Effects of Quantitative Easing on Economic Sentiments: Evidence from Three Large Economies [1]

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Abstract

We analyse the impact of Quantitative Easing (QE) on economic sentiments (business and consumer confidence, economic policy uncertainty, and volatility) within three large and advanced economies (Europe, Japan, and the US), an area which has been left relatively unexamined. We observe a strong response of the economic sentiment variables in the US to a QE shock. Over a longer time-horizon, the forecast error variance decompositions show that the US is the only economy where the QE shock accounts for a large and persistent portion of the variance in the economic sentiment variables across the different specifications used. The shocks in Japan and Europe tend to account for a very small amount of the variance in the corresponding variables, even at longer time horizons.

Keywords: Quantitative easing, confidence, uncertainty, volatility, VAR
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[1] The views expressed here are those of the authors and not necessarily those of the institutes they are affiliated to. Some parts of this article are based on the first author's master thesis (Baker, 2020), which was supervised by the second author.

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1. Introduction

The financial crisis that began in 2007 was one of the most intense periods of global financial strain since the Great Depression, leading to a deep and prolonged global economic downturn. Several institutions, both fiscal and monetary, took extraordinary actions in response to the financial crisis to help stabilise the national and global economic and financial system. Policymakers were forced to rapidly expand their toolkits to counteract the crisis. In the fall of 2008, the Federal Open Market Committee (FOMC) in the United States (US) lowered the federal funds rate, its main policy tool, to near zero. The Committee also began *"unconventional monetary policy,"* (UMP) programmes explicitly aimed at providing further policy accommodation with interest rates near zero (i.e., at the zero-lower bound) and stimulating aggregate expenditures (Contessi and Li, 2013).

The use of quantitative easing (QE)[4] was just one such UMP, and the scale of the purchases made globally marked a seismic shift in what is considered the normal policy response of central banks to novel economic conditions. The scale of QE in particular was unprecedented (see Figure 1). Yet the crisis of 2007-08 was not the first time QE had been used as a monetary policy tool; the BoJ began using QE in 2001. Two decades later, and although QE has been used extensively, the exact transmission and mechanics behind QE remain controversial. The complexity of the topic was summed up by former Fed Chair Ben Bernanke, who famously quipped that QE "works in practice, but it doesn't work in theory" (Bernanke, 2014).

This paper adds to the growing literature on the impact of QE on three large and advanced economies, Japan, Europe,[5] and the US. We use Bayesian vector autoregressions (BVARs) to analyse the impact of QE on business and consumer confidence, uncertainty, and volatility indicators within these economies, an area which has been left relatively unexamined by researchers. There is a noticeable and understandable tendency from researchers to focus on real variables, such as unemployment, inflation, and bond yields when assessing the success of QE.[6]

[4] Throughout this paper, QE refers to the level of assets held on the balance sheets at any one of the three central banks, while an increase in QE refers to an increase in those asset holdings.
[5] This paper studies the ECB actions on a set of 19 European countries sharing the same monetary union, the Eurozone, rather than the 28 countries within the European Union (in 2019).
[6] See, among many others, Lenza et al., 2010; Gagnon et al., 2011; Joyce et al., 2011; Girardin and Moussa, 2011; Krishnamurthy and Vissing-Jorgensen, 2011; Lam, 2011; Chung et al., 2012; Ueda, 2012; Baumeister and Benati,

Though these studies are vital, as they align with the stated goals of QE from the three large central banks, central bankers also concern themselves with economic sentiments, such as confidence,[7] uncertainty,[8] and volatility within the economy when making decisions.[9] This is the case both in normal times and in times of recession, given many of these variables are ones policymakers rely on for their policies to operate through, and form one of the key transmission mechanisms for quantitative easing (Hausken and Ncube, 2013, Chapter 2). Prima facie, QE appears to have some relationship with confidence, uncertainty, and volatility (Baker, 2020). On the 4th January 2020, when Bernanke delivered the 2020 American Economic Association Presidential Address on the new tools of monetary policy, he lamented the failure of researchers to assess the impact of policy interventions on confidence, risk-taking and credit flows (Bernanke, 2020).

In this paper we address one of Bernanke's concerns, economic sentiments, by providing several empirical analyses to four variables that are generally perceived to represent economic sentiments within an economy: (i) business confidence index, (ii) consumer confidence index, (iii) volatility index, and (iv) economic policy uncertainty index.[10] The business confidence index (BCI), constructed by the OECD, attempts to measure confidence using opinion surveys on developments in production, orders, and stocks of finished goods in the manufacturing sector. The consumer confidence index (CCI), also constructed by the OECD, assesses the future consumption and saving habits of households. In order to assess confidence in the financial markets, we use market expectations of near-term volatility as measured by stock index option prices in each economy (VIX for the US, VSTOXX for Europe, and JNIV for Japan). Finally, we use a news-based measure of economic policy uncertainty (EPU), which differs from the other measures of confidence as it measures uncertainty related to economic policy, rather than economic conditions more generally. In general, an increase in uncertainty or volatility, or a

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2013; Bekaert et al., 2013; Hausken and Ncube, 2013; Schenkelberg and Watzka, 2013; Rogers et al., 2014; De Rezende et al., 2015; Fratzscher et al., 2016; Georgiadis and Gräb, 2016; Hatzius et al., 2016; Michaelis and Watzka, 2017; Borio and Zabai, 2018; Greenlaw et al., 2018; Koeda, 2019; Matousek et al., 2019; Di Maggio et al., 2020; Fabo et al., 2021; Neely, 2022.

[7] See Nowzohour and Stracca (2020, Section 3.2) for a literature on confidence.

[8] See Nowzohour and Stracca (2020, Section 3.4) for a literature on uncertainty.

[9] See, for example, Correa et al., 2021.

[10] See Nowzohour and Stracca (2020) for an overview of the recent literature on the nexus between sentiment (considering both confidence and uncertainty) and economic activity.

decrease in business and consumer confidence, will result in lower economic activity as confidence feeds into investment activity, asset prices, and exchange rates.

We provide evidence on the relationship between QE and economic sentiments within the three large, advanced economies. Our quantitative analysis is based on reporting impulse response functions (IRFs) with recursive identification and forecast error variance decompositions (FEVDs) from BVARs featuring the size of the central banks' assets, economic sentiment variables, and macroeconomic and financial variables. We study three VAR specifications where we change the orderings. In VAR-1, all variables except the share price index, EPU, consumer price index, and the long-term interest rate respond contemporaneously to a QE shock. In VAR-2, the central bank assets are placed first so that QE shocks can affect all variable contemporaneously, but not vice versa. In VAR-3, the central bank assets are placed at the end. If one believes that unconventional monetary policy only affects other variables with a lag, it is appropriate to place the central bank assets last in the ordering. This choice of ordering precludes a contemporaneous response of remaining variables to a QE shock.

There are several points of interest to note from our study. The first is the strength of the response of the economic sentiment variables in the US to a QE shock. Over a longer time-horizon, the FEVDs show that the US is the only economy where the QE shock accounts for a large and persistent portion of the variance in the economic sentiment variables across the different specifications used. The shocks in Japan and Europe tend to account for a very small amount of the variance in the corresponding variables, even at longer time horizons. The second point to note is that in general, and with the exceptions of the business confidence in the US and in Europe, consumer confidence in VAR-2 specification in Europe, volatility in Japan (and in VAR-2 specification in the US), economic sentiment variables tend not to respond in the very short run (1-month) to QE shocks, instead the shocks only have some explanatory effect after a year. Most of the variance is typically explained later in the time horizon, typically after 3, though in some cases after 5, years.

The rest of the paper is organised as follows. Section 2 details the related history of QE's use by the Bank of Japan (BoJ), the European Central Bank (ECB), and the Federal Reserve System

(Fed). Section 3 presents the data and discusses the model specifications as well as the estimation approach. Section 4 provides the quantitative analysis. Section 5 concludes.

2. QE: A Roadmap of the Experiences

The 2008 Financial Crisis had a significant impact on central banks' monetary and prudential policies for the banking system. For decades prior to 2008, the Fed's FOMC would adjust monetary policy to match economic conditions by raising or lowering its target rate for the federal funds rate (FFR).[11] Figure 2 shows the time path of the effective federal funds rate, which is essentially determined by the market, but is influenced by the Fed through open market operations to reach the federal funds rate target. Prior to 2008, the FOMC set a single target for the FFR and used open market operations (OMOs) to maintain the rate at or around their target. Prior to the crisis, capital requirements for banks were low, weakly monitored and readily by-passed through the creation of off-balance sheet special purpose vehicles. Prior to September 2008, the Fed primarily bought and sold relatively small quantities of Treasury securities in the open market (OMOs) to adjust the level of bank reserves and influence the FFR (Wolla, 2019). By December 2008, the Fed had lowered the FFR to a target range between 0 to 25 basis points (Wolla, 2019).

After the crisis, the banking landscape changed dramatically. Banks and shadow banks were subject to significant increases in capital requirements, and banks, especially those deemed systemically important, were now carefully monitored. The toolkits of the three largest central banks have been expanded to include interest payments on the reserves of depository institutions, and several rounds of QE were undertaken, which led to more than a fivefold increase in the Fed's balance sheet (Magill et al., 2016). To provide stimulus and liquidity with short-term interest rates approaching zero, the Fed made a series of large-scale asset purchases (LSAPs) of longer-term fixed income assets to reduce long-term interest rates[12] between late 2008 and October 2014.[13] The scale of the crisis was such that the FFR remained near zero until December 2015.

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[11] The FFR is the interest rate at which depository institutions trade federal funds with each other overnight.
[12] The decline in long-term interest rates across the three economies is highlighted in Figure 3.
[13] See Tables A.1-A.3 for a more detailed timeline on each central bank's QE related announcements.

2.1 QE Experience of the US

In December 2008, with the FFR at the zero lower bound and having exhausted lending facilities,[14] the Fed turned initially to unconventional crisis facilities, such as the Commercial Paper Funding Facility, and the Asset-Backed Commercial Paper Money Market Fund Liquidity Facility. Realising that more was required to provide liquidity and settle financial markets with ever increasing credit spreads, the Fed turned to large-scale asset purchases. Recognising that the crisis was rooted in the housing sector, and that the fall in value of mortgage-backed securities (MBS) had led to a gaping hole in many banks balance sheets, in November 2008 the Fed announced they were purchasing $100 billion in Government Sponsored Enterprise (GSE) debt and $500 billion in agency-backed MBS. In early 2009, as the crisis worsened, the programme was expanded dramatically to include purchases of Treasuries and further MBS and GSE debt. At the end of QE1 $1.73 trillion securities had been purchased by the Fed, doubling the balance sheet of the central bank. What distinguished these actions from credit easing and the general pumping of liquidity into the banking system, was that the Fed was now removing, or transforming, the maturity mismatch in the market and providing liquidity in exchange.

In many respects QE1 was an attempt to stabilise financial markets, rather than to achieve any broader macroeconomic goals. It was only once normalisation of the financial markets had occurred that the Fed instituted QE2 in order to achieve such goals. In November 2010, the FOMC began purchasing $75 billion securities a month. It is worth noting that a minority of the FOMC wanted a larger stimulus in an attempt to surprise the markets into action, but Bernanke insisted on a 'middle of the road' strategy (Tooze, 2018 p. 367). This is a point not lost on commentators, who note that the effect of QE2 may have already been 'priced in' before it was announced, somewhat obscuring the impact QE2 had on markets (Agostini et al., 2016).[15]

In September 2011, noting that the economy was still weak, the Fed announced the Maturity Extension Programme and Reinvestment Policy. 'Operation Twist,' (or 'QE 2 1/2') as it was

[14] These include the Primary Dealer Credit Facility, International Swaps Agreements, and the Terms Securities Lending Facility.

[15] Indeed, as Agostini et al. (2016) point out, a CNBC survey of economists, fixed income and equity managers on November 1, 2010 showed that 99% of the respondents expected the QE announcement.

more commonly referred to, sought to influence the yield curve through purchases of long-term Treasuries, sterilised by selling off short-term Treasuries. The 'twisting' refers to changing the shape of the yield curve at the longer end. Yet in 2012, the crisis that had begun four years earlier was still dragging on the US economy. The FOMC instituted the biggest expansion in asset purchases yet, promising to do so until they saw a "substantial improvement in the outlook for the labour market." This statement was made in conjunction with a promise to keep interest rates at zero until unemployment fell below 6.5%. Another announcement was made in December, effectively increasing the number of securities purchased per month to $85 billion. As Tooze (2018, p. 442) notes, this led to QE3 obtaining the nickname: "QE infinity," a tag that the Fed is still struggling to shake off.

Yet shortly after QE3, it appeared the Fed were changing tack. In mid-2013 with the unemployment rate approaching 7%, then Fed Chair Ben Bernanke announced that provided economic activity remained positive, there would be a moderation in the amount of purchases the Fed was undertaking. This led to what is known as the 'taper tantrum,' a major selloff in fixed-income assets. The Fed ended its purchases in October 2014 and raised interest rates for the first time in eight years in December 2015. This concluded a six-year programme where an unprecedented $3.5 trillion worth of securities were purchased. In October 2019, the Fed announced that they would be engaging in repurchase agreements, purchasing Treasury bills at a rate of $60 billion per month. Though the Fed maintain that this is not QE, their balance sheet is growing, and commentators have labelled the action 'QE-lite.'[16]

2.2 QE Experience of Japan

At the height of the crisis, the BoJ was well equipped to roll out QE, having had experience with QE since March 2001. The Japanese economy had already experienced several crises; their asset bubble crash in 1992 saw a decade of economic stagnation, and just as the economy appeared to be recovering, it was hit with the burst of the dot-com bubble. Having exhausted standard monetary tools on countering the effects of deflation, low economic growth, and an aging population, the BoJ announced that they would be targeting an increase in the outstanding

[16] Financial Times, "Fed's divided views reflect investor confusion" https://www.ft.com/content/5cc56ea0-dad1-11e9-8f9b-77216ebe1f17

balance of current accounts at the Bank, rather than targeting any reduction in long-term rates through asset purchases. 'QE1' saw an increase in the commercial bank current account balance (CAB) from ¥5 trillion to ¥35 trillion up until the programme ceased in early 2006 (Watanabe and Yabu, 2013). However, QE1 was also somewhat limited by rules governing moral hazard and loss limitation, in particular a rule that stipulated that the Bank could only purchase short-term bonds, preventing it from targeting the longer-end of the yield curve, and by the "banknote rule," a rule preventing holdings of longer-term Japanese government bonds from exceeding banknotes in circulation.

In 2010 the BoJ instituted its second round of QE ('QE2'). This programme was expanded on multiple occasions and was complemented by what came to be known as 'Abenomics,' a massive expansion in fiscal spending which did not accompany the initial round of monetary easing. The limits imposed on the Bank during QE1 were somewhat lifted when the Comprehensive Monetary Easing (CME) programme was enacted. The Bank moved into purchasing exchange-traded funds (ETFs), Japanese real estate investment trusts (J-REITs), corporate bonds, commercial paper and shorter-duration government securities.

In 2013, with 'Abenomics' in full swing, the BoJ under their new governor Haruhiko Kuroda, instituted their most aggressive version of QE yet, termed "Quantitative and Qualitative Monetary Easing (QQE)". Their target became the doubling of the monetary base (quantity), rather than the uncollateralised overnight call rate (interest rate). In 2014 the programme became more aggressive, with longer-duration bonds being targeted at an increased rate of ¥80 trillion annually, while tripling the purchases of ETFs and REITs. In 2016, having cut interest rates to -0.1% in conjunction with QQE, the Bank altered QQE once more. 'QQE with yield curve control' was implemented. This programme allowed the Bank to control short-term and long-term interest rates through market operations, while committing to "inflation overshooting," whereby the bank would allow for the monetary base to expand such that the consumer price index exceeded and stayed above the price target of 2%. The experience of the BoJ is almost inverse to that of their American counterparts: choosing to purchase slowly at first, before aggressively increasing purchases.

2.3 QE Experience of the European Union (EU)

Europe was a relative latecomer to QE. This was partly due to the complex politics of the region, but more so for legal reasons, the ECB being unable to buy newly issued Government securities.[17] So confident was the ECB about upside inflation due to an increase in commodity prices, they actually increased interest rates in July 2008. Beginning in May 2009, the ECB operated instead what was known as the "grand bargain," preferring to provide cheap liquidity to commercial banks via long-term refinancing operations (LTRO) in response to the crisis. This in effect meant that the commercial banks absorbed the sovereign debt onto their own balance sheets (Tooze, 2018, p. 286), rather than onto the central banks.[18]

The ECB's focus on liquidity support was backed by private asset purchases. The ECB made a conscious decision to avoid government bonds to put governments in the EU under pressure to adopt structural and fiscal reform. The ECB's mandate to purchase was in effect, inverse to that of the Fed (Ubide, 2017, p. 60). Purchases of private assets were unrestricted, unlike the Fed which was restricted to government bonds and mortgages, while the ECB was restricted from purchasing public debt. Private asset purchases increased from 2009-2014, until in Jackson Hole in August 2014, the president of the ECB, Mario Draghi, finally hinted at the potential for the ECB to engage in the purchase of government bonds. It took until 2015 until QE was finally undertaken in Europe. The European Court of Justice had determined that the ECB's bond buying scheme of 2012 did not constitute "monetary financing," pathing the way for Mario Draghi to respond to the threat of deflation by purchasing €60 billion worth of bonds monthly, with maturities varying between 2-30 years. These purchases rose to €80 billion a month in 2016, before gradually tapering off to €60 billion a month in April 2017, and €15 billion a month in late 2018. The QE programme continued at a slower rate in Europe until December 2018. This was to be temporary, with the ECB resuming asset purchases in November 2019 at a rate of €20 billion per month.

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[17] These legal issues rage on in 2019: https://www.ft.com/content/c19132ec-b2b3-11e9-bec9-fdcab53d6959

[18] Had it not been for these legal barriers, QE would almost certainly have been undertaken earlier with the IMF recommending such a policy in 2010: IMF, https://www.imf.org/en/News/Articles/2015/09/14/01/49/pr09159

3. Specifications and Data

The choice of policy instrument to use in a VAR to identify the impact of QE on the wider macroeconomy has been wide ranging. Neely (2022) notes that most studies use some measure of spread, such as the mortgage or term spread, while others use the central bank's balance sheet as a proxy for their respective QE programmes. Gambacorta et al. (2014) estimate a panel VAR with shocks to central bank assets as a proxy for a QE shock, concluding that an increase in assets leads to temporary increases in output and prices during periods of crisis. Similarly, Bhattarai et al. (2021) use a structural BVAR with the size of the Fed's asset holdings as an instrument for QE. Authors tend to use term spread shocks as central bank purchases of bonds attempt to reduce spreads, shocks to those spreads are then able to be used as a proxy for central bank action. Baumeister and Benati (2013) use a pure term spread shock in a time-varying parameter VAR framework. Liu et al. (2019) also use the spread shock as a proxy for the asset purchase programme. Neely (2022) notes that several other methods are included as proxies, such as shadow rates or long-term yields.

3.1 Model Specifications and Identification

We follow Bhattarai et al. (2021) in using the size of central bank balance sheets as our QE instrument. We investigate the role of QE shocks on several macroeconomic variables using BVAR framework. We use ten variables that incorporate both macroeconomic and financial variables consistent with Hausken and Ncube (2013) and Kapetanios et al. (2012). Though our model contains a relatively small set of variables compared to many similar studies (e.g., Kapetanios et al., 2012; Hausken and Ncube, 2013), studies have shown that any loss in accuracy of estimates is relatively minor, and may even be more accurate than models containing a large set of variables over longer periods (Carriero et al., 2015). Having a small, yet rich, set of variables that summarise the economies of the three large economies also allows us to analyse the impact of QE in a more parsimonious form.

Regarding the real economy, we use industrial production as a proxy for general economic activity, the harmonised unemployment rate, and the consumer price index to measure inflation. In order to obtain the impact of QE on the financial markets, we use share price indices, volatility indices, and the long-term (10-year) interest rate. Alongside volatility, large changes in which can impact confidence both via business investment and consumer spending, we introduce 3 variables to measure confidence within the broader economy. These include measures of business (BCI) and consumer (CCI) confidence, and an additional economic policy uncertainty (EPU) variable. All variables are transformed by their natural logarithm except the long-term interest rate and the harmonised unemployment rate.

VAR- 1	VAR- 2	VAR- 3
ln (Share Price)	ln (Central Bank Assets)	ln (Share Price)
ln (Uncertainty)	ln (Share Price)	ln (Uncertainty)
ln (CPI)	ln (Uncertainty)	ln (CPI)
Long Term Interest	ln (CPI)	Long Term Interest
ln (Central Bank Assets)	Long Term Interest	ln (Industrial Production)
ln (Industrial Production)	ln (Industrial Production)	Harmonised Unemployment
Harmonised Unemployment	Harmonised Unemployment	ln (BCI)
ln (BCI)	ln (BCI)	ln (CCI)
ln (CCI)	ln (CCI)	ln (Volatility)
ln (Volatility)	ln (Volatility)	ln (Central Bank Assets)

A key aspect of the VARs we employ is the Cholesky ordering. VAR-1 is our baseline ordering for each of the three economies. It is important to note that alternative orderings are always possible, and excessive reliance on the Granger-type causality tests may lead to inaccurate responses to a shock to asset holdings. With this in mind, we present two extreme cases. The first case presents asset holdings as the first variable in the ordering (VAR-2), where a shock to asset holdings can impact all variables contemporaneously. The second extreme case has asset holdings as the final variable (VAR-3), which represents the belief that asset holdings impact all variables with a lag. VAR-2 and VAR-3 allow us to assess whether asset holdings exhibit robust effects across specifications and economies.

3.2 Data and Sample Periods

The OECD[19] is the source for the following variables for Europe, Japan, and the US: (i) business confidence index (BCI), (ii) consumer confidence index (CCI), (iii) consumer price index (CPI), (iv) harmonised unemployment, (v) industrial production (IP), (vi) long-term interest rate, and (vii) share prices. For volatility, we use the series "CBOE Volatility Index: VIX, Index, Monthly,

[19] https://stats.oecd.org/

Not Seasonally Adjusted"[20] for the US. For Japan, we use the series "Nikkei Volatility Historical Data."[21] For Europe, we use the series "STOXX 50 Volatility VSTOXX EUR Historical Data."[22] For uncertainty, we use the US economic policy uncertainty (EPU) index,[23] the Japan EPU index,[24] and the Europe EPU index.[25] For central bank assets, we use the series "Total Assets: Total Assets (Less Eliminations from Consolidation): Wednesday Level, Millions of U.S. Dollars, Monthly, Not Seasonally Adjusted"[26] for the US. For Japan, we use the series "Bank of Japan: Total Assets for Japan, 100 Million Yen, Monthly, Not Seasonally Adjusted."[27] For Europe, we use the series "Central Bank Assets for Euro Area (11-19 Countries), Millions of Euros, Monthly, Not Seasonally Adjusted."[28] All data is monthly. The sample period is 2003:01-2009:12 for the US, 2000:01-2009:12 for Japan, and 2000:01-2009:12 for Europe.

3.3 Estimation Approach

We estimate the model as p^{th}-order VAR in levels including both a constant term and a linear time trend:

$$y_t = c + \gamma t + B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_P y_{t-P} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \Xi). \tag{1}$$

Here y_t denotes a $n \, x \, 1$ vector of endogenous variables, ε_t a $n \, x \, 1$ vector of errors, and $c, \gamma, B_1, B_2, \dots, B_p$, and Ξ represent matrices of suitable dimensions containing the unknown parameters of the model, including the constant (c), time trend (γ), coefficients of lagged endogenous variables ($B_1, B_2, \dots, B_p$), and the covariance matrix (Ξ). Classical estimations of models like (1) may yield a problem known as *overfitting* in the literature. Overfitting proves to be a serious issue when the dataset is short, sample information is weak or the number of parameters is large. To overcome the overfitting problem, we employ Bayesian estimation techniques. We follow Meinen and Roehe (2017) and use an independent Normal inverse

[20] https://fred.stlouisfed.org/series/VIXCLS
[21] https://www.investing.com/indices/nikkei-volatility-historical-data
[22] https://www.investing.com/indices/stoxx-50-volatility-vstoxx-eur-historical-data
[23] https://www.policyuncertainty.com/us_monthly.html
[24] https://www.policyuncertainty.com/japan_monthly.html
[25] https://www.policyuncertainty.com/europe_monthly.html
[26] https://fred.stlouisfed.org/series/WALCL
[27] https://fred.stlouisfed.org/series/JPNASSETS
[28] https://fred.stlouisfed.org/series/ECBASSETSW

Wishart prior, assuming that $\beta \equiv vec\,(c, \gamma, B_1, B_2, \dots, B_p)$ is normally distributed, $\beta \sim N(b, H)$. Ξ has an inverse Wishart distribution with scale S and v degrees of freedom, $\Xi \sim IW(S, v)$.

The prior for β is of the so-called Minnesota-type (Doan et al., 1984; Litterman, 1986). The rest of our approach directly follows Meinen and Roehe (2017). Let i refer to the dependent variable in the i^{th} equation, j to the independent variable in that equation, and l to the lag number. The prior distribution for β is defined such that $E\left[(B_l)_{ij}\right] = 1$ for $i \neq j$ and $l = 1$ and 0 otherwise, while all other elements in b are set to zero. The diagonal elements of the diagonal matrix H are defined as $\left(\frac{\lambda_1}{l^{\lambda_3}}\right)^2$ if $i = j$, $\left(\frac{\sigma_i \lambda_1 \lambda_2}{l^{\lambda_3} \sigma_j}\right)^2$ if $i \neq j$, and $(\sigma_i \lambda_4)^2$ for the constant and time trend. The prior parameters σ_i and σ_j denote the standard deviations of error terms from the OLS regressions. We set hyperparameters $\lambda_1 = 0.2$, $\lambda_2 = 0.5$, $\lambda_3 = 1$, and $\lambda_4 = 100$. Turning to the inverse Wishart distribution, the degrees of freedom v amount to $T+n+1$, with T denoting the sample length. The scale parameter S is n x n diagonal matrix with diagonal elements ${\sigma_i}^2$. A Gibbs sampling approach is employed to generate draws of β and Ξ from their respective marginal posterior distribution. We simulate 10,000 draws and discard the first 90% as a burn-in. The frequency of the series in the VARs is monthly. The VARs are estimated with 4 lags to account for any serial correlation in the variables, which enables us to consistently estimate the impulse responses and forecast error variance decompositions even using variables in levels.[29] We estimate a VAR system using all the variables in levels. This level of specification is robust to possible cointegration of the model variables.[30,31,32]

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29 See Toda and Yamamoto, 1995; Bachmann et al., 2013; Jurado et al., 2015; Charles et al., 2018; Ma and Samaniego, 2019.

30 See, among many others, Sims et al., 1990; Inoue and Kilian, 2002; Christiano et al., 2005; Uhlig, 2005; Bachmann et al., 2013; Baumeister and Kilian, 2014; Jurado et al., 2015; Ma and Samaniego, 2019.

31 Bloom (2009) applies an HP filter to all series before estimating the VAR. Unlike Bloom (2009), we do not HP filter the variables before estimating the VAR. HP filtering prior to estimation is neither a common nor a recommended practice in the structural vector autoregressions (SVAR) literature, because HP filtering the data precludes by construction very persistent or permanent effects of uncertainty shocks (Bachmann et al., 2013).

32 Possible concerns regarding the stationarity/non-stationarity discussions are not that important in our setup. Even if some variable we employ may contain unit roots, estimating the VAR with variables in non-stationary forms may generate important insights that can be missed by using stationary forms because we are interested in the dynamic nature of relationships between asset holdings and confidence variables, but not in parameter estimates per se (Ma and Samaniego, 2019).

4. Results

4.1 Impulse Responses

This analysis uses two tools to assess how various economic sentiments measures react in response to a shock to asset holdings of the relevant central bank. The first tool we use is graphical, using impulse response functions (Figures 4-15) to illustrate the responses of the measures in the three large economies to a standard deviation shock to asset holdings at the relevant central bank. Solid black lines depict median responses to a shock of one standard deviation. 'Red' and 'blue' shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figures 4-7 illustrate the response of sentiment measures in the US. The business confidence index (BCI) (Figure 4) initially decreases in both the VAR-1 and VAR-2 specifications. These decreases are statistically significant. In the baseline case, a peak fall is observed around -0.05% after four months. There is a rebound effect after that. In the baseline case, a peak increase is observed around 0.10% after 18 months. This result is robust to the choice of specification, though in VAR-2 the response is slightly larger in magnitude, increasing around 0.13%. The impact of the shock declines and bottoms slightly below the pre-shock level after four years. The initial reaction is insignificant in the VAR-3 specification. After that, the BCI shows responses similar to those observed in the other specifications. The consumer confidence index (CCI) in the US (Figure 5) reacts with a lag and increases by similar magnitudes as business confidence. The only noticeable difference between the two confidence indicators is that consumer confidence appears to react slightly earlier after the shock and persists for slightly longer. Again, this result is robust to specification. Economic policy uncertainty (EPU) in the US (Figure 6) shows an immediate and statistically significant decrease across all specifications. The negative EPU response is prolonged and quite persistent in all specifications. Finally, volatility in the US (Figure 7) shows a u-shaped response, albeit persistent negative one in each case. In the baseline case, a peak fall is observed around -2.35% after two years.

Figures 8-11 illustrate the response of confidence measures in Japan. Figure 8 shows that the business confidence displays a similar response to a QE shock as we observe in the US with two differences. First, we observe a smaller magnitude of change in Figure 8 (for Japan) in comparison with the ones in Figure 4 (for the US). In Japan, in the baseline case, a peak fall is observed around -0.03% after six months. There is a rebound effect after that. In the baseline case, a peak increase is observed around 0.05% after two years. Second, the shock on the BCI dies out after four years in Japan. We have similar observations for CCI in Japan (Figure 9). Economic policy uncertainty in Japan (Figure 10) shows an immediate decrease in the VAR-1 and VAR 3 specifications, but is not statistically significant nor as sizeable as seen in the US cases. The negative EPU response is prolonged and quite persistent in all specifications. The only economic sentiment variable that the shock has a visible statistically significant impact on in Japan is volatility (panel (a) and panel (b) in Figure 11). The shock has two moments where statistical significance occurs in both VAR-1 and VAR-2 specifications. Initially, there is a significant increase in volatility as a result of the shock to central bank assets. These initial impacts are followed by a prolonged negative response.

Figures 12-15 illustrate the response of economic sentiments measures in Europe. Business confidence (Figure 12) shows an immediate and statistically significant decrease in the first two specifications, decreasing around 0.07%, for a period of around six months in the baseline, though the impact is not significant when asset holdings are placed last in the Cholesky ordering (VAR-3). Consumer confidence (Figure 13) also shows a statistically significant decrease, decreasing in both VAR-1 and VAR-2, while the shock dies out before two years have passed in VAR-2. Again, VAR-3 shows no significant impact. Uncertainty shows a hump-shaped pattern (Figure 14). Uncertainty increases starting with the second month in the baseline case. We observe an increase to the levels of 1.63% around six months. The peak is statistically significant. Figure 15 shows no statistically significant impact of the shock on volatility, and this result is robust across all variations to the BVAR.

4.2 Subsample Analysis

We now present subsample analysis in Figures 16-18. We persist with using the baseline specification, VAR-1. The subsample includes data from 2008:01-2019:12, incorporating all the major QE programmes across the three economies.[33] In doing so, we can analyse whether a QE

[33] Although Japan had QE1 and QE2, QQE was widely considered to be the largest and most effective of the QE programmes instituted.

shock has any differing results, specifically, whether the variables exhibit diminishing marginal effects, or whether agents 'learn' from QE programmes, such that the variables actually increase in the magnitude of their reactions.

The results for the US are presented in Figure 16. The business confidence index (BCI) initially decreases as we observe in Figure 4. This decline is statistically significant. A peak fall is observed around -0.04% after three months. There is a rebound effect after that. A peak increase is observed around 0.10% after 15 months. These responses are slightly similar to those in the baseline in Section 4.1. In the case of the CCI, the magnitude of responses shown in Figure 16 are smaller than those in the full sample. In addition, the shock dies out after three years in the subsample case. Economic policy uncertainty (EPU) in the US (Figure 16) shows an immediate decrease, both in terms of magnitude and statistical significance, which is similar to what we observe in Figure 6. Figure 16 also shows that volatility in the US displays a U-shaped response, again similar to the responses in Figure 7. In the full sample, the initial impact is on the positive domain and then we observe decreases. In the subsample case, however, the initial impact is on the negative domain, and we see further declines. In the baseline case in Figure 7, a peak fall is observed around -2.35% after two years. In Figure 16, however, a peak fall is observed around -1.49% after one year.

The results for Japan are presented in Figure 17. In the BCI case, the turning points are statistically significant. The significance in subsample analysis is more pronounced in comparison to the full sample analysis in Figure 8. In Figure 17, a peak fall is observed around -0.03% after 4 months and a peak increase is observed around 0.07% after a year and a half. In the CCI case, the shock dies out quicker in the subsample case. As in the baseline case of Section 4.1, the impact on uncertainty shows no statistical significance in the subsample case in Figure 17. The results for volatility are robust to those in both VAR-1 and VAR-2 in Section 4.1.

The results for Europe are presented in Figure 18. The peak fall is statistically significant, whereas the peak increase is not. This is similar to the responses we obtain in both VAR-1 and VAR-2 in Section 4.1. As in both VAR-1 and VAR-3 cases of Section 4.1, the impact on the CCI shows no statistical significance in the subsample case in Figure 18. Similarly, the impact on uncertainty shows no statistical significance in the subsample case in Figure 18. This is in contrast to what we observe for the full sample cases in Figure 14, where the peak increases are statistically significant, as indicated by the 68% highest posterior density intervals. Unlike in Section 4.1 where volatility shows no statistically significant moments, initial shock in the subsample exhibits a significant fall in the volatility.

4.3 Forecast Error Variance Decomposition

We use forecast error variance decompositions (FEVDs) as our second tool to assess the impact of a shock to asset holdings, displayed in Tables 1-3, to quantify the level of variance for each confidence variable explained by surprise changes to asset holdings over various time horizons, as distinct from the other variables in the VAR. Specifically, we assess each variable in each economy at different forecast horizons (h=1, 12, 36, 60). We use the full sample periods we study in Section 4.1

Table 1 summarises the FEVDs at various forecast horizons for all model specifications for the US. Variation in business confidence (panel (a)) accounted for by the shock reaches 20% in the baseline specification (the VAR-1 specification) over a three-year horizon. This figure increases in the VAR-2 specification, with the shock accounting for a larger percentage of the variance. In the baseline specification, surprise changes in the Fed's asset holdings account for 26% of the variance in consumer confidence (panel (b)) over the 5-year time horizon. In the baseline specification, almost 10% of the variance in uncertainty (panel (c)) is accounted for by the shock at the five-year time horizon. Finally, in the case of volatility (panel (d)), 13.25% of the variance is explained by the shock at the five-year time horizon. In general, the VAR-2 specification shows an increase in the amount of variance explained by the shock, in comparison with the baseline specification, in almost all cases in Table 1, whereas the VAR-3 specification shows a relative decrease in the amount of variance explained by the shock.

Unlike the US, the amount of variance explained by the shock across all four economic sentiments variables in Japan (Table 2) is relatively small. In the consumer confidence case (Panel (b)), the baseline specification shows only 5.21% of variance being explained by the shock over the long run. This figure increases to 7.13% in the VAR-2 specification. The corresponding figures are higher for business confidence (Panel (a)), where in the VAR-1 and VAR-2 specifications this figure increases to 6.12% and 9.02% at the five-year time horizon, respectively. The shock fails to explain uncertainty (Panel (c)) relative to other variables, with only 3.60% explained at the five-year time horizon in the baseline, increasing to 5.43% in the VAR-2 specification. The shock explains 5.41% of the variance in volatility at the five-year time horizon, though importantly at the 1-month time horizon, a large percentage of the variance explained at the 5-year time horizon is already explained. In the VAR-2 specification, 6.04% of the variance in volatility is explained after 1 month.

Europe (Table 3), like Japan, also sees a relatively small amount of variance explained by the shock across the four economic sentiments variables. Only 3.64% of the variance in consumer confidence (Panel (b)) is explained by the shock in the baseline specification at the five-year time horizon, while this increases slightly to 5.14% in the business confidence case (Panel (a)). The shock explains slightly more of the variance in the uncertainty variable (Panel (c)), with 3.19% explained in the baseline at the five-year time horizon, increasing to 4.94% in the VAR-2 specification. The shock explains only 2.91% of the variance in volatility (Panel (d)) at the five-year time horizon.

5. Concluding Remarks

This paper contributes to the literature through several findings. In the US, QE resulted in a substantial and persistent increase in both business and consumer confidence, and a sudden QE shock today is predicted to still have a strong impact on US domestic confidence. Under both business and confidence measures in Europe, the impact of QE was not enough to increase confidence statistically in the economy. Finally in Japan, we observe significant declines in volatility over the mid-term. In Europe, the results from the whole sample impulse responses show increased uncertainty in response to the QE shock (panel (a) in Figure 14), the opposite to the results for the US (Figure 6) and Japan (Figure 10). In addition, the shocks die out quicker in the cases of business and consumer confidence in Europe and we do not observe any significant increases in confidence variables, whereas we see periods of significant increases in both business and confidence increases in the US and in Japan. This may glean some light on the credibility of the ECB's programme, who in contrast to the Federal Reserve who acted immediately, the ECB held off QE (for reasons that were, as already discussed, largely out of their control) until 2015, 5 years after the Euro crisis and 7 years after the global financial crisis. The ECB were instead forced into various forms of longer-term refinancing operations and corporate sector purchases immediately after the financial crisis, both of which were limited relative to the QE options that were available to the Fed and the BoJ. Another potential explanation for the differing results may lie in the stated *purpose* and *timing* of the programmes. The programmes that had no real influence on confidence (Europe's QE programme), were implemented with the stated goal of preventing deflation. While the Fed's programmes were implemented to avoid deflation too, that was more of an after-thought to supporting a rapidly diminishing financial and economic system.

Our paper studies the pre-COVID-19 period. The coronavirus first appeared in China in late 2019, just a few weeks before it made its way to the rest of the world. On 11 March 2020, the World Health Organisation declared COVID-19 to be a pandemic. The pandemic, which has reached almost every country in the world, and shutdown measures to contain it plunged the global economy into a severe contraction. In many respects, the response of the three major central banks to the pandemic mirrored those of the GFC. The initial response was aimed at stabilising financial markets and providing liquidity, while ensuring that the provision of credit kept flowing into the real economy. All three central banks stepped in to provide comprehensive lending operations and increased asset purchases.

The Fed cut its target rate by 1.5 percentage points at its meetings on March 3 and March 15, 2020, provided targeted support to specific segments of the financial market, including primary dealers and money market mutual funds, and reactivated the Term Asset-Backed Securities Loan Facility (TALF) to support asset-backed securities (Milstein and Wessel, 2021). The Fed and the BoJ also instituted favourable lending rates to banks conditional on lending to small and medium enterprises (SMEs) and increased the amount and length of repurchase agreements. The BoJ, limited by their already low policy rates, increased their pace of commercial paper and corporate bonds, ETF, and J-REIT purchases, and reinforced its JGB yield curve control**.** The ECB, also limited by negative policy rates, altered the liquidity profile of European banks through its Targeted Long-Term Refinancing Operation and Pandemic Emergency Longer-Term

Refinancing Operations to support money markets. Once financial markets began to show signs of relative stability, attention then turned to more sustained quantitative easing in an attempt aimed to stimulate the real economy. The BoJ and Fed announced unlimited purchases of government bonds, with the Fed included agency MBS in these purchases. The ECB expanded its APP by purchasing an additional EUR 120 billion in assets by the end of 2020 and allocating 1.35 trillion to asset purchases under the newly established Pandemic Emergency Purchase Programme (PEPP) (Cantú et al., 2021). The sharp increase in the size of central bank balance sheets can be seen in Figure 1.

COVID-19 poses an acute challenge to econometric modelling, particular for the VARs we use in this paper. Predicting the macroeconomic impact of the COVID-19 pandemic with reduced-form time series models is challenging, because a pandemic of this scale isn't observed in the historical time series. Several studies propose to synthesize the Covid shock through a combination of the macroeconomic disturbances that have been observed in the past, augmented with particularly strong assumptions on the future dynamics of the pandemic.[34]

[34] See, for example, Del Negro et al., 2020; Primiceri and Tambalotti, 2020; Lenza and Primiceri, 2021.

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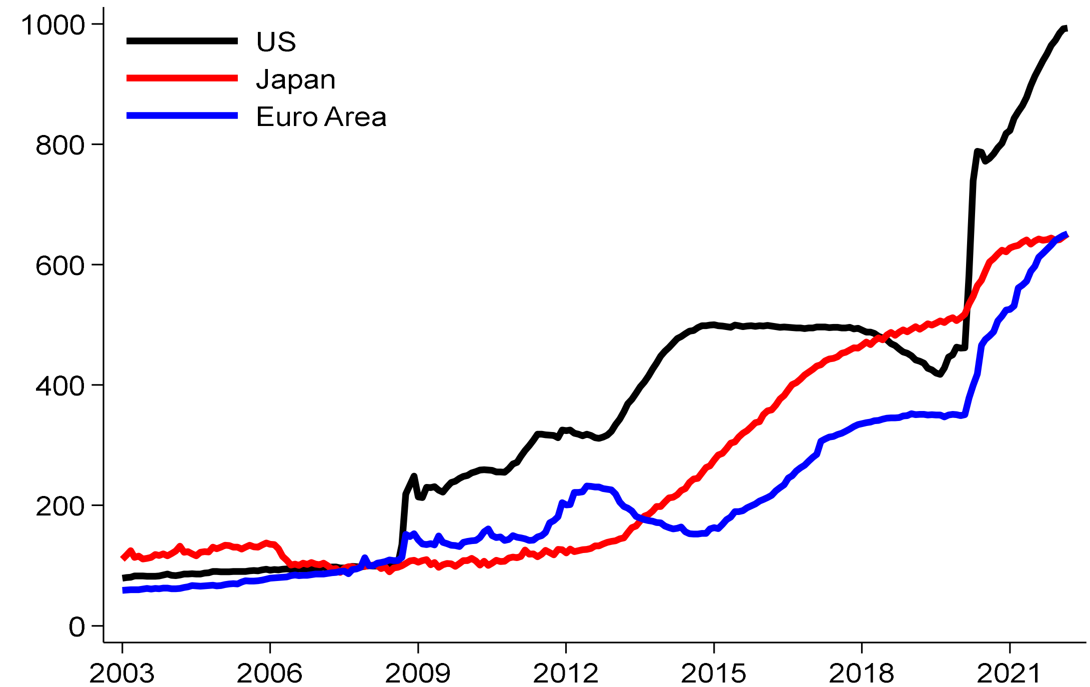
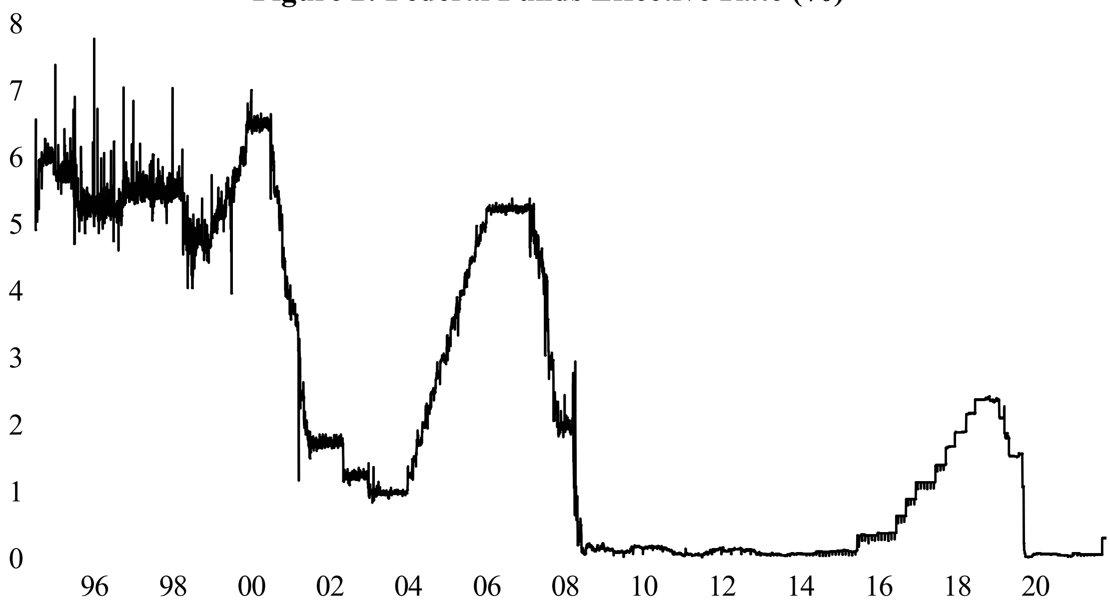
Figure 1: Total Central Bank Asset Holdings, 2003:01-2022:03 (2008:01 = 100)*



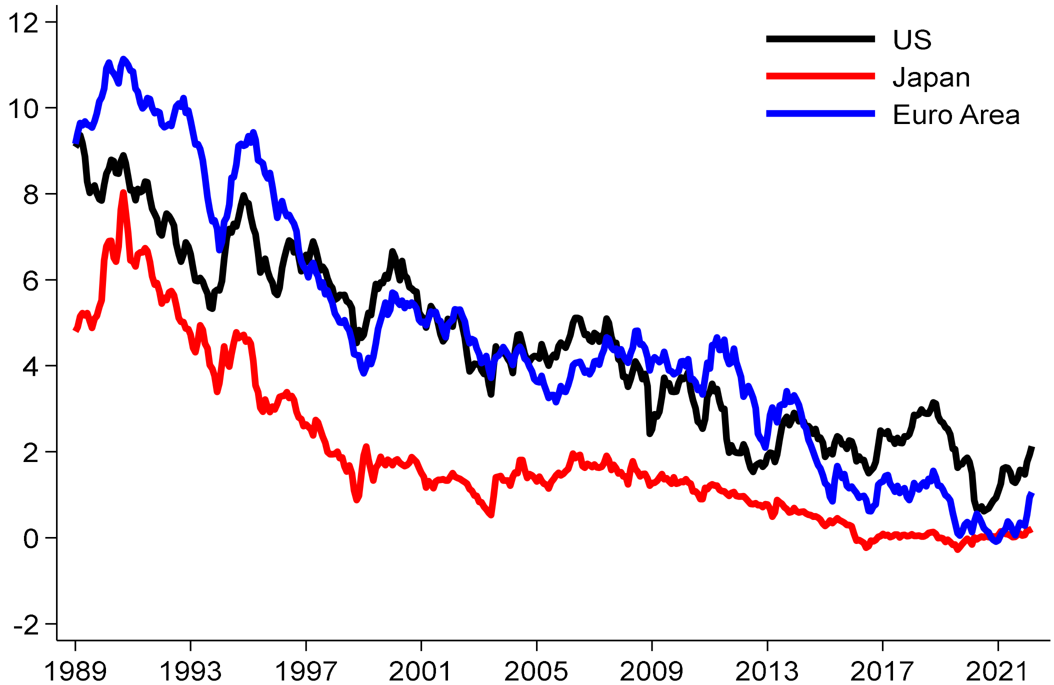
* Monthly (end of period), Not Seasonally Adjusted.
Source: FRED®, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/JPNASSETS https://fred.stlouisfed.org/series/ECBASSETSW; https://fred.stlouisfed.org/series/WALCL
Accessed 30 April 2022.

Figure 2: Federal Funds Effective Rate (%)*



* Daily, Not Seasonally Adjusted. 1995-01-01, 2022-04-28.
Source: FRED®, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/graph/?g=n3IM
Accessed 30 April 2022.

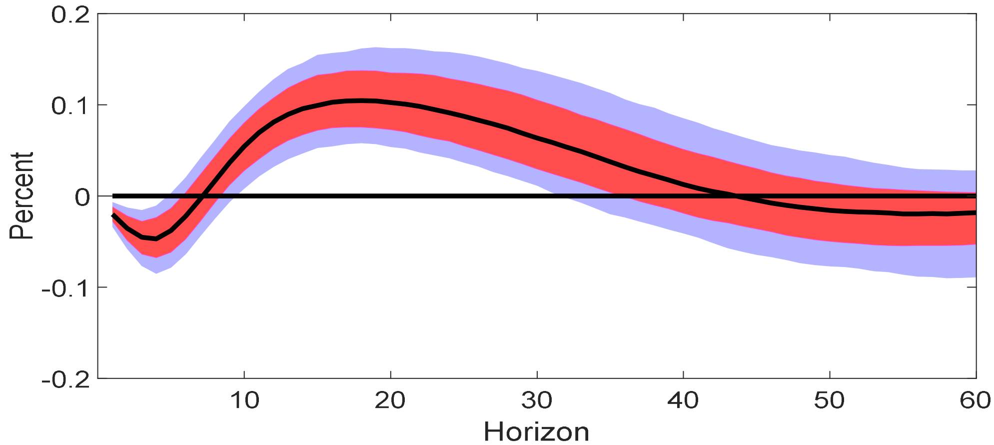
Figure 3: Long-Term Government Bond Yields (%): 1989:01-2022:03*



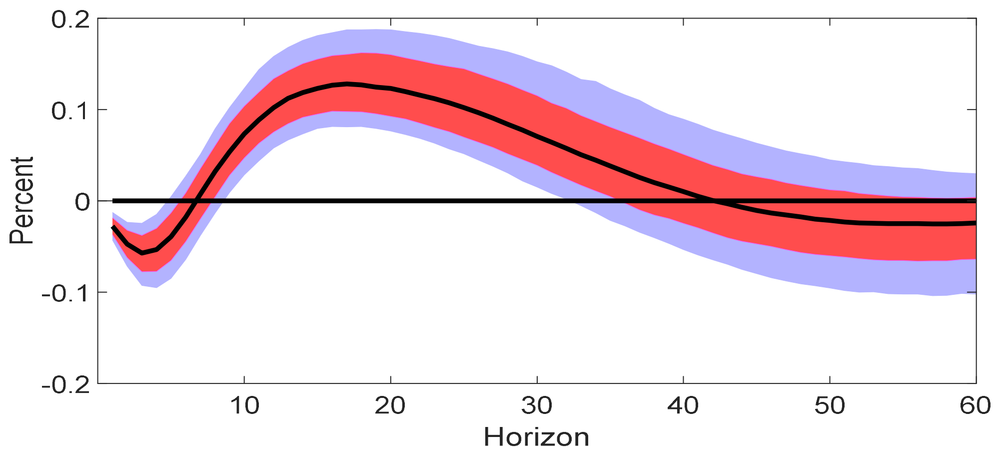
* Monthly, Not Seasonally Adjusted.
Source: FRED®, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IRLTLT01USM156N https://fred.stlouisfed.org/series/IRLTLT01JPM156N; https://fred.stlouisfed.org/series/IRLTLT01EZM156N Accessed 30 April 2022.

Figure 4: BCI to assets, US, full sample

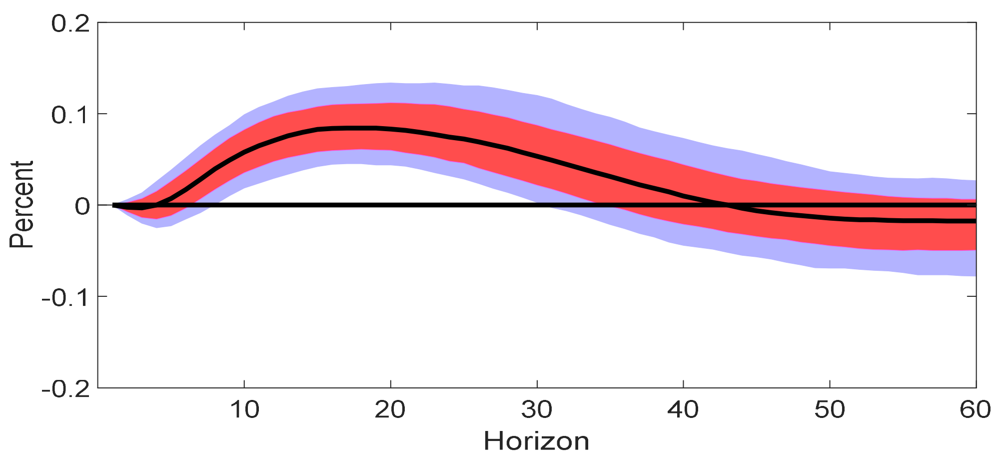
Panel (a): VAR 1



Panel (b): VAR 2



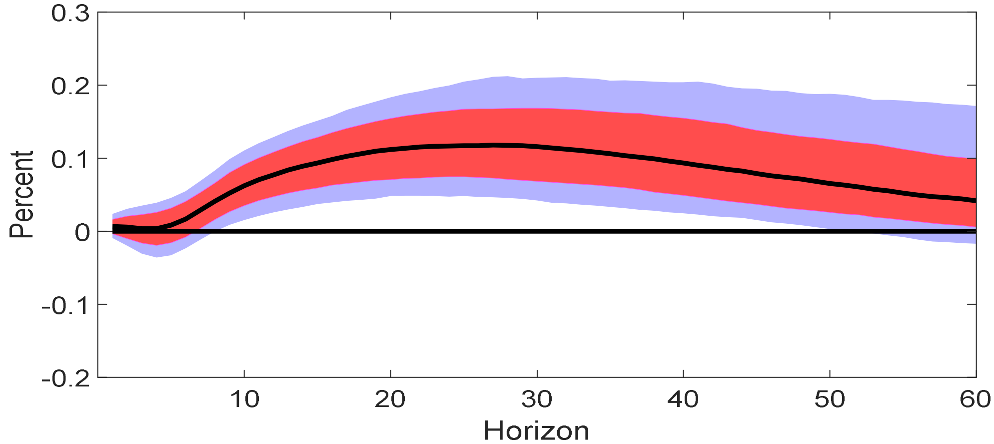
Panel (c): VAR 3



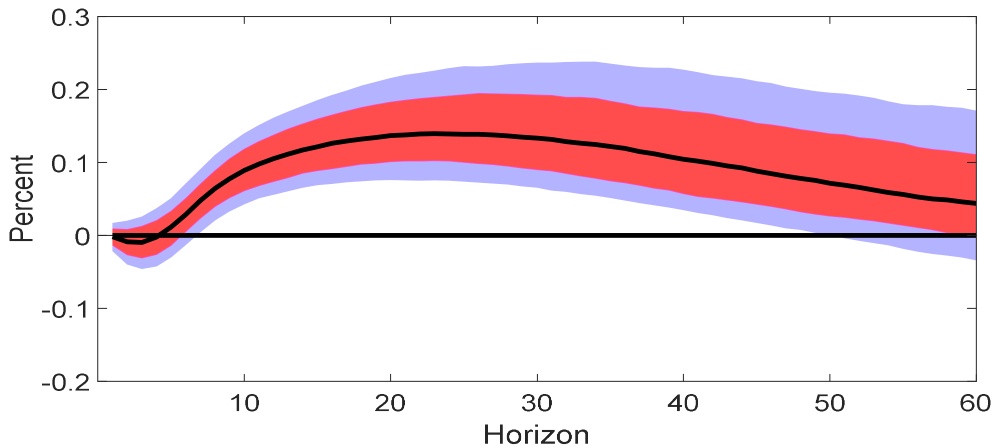
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 5: CCI to assets, US, full sample

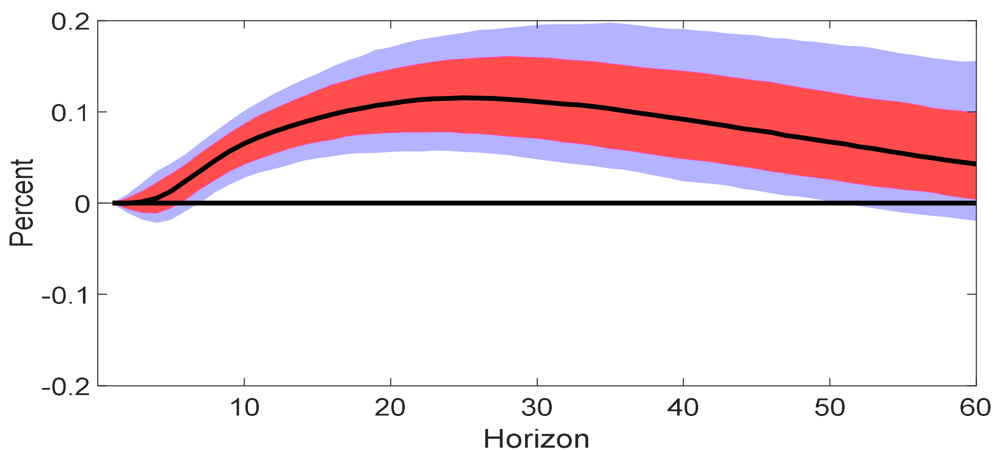
Panel (a): VAR 1



Panel (b): VAR 2



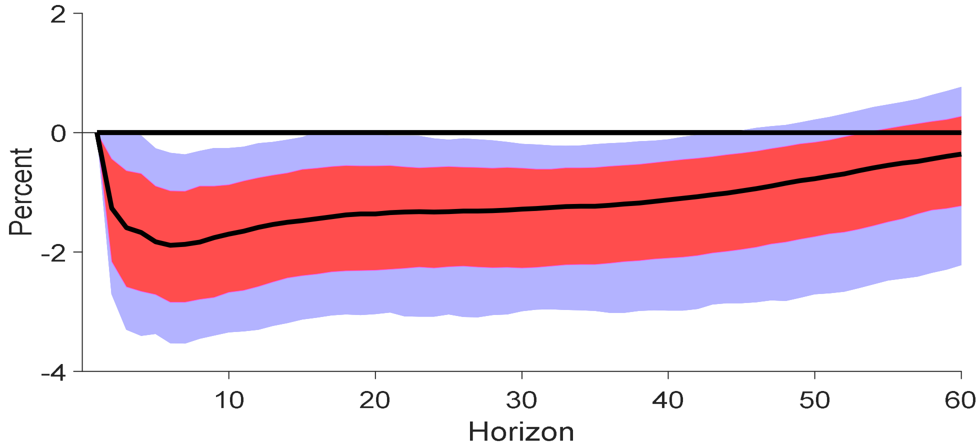
Panel (c): VAR 3



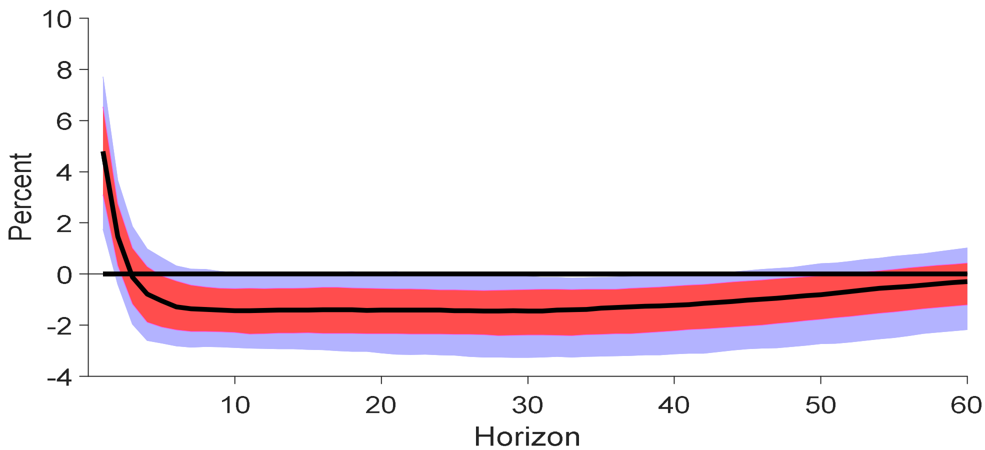
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 6: Uncertainty to assets, US, full sample

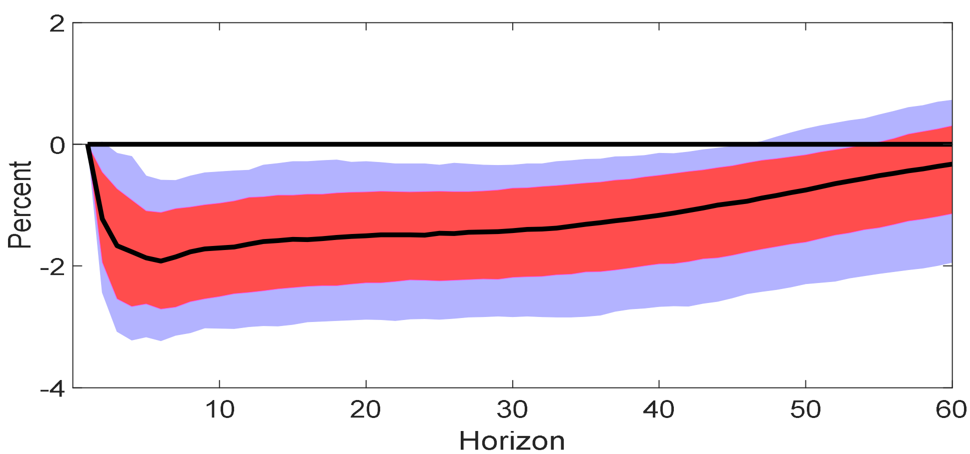
Panel (a): VAR 1



Panel (b): VAR 2



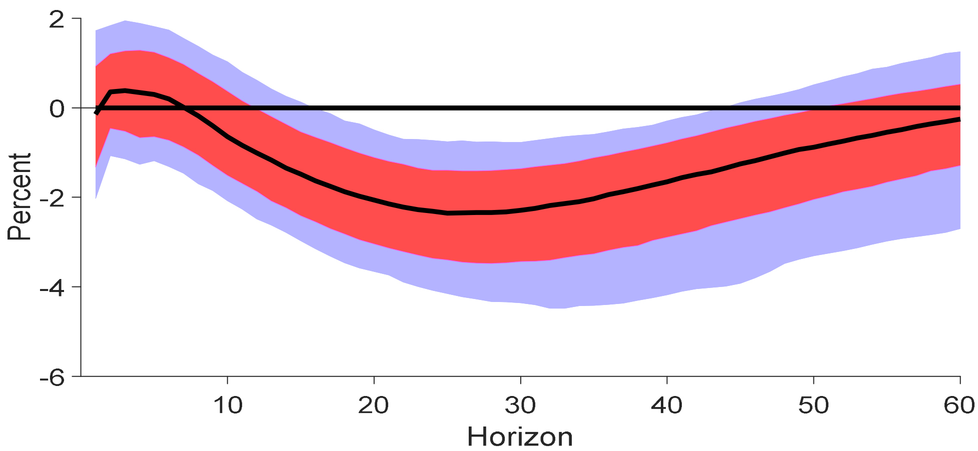
Panel (c): VAR 3



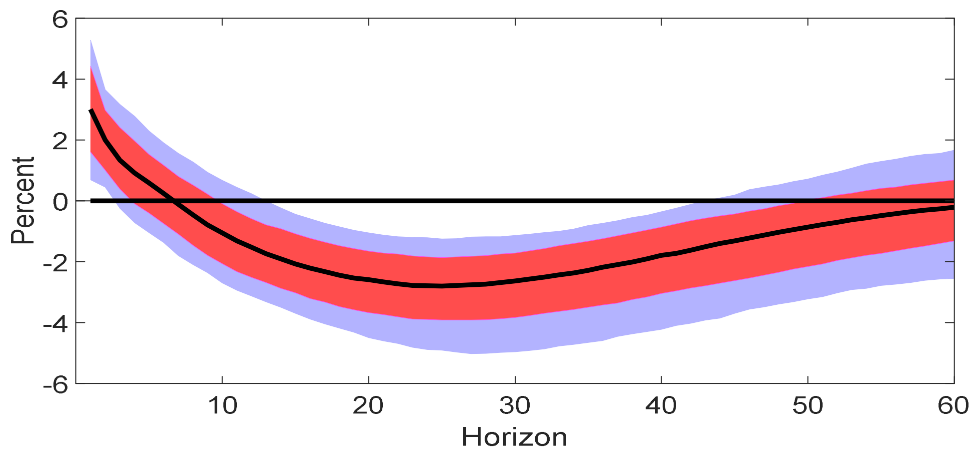
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 7: Volatility to assets, US, full sample

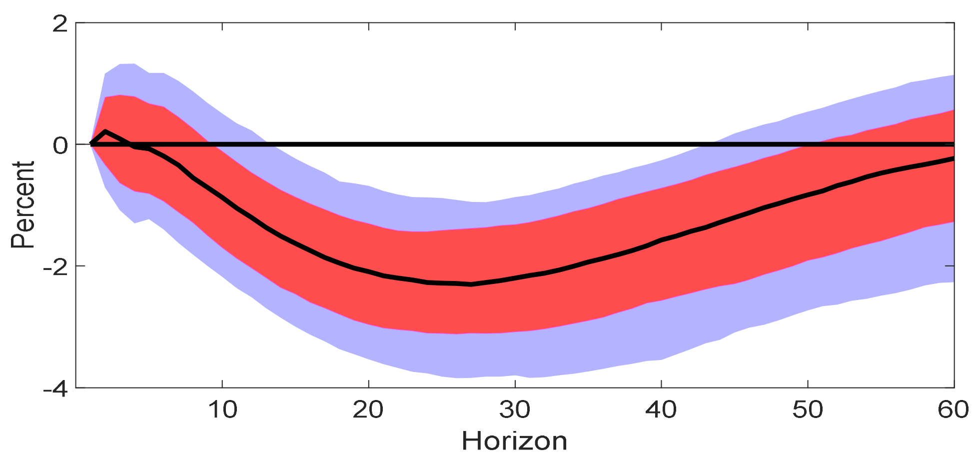
Panel (a): VAR 1



Panel (b): VAR 2



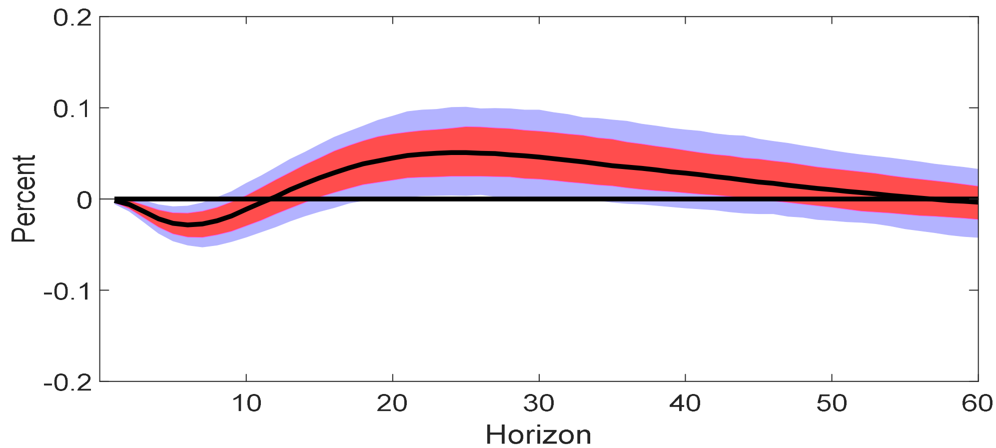
Panel (c): VAR 3



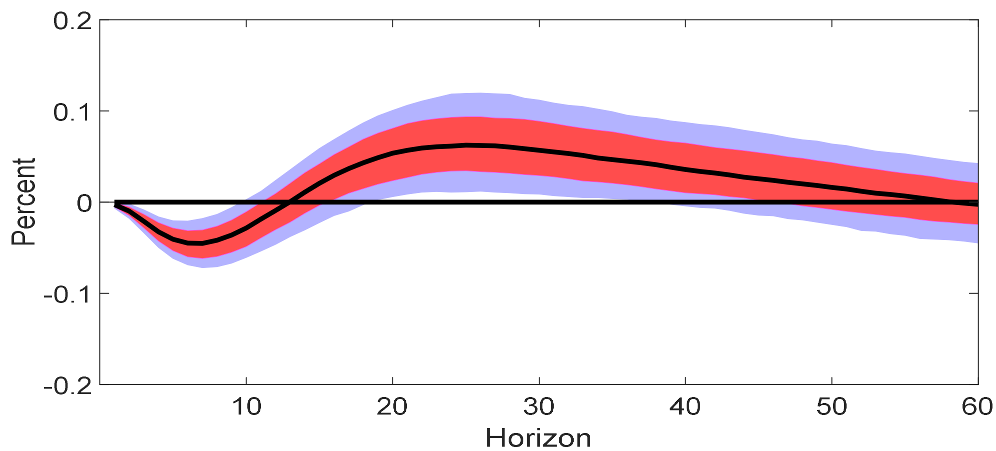
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 8: BCI to assets, Japan, full sample

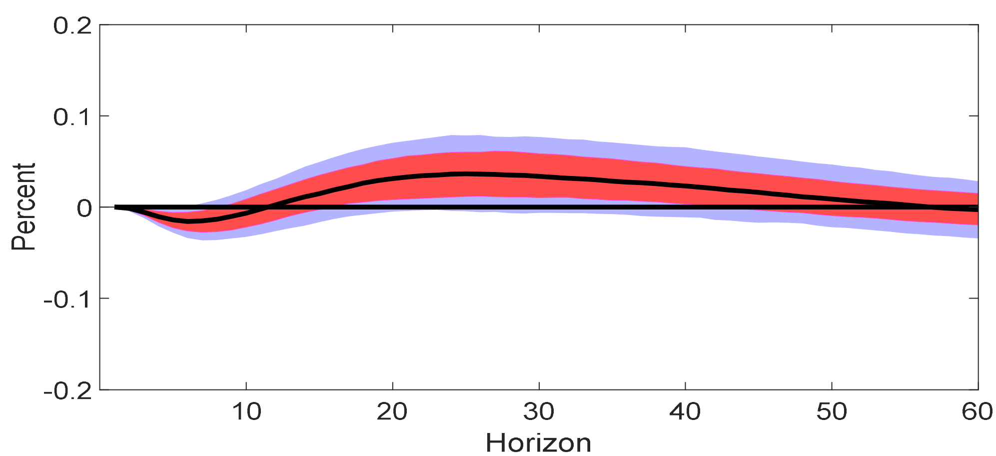
Panel (a): VAR 1



Panel (b): VAR 2



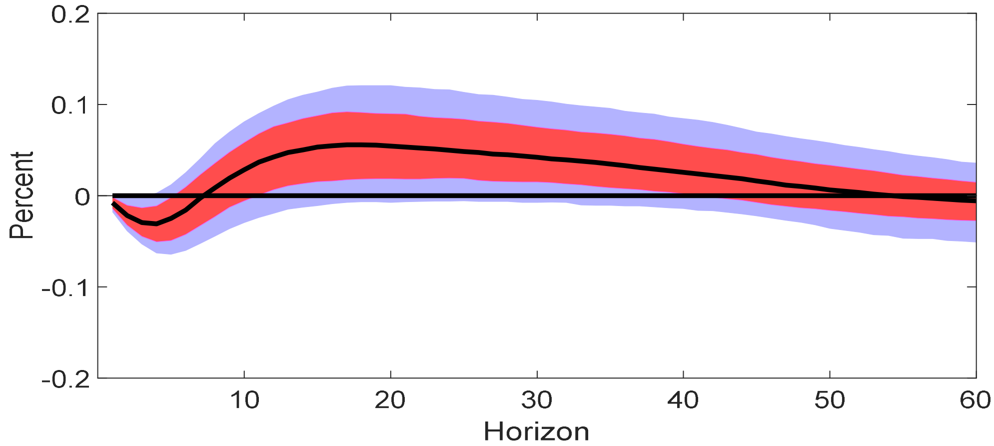
Panel (c): VAR 3



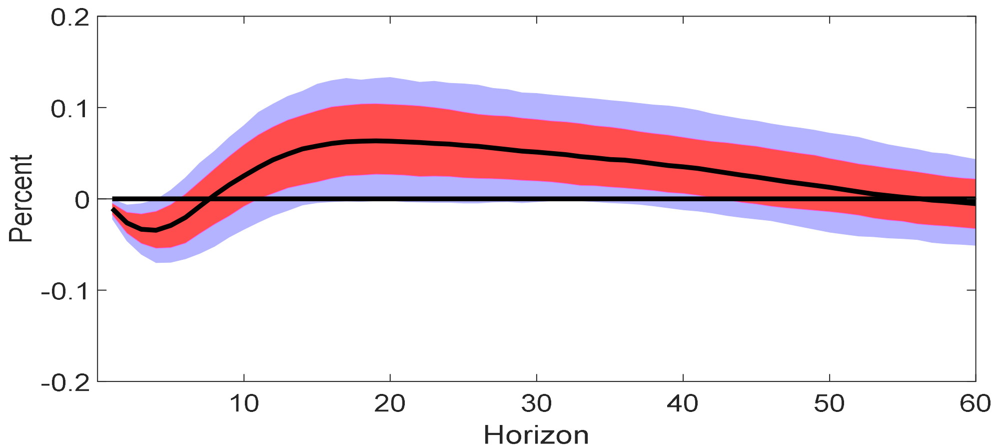
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 9: CCI to assets, Japan, full sample

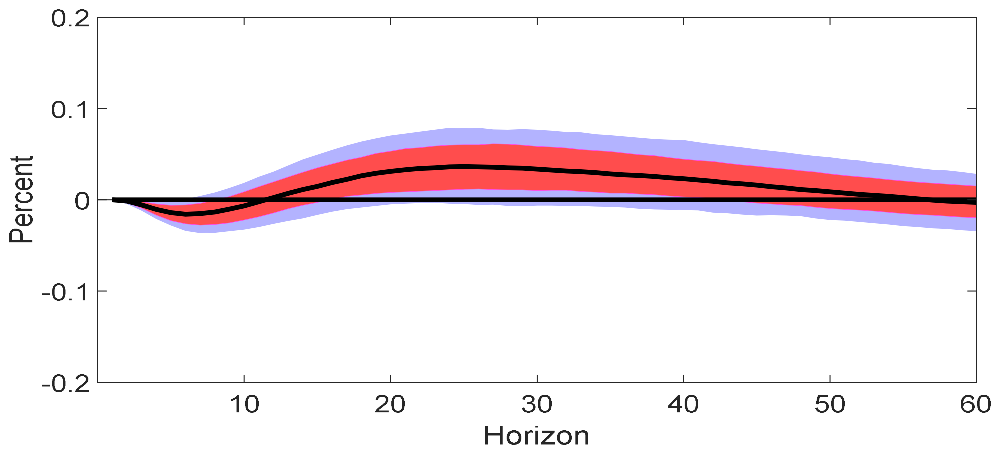
Panel (a): VAR 1



Panel (b): VAR 2



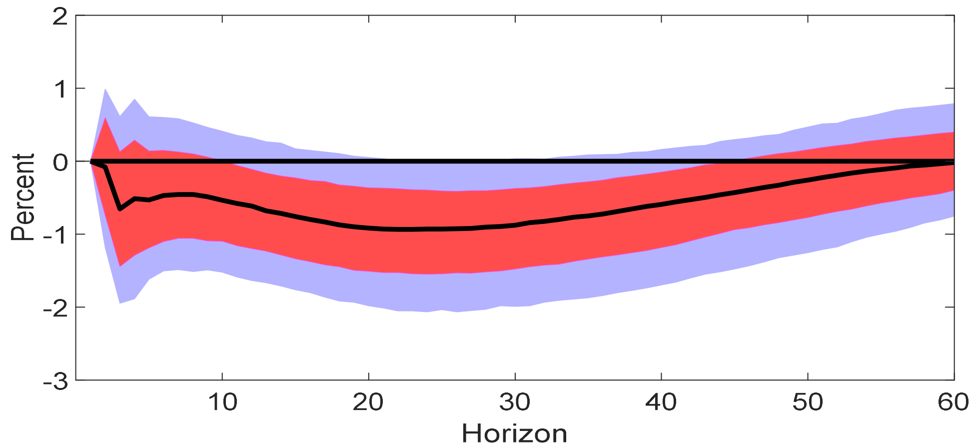
Panel (c): VAR 3



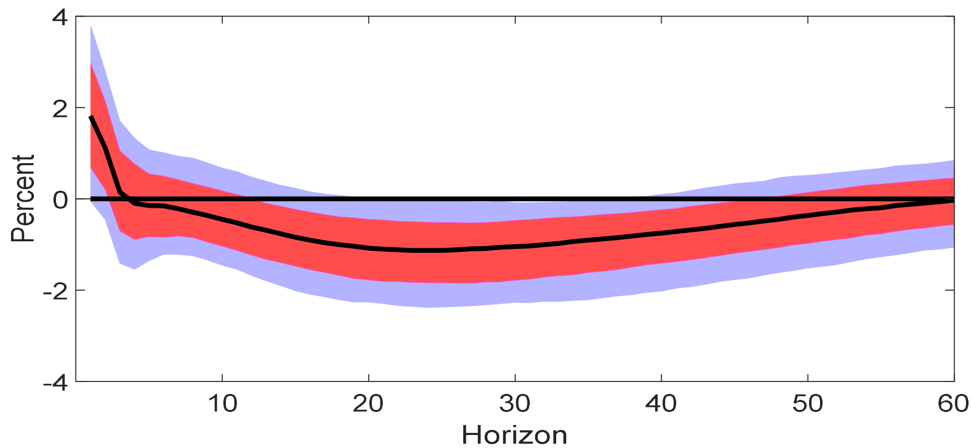
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 10: Uncertainty to assets, Japan, full sample

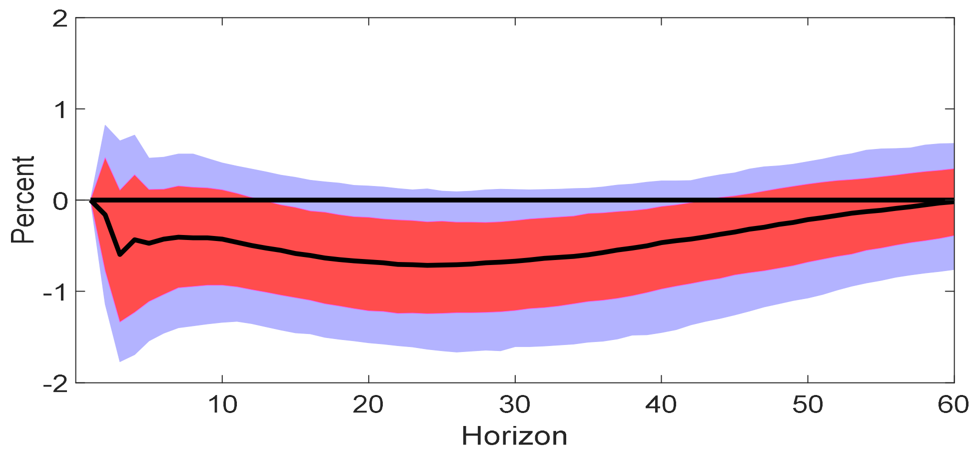
Panel (a): VAR 1



Panel (b): VAR 2



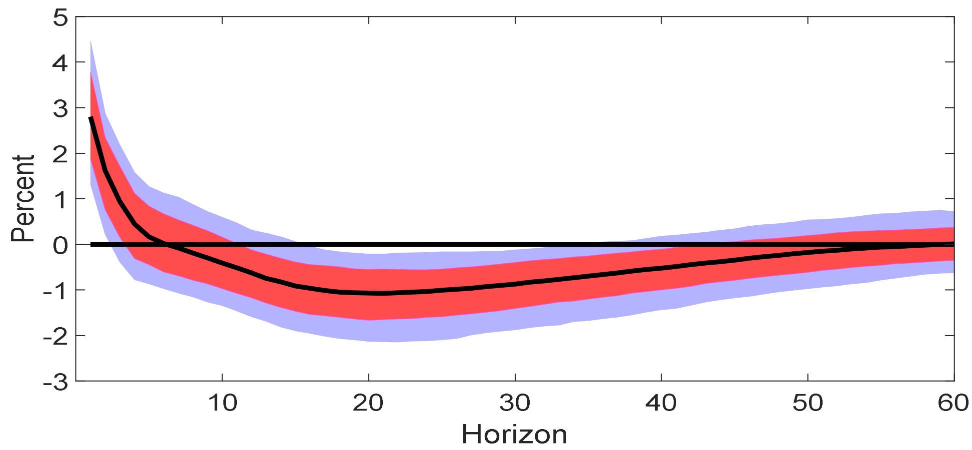
Panel (c): VAR 3



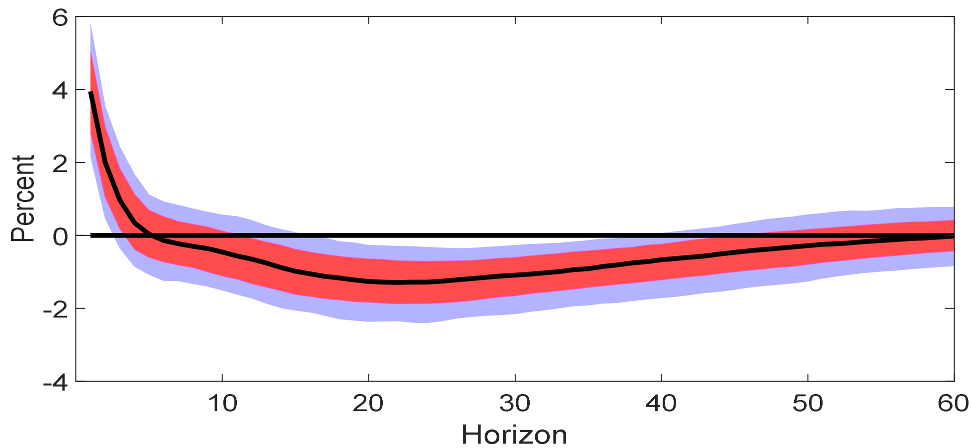
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 11: Volatility to assets, Japan, full sample

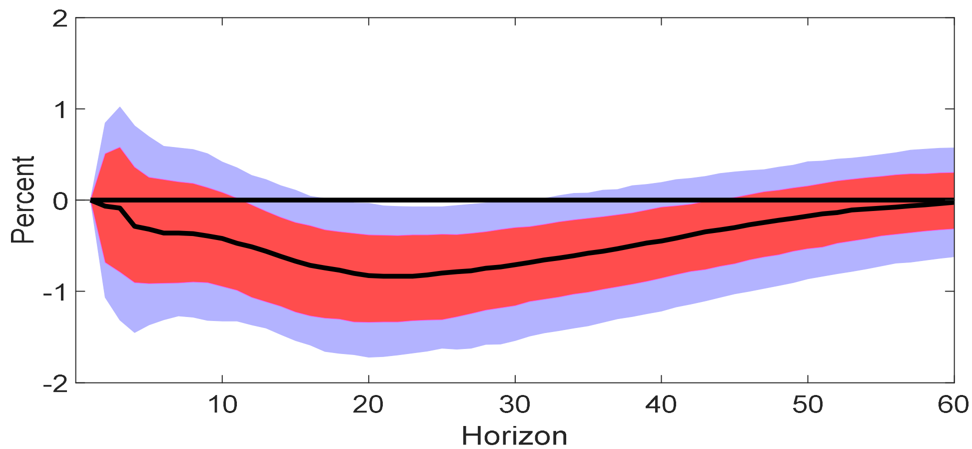
Panel (a): VAR 1



Panel (b): VAR 2



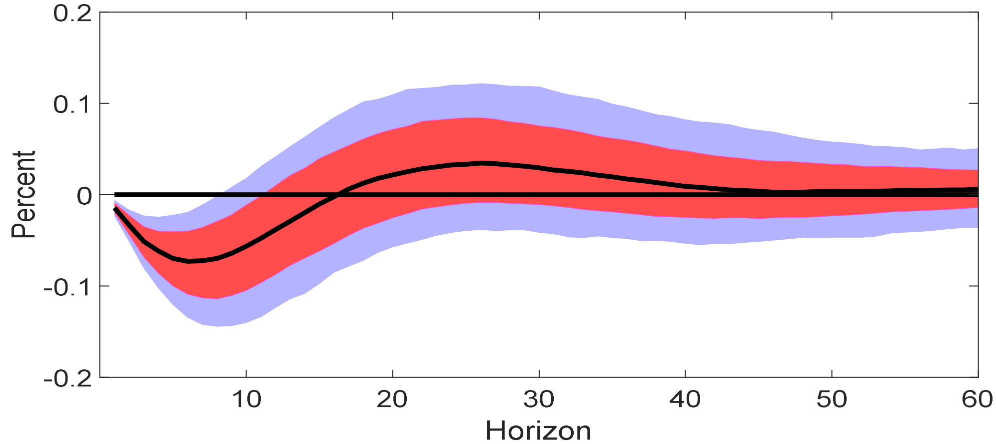
Panel (c): VAR 3



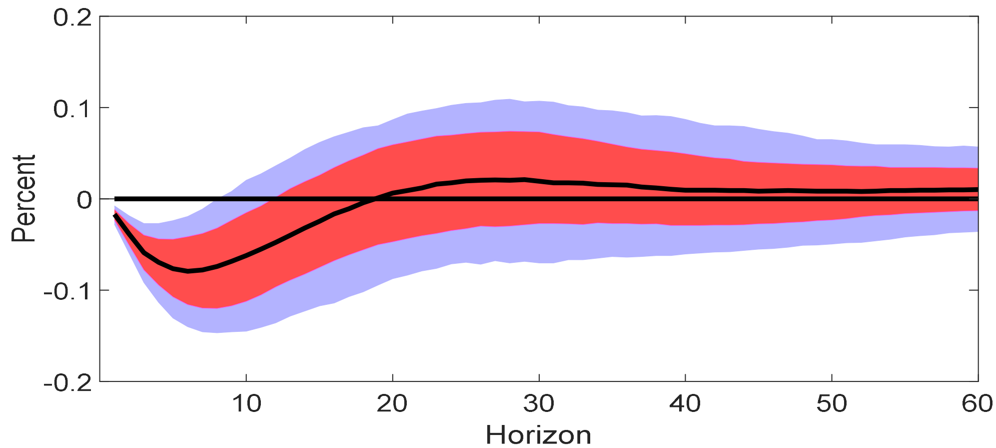
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 12: BCI to assets, Europe, full sample

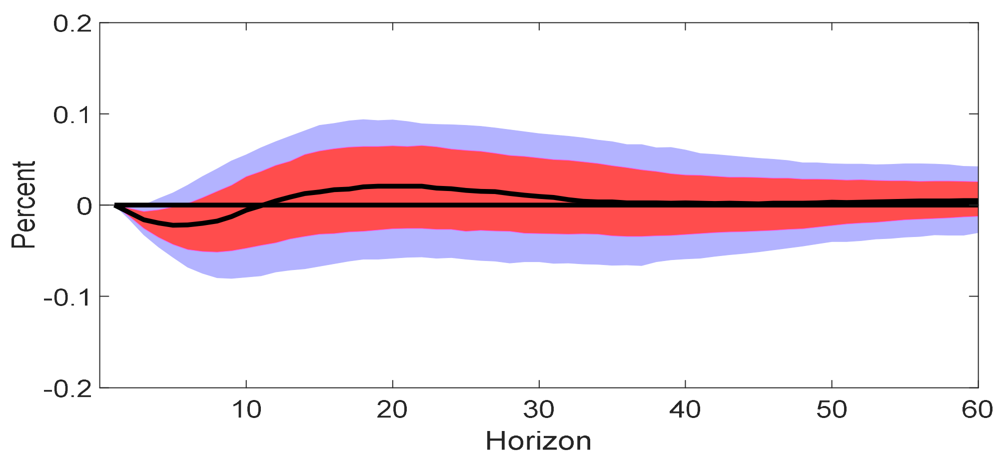
Panel (a): VAR 1



Panel (b): VAR 2



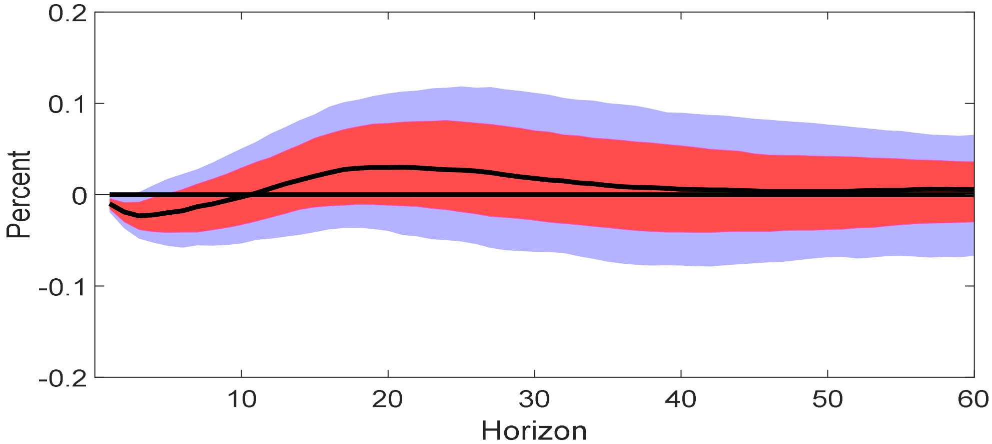
Panel (c): VAR 3



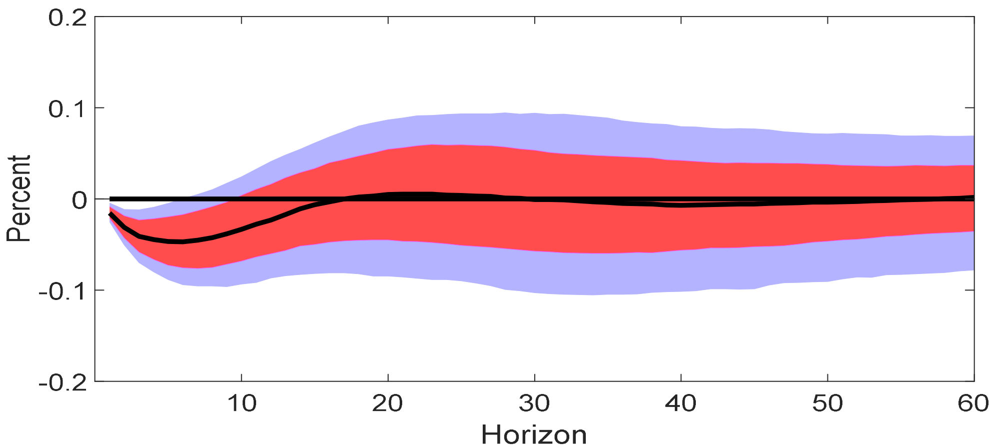
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 13: CCI to assets, Europe, full sample

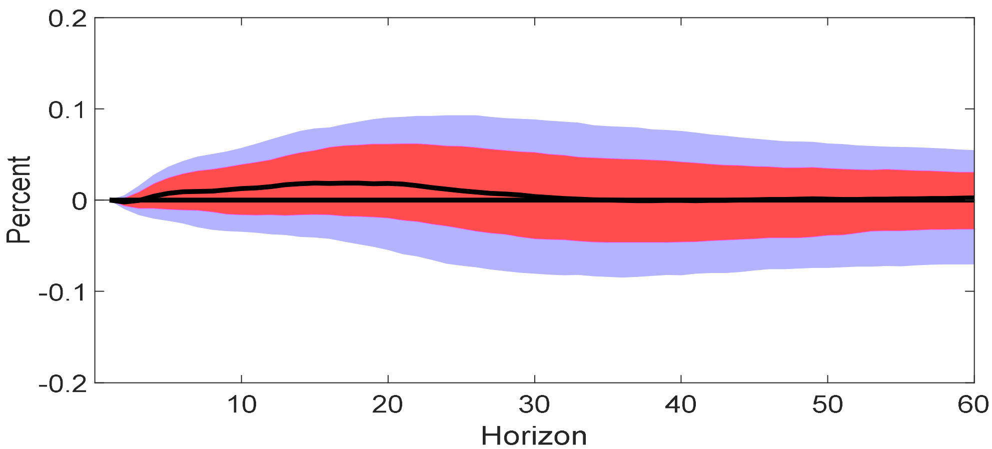
Panel (a): VAR 1



Panel (b): VAR 2



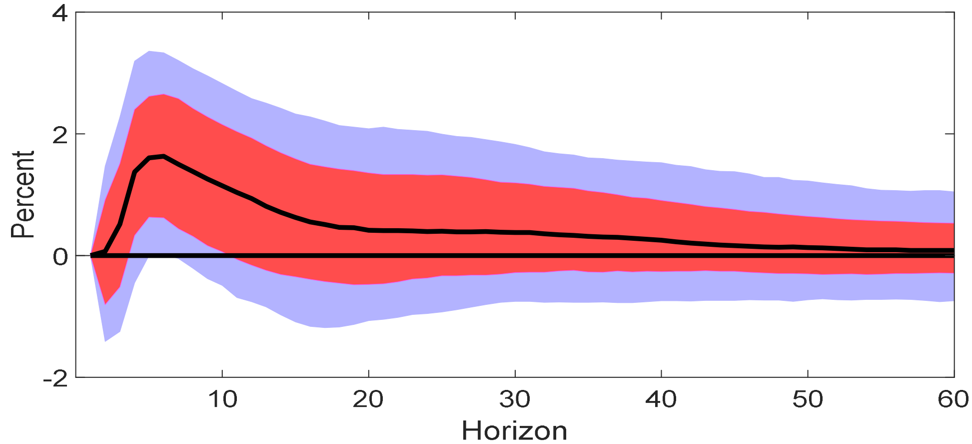
Panel (c): VAR 3



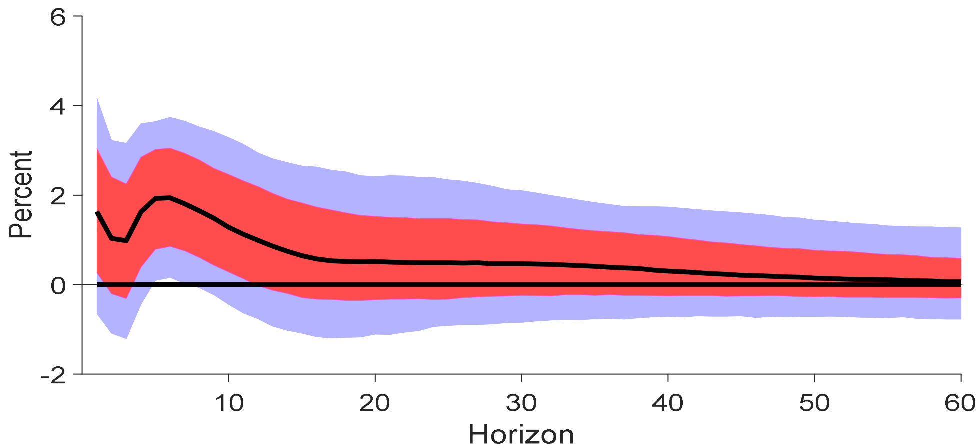
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 14: Uncertainty to assets, Europe, full sample

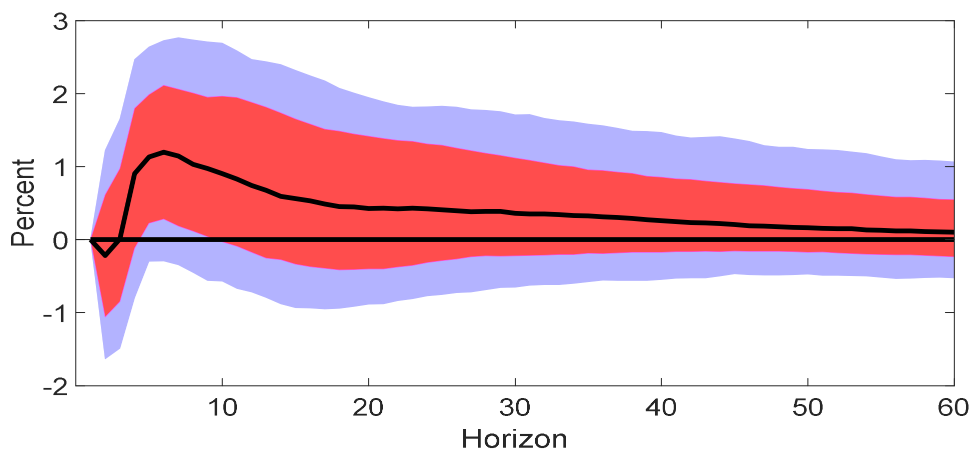
Panel (a): VAR 1



Panel (b): VAR 2



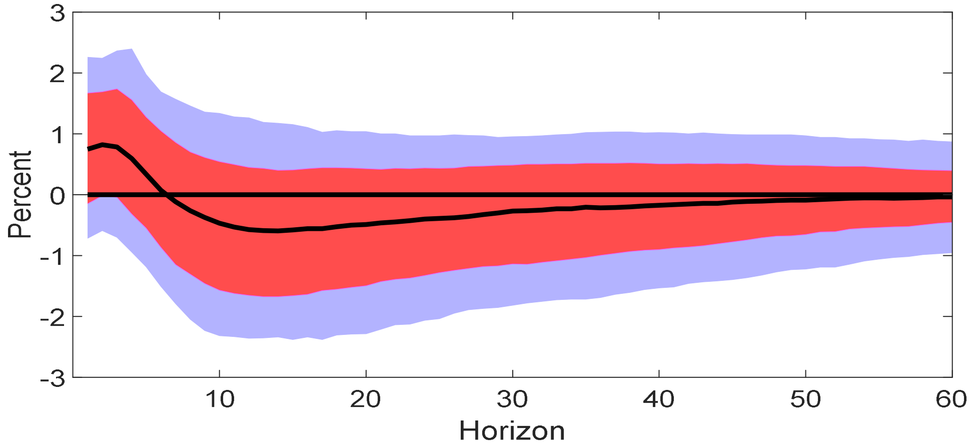
Panel (c): VAR 3



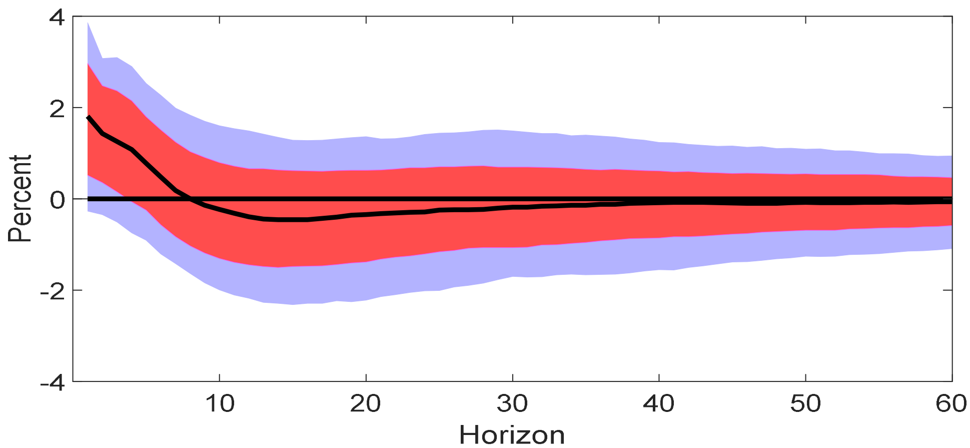
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 15: Volatility to assets, Europe, full sample

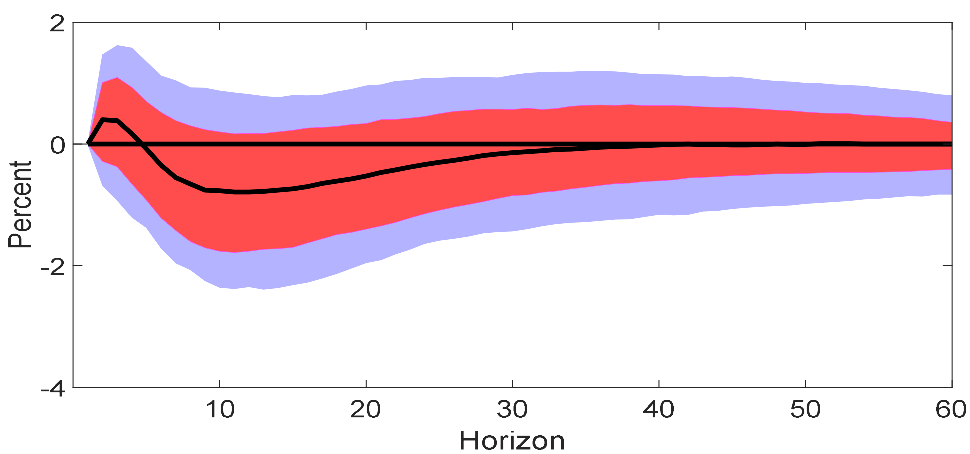
Panel (a): VAR 1



Panel (b): VAR 2

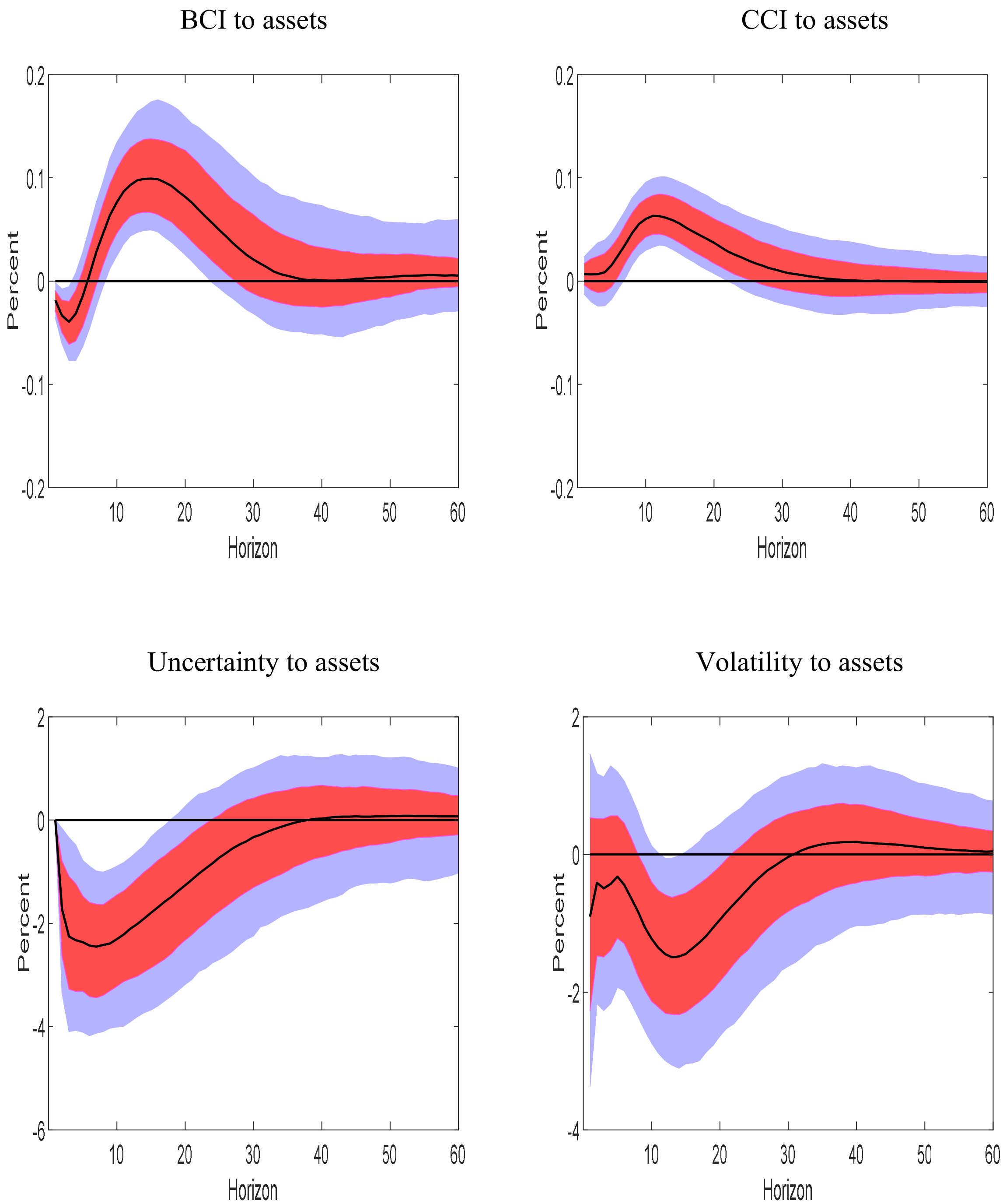


Panel (c): VAR 3



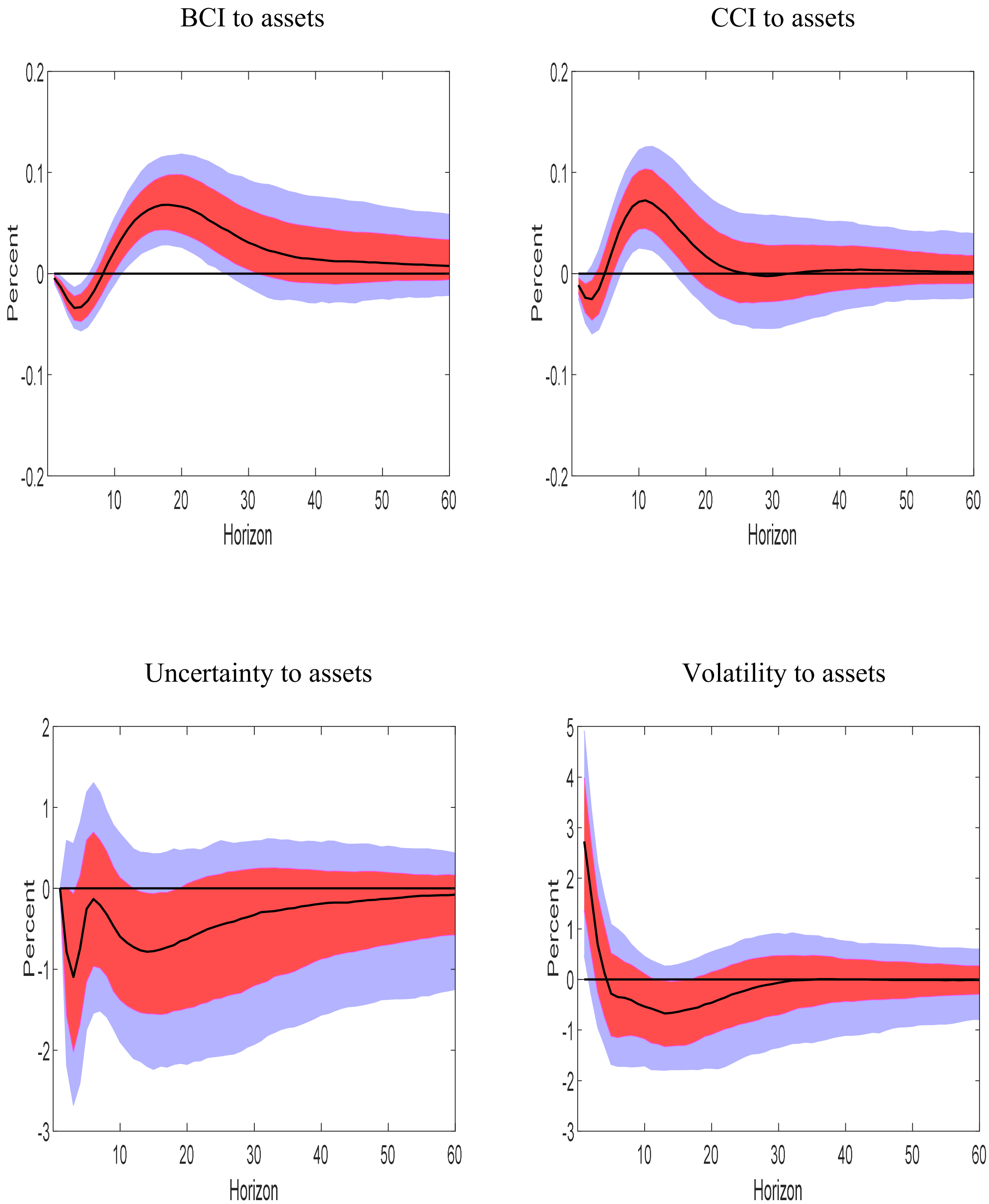
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively.

Figure 16: Subsample analysis for the US



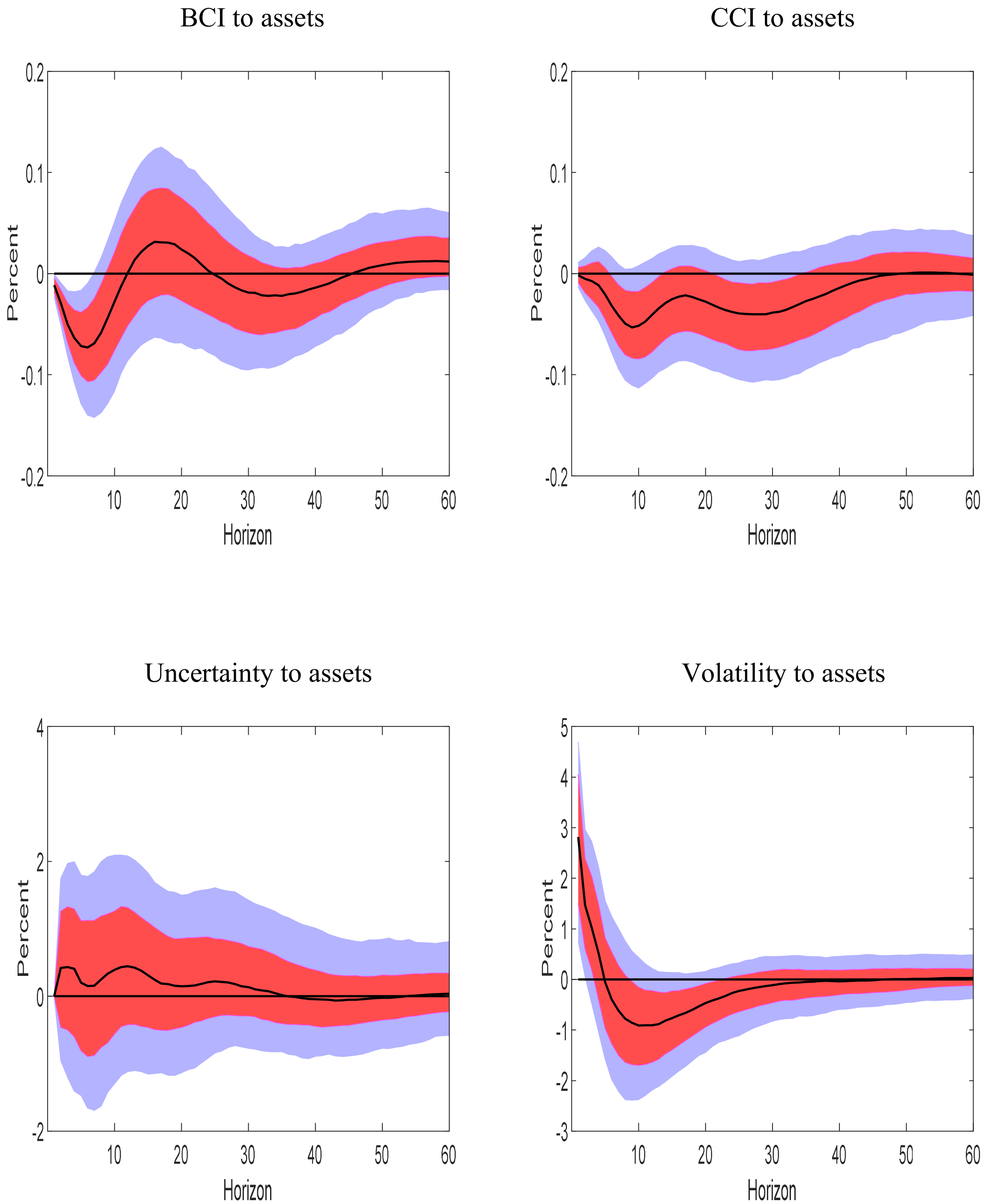
Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively. The sample period for is common from 2008:01-2019:12. We persist with the baseline VAR-1 specification.

Figure 17: Subsample analysis for Japan



Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively. The sample period for is common from 2008:01-2019:12. We persist with the baseline VAR-1 specification.

Figure 18: Subsample analysis for Europe



Note: Solid black lines depict median responses to shock of one standard deviation. Red and blue shaded areas indicate the 68% and 90% posterior probability regions, respectively. The sample period for is common from 2008:01-2019:12. We persist with the baseline VAR-1 specification.

Table 1: Variance Decomposition, US

Panel (a): BCI to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	3.19	6.21	0.00
h = 12	7.30	11.19	4.90
h = 36	20.30	28.47	13.76
h = 60	20.14	28.02	13.91

Panel (b): CCI to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.30	0.26	0.00
h = 12	5.22	10.36	5.65
h = 36	23.53	33.89	22.16
h = 60	26.28	34.88	24.61

Panel (c): Uncertainty to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.00	4.33	0.00
h = 12	4.07	5.54	3.92
h = 36	8.18	10.04	8.54
h = 60	9.91	11.89	10.04

Panel (d): Volatility to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.17	2.68	0.00
h = 12	1.36	4.26	1.04
h = 36	10.73	16.93	10.43
h = 60	13.25	18.85	12.32

Notes: The sample period for all VARs is common from 2003:01-2019:12. The frequency of the series in the VARs is monthly, the VARs are estimated with 4 lags. The rows show the percentage of the total forecast error variance of each confidence variable of the US due to innovations in the Fed's asset holding.

Table 2: Variance Decomposition, Japan

Panel (a): BCI to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.36	0.86	0.00
h = 12	2.29	5.82	0.91
h = 36	5.87	8.82	3.16
h = 60	6.12	9.02	3.40

Panel (b): CCI to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.78	1.42	0.00
h = 12	1.79	1.98	0.69
h = 36	4.96	6.52	2.57
h = 60	5.21	7.13	2.91

Panel (c): Uncertainty to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.00	1.08	0.00
h = 12	0.82	1.79	0.59
h = 36	3.03	4.82	2.03
h = 60	3.60	5.43	2.37

Panel (d): Volatility to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	3.05	6.04	0.00
h = 12	3.06	4.87	0.63
h = 36	5.39	7.89	2.50
h = 60	5.41	8.04	2.83

Notes: The sample period for the Japanese VARs is common from 2000:01-2019:12. The frequency of the series in the VARs is monthly, the VARs are estimated with 4 lags. The rows show the percentage of the total forecast error variance of each confidence variable of Japan due to innovations in the BoJ's asset holdings.

Table 3: Variance Decomposition, Europe

Panel (a): BCI to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	3.04	4.04	0.00
h = 12	4.40	5.52	0.80
h = 36	4.79	5.15	2.11
h = 60	5.14	5.68	2.48

Panel (b): CCI to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	1.32	3.25	0.00
h = 12	1.13	3.20	0.53
h = 36	2.59	3.63	1.87
h = 60	3.64	4.47	2.79

Panel (c): Uncertainty to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.00	0.68	0.00
h = 12	1.92	3.48	1.26
h = 36	2.95	4.58	2.10
h = 60	3.19	4.94	2.31

Panel (d): Volatility to Assets

Forecast horizon	VAR 1	VAR 2	VAR 3
h = 1	0.22	1.06	0.00
h = 12	1.33	2.14	0.96
h = 36	2.55	3.19	2.00
h = 60	2.91	3.73	2.42

Notes: The sample period for all VARs is common from 2000:01-2019:12. The frequency of the series in the VARs is monthly, the VARs are estimated with 2 lags. The rows show the percentage of the total forecast error variance of each confidence variable of Europe due to innovations in the ECB's asset holdings.

Table A.1 Important Announcements by the Federal Reserve, 2008-2019

Date	Programme	Asset Purchases/Lending News
Nov 25, 2008	QE1	LSAPs announced: purchase of $100 billion in GSE debt and $500 billion in MBS
Dec 16, 2008	QE1	FOMC suggests extending QE to Treasuries
Jan 28, 2009	QE1	Fed announces they are ready to expand QE and buy Treasuries
Mar 18, 2009	QE1	Fed will purchase $300 billion in long-term Treasuries and an additional $750 billion in MBS and $100 billion in GSE
August 12, 2009	QE1	LSAPs slowed: all purchases will finish by end of October, not mid-September
September 23, 2009	QE1	LSAPs slowed: purchases of agency debt and MBS will finish by end of first quarter 2010.
November 4, 2009	QE1	LSAPs downsized: Agency debt purchases will finish at $175 billion
Aug 10, 2010	QE1	Balance sheet maintained: Fed will reinvest principal payments from LSAPs in Treasuries
Aug 27, 2010	QE2	Fed chair Ben Bernanke suggests role for additional QE should it be necessary
Nov 3, 2010	QE2	QE2 announced: Fed will purchase $600 billion in Treasuries
June 22, 2011	QE2	QE2 finishes; principal payments will continue to be reinvested
Sep 21, 2011	OT	Maturity Extension Programme announced: Fed will purchase $400 billion of Treasuries with remaining maturities of three years or less; MBS and agency debt principal payments reinvested in MBS instead of Treasuries
Jun 20, 2012	OT	OT extended: Fed will continue to purchase long-term securities and sell short-term securities to the end of 2012 at a pace of around $45 billion a month
Sep 13, 2012	QE3	QE3 announced: Fed will purchase $40 billion a month of MBS
Dec 12, 2012	QE3	QE3 expanded: Fed will continue to purchase $45 billion of long-term Treasuries a month but will no longer sterilize purchases through sale of short-term Treasuries.
Jun 19, 2013	QE3	"Taper tantrum" as Bernanke announces Fed will reduce its $85 billion a month of bond purchases by end of year if economy continues to improve
Dec 18, 2013	QE3	Tapering begins, reducing speed of asset purchases: beginning in January, asset purchases will slow by $10 billion a month, split evenly between MBS and Treasuries
April 30, 2014	QE3	Asset purchases slowed: MBS added at rate of $20 billion (rather than $25 billion) a month, and add Treasuries at pace of $20 billion (rather than $30 billion) a month
June 18, 2014	QE3	Asset purchases slowed: MBS at a pace of $15 billion a month, and Treasuries at $20 billion a month
July 30, 2014	QE3	Asset purchases slowed: MBS at a pace of $10 billion a month, and Treasuries at $15 billion a month
September 17, 2014	QE3	Asset purchases slowed: MBS at a pace of $5 billion a month, and Treasuries at $10 billion.
October 29, 2014	QE3	QE3 ends. FOMC concludes asset purchases, citing "substantial improvement in the outlook for the labour market since the inception of its current asset purchase programme."
June 14, 2017	Normalization	FOMC announces normalization; this programme will see a gradual reduction in the Federal Reserve's holdings of securities by decreasing reinvestment of principal payments from those securities.
Nov 1, 2017	Normalization	FOMC confirms balance sheet normalization is proceeding.
Dec 19, 2018	Normalization	Fed chair Jerome Powell states that balance sheet runoff is on "autopilot."
Mar 20, 2019	Normalization	Fed announces intent to slow their balance sheet wind down, and then to end it.
October 11, 2019	Money Market Intervention	Fed announces that it will begin buying $60 billion of Treasuries per month to improve its control over its benchmark interest rate. The Fed state that these actions "do not represent a change" in its monetary stance, and Fed Chair Jerome Powell insisted the purchases would not be a resumption of quantitative easing.

Notes: OT stands for Operation Twist (Maturity Extension Programme). GSE stands for Government Sponsored Enterprises. MBS stands for mortgage-backed security, LSAPs stand for large-scale asset purchases. QE1, QE2, QE3 refer to the first, second, and third major rounds of QE undertaken by the Fed. FOMC refers to the Federal Open Market Committee.

Source: Ubide (2017, pp. 239-256), Ugai (2006), Federal Reserve, https://www.federalreserve.gov/newsevents/pressreleases/2019-press.htm, accessed December 18, 2019.

Table A.2 Important Announcements by the ECB 2008-2019

Date	Programme	Asset Purchases/Lending News
March 28, 2008	LTRO	ECB announces six-month LTROs
May 7. 2009	CBPP/LTRO	CBPP announced, LTRO expanded: ECB will purchase €60 billion in euro-denominated covered bonds; 12-month LTROs announced
May 10, 2010	SMP	ECB will conduct interventions in euro area public and private debt securities markets; purchases will be sterilized
June 30, 2010	CBPP	CBPP purchases finished on schedule; bonds purchased will be held through maturity
October 6, 2011	CBPP2	CBPP2 announced: ECB will purchase €40 billion in euro-denominated covered bonds
December 8, 2011	LTRO	LTRO expanded: 36-month LTROs announced; eligible collateral expanded
August 2, 2012	OMT	Draghi indicates that ECB will expand sovereign debt purchases, proclaims that "the euro is irreversible."
September 6, 2012	OMT	Countries that apply to European Stabilization Mechanism for aid and abide by its terms and conditions will be eligible to have their debt purchased by ECB in unlimited amounts on the secondary market.
June 5, 2014	TLTRO, MRO, LTRO, SMP, ABSPP	ECB announces major stimulus package, including a decrease in the interest rate, a negative depo rate, a new TLTRO programme, a continuation of MRO, an introduction of LTROs announced for 2016
August 22, 2014	Jackson Hole speech	Draghi hints at QE and other unconventional measures.
September 18, 2014	TLTRO, MRO, LTRO, SMP, ABSPP	ECB allots €82.6 billion to 255 counterparties in first of eight TLTROs to be conducted between September 2014 and June 2016
October 20, 2014	CBPP3	ECB begins purchases of covered bonds (CBPP3)
November 21, 2014	ABSPP	ECB begins asset backed securities (ABSPP)
January 22, 2015	PSPP, APP	ECB announces expanded asset purchase programme to be introduced (PSPP)
March 9, 2015	PSPP, APP	ECB begins PSPP. Monthly purchases under APP are set at €60 billion a month. Securities purchased under the PSPP include bonds issued by central government, regional and local government, international organisations and multilateral development banks in the euro area.
June 18, 2015	OMT	European Court of Justice finds that programme falls within scope of ECB's mandate and includes sufficient safeguards to avoid monetary financing
April, 2016	APP	ECB increases monthly bond purchases under their APP to €80 billion.
June 8, 2016	CSPP	ECB begins purchases of corporate sector bonds (CSPP) in their APP
April, 2017	APP	ECB reduces monthly bond purchases to original level of €60 billion
October, 2017	APP	Draghi announces plans to phase out APP as it stands, with a proposed end date of December 2017.
January, 2018	APP	ECB asset purchases are reduced to €30 billion per month
June 14, 2018	APP	ECB announces that asset purchases will be reduced to €15 billion per month
October, 2018	APP	ECB asset purchases are reduced to €15 billion per month
December 13, 2018	APP/Forward Guidance	ECB notes that Governing Council intends to continue reinvesting the principal payments from maturing securities for an extended period of time past the date where it begins raising the key ECB interest rates, and in any case for as long as is necessary to maintain favourable liquidity conditions and an ample degree of monetary accommodation.
December 19, 2018	CSPP, PSPP	CSPP, PSPP, ABSPP programmes end
September 12, 2019	APP	ECB Governing Council decide that "net purchases will be restarted under the Governing Council's asset purchase programme (APP) at a monthly pace of €20 billion as from 1 November 2019. The Governing Council expects them to run for as long as necessary to reinforce the accommodative impact of its policy rates, and to end shortly before it starts raising the key ECB interest rates."
November 1, 2019	CSPP, PSPP, ABSPP	CSPP, PSPP, ABSPP programmes restart (APP2)

Notes: MRO stands for main refinancing operations. TLTRO stands for targeted longer-term refinancing operations. LTRO stands for longer-term refinancing operations. ABSPP stands for asset-backed securities purchase programme. CBPP3 stands for covered bond purchase programme 3. PSPP stands for public sector purchase programme. CSPP stands for corporate sector purchase programme. SMP stands for Securities Markets Programme APP stands for the ECB's asset purchase programme, which is defined as a package of non-standard monetary policy measures that also includes targeted longer-term refinancing operations. APP2 refers to the newly restarted asset purchase programme.
Source: Ubide (2017, pp. 239-256), European Central Bank, "Asset Purchase Programmes" https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html#cspp, accessed December 18, 2019.

Table A.3 Important Announcements by the BOJ, 2001-2019

Date	Programme	Asset Purchases
March 19, 2001	QE1	Introduction of QE: purchase of ¥400 billion worth of Japanese Government bonds per month. The main operating target is to have the BoJ's current account balance (CAB) at ¥5 trillion.
August 14, 2001	QE1	Increase in purchases to ¥600 billion per month, CAB target increases to around ¥6 trillion.
September 18, 2001	QE1	Increase in CAB target to above ¥6 trillion
December 19, 2001	QE1	Increase in purchases to ¥800 billion per month, CAB target increases to around ¥10-15 trillion.
February 28, 2002	QE1	Increase in purchases to ¥1 trillion per month. CAB target scrapped, so long as liquidity is available.
October 30, 2002	QE1	Increase in purchases to ¥1.2 trillion per month. CAB target set to around ¥15-20 trillion.
March 25, 2003	QE1	CAB target increases to around ¥17-22 trillion per month.
April 30, 2003	QE1	CAB target increases to around ¥22-27 trillion per month.
May 20, 2003	QE1	CAB target increases to around ¥27-30 trillion per month.
October 10, 2003	QE1	CAB target increases to around ¥27-32 trillion per month.
January 20, 2004	QE1	CAB target increases to around ¥30-35 trillion per month.
March 9, 2006		QE1 ends due to economic recovery and increased CPI. Purchases will continue at the current amounts and frequency for "some time." CAB balance will be reduced towards a level in line with required reserves.
December 19, 2008	CFI	Expansion of outright purchases of Government bonds and commercial paper
January-October 2009	CFI, SFSO	BoJ expands outright purchases of commercial paper, asset-backed commercial paper, government bonds, and SFSOs.
October 5, 2010	CME	APP established: BoJ will purchase ¥5 trillion in assets
March 14, 2011	CME	APP expanded: BoJ will purchase an additional ¥5 trillion in assets
August 4, 2011	CME	APP expanded: BoJ will purchase around ¥5 trillion more in assets
October 27, 2011	CME	APP expansion: BoJ will purchase around ¥5 trillion more in assets
February 14, 2012	CME	APP expanded: BoJ will purchase an additional ¥10 trillion in assets
April 27, 2012	CME	APP expanded: BoJ will purchase just over ¥10 trillion in assets.
July 12, 2012	CME	APP expanded: BoJ will purchase additional ¥5 trillion in Treasury discount bills
September 19, 2012	CME	APP expanded: BoJ purchases additional ¥5 trillion in Japanese government bonds and ¥5 trillion in Treasury discount bills.
October 30, 2012	CME	APP expanded: BoJ purchases around ¥11 trillion in additional assets
December 20, 2012	CME	BoJ will purchase an additional ¥5 trillion in Japanese government bonds and ¥5 trillion in Treasury discount bills.
April 4, 2013	QQE	BoJ establishes price-stability target of 2%, adopts "monetary base control" and increase purchases of Japanese government bonds and extends their maturity. BoJ will expand monetary base at annual pace of around ¥60-¥70 trillion. Will purchase ETFs and J-REITs, so that amounts outstanding increase at an annual pace of ¥1 trillion and ¥30 billion respectively.
October 31, 2014	QQE	BoJ expands QQE by increasing Japanese government bond purchases to "approximately ¥8-¥12 trillion per month in principle" as price goal is threatened.
November 19, 2014	QQE	BoJ increases annual monetary base by ¥80 trillion. Will purchase Japanese government bonds "so that their amount outstanding will increase at an annual pace of about ¥80 trillion." Announces increased purchases of ETFs and J-REITs.
December 18, 2015	QQE	BoJ extends average maturity of Japanese government bond purchases to 7-12 years. Expands ETF purchases by ¥300 billion, with purchases of JPX-Nikkei 400 Index, and increases limit on J-REIT purchases from 5% to 10% of issuance.
January 29, 2016	QQE	BoJ increases annual purchases of ETFs to ¥2.2 trillion and J-REITs to ¥90 billion.
September 21, 2016	QQE with YCC	BoJ alters QQE by introducing a Yield Curve Control mandate, aimed at maintaining a 0% target for 10-year Government bond yields.
July 31, 2018	QQE with YCC	BoJ expands the band within which yields can fluctuate.
July 30, 2019	QQE with YCC	BoJ promises to ease policy "without hesitation" if global slowdown continues.

Notes: QE1 refers to the first QE programme undertaken by the Bank of Japan. CFI stands for Corporate Finance Instruments. SFSO stands for Special fund-supplying operation. CME stands for Comprehensive monetary easing. QQE stands for Qualitative and Quantitative Easing. QQE with YCC stands for Qualitative and Quantitative Easing with Yield Curve Control. BoJ stands for the Bank of Japan.
Source: Ugai (2006) and Ubide (2017, pp. 239-256).