U.S. share in world GDP (expressed in PPP)
Price of Oil in USD	Bloomberg	Brent crude oil price in U.S. dollars
Price of Non-energy Commodities	OECD	Prices of raw materials, total index exluding energy (U.S. dollars)
Nominal Effective Exchange Rate	BIS	Nominal effective exchange rate vis-à-vis twenty-six trading partners
USD/EUR Exchange Rate	ECB	Exchange rate against euro, spot (mid)
Euro-Area Real GDP	Eurostat	Chain-linked volume, calendar and seasonally adjusted
Euro-Area HICP	Eurostat, ECB	Harmonized index of consumer prices, seasonally adjusted
Euro-Area EONIA	ECB, AWM	Historical close, average of observations through period. Available since 1999, extended back using data from the Area Wide Model (AWM) database

(*continued*)

Table A2. (Continued)

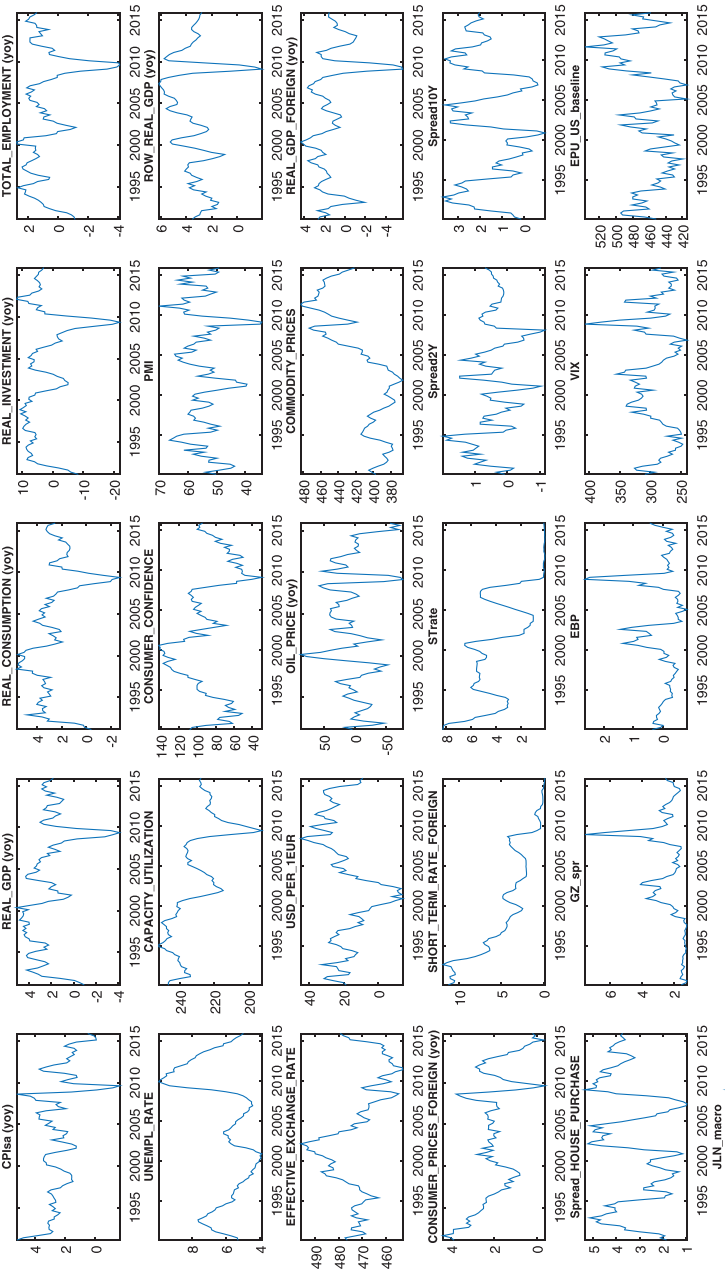
Variable	Source	Definition
Financial Variables and Uncertainty		
Short-Term Interest Rate	BIS	Federal funds rate, average
Two-Year Government Bond Spread	BIS	U.S. Treasury two-year bond yield minus federal funds rate
Ten-Year Government Bond Spread	BIS	U.S. Treasury ten-year bond yield minus federal funds rate
Mortgage Bank Lending Spread	BIS	Mortgage rate (thirty years maturity) minus federal funds rate
GZ Credit Spread	Gilchrist and Zakrajsek (2012)	The difference between the corporate bond yields and the yield of a synthetic Treasury security with the same maturity, aggregated acoss individual U.S. bonds
Excess Bond Premium	Gilchrist and Zakrajsek (2012)	As above, corrected for the risk of default
VIX	DataStream	Chicago Board of Exchange (CBOE) SPX Volatility VIX (new), before 1994 replaced with the VXO index
Economic Policy Uncertainty Index	Baker, Bloom, and Davis (2016)	U.S. baseline overall index
JLN Macroeconomic Uncertainty	Jurado, Ludvigson, and Ng (2015)	Twelve months ahead

Figure A1. Euro-Area Data



Note: The series marked (yoy) have been transformed to year-on-year changes for this plot, but we used levels for the estimation.

Figure A2. U.S. Data



Note: The series marked (yoy) have been transformed to year-on-year changes for this plot, but we used levels for the estimation.

Appendix B. Further Details on the Second Structural VAR

In this section we discuss in more detail the sign restrictions in panel B of table 2 in the main text.

We distinguish global demand shocks from domestic demand shocks using sign restrictions on the domestic real GDP and its world share. These sign restrictions are inspired by Corsetti, Dedola, and Leduc (2014) and are akin to the sign restrictions in the first structural VAR. Consider a shock that increases real GDP. If the economy's share in world GDP also increases, this means that the shock had more effect on the domestic economy than on the rest of the world and we label the shock as domestic. By contrast, if the economy's share in world GDP falls, the shock had more effect on the rest of the world and we label the shock as global.[1] Corsetti, Dedola, and Leduc (2014) use the same logic to identify productivity and global demand shocks affecting U.S. manufacturing. Following this logic, we assume that a positive *global demand shock* increases the price of oil, consumer prices, and real GDP but reduces the domestic GDP share in the world. A positive *domestic demand shock* increases both real GDP and its world share, and consumer prices.

Next, we identify an *oil supply shock* that increases the price of oil, has a negative impact on real activity, and has a positive impact on inflation. These restrictions flow from the lessons of the literature that identifies various types of oil-related shocks by modeling the global crude oil market and then investigates the impact of these shocks on the key macroeconomic variables (see, for example, Kilian 2009 and Baumeister and Peersman 2013 for the case of the United States). We impose a zero restriction on the immediate reaction of the short-term interest rate, because the short-term interest rate is largely controlled by the central bank, and central banks try, at least initially, not to react to oil supply shocks. Finally, it turns out that in

[1] A caveat is that one can imagine a shock that is global in nature but increases the demand for domestic products more than the demand for rest-of-the-world products. Such a shock would generate a positive co-movement between domestic GDP and its world share. Hence, we would label this shock as domestic. This means that this identification might capture some foreign shocks, but we can reasonably hope that most of the shocks that we label as domestic are indeed domestic.

the euro area (unlike in the United States) the exchange rate appreciates after a contractionary oil supply shock identified with the above restrictions. We conjecture that this is because the euro-area monetary policy tends to be tighter than the U.S. monetary policy in the wake of oil price increases. We add the positive reaction of the exchange rate as an additional restriction for the euro area, even though this restriction is basically never binding (it holds even if we do not impose it), in order to highlight that the oil supply shock is well distinguished from the domestic supply shock discussed next.

We assume that a positive *domestic supply shock* increases domestic output as well as its world share (following the Corsetti, Dedola, and Leduc 2014 logic) and, in contrast to the demand shock, it reduces domestic prices. With only the above restrictions, oil supply shocks and domestic supply shocks are still not distinguished, as suggested by their similar impulse responses. To disentangle them, we require that the exchange rate appreciates after a positive domestic supply shock (see Corsetti, Dedola, and Leduc 2014). In the euro area this restriction suffices to distinguish the two shocks, and the two sets of impulse responses now become distinct. In the United States this restriction does not suffice, so in the United States we also impose a magnitude restriction that the response of the price of oil to a domestic supply shock is "small" (defined here as less than 5 percent in absolute value). With this set of restrictions, the euro-area and the U.S. impulse responses are all distinct. (See figures B1 and B2.)

We identify a monetary policy shock and a spread shock following Baumeister and Benati (2013). A contractionary *monetary policy shock* is an increase of the short-term interest rate that has an immediate negative effect on output and prices, a negative effect on the bond spread, and a positive effect on the exchange rate. Since bond yields do not respond one-to-one to the short rate, the spread shrinks after a short-term rate increase. Following the same logic as before, since the monetary policy shock is a special case of a domestic demand shock, domestic output and its world share move in the same direction, i.e., the share falls.

A Baumeister-Benati *spread shock* increases the spread, while leaving the short-term interest rate unchanged. This shock also appreciates the exchange rate, and reduces output and prices. Including such a shock is useful for reflecting non-standard monetary

Figure B1. Euro-Area Impulse Responses, Identification from Panel B of Table 2

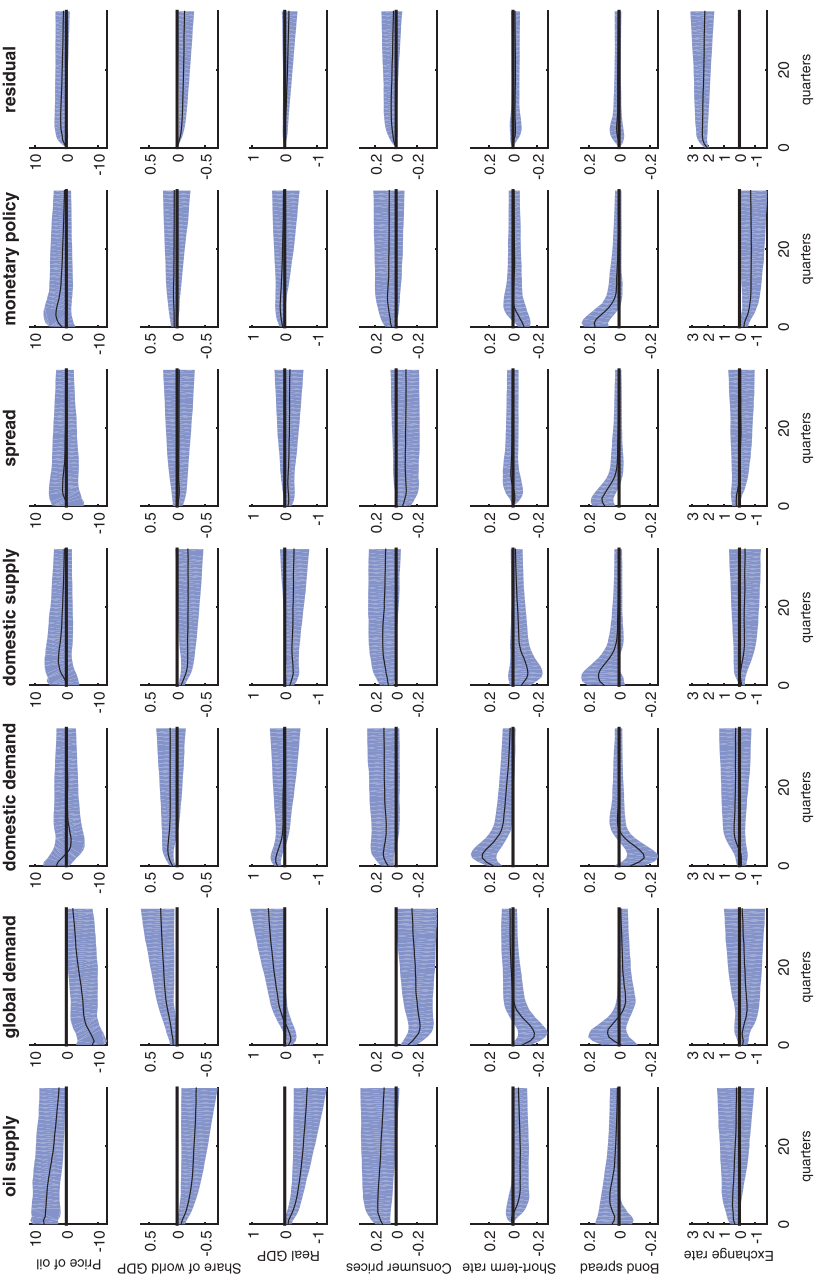


Figure B2. U.S. Impulse Responses, Identification from Panel B of Table 2

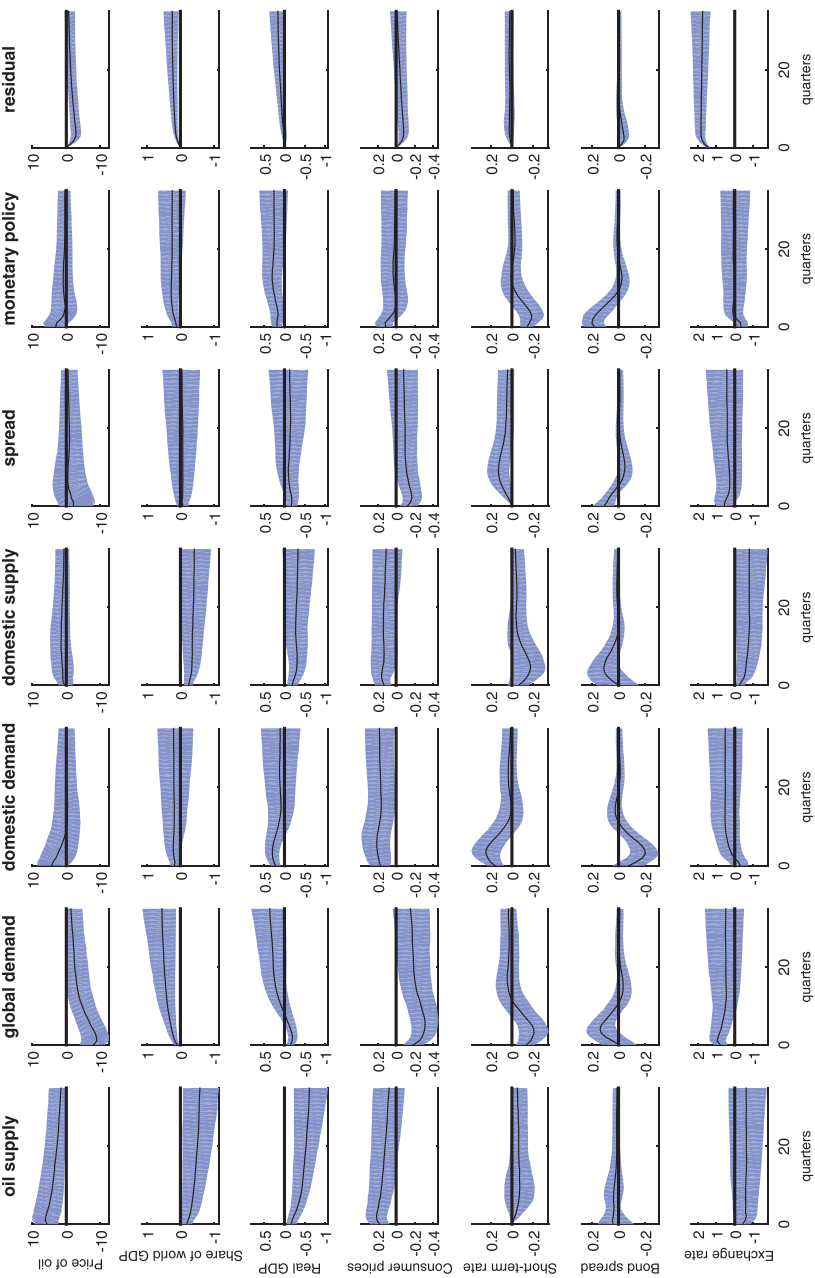
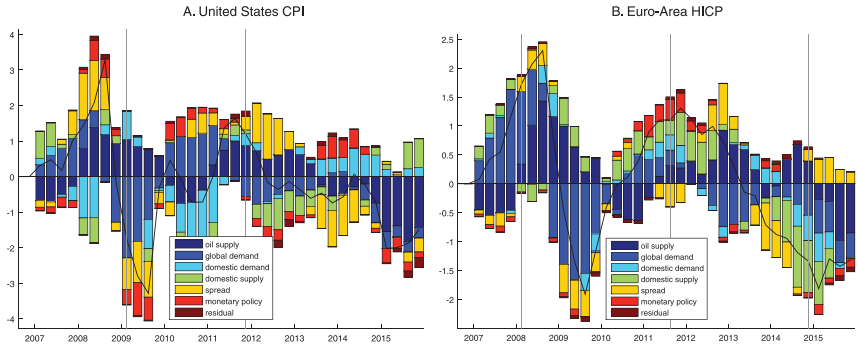


Figure B3. Historical Decompositions of Inflation in the United States and in the Euro Area in the Second Structural VAR



Notes: The black line is the deviation of year-on-year inflation from the unconditional forecast as of 2006:Q4; the bars show the contributions of different types of shocks to this deviation. Identification for both panels is from panel B of table 2.

policies when the short-term interest rates are at their effective lower bound. This shock can, however, capture also non-policy factors affecting the term structure, such as the euro-area sovereign debt crisis.

The last shock is a residual shock that accounts for the fluctuations of the exchange rate not explained by the previous shocks, and has no contemporaneous effect on all the other variables. The shock plays very little role in the dynamics of all the variables other than the exchange rate.

When implementing the above restrictions, we randomly search for orthogonal matrices that rotate the Cholesky factor of the residual variance matrix and reproduce our sign restrictions while preserving the zero restrictions. Technical details on imposing sign and zero restrictions can be found in Arias, Rubio-Ramirez, and Waggoner (2014). It takes several hours to generate 1,000 draws of the impulse responses.

Figures B1 and B2 report the impulse responses: median, 16th and 64th quantiles of the posterior distribution. We can see that all the shocks are distinct, i.e., there are no two shocks with similar impulse responses of all variables. Figure B3 reports the detailed historical decomposition.

References

Arias, J. E., J. F. Rubio-Ramirez, and D. F. Waggoner. 2014. "Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications." International Finance Discussion Paper No. 1100, Board of Governors of the Federal Reserve System.

Baker, S. R., N. Bloom, and S. J. Davis. 2016. "Measuring Economic Policy Uncertainty." *Quarterly Journal of Economics* 131 (4): 1593–1636.

Baumeister, C., and L. Benati. 2013. "Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound." *International Journal of Central Banking* 9 (2, June): 165–212.

Baumeister, C., and G. Peersman. 2013. "Time-Varying Effects of Oil Supply Shocks on the US Economy." *American Economic Journal: Macroeconomics* 5 (4): 1–28.

Corsetti, G., L. Dedola, and S. Leduc. 2014. "The International Dimension of Productivity and Demand Shocks in the US Economy." *Journal of the European Economic Association* 12 (1): 153–76.

Gilchrist, S., and B. Mojon. 2017. "Credit Risk in the Euro Area." *Economic Journal* 128 (608): 118–58.

Jurado, K., S. C. Ludvigson, and S. Ng. 2015. "Measuring Uncertainty." *American Economic Review* 105 (3): 1177–1216.

Kilian, L. 2009. "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market." *American Economic Review* 99 (3): 1053–69.