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Uncertainty shocks and business cycles in the US: New insights from the last three decades

Oussama Houari[‡]

Abstract

The Global Financial Crisis revealed the complex and potentially negative impact of uncertainty shocks on macroeconomic and financial variables. In the academic literature, there is no consensus on the transmission mechanisms of this type of shock to the real economy. Using data from the US for the 1990-2018 period, we measure the effects of financial, macroeconomic and policy uncertainty shocks on a large panel of independent variables. Our results show that the heterogeneity of uncertainty measures plays an important role in assessing the evolution of the macroeconomic environment. In particular, high financial uncertainty disturbs financing conditions as the risk premium increases and pushes both households to raise savings and firms to postpone investments. In contrast, the effects of macroeconomic uncertainty on precautionary savings and policy uncertainty on risk premiums are mostly insignificant, suggesting that there is a decoupling between policy uncertainty and financial market performance in the US.

Keywords: Uncertainty shocks; Economic fluctuations; Transmission mechanisms; Causality; Structural VAR

JEL classification: C32, E32, G12

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1 Introduction

The 2008 Global Financial Crisis (GFC) marked a new era in the evolution of financial and macroeconomic dynamics at a global scale, raising several issues with respect to the role of economic policies in monitoring systemic crises. Hence, financial instability and uncertainty, macroeconomic stress, contagion, and macroprudential regulation have become the primary areas of concern for academics and practitioners in the past fifteen years. For example, [Greenspan \(2011\)](#)¹ deduces that half, or even three-fourths, of the crisis's effects can be explained by uncertainty shocks that profoundly disturb financial and institutional environments. More recently, the January 2021 minutes of the Federal Open Market Committee (FOMC) stress that the economy remained far from the committee's long-run goals, thus raising uncertainty about GDP growth and employment projections.

There is a broad consensus in the academic literature about the significant harmful effects of uncertainty on macroeconomic aggregates. Thus, [Leduc and Liu \(2016\)](#) show that an increase in uncertainty raises US unemployment. This idea is confirmed by [Caldara et al. \(2016\)](#), which indicates that uncertainty shocks have robust negative effects on economic activity, and [Bekaert et al. \(2013\)](#), [Jurado et al. \(2015\)](#), [Ludvigson et al. \(2020\)](#), and [Baker et al. \(2016\)](#), which provide evidence that uncertainty has a statistically strong negative effect on the business cycle. Three main channels of transmission are thus identified in the theoretical literature: the risk premium channel ([Christiano et al. \(2014\)](#), [Gilchrist et al. \(2014\)](#) and [Arellano et al. \(2019\)](#)), the real-options channel ([Bernanke \(1983\)](#), [Dixit and Pindyck \(1994\)](#) and [Baker and Bloom \(2013\)](#)) and the precautionary saving channel ([Leduc and Liu \(2012\)](#), [Basu and Bundick \(2017\)](#) and [Yıldırım-Karaman \(2018\)](#)).

In addition to an interest in measuring the effects of uncertainty on macroeconomic aggregates, the literature has also dealt with the potential connectedness between finan-

1. Greenspan had long denied the existence of a housing bubble and had repeatedly confirmed that the rapid growth in housing prices was just *froth*. This dramatic misevaluation of default rates and therefore of the intrinsic value of financial assets, widely shared in financial circles during the pre-2008 financial crisis, is a fundamental aspect of uncertainty shocks.

cial, economic and political uncertainty without providing any unitary vision about the nature of the causal relationships between these measures. Thus, using a general equilibrium framework, [Pastor and Veronesi \(2012, 2013\)](#) emphasize that economic policy uncertainty leads to stock price declines and a risk premium increases, implying that financial uncertainty is an increasing function of EPU. Contrary to this vision, [Borio \(2012, 2014\)](#) argues that financial uncertainty generated by financial valuation processes represents the key driver of economic fluctuations. More recently, [Yıldırım-Karaman \(2018\)](#) shows that uncertainty shocks emerge from the financial sector, and spread to the real sector through a twofold mechanism of negative wealth shocks and precautionary saving incentives.

Empirically, these controversial visions are confirmed by the scarce and recent literature on the topic. Thus, [Antonakakis et al. \(2013\)](#) find that for a sample ranging from 1985 to 2013, the correlations between S&P500 returns, implied volatility and EPU are time-varying and sensitive to US recessions. In international settings excluding the US, [Das and Kumar \(2018\)](#) and [Tiwari et al. \(2019\)](#) reveal that the relationship between financial and economic policy uncertainties is time-varying and market varying, respectively.

Two main drawbacks can be identified in this literature. First, the comparative analysis of the macroeconomic and financial effects generated by different types of uncertainty are particularly scarce and strictly limited to a small number of variables (generally between two and five).² Nevertheless, the question of the heterogeneity in the transmission mechanisms of uncertainties represents a crucial issue allowing us to better seize the evolution of the macroeconomic environment and consequently to drive the potential preventive or curative decisions of policy-makers aiming to stabilize the economic and financial systems.

Second, the analysis of the relationships between different sources of uncertainty is not sufficiently documented in the literature, and the results suggested by the few studies

2. Many examples could be cited in this regard. See, e.g., [Jurado et al. \(2015\)](#), [Leduc and Liu \(2016\)](#) and [Oh and Rogantini Picco \(2020\)](#), who limit their comparative study of the different uncertainty measures' effects to two, four and five variables, respectively.

that deal with the subject are highly dependent on the period considered, the definition of the uncertainty indicators and the nature of the macroeconomic outcome.

The paper aims to fill the gap in this literature by taking into consideration three distinct indicators of uncertainty: (i) a financial uncertainty measure, proxied by the VIX index, which captures the expected volatility of the Standard and Poor's 500 stock index over the next thirty days under the risk-neutral measure, (ii) a macroeconomic uncertainty index, measured by the MU indicator estimated by [Jurado et al. \(2015\)](#) and updated by [Ludvigson et al. \(2020\)](#), which captures time-varying macroeconomic uncertainty based on the unforecastable component of a large set of economic variables, and (iii) an economic policy uncertainty measure, represented by the EPU index constructed by [Baker et al. \(2016\)](#), which indicates the frequency of articles containing the words "uncertain" or "uncertainty" and "economy" or "economics" and other uncertainty-related keywords in ten leading US newspapers. The comparative analysis of highly structurally different sources of uncertainty allows us to refine the understanding of the transmission mechanisms of uncertainties to macroeconomic and financial variables in the US. In addition to the possibility of capturing the potential heterogeneity of the effects of uncertainty, our paper considers a particularly large perimeter of dependent variables that take into consideration new variables, rarely investigated in the literature, i.e., part-time employment and the delinquency rate on commercial and industrial loans.

Another element of originality in our paper is that it explicitly examines explicitly the causal relationship between financial and economic policy uncertainty. A thorough comprehension of the potential interactions between these two main sources of uncertainty, associated with a precise identification of the channels of transmission of uncertainties, could have important economic policy implications, allowing policy-makers to adapt their measures to both reinforce the performance of the US economy and preserve the stability of the financial system.

Our results show that uncertainty shocks have a significant negative impact on households, firms and the financial sector. Nevertheless, the effects of uncertainty are highly heterogeneous according to the nature of the uncertainty shocks. If the MU shocks

generate a highly persistent impact on output and employment, their effects on both precautionary saving and disinflationary processes are mostly insignificant. The effects of EPU shocks on all variables are less significant than those of VIX and MU shocks. Moreover, the VIX seems to generate the most significant impact on all of the components of the US economy.

Concerning the relationship between the different uncertainty sources, our findings indicate that financial uncertainty leads economic policy uncertainty, suggesting that shocks in financial markets have been the most influential drivers of economic fluctuations in the US during the last three decades.

The remainder of this paper proceeds as follows. [Section 2](#) describes the data, and presents the model that assesses the effects of uncertainty shocks on macroeconomic dynamics. The results and a set of robustness tests are presented in [Section 3](#). [Section 4](#) outlines the dynamic relationship between financial and economic policy uncertainty measures. [Section 5](#) summarizes and concludes the paper.

2 Methodology and data

This section presents the methodology and the data employed to analyse the impact of uncertainty shocks on US macroeconomic variables. Given our research question and the statistical characteristics of our data, we choose a structural VAR model to perform our analysis. Since this methodology is largely used in applied research, we only briefly present the model here and refer the reader to [Lütkepohl \(2005\)](#) for a detailed discussion on SVARs.

We estimate the following SVAR:

$$Az_t = c + \sum_{i=1}^p z_{t-i}A_i + \epsilon_t \quad (1)$$

where z_t is an n -vector of endogenous variables. A is a nonsingular ($n \times n$) matrix of contemporaneous relationships between endogenous variables, A_i is a ($n \times n$) matrix of structural parameters, c is an n -vector of intercepts, and ϵ_t is an n -vector of structural

innovations with mean zero and diagonal covariance matrix Σ_ϵ . Moreover, ϵ_t is equal to Ae_t , with e_t being the reduced form disturbances.³

To identify our SVAR models, $\frac{n^2-n}{2}$ restrictions are needed. We use a recursive identification scheme where exclusion restrictions to zero are imposed above the main diagonal of A , i.e., A is a lower-triangular matrix. Thus, the structural shocks and the associated impulse responses are just identified.

Equation (1) is estimated for each of our three uncertainty measures. We successively consider the VIX, MU and EPU indexes to capture financial, macroeconomic and economic policy uncertainty, respectively. Figure 1 shows the time series plots of these measures. We observe that, unlike MU and VIX, which rise in recessions (shaded grey areas) and fall in expansions,⁴ EPU is not completely countercyclical. Thus, during the 2011 debt ceiling, the 2012 fiscal cliff, the 2013 government shut-down and the 2016 US presidential election, EPU took off, while MU and VIX only recorded "reasonable" irregularities. One more noteworthy difference is that the 1998 Russian debt crisis/LTCM default led to important surges in the EPU index but did not have a major impact on the MU index. The last notable difference is that the VIX is the only index to have recorded increases during the 1997 Asian financial crisis and the 2001 corporate scandals. These differences give us a reason to believe that the three uncertainty measures provide complementary information, and their related shocks might, therefore, transmit through different channels to the real economy. Our analysis is precisely intended to capture these different transmission channels.

To perform our analysis, we use US monthly data over the period 1990 to 2018. Table 1 in Appendix A presents all the variables included in our empirical model. In addition to the uncertainty measure, we introduce eight other macroeconomic variables.

3. We make the following assumptions:

$$E(e_t) = 0 \quad ; \quad var(e_{it}^2) = \sigma_{ii} \quad ; \quad cov(e_{it}e_{jt}) = \sigma_{ij} \quad ; \quad E(e_t e_s) = 0 \quad (2)$$

This implies that the error terms in reduced-form VAR models cannot be correlated across time but can be correlated across different equations, i.e., the variance covariance matrix Σ_ϵ can have nonzero off-diagonal terms. Therefore, the contemporaneous relationships across variables can only come from the terms in Σ_ϵ and not from the A matrix, as in the structural A-model we are identifying.

4. An exception is the case where the MU index's value in 1991, a recession year, is lower than its value in 2005, which is not a recession year.

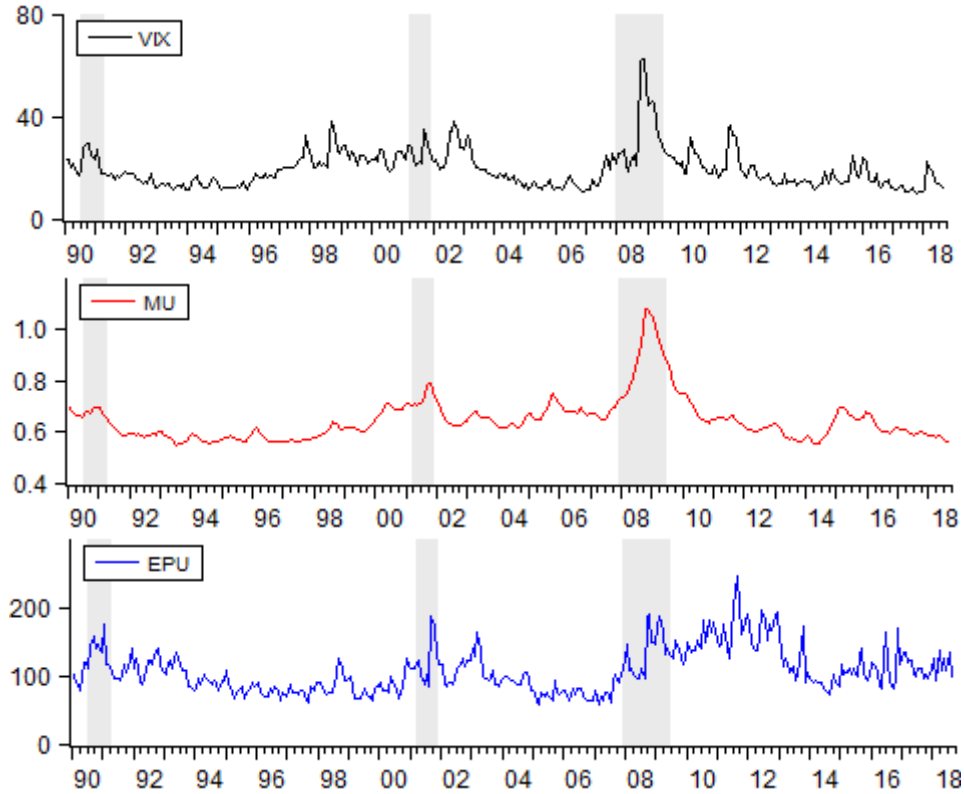


Figure 1 Implied Volatility Index (VIX), Macroeconomic Uncertainty index (MU) and Economic Policy Uncertainty index (EPU). Shaded grey areas indicate NBER-defined recessions for the US economy.

The industrial production index is included as a business cycle indicator. The choice of the other variables is dictated by the need to capture the impact of uncertainty shocks on the economy. The effect might pass through three main uncertainty transmission channels. First, the real-options channel, based on the premise that higher uncertainty pushes firms, which face irreversible investments to adopt the so-called "wait and see" attitude, causing a decline in output, investment and hiring. This channel is accounted for by introducing variables such as investments (INV), civilian unemployment (CIV) and part-time employment (PT).

The second channel through which uncertainty shocks might impact the economy is the precautionary saving channel. To withstand uncertainty shocks, risk averse agents will put more weight on future consumption and, thus, increase their current savings. To account for this effect, we include in our model the difference between the two first monetary aggregates M2-M1 as a proxy of saving deposits. We suppose that this latter's increase is tightly related to the decrease in actual consumption expenditures, which could

translate into lower inflation. Thus, we also include the consumer price index (CPI) as a measure of inflation.

A third mechanism through which uncertainty may affect the economy is through financial frictions. As uncertainty rises, investors want to be compensated for higher risk (notably the risk of defaults) and thus the cost of finance, i.e., the risk premium increases. Empirically, this drives banks to charge higher interest rates to entrepreneurs, reducing investments and economic growth. In our model, this mechanism is captured by the introduction of a credit market risk indicator (TED spread) and of the delinquency rates on commercial and industrial loans (DEF).

Before estimating [Equation \(1\)](#), we identify the order of integration of all variables. The results of the augmented Dickey-Fuller test (ADF-test) are presented in [Table 2 \(Appendix A\)](#). Six variables (IPI, CIV, PT, INV, CPI and M2-M1) possess unit roots in their levels since each reported t-statistic is not smaller than its respective critical values. Those variables are stationary in first differences, i.e., I(1) variables. The remaining variables (the uncertainty measures, DEF and TED) are stationary in levels, i.e., I(0) variables.

According to the Bayesian information criterion, our SVARs are estimated using a laglength of three. The causal ordering is as follows: the uncertainty measure (successively VIX, MU and EPU), TED, DEF, CPI, M2-M1, CIV, PT, INV and IPI. This reflects the fact that uncertainty is a cause of economic stagnation and instability. Therefore, all non-uncertainty shocks (ϵ_{2t} , ϵ_{3t} , ϵ_{4t} , ϵ_{5t} , ϵ_{6t} , ϵ_{7t} , ϵ_{8t} , and ϵ_{9t}) have zero contemporaneous effects upon uncertainty proxies.

3 Results

In this section, we first analyse the results from our SVAR models with the aim of better understanding the channels through which structurally different sources of uncertainty influence the US economy. We also engage in a comparative analysis to see the differences that emerge between the impact of each of these measures on the real economy and the

financial sector. Finally, in this section, we present the results of several robustness tests.

3.1 Structural VAR results

We estimate three SVAR models where the first equation is one of structural uncertainty. The estimated residuals are a measure of the uncertainty shock. The recursive identification strategy allows us to obtain all the impulse responses to a one-standard deviation uncertainty shock, as shown in [Appendix B](#).

First, from the results presented in [Figure B.1](#), we can note that a financial uncertainty shock is transmitted to the real economy and to the financial system through all three channels usually underlined in the literature. Indeed, after a one standard deviation VIX shock, investment and output diminish while unemployment increases. The response of industrial production is more important than that obtained by other researchers using different identification strategies ([Bloom \(2009\)](#), [Jurado et al. \(2015\)](#)). The combined responses of these variables highlight the presence of the real-options channel, where firms postpone investment and hiring because of the higher value of the waiting option in recession periods. Moreover, given the increase in the TED spread, the cost of credit increases in the economy with a negative impact on investment.

Moreover, following a financial uncertainty shock, part-time employment increases for 17 months to reach approximately 2.1%. The introduction of this variable in our framework is important, as it clarifies the way in which US part-time employment reacted after the Great Recession.⁵ We can explain its protracted increase by the fact that in times of crisis, firms prefer hiring part-time, as uncertainty about future cash-flows is high. In the literature, this effect is not well captured. For example, in the [Bloom \(2009\)](#) setup, employment falls significantly for only seven months and records a very quick drop and rebound. However, our results are in line with a growing body of literature suggesting that fluctuations in part-time employment are very relevant to understanding how a severe recession can cause persistent and structural changes in the US labour

5. [Yellen \(2014\)](#) expresses that “*several years after the end of the Great Recession, the involuntary part-time employment share remains above its pre-crisis level in the US; the causes behind this persistence are not well understood.*”

market's functioning (see, e.g., [Borowczyk-Martins and Lalé \(2020\)](#)).

Next, in line with the precautionary saving channel, we find that the financial uncertainty shock increases savings and reduces inflation, as expected. These findings could suggest an increase in the risk aversion of American households in response to higher uncertainty.

The VIX shock also seems to be transmitted to financial variables, as the TED spread and the delinquency rate on commercial and industrial loans both significantly increase. We can identify here the disciplinary effect of a high level of uncertainty leading to a slowdown in indebtedness activity. Moreover, the delinquency rate is the variable that shows a significant variation for the longest period. We notice that the particular shape of the delinquency rate response function may be a signal of how bankruptcy procedures occur in US law. Depending on the chapter under which a firm files for bankruptcy, the time of the procedure may be very lengthy, translating into defaults occurring several periods after the uncertainty shock occurs. We therefore conclude that financial uncertainty not only has a negative impact on real and financial variables but also largely spreads through the economy through the three channels at the same time.

Considering macroeconomic uncertainty, two main elements can be underlined. First, we identify the same negative impact on the economy after a one standard deviation shock in MU. Indeed, industrial production and investment decrease, unemployment and part-time employment both increase, whereas financial conditions deteriorate with a higher risk premium and a high and persistent delinquency rate. However, the magnitude and persistence of this uncertainty shock are more important than in the VIX case, as also underlined by the results of [Jurado et al. \(2015\)](#).

Second, the transmission of the shock through the precautionary saving channel seems rather weak, as the increase in savings is less persistent than the impact of the VIX shock. Furthermore, there is no significant impact on inflation following a macroeconomic uncertainty shock. One potential explanation is that the recession fear – depicted by high levels of the VIX index – causes households to become more risk averse through a habit stock mechanism ([Bekaert et al. \(2009\)](#)), which makes them more willing to save. For

example, [Bekaert and Engstrom \(2017\)](#) find that movements in the VIX are related to the conditional distribution of consumption growth, namely, when the VIX is high, the distribution of consumption growth is more left-skewed, which leads to an increase in savings demand.⁶ In contrast, no evidence was found in the literature of the existence of a similar relationship between macroeconomic uncertainty and precautionary saving incentives.

Concerning the economic policy shock, its effect seems only to pass through the real-options channel, as output and investment diminish and unemployment and part-time employment rise. The impact on the other variables – savings, inflation, TED spread and delinquency rate – is small and mostly nonsignificant. We can therefore conclude that an EPU shock will have an impact on the real economy but not on the financial sector. The increase in savings after this uncertainty shock remains moderate, underlining the habit stock mechanism, which implies that it is only financial uncertainty that drives agents to increase their precautionary savings and that other types of uncertainty arising from macroeconomic or economic policy do not have such an effect.

Regarding the comparative analysis between the three types of shocks considered in this paper, we can note that EPU has the least significant impact compared with the VIX and MU shocks. For example, the estimated peak of a financial uncertainty shock on unemployment is approximately two-fold that obtained in the economic-policy uncertainty model. Additionally, shocks to the VIX index generate a peak response of part-time employment that is approximately one-third larger than that in the economic policy uncertainty model. Although the VIX accounts for firms that cover only a third of private employment, these firms are leaders in their industries and, therefore, represent a large part of the sales of each sector and, more importantly, a crucial part of the added value in the economy in general ([Comin and Philippon \(2005\)](#)). It is, however, difficult to establish such a strong and direct linkage between employment and EPU. For example, while EPU increases sharply before and after the 2016 US presidential election,

6. This is because an increase in negative skewness implies that risk averse agents know that states far out on the left tail of the distribution become more likely, causing them to increase their savings because of a higher financial uncertainty.

the unemployment rate never exceeded 5% at the same time, a rate never reached since before the GFC.

In addition, EPU is the only uncertainty measure among the three considered here that does not impact the risk premium. This might be, because economic policies, in particular accommodating monetary policy, along with the deregulation of the financial sector were perceived as growth friendly, even if they could generate an increase in uncertainty. This is also consistent with the decoupling we have seen this last decade between EPU and financial performances in the US.⁷

Furthermore, and unlike shocks to VIX, innovations to EPU do not cause a disinflationary effect, as the generated fall in inflation is totally insignificant. These findings extend [Jones and Olson \(2013\)](#), who use only EPU to control for uncertainty and show that the dynamic correlation between EPU and inflation has turned from negative to positive since the early 2000s. Our study, based on a structural cause and effect model, compares the effects of three different sources of uncertainty on inflation and shows that only financial uncertainty has a disinflationary effect.

From the above analysis, we conclude that the VIX is the only uncertainty measure that spreads to the real economy and to the financial sector through all three transmission channels. Its widespread effect therefore emphasizes the importance of this index as a reference variable in the economy.

Finally, focusing on the recovery period, we find that unemployment, part-time employment, and the delinquency rate on commercial and industrial loans are the variables suffering the most from a slow recovery after an uncertainty shock. This result is in line with the evolution of these variables after the GFC, as seen in [Figure A.1](#). The delinquency rate on commercial and industrial loans is considered a key variable⁸ to measure credit stress in financial markets. Indeed, a higher delinquency rate is usually associated with recession periods and the collapse in the financial value of assets. Thus, the slow return of delinquency rates toward the steady state illustrates how banks are seeking to

7. This concern will be thoroughly addressed in [Section 4](#).

8. We refer here to all the literature that studies financial frictions from a contract theory perspective, particularly the seminal works of [Krasa and Villamil \(2000\)](#) and [Krasa et al. \(2008\)](#).

repair their balance sheets in the aftermath of an uncertainty shock and how, despite an accommodating monetary policy, they are tightening credit conditions for households and nonfinancial corporations for several periods (Illes et al. (2015)), leading to even more defaults.

3.2 Robustness checks

Using a range of alternative variables, we conduct several tests to check the robustness of our results. First, we use gross private domestic investment as an alternative measure of gross domestic investment to correct for government investments. We also include nonperforming loans (past due 90+ days plus non-accrual) to total loans for all US banks to control that the risk premium channel response does not depend on the specific calculation of the delinquency rate on commercial and industrial loans. Although the impact of the shocks recedes more quickly for variables such as CIV, PT and TED, the general inferences from these new specifications are similar to those we have found previously.

Second, we consider an alternative test supposing that the order of variables is reversed, i.e., industrial production index is ordered first, and uncertainty proxies are ordered last. This alternative ordering reflects that variations in the economy have no direct and simultaneous effect on output, whereas these economic variations impact the uncertainty measures simultaneously. We find that disturbances to the VIX index have smaller, albeit significant, effects on the economy relative to our benchmark ordering, except for inflation, for which the effect is more persistent. Moreover, MU still has a nonsignificant effect on the growth rate of saving deposits as well as on inflation. Concerning the innovations to EPU, our results suggest a mostly nonsignificant impact on the economy except for the industrial production index from the 4th to the 7th periods.⁹ These results reinforce the idea that the VIX is the uncertainty measure that significantly impacts the three uncertainty transmission channels all at once.

Quantifying the effects of the different uncertainty shocks on the US economy by

9. The complete results of the different robustness tests are available upon request.

integrating them one by one into the models, we show that financial and economic policy uncertainties play important roles in explaining business cycles. The analysis of the relationship between these two measures thus becomes particularly relevant to better understand the impact of uncertainty on macroeconomic and financial aggregates. The next section aims to shed light on this point.

4 Dynamic interactions between uncertainty measures

This section is motivated by a particular phenomenon: the “puzzle of high policy uncertainty and low market volatility” (Pastor and Veronesi (2017)). We aim to investigate this puzzle by analysing the interactions between financial and economic policy uncertainties.¹⁰

Discriminating between financial and economic policy uncertainty shocks is empirically challenging, as financial uncertainty peaks are often associated with upsurges in economic policy uncertainty. Indeed, Table 3 in Appendix C reveals a strong positive correlation between financial and economic policy uncertainties as close as 42%. This is also illustrated in Figure 2, which presents the linkage between the monthly growth rates of VIX and EPU, clearly highlighting the existence of a significant relationship between the two uncertainty measures.

To analyse the causal relationships between the two different uncertainty measures, we use two categories of empirical models: Granger causality tests and structural VAR models.

10. For several reasons, we will not analyse in this paper the nexus between the VIX and MU indexes. In fact, the MU index calculation methodology de facto includes 25 financial time series, which may explain why the two indicators often move together (correlation of 0.63). This makes a Sims-like cause and effect analysis, which we have adopted in this paper, less relevant to us. An analysis of this interaction by a GMM estimation is in progress and should be the subject of a separate paper.

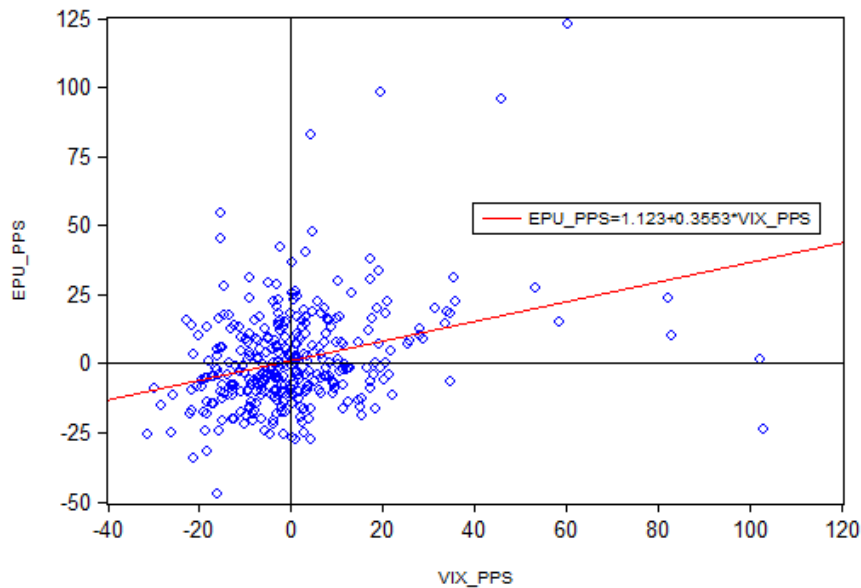


Figure 2 Monthly growth rate of financial uncertainty in percentage points and monthly growth rate of economic policy uncertainty in percentage points

Notes: The scatter plot shows the relationship between the monthly growth rates of VIX and EPU. We estimate a simple linear regression where the monthly growth rate of EPU is the dependent variable, while the monthly growth rate of VIX is used as a predictor. We find that the line slope is positive and significant at the 1% level.

4.1 Pairwise Granger-causality tests

We consider two pairwise Granger-causality tests. Variable x is called "Granger-caused" by variable y if lags of this latter help to predict x . Thus, the forecast capacity of time series is very sensitive to the chosen lag length. Table 4 in Appendix C presents the results where two lag specifications are used. The first is based on the Bayesian information criterion and shows a fuzzy causal path since the two null hypotheses are not rejected. We then opt for a parametrisation of 5 lags to see if we can bring more clarity to the prediction power of our variables. Our results show a significant causality relationship, as VIX is the driving variable, i.e., VIX Granger causes EPU at the 10% level. These preliminary results are to some extent in line with Zhang et al. (2019), who argue that stock market performance (financial variable) Granger causes economic policy uncertainty, not the opposite. However, these findings should be considered guardedly, as they are sensitive to lag length specifications.

To refine our analysis of the relationships between financial and economic policy uncertainties, we consider a structural VAR framework. We use three different identification strategies. First, we estimate a standard recursive SVAR system. Second, we perform a structural VAR model following the well-known zero contemporaneous and long-run restrictions. Finally, we present the results based on sign restrictions.

4.2 Recursive SVARs

Within the SVAR-4(3) framework, the ordering¹¹ is as follows:

$$\begin{bmatrix} d(IPI) \\ \text{federal funds rate } (R_b) \\ \log(VIX) \\ \log(EPU) \end{bmatrix}$$

We use a Cholesky decomposition of the estimate of the variance–covariance matrix to identify our shocks of interest. We also consider an alternative version where the order of VIX and EPU is interchanged. Panel A (EPU ordered after VIX) and Panel B (VIX ordered after EPU) in [Table 5](#) show the interrelated dynamic responses of VIX and EPU. Two main results must be noted. First, the effects of disturbances to the EPU index appear to be largely determined by the order of variables, in contrast to disturbances to the VIX index, which even in Panel B have a highly significant impact on EPU for the first ten months. More importantly, the EPU response to a VIX shock in Panel A is significant for 15 months, while the VIX response to an EPU shock in Panel B is significant for only 4 months.

Economically, our estimates indicate that favourable financial developments in the US can outweigh a shock of economic-policy uncertainty in far less time than that needed by good policies to offset shocks of financial uncertainty. This is consistent with [Kostka and van Roye \(2017\)](#), who demonstrate that economic policy uncertainty can tighten financial conditions, but only around the respective political event.¹²

11. This first ordering is motivated by the above Granger causality results, which show that the VIX "Granger-causes" EPU.

12. On November 3rd 2017, that is, one year after the 2016 US presidential election, the VIX index closed at 9.14, reaching an all-time record low.

In summary, these findings further corroborate the results of the Granger causality tests obtained above, but it seems that ordering matters, particularly for economic policy uncertainty effects. Thus, we opt for an identification scheme that addresses this gap.

4.3 Identification based on contemporaneous/long-run restrictions

Our second approach is based on a structural VAR-4(3) model. There are four shocks in the model: ε_{1t} is a supply shock, ε_{2t} is a monetary policy shock, ε_{3t} is a financial uncertainty shock and ε_{4t} is an economic policy uncertainty shock. Following [Shapiro and Watson \(1988\)](#) and [Ouliaris et al. \(2016\)](#), we use the identification approach of short- and long-run restrictions, with the short-run restrictions being:

- There is no contemporaneous effect of uncertainty shocks (ε_{3t} and ε_{4t}) on monetary policy. The established SVAR literature has either assumed that uncertainty variables respond with a lag to monetary policy shocks (the uncertainty measures are ordered above the federal funds rate), or that monetary policy responds with a lag to uncertainty shocks. Based on the literature on monetary policy news and following [Bekaert et al. \(2013\)](#) and [Jurado et al. \(2015\)](#), we impose the restriction that uncertainty variables respond contemporaneously to monetary policy shocks. These assumptions will be relaxed in the next model.
- Uncertainty shocks (ε_{3t} and ε_{4t}) have no contemporaneous effect on output. This assumption is motivated by the SVAR results we have presented in [Section 3](#), which show that contemporaneous responses of output to both VIX and EPU shocks are statistically nonsignificant. This is possibly due to the fast-moving nature of uncertainty measures, whereas the business cycle variables are relatively more slow-moving (see, e.g., [Bernanke et al. \(2005\)](#), [Bekaert et al. \(2013\)](#) and [Belke and Oskowski \(2019\)](#) for a discussion on the split between slow- and fast-moving variables). In addition, [Jones and Olson \(2015\)](#) and [Jurado et al. \(2015\)](#) find no systematic contemporaneous association between uncertainty shocks and output under differ-

ent identification schemes. Again, these constraints are relaxed when we apply the agnostic sign restrictions below.

The long-run restrictions are:

- Monetary policy shock ε_{2t} has a zero long-run effect on output. Long-run monetary neutrality over real variables, is an essential and lively debate in macroeconomics, and an enormous amount of literature can be cited here. See, e.g., [King and Watson \(1997\)](#) and [Bernanke and Mihov \(1998\)](#) or [Bullard \(1999\)](#) for a good survey.
- There is no long-run effect of economic policy uncertainty shock ε_{4t} on the financial uncertainty index. This is due, as discussed above, to the decoupling between EPU and US stock market performance during the last decade, as found by [Kostka and van Roye \(2017\)](#), [Tiwari et al. \(2019\)](#) and [Białkowski et al. \(2021\)](#).¹³ However, this assumption will be released when we use sign restrictions as an alternative identification strategy.

This identification strategy satisfies necessary and sufficient conditions for global identification of structural VAR models as established by [Rubio-Ramirez et al. \(2010\)](#).¹⁴ The restrictions are imposed using the two-stage least squares (TSLS) methodology. Appendix D presents the precise form of the equations we estimate. Panels C and D in [Table 5](#) show the impulse responses of the uncertainty variables to interrelated structural shocks out to a horizon of 60 months. Our results clearly indicate that it is the financial uncertainty index that has a significant impact on the economic policy uncertainty index and not the opposite.

As already mentioned, even if the above short- and long-run restrictions are generally accepted and commonly applied in other research papers, we are aware that some of them are stringent.¹⁵ Thus, we will analyse the robustness of our results by relaxing them and adopting an "*agnostic*" identification scheme.

13. One might conclude that this restriction could bias our results. Therefore, we consider a robustness model where we assume that the VIX shock has no long-run effect on economic policy uncertainty. Our results are robust to this check.

14. We thank a referee for drawing our attention to this important point.

15. Whereas long-run monetary neutrality is better justified by theory, zero short-run restrictions are always the subject of great disagreement in the literature.

4.4 Sign-restricted VAR

Following Uhlig (2005), our third set of restrictions uses sign constraints on the impulse response functions. In order to be agnostic and let the data freely determine the sign of these responses, we restrict our shock of interest, i.e., uncertainty proxy (VIX) to be positive and industrial production to be negative,¹⁶ whereas we leave the federal funds rate and the other uncertainty proxy unrestricted (EPU). The purpose of doing so is to be agnostic and let the data freely determine the sign of these responses, specifically the response of the impacted uncertainty proxy (EPU). A similar exercise is carried out in the other direction, i.e., we restrict EPU to be positive and leave VIX unrestricted.

Impulse response functions in Panel E¹⁷ are qualitatively similar to the responses based on the zero short- and long-run restrictions. The financial uncertainty index has a significant impact on the economic policy uncertainty index and not the opposite. Nevertheless, two main differences can be identified. First, the response of VIX to an EPU shock is now positive, even if it is nonsignificant over the whole period. Second, the pass-through of a VIX shock for EPU is faster under zero short- and long-run restrictions than under sign restrictions.

In sum, our findings are consistent with the sequencing of events of the last three decades. Indeed, we noticed that there is almost no instance where VIX has increased without EPU also going up sharply, whereas high economic policy uncertainty is not consistently translated into high financial market volatility, and even when the effect of EPU on VIX is more or less strong in the first periods, it is rapidly muted. Favourable financial conditions following the 2016 US presidential election provide a striking example.

5 Conclusion

The paper aims to analyse the interactions between uncertainty shocks and the business cycle in the US, by considering an integrated approach with a large number of

16. These sign restrictions are in line with uncertainty shocks acting like a typical negative aggregate demand shock in the US. See Leduc and Liu (2016) and Kumar et al. (2021) for a more informative discussion on this point.

17. Impulse response functions of output and federal funds rate are not reported here. We verify that the sign restrictions are never violated. These results are available upon request.

macroeconomic variables that discriminate between three specific uncertainty transmission channels.

Our findings indicate that an increase in uncertainty causes a persistent contraction of output and its subcomponents. The VIX index is the only uncertainty measure that spreads to the US economy and the financial sector through all potential transmission channels, whereas the impact of EPU is the least significant compared with VIX and MU. Moreover, we find that the unemployment, part-time employment and delinquency rate on commercial and industrial loans are the variables suffering the most from slow recovery after an uncertainty shock. The persistent increase in part-time employment provides a measure of how the GFC structurally changes the US labour market. We finally show that it is the financial uncertainty index that has a more significant and prolonged impact on the economic policy uncertainty index and not the opposite.

In terms of policy implications, as VIX causes the EPU index, policy-makers should adapt their interventions according to the nature of shocks, which are likely to generate an increase in financial uncertainty. The VIX acts as a warning indicator allowing public authorities to react quickly to any rise in financial uncertainty to preserve the stability of both financial and macroeconomic systems. For instance, as we have already noticed in the case of the GFC or the current COVID crisis, specific monetary and fiscal tools could be activated, such as quantitative easing instruments, communications strategy, and public subsidies.

Our analysis can be further developed by examining the nexus between financial and macroeconomic uncertainties to refine the comprehension of the potential causal relationships between different sources of uncertainty. Another potential extension of our paper could rely on an investigation of the impact of uncertainty on macroeconomic and financial aggregates in the Eurozone by explicitly taking into consideration the heterogeneity of country members.

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A Preliminary analysis

Table 1
Description of variables.

Variable	Label	Description
(Growth of) Industrial production	IPI	Log (difference of) industrial production index; Index 2012=100
Effective federal funds rate	R_b	Effective federal funds rate is calculated as a volume-weighted median of overnight federal funds transactions. It is published by the New York Fed for the prior business day
Uncertainty measures		
CBOE Volatility index	VIX	30-day implied volatility index
Macroeconomic uncertainty index	MU	Macroeconomic Uncertainty index estimated by Jurado et al. (2015) and updated by Ludvigson et al. (2020)
Economic-policy uncertainty index	EPU	Economic policy uncertainty index constructed by Baker et al. (2016)
Real-options channel		
(Growth of) Gross domestic investment	INV	Log (difference of) the sum of gross private domestic fixed investment, the change in private inventories, and government gross investment
Civilian unemployment rate	CIV	(Difference of) the percentage of unemployed labour force
(Growth of) Part-time employment	PT	Log (difference of) thousands of persons working 1 to 34 hours per week for economic reasons, in all industries
Precautionary saving channel		
(Growth of) M2 money stock - M1 money stock	M2-M1	Log (difference of) M2 minus M1 consists of summing savings deposits, small-denomination time deposits (time deposits in amounts of less than \$100,000), and retail money market mutual funds
(Growth of) Consumer price index	CPI	Log (difference of) consumer price index, all items; Index 1982-1984=100
Risk premium channel		
Delinquency rate on commercial and industrial loans	DEF	Delinquent loans are those past due thirty days or more and still accruing interest as well as those in nonaccrual status
Ted spread	TED	The spread between 3-Month LIBOR based on US dollars and 3-Month Treasury Bill

Notes: The variables are quoted above according to the channel they highlight. All variables are of monthly frequency except DEF and INV, which are only available in quarterly frequencies. We use the cubic spline interpolation method to obtain monthly values for these two variables. The variables are, if necessary, seasonally adjusted using the well-known X-13 method developed by the US Census Bureau. The data are from FRED except for EPU and MU that are available, respectively on www.policyuncertainty.com/ and www.sydneyludvigson.com/.

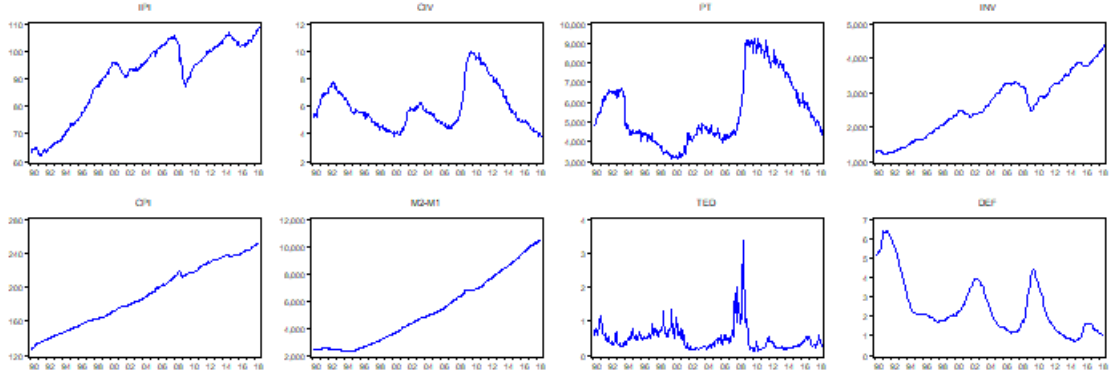


Figure A.1 Plots of the main variables.

Table 2
Summary of ADF unit root tests.

Variables	Constant and trend			Constant, no trend			No constant, no trend		Results
	Stats	p-value	t (trend)	Stats	p-value	t (drift)	Stats	p-value	
IPI	-2.263277	0.4525	1.830667	-	-	-	-	-	DS
DIPI	-4.891541	0.0004	-0.398226	-4.885144	0.0000	1.635709	-	-	I(0) with drift only
R_b	-4.706481	0.0008	-3.304712	-	-	-	-	-	I(0) with drift and trend
VIX	-4.178652	0.0053	-0.367028	-4.170762	0.0009	3.872499	-	-	I(0) with drift only
MU	-3.548384	0.0360	0.510360	-3.518223	0.0081	3.473023	-	-	I(0) with drift only
EPU	-3.500878	0.0408	0.932825	-3.381772	0.0123	3.292513	-	-	I(0) with drift only
INV	-2.311255	0.4262	2.413808	-	-	-	-	-	DS
DINV	-3.532035	0.0376	0.717117	-3.481020	0.0091	2.388885	-	-	I(0) with drift only
CIV	-2.381205	0.3887	-0.329103	-2.433403	0.1333	2.278765	-	-	DS
DCIV	-3.684222	0.0247	-0.582087	-3.641632	0.0055	-0.315325	-3.635883	0.0003	I(0) with none
PT	-0.965812	0.9459	-0.202200	-1.156767	0.6939	1.090838	-0.388027	0.5438	DS
DPT	-20.12643	0.0000	-0.759806	-20.12483	0.0000	-0.048779	-20.15436	0.0000	I(0) with none
M2-M1	-2.664296	0.2523	3.918104	-	-	-	-	-	DS
DM2-M1	-9.707211	0.0000	5.626791	-	-	-	-	-	I(0) with drift and trend
CPI	-2.467107	0.3444	2.442390	-	-	-	-	-	DS
DCPI	-12.20473	0.0000	-0.277525	-12.21823	0.0000	7.737590	-	-	I(0) with drift only
DEF	-3.604209	0.0309	-2.110267	-	-	-	-	-	I(0) with drift and trend
TED	-3.538570	0.0369	-0.870132	-3.431599	0.0106	2.823753	-	-	I(0) with drift only

Notes: The null hypothesis of the ADF test is equivalent to the assumption that the respective series is non-stationary.

B SVAR irfs

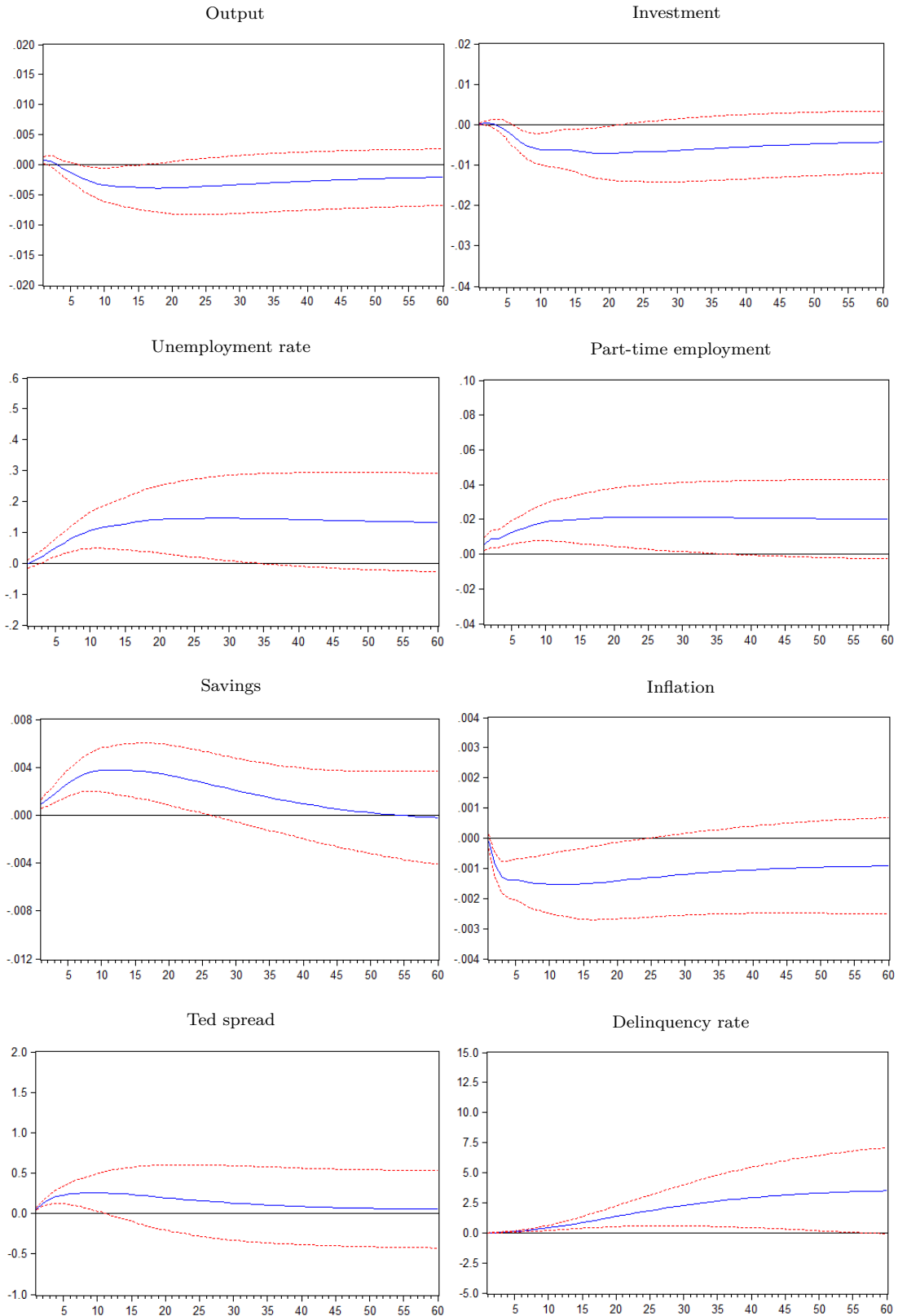


Figure B.1 Impulse responses to one-standard deviation VIX shock

Notes: Accumulated responses of variables to structural one-standard deviation VIX shock from estimation of the SVAR model. Dashed lines show 95% standard error bands. As described in [Table 1](#), variables are all in log-differences except for the unemployment rate, which is in differences, and the Ted spread and delinquency rate, which are in levels.

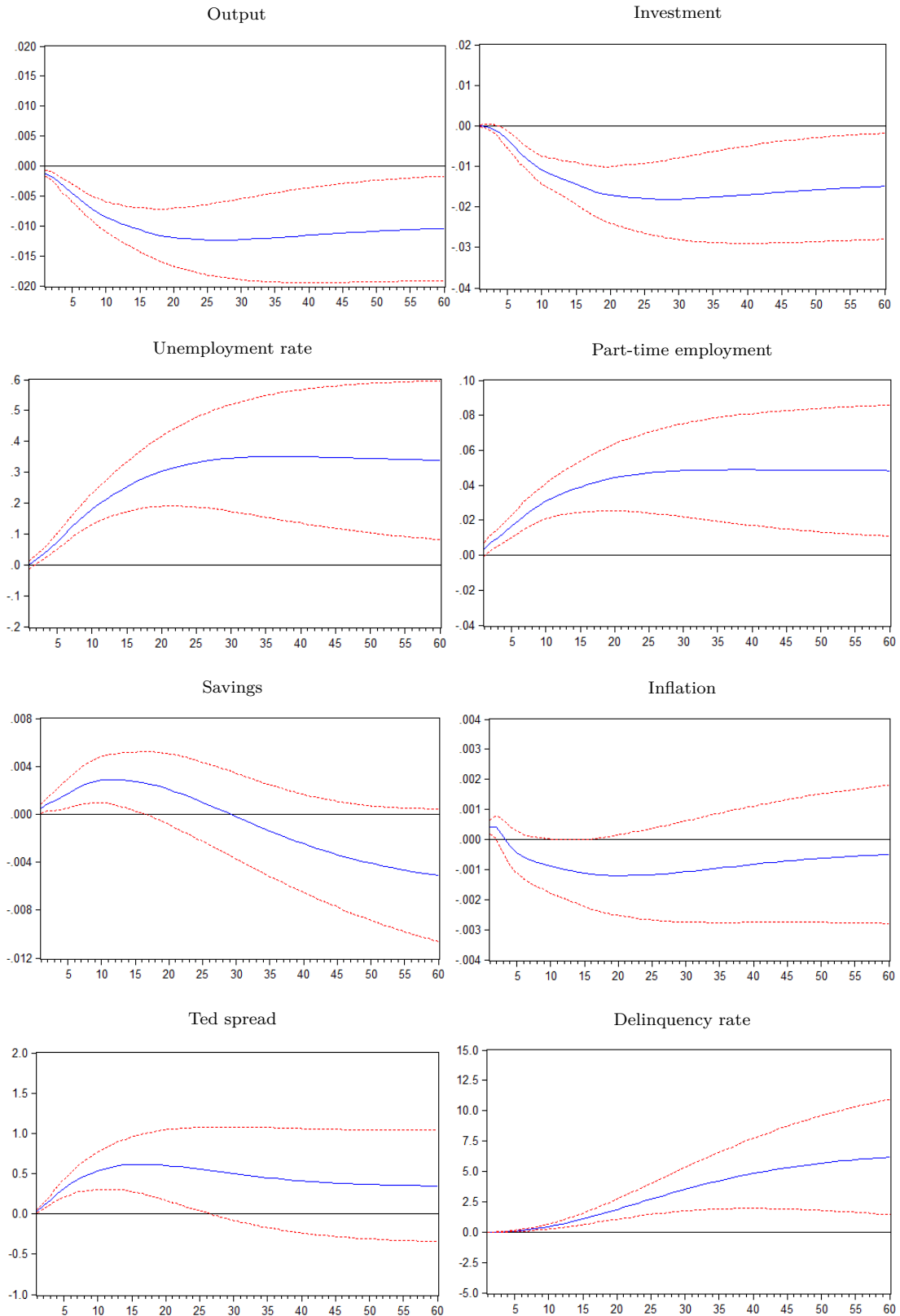


Figure B.2 Impulse responses to one-standard deviation MU shock

Notes: Accumulated responses of variables to structural one-standard deviation MU shock from estimation of the SVAR model. Dashed lines show 95% standard error bands. As described in [Table 1](#), variables are all in log-differences except for the unemployment rate, which is in differences, and the Ted spread and delinquency rate, which are in levels.

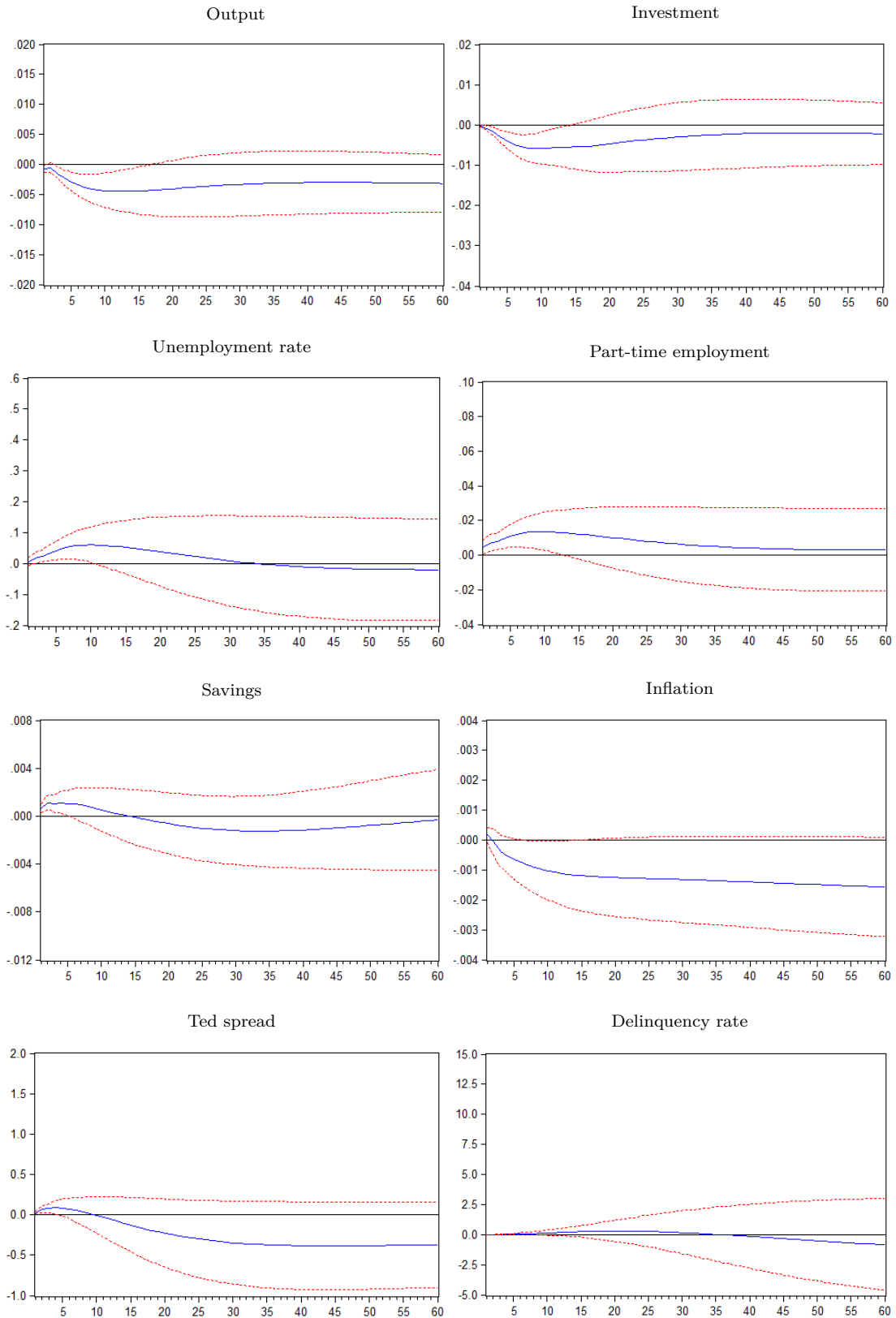


Figure B.3 Impulse responses to one-standard deviation EPU shock

Notes: Accumulated responses of variables to structural one-standard deviation EPU shock from estimation of the SVAR model. Dashed lines show 95% standard error bands. As described in Table 1, variables are all in log-differences except for the unemployment rate, which is in differences, and the Ted spread and delinquency rate, which are in levels.

C Cross-uncertainties dynamics

Table 3

Correlation matrix.

Variable	Vix	MU	EPU
VIX	1.0000		
MU	0.6308*** (15.057)	1.0000	
EPU	0.4220*** (8.621)	0.3122*** (6.087)	1.0000

Notes: *** indicate statistical significance at 1%. The Student t values are in brackets.

Table 4

Granger-causality test.

	VIX	EPU
Lag length selected by BIC (4 lags)		
VIX	NA	10.50%
EPU	11.24%	NA
Lag length set to 5		
Vix	NA	16.44%
EPU	8.63%*	NA

Notes: The reported values are p-values of the pairwise Granger-causality test. * indicates rejection of the null hypothesis (variable in columns does not Granger-cause variable in row) at the 10% level.

Table 5

Impulse response functions for the structural four-variable VAR models.

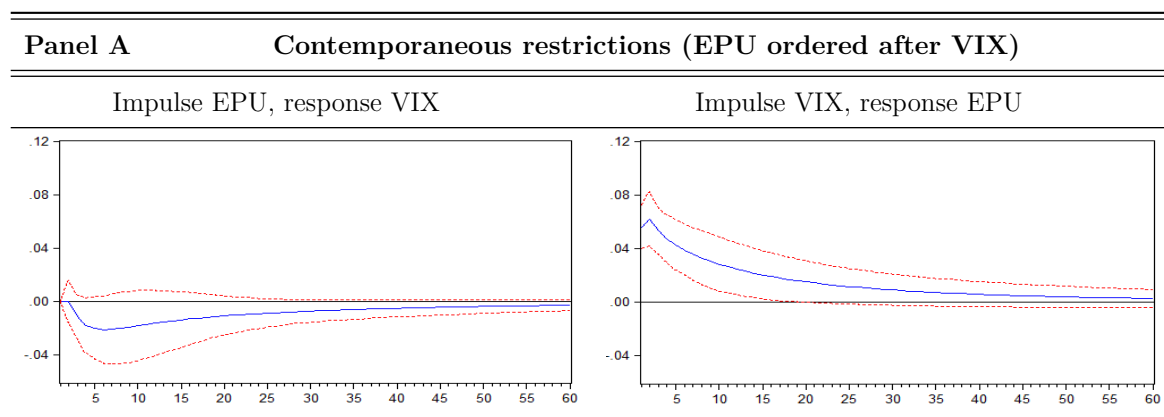
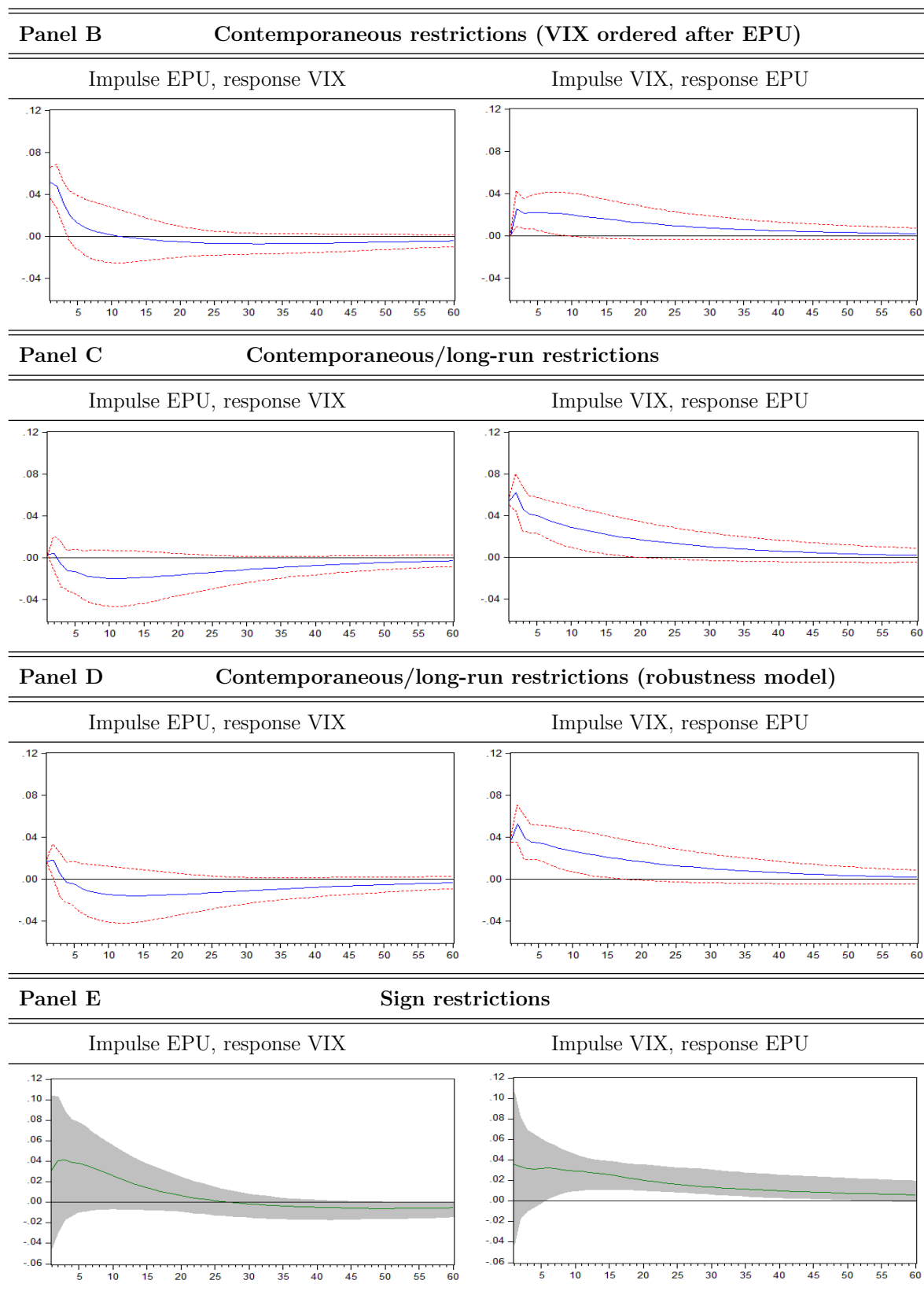


Table 5
(continued)



Notes: Estimated impulse response functions for VIX and EPU to interrelated dynamic shocks with 95% confidence bands for Panels A, B, C and D, and 68% confidence bands for Panel E. Identification in Panel A is based on three lags (selected by the BIC) and a Cholesky decomposition with the following ordering: (difference of) industrial production index, federal reserve funds rate, log(VIX) and log(EPU). EPU is placed before VIX in the causal ordering in Panel B. Panel C results of the SVAR model with contemporaneous/long-run restrictions. Panel D results of the robustness SVAR model with contemporaneous/long-run restrictions, with the assumption that VIX has no long-run effect on economic policy uncertainty. Panel E results of the Sign-restricted VAR model.

D SVAR estimation using the TSLS approach

Here, we present a brief overview of the TSLS methodology we apply to estimate our SVAR model with contemporaneous and long-run restrictions. For a detailed discussion, we refer to [Shapiro and Watson \(1988\)](#), [Fisher et al. \(2016\)](#) and [Ouliaris et al. \(2016\)](#).

We recall the four shocks we identify in this model: ε_{1t} is a supply shock, ε_{2t} is a monetary policy shock, ε_{3t} is a financial uncertainty shock and ε_{4t} is an economic policy uncertainty shock. The six contemporaneous/long-run restrictions we imposed in [Section 4.3](#) exactly identify the system. Here is the precise form of the equations we estimate.

1- Output equation:

$$\Delta ipi_t = \Delta r_{b,t} + lags + \varepsilon_{1t} \quad (3)$$

where “lags” represent the lags of all variables in the model. Following [Pagan and Pesaran \(2008\)](#), [Fisher et al. \(2016\)](#) and [Ouliaris et al. \(2016\)](#), we specify the structural equation for industrial production so that the first difference of the I(0) variable $r_{b,t}$ (and not its level) appears in the equation to ensure its transitory effect upon output.¹⁸ Therefore, $\Delta r_{b,t}$ depicts the zero long-run effect of monetary policy shock upon output. Hence, we use $r_{b,t-1}$ as an instrument to estimate this equation and obtain $\hat{\varepsilon}_{1t}$.

2- Interest rate equation:

$$r_{b,t} = \Delta ipi_t + lags + \varepsilon_{2t} \quad (4)$$

Here, we use $\hat{\varepsilon}_{1t}$ as the instrument for Δipi_t to estimate the equation and obtain $\hat{\varepsilon}_{2t}$.

3- Financial uncertainty equation:

18. We verify that differentiating $r_{b,t}$ does not change its order of integration.

$$lvix_t = \Delta ipi_t + r_{b,t} + \Delta lepu_t + lags + \varepsilon_{3t} \quad (5)$$

where $\Delta lepu_t$ depicts the zero long-run effects of economic-policy uncertainty shocks upon financial uncertainty. Therefore, we use $\hat{\varepsilon}_{1t}$, $\hat{\varepsilon}_{2t}$ and $lepu_{t-1}$ as the instruments to estimate the equation and obtain $\hat{\varepsilon}_{3t}$.

4- *Economic-policy uncertainty equation:*

$$lepu_t = \Delta ipi_t + r_{b,t} + lvix_t + lags + \varepsilon_{4t} \quad (6)$$

Here, we use all the estimated residuals $\hat{\varepsilon}_{1t}$, $\hat{\varepsilon}_{2t}$ and $\hat{\varepsilon}_{3t}$ as the instruments to estimate this final equation.

Estimated impulse response functions for financial uncertainty and economic policy uncertainty to interrelated dynamic shocks with 95 percent confidence bands are given in Panel C in [Table 5](#). These results are in line with what we have seen in the last two decades, where high financial uncertainty is consistently translated into high economic policy uncertainty, whereas the opposite amplification direction is not confirmed.