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Role of Global Uncertainty: Evidence from COVID-19 Pandemic

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Abstract

By estimating a wide range of factor-augmented vector autoregression models, I investigate the role of global uncertainty on global financial asset and oil prices during the COVID-19 pandemic. The results suggest that the global uncertainty shock explained from a third to three fifths of total variations in the variables after the pandemic, which impacts are two to four times as sizeable as what are assessed based on the pre-pandemic period. The shocks were in nature demand-driven; higher global uncertainty was associated with significant declines in global stock prices, implied inflation, economic activity, and oil prices. However, the shocks led to significant rise in global interest rates, possibly reflecting raised term and risk premia.

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1. Introduction

This paper investigates the impact of global uncertainty shocks on global financial market developments since the outbreak of the novel Corona virus disease (COVID-19). Identifying the nature of underlying shocks is a key in understanding global financial and business cycle fluctuations and thus designing proper economic policies. While it is clear that since the outbreak of COVID-19, global economy has been hit by huge negative economic shocks, it is not clear whether the underlying shocks are demand- or supply-driven. While most recessions in the history were triggered by either demand or supply shock, including oil shock in 1970s, monetary policy in 1980s, or financial shocks in late 2000s, a growing consensus is that COVID-19 is delivering all of the shocks in a single package (Baldwin and di Mauro 2020; Leduc and Liu 2020; Ludvigson, Ma, and Ng 2020; Triggs and Karras 2020).

The most obvious type of macroeconomic shock that hit the global economy during the COVID-19 outbreak may be *uncertainty shocks*. Paramount uncertainty surrounding the spread of the crisis, future economic conditions, and future policies is still widespread. There is no clear prediction on magnitude and duration of the on-going economic downturns and the break between the pandemic and recovery is never clear to identify. That said, other type of demand shock is obvious as well as whole populations went into quarantine in majority of economies, dealing a massive body blow to all consumer services, in particular in such sectors as tourism, hospitality, and travel.[1] Equally, the supply shock seems to have been widespread. High mortality and morbidity rates caused a decrease in labor, production capacity, and productivity as well as disruptions in global value chains. Since January 2020, oil prices have been undergoing large swings reflecting oil-specific news shocks. Finally, large scale of policies (on both monetary and fiscal) have been underway and their impacts have played as important sources of macroeconomic and financial fluctuations.

The literature on the impact of uncertainty shocks on business and financial cycles has shown great strides over the recent decades, both theoretically and empirically.[2] While different studies employ different ways of measuring the shocks,[3] the studies have consistently shown that sudden and outsized spikes in uncertainty have led to large and protracted decline in economic activities inflation, and financial asset prices which effects are similar to those resulting from declines in aggregate demand (Leduc and Liu 2020; 2016). Since the outbreak of COVID-19 pandemic, using a novel set of uncertainty measures, increasing number of empirical studies have analyze that the uncertainty spikes due to COVID-19 pandemic will have devastating economic impacts of the shocks on global economy through various channels (Baker et al. 2019, 2020; Baldwin and di Mauro 2020; Leduc and Liu 2020; Ludvigson, Ma, and Ng 2020, among many others). [4]

[1] A large decline in the global economic growth will result in plunges in demand for global trade.
[2] Cascaldi-Garcia et al. (2020) provided with excellent surveys on the extensive literature on uncertainty.
[3] This includes, among many others, Bloom (2009) on firm-level or business-related uncertainty, Jurado, Ludvigson, and Ma (2015) on macroeconomic uncertainty, Leduc and Liu (2020; 2016) on financial market uncertainty; Acharya et al. (2017) on uncertainty based on banking sector, Baker, Bloom, and Davis (2016) on economic policy uncertainty, Doan et. al. (2018) or Rossi et al. (2016) on aggregate uncertainty that encompasses macroeconomic and financial uncertainty.
[4] The large literature on the economic impacts of uncertainty shocks is reviewed in Appendix 1.

This paper seeks to contribute to the literature by formally testing the role of global uncertainty shocks using high-frequency financial data. To this end, I examine global uncertainty confidence shocks that are transmitted into global and country-specific financial asset prices. I define the global uncertainty using VIX index, or alternatively, common global factor in stock market volatility index across countries and investigate how the shocks are propagated into stock price, implied inflation, and interest rates, and oil prices throughout the world. I also compare the contribution of the shocks in the period of pre- and post-pandemic.

I estimate a factor-augmented vector auto regression (FAVAR) model of for daily financial indicators that consists of two steps. In the first step, the dynamics of six global variables are characterised as a global block, using a 6-variable SVAR model. In the second step, a country-specific block is used to examine the impact of global uncertainty shocks on domestic indicators.

In the global block, I extract a set of global factors from a wide range of cross-country data and estimate a structural VAR model of the global variables to investigate the role of global uncertainty shocks. Measures of global equity price, equity price volatility, implied inflation, and interest rates are obtained using principal components of cross-country data. Global uncertainty and oil prices are proxied by VIX and international oil spot oil prices, respectively. Finally, the Citi global economic surprise index is included to reflect high-frequency fluctuations in global economic activity. The estimated global variables are then further explored to identify the global uncertainty shock in a FAVAR estimation, where the identification of shocks is achieved using Cholesky restrictions (Barsky and Sims 2012; Leduc and Liu 2016; Baker, Bloom, and Davis 2016; Jurado, Ludvigson, Ma 2015). In this framework, it is assumed that global uncertainty shock is transmitted to other global asset prices and economic activity within a day, but that the global uncertainty do not respond to other types of shocks within the period.

Next, the model is expanded by using a country-specific block. The country-specific block includes a SVAR model of the global variables explained above, and five domestic variables—stock market volatility, stock prices, interest rates, exchange rates, implied inflation (for the countries where the corresponding countries are available).[5] In this framework, the impulse response of domestic variables following the global uncertainty shocks are estimated.

The main results of the paper are as follows. Global financial uncertainty soared sharply after the outbreak of the COVID-19 pandemic. The FAVAR results suggest that the uncertainty shocks explained a large portion, over a third of total variation, of all types of financial asset prices and economic surprise index during the sample period. Second, in line with the findings in the previous literature (e.g., Leduc and Liu 2020), the global uncertainty shock is in nature a global demand shock; the shock was significantly associated with declines in stock prices, implied inflation, economic activity, interest rates, and oil prices, respectively.

Third, the results further suggest that the impact of uncertainty shocks have become much more sensitive to global uncertainty shocks since the outbreak of the pandemic.[6] The contribution of the

[5] Domestic economic surprise index is not included due to the data limitations.

[6] As a result, since the outbreak of the COVID-19 pandemic, the variance contribution of the global uncertainty shocks have increased to around a half and a third, respectively, of total variations in global equity prices and implied inflation while the same type of shock explained a tenth of variations at most in the corresponding variables.

global uncertainty shocks during the pandemic was two to four times as much as the estimated based on the pre-COVID period. These results imply that the negative impact of uncertainty shocks induced by the pandemic may be more sizeable than what is assessed on the basis of long-term monthly data. The results are robust to an alternative data transformation, alternative measures of uncertainty, and alternative definition of global variables, or alternative sets of sample countries.[7]

This paper is organized into five sections. In Section 2, empirical models and data are explained. In Section 3, I introduce the measures of global uncertainty and other asset prices and present some stylised facts on the relationship between global uncertainty and global financial indicators. In Section 4, I estimate the FAVAR model and quantify the impact of global confidence and uncertainty shocks on other global indicators and on country-specific variables. Section 5 concludes.

2. Empirical Methodology

Model. To tackle the empirical questions, I estimate a Factor-Augmented Vector Auto Regression. To focus on the period of COVID-19 pandemic, I employ high-frequency daily financial and macroeconomic survey data. More specifically, I take the following steps. First, I construct a set of global variables using cross-country data or global indicators in financial markets. Second, using the global variables, I estimate a structural vector autoregression model to investigate the role of global uncertainty shocks on the endogenous variables.

In its structural form, the FAVAR model is represented by (1):

$$B_0 Z_t = \alpha + \sum_{i=1}^{L} B_i Z_{t-i} + \varepsilon_t \quad (1)$$

where ε_t is a vector of orthogonal structural innovations, and Z_t consists of five domestic indicators--in this order, stock market volatility, stock price index, implied inflation, interest rates, and exchange rates. The variables were augmented with six global variables that include, in this order, global uncertainty, global equity price, global implied inflation, global economic surprise index, global interest rates, and oil prices. Block exogeneity is assumed between global and domestic variables.

I assume the recursive structure of structural parameters with the global uncertainty measure ordered first. That is, in line with the assumptions in Leduc and Liu (2020), and Baker, Bloom, and Davis (2016), I assume that the shocks have contemporaneous impacts on VIX and other variables and not vices versa. I estimate the parameters using Bayesian methods with Minnesota priors.

Data. Stock prices and their implied volatilities are based on the sovereign equity price index. Implied inflation is measured as breakeven inflation (the difference between nominal 10-year and real government bond yields), and interest rates refer to 10-year bond yields.[8] FX rates are proxied by the exchange rate of domestic currencies per US dollar. For global equity price, inflation, and

[7] These results are presented in Appendix 2.

[8] For the economies where long-term bond yields are not available, medium- or short-term interest rates are included instead.

interest rates, I estimate a common component extracted from cross-country data for the corresponding variables. For oil price, I employ the average of Brent and WTI spot oil prices. For economic activity, I employ the Citi global economic surprise index that reflects the differences in the actual and expected global economic indicators.[9] For the measures of global uncertainty, I use VIX (as the baseline measure) or the global factor of cross-country stock market implied volatility (as an alternative). The database includes an unbalanced set of 47 countries (of which 30 are advanced economies and 17 are emerging market and developing economies or "EMDEs") as shown in Table 2. The baseline sample period is 2020.1.2-2020.5.31 and the period of 2019.7.1.-2019.12.31 is considered as a pre-crisis sample.[10]

3. Evolution of global indicators during the COVID-19 pandemic

3.1 Global indicators

Figure 1 shows the evolution of daily global indicators after the outbreak of the COVID-19 pandemic. The VIX soared between mid-February and end-March in 2020 reflecting the negative news on the rapid increase in the number of COVID-19 confirmed cases around the world (Panel A). On March 16, the VIX reached a record high level, jumping to 82.7, about six standard deviations from the long-term average (13.46). The VIX then continued to decrease, and as of the end of May 2020, was in the order of 30, which is still above the pre-COVID level.

The movements in global equity price and implied inflation were similar, and they mirrored the reverse of the evolution of VIX. The indicators were bottomed around the end of March 2020 and have risen since then. As of the end of May 2020, however, their levels were still below the pre-COVID level. More interestingly, global interest rates fluctuated in an opposite way to global equity price and global breakeven inflation. Global interest rates decreased until around March and then soared to around 12 percentage points. Despite the low level of policy or short-term interest rates globally, the rapid increase in long-term interest rates is attributable to the spikes in credit and term spreads, reflecting the heightened economic uncertainty. Finally, oil prices decreased constantly until mid-April when they began to recover. As of the end-May, oil prices remained around 35 US dollar per barrel.

The synchronisation of cross-country daily indicators within each financial asset class has substantially strengthened since the outbreak of COVID-19 pandemic. The proportion of country-specific indicators explained by the principal components is summarised in Figure 2. Over 90 percent of variations in cross-country stock market volatility, stock price, and breakeven inflation were explained by the corresponding global factors since the outbreak of COVID, compared with the degrees of co-movement before the outbreak of COVID-19 (the corresponding numbers were around 0.8, 0.5 and 0.6, respectively). The degree of synchronisation among cross-country interest rates did not change much.

[9] As a robustness check, I also test the Baltic Dry Index (BDI) as an alternative proxy for global economic activity The results were not qualitatively changed.

[10] I employed the pre-crisis sample period with almost equal length with the crisis sample. That said, the results were not sensitive to the longer sample period.

The greater degree of synchronisation was seen not only among the same type of indicators, but also across different asset classes. The correlation between such global indicators has substantially increased since the outbreak of the COVID-19 pandemic. A common factor across different types of daily indicators is presented in Panel A in Figure 3. This is quite similar to the evolution in the global equity prices or the reverse of VIX, as shown in Figure 1. The shares of each global indicator explained by the common global factor (as shown in Panel B) were all over 0.9, which is well above the pre-COVID-19 level. This suggests that global indicators have been driven by a strong and common economic shock; the economic impact of COVID-19 pandemic in this case. More interestingly, as shown in Panel C, the factor loadings of global equity price, breakeven inflation, and oil prices are positive, while that of VIX and interest rates are negative. This suggests that the common factor reflects the economic uncertainty during the COVID-19 pandemic, which increases future economic uncertainty while reducing asset prices. The negative sensitivity of interest rates may reflect the term and risk premium rather than future economic expectations or short-term interest rates.

3.2. VIX and other global indicators

The principal component analysis explained above suggests that global financial markets have been mainly driven by common shocks during the outbreak of COVID-19 pandemic. What are the common shocks? Which global indicators reflect the shocks? To shed some light on this issue, I observe the relationship between VIX and other global indicators using cross-correlations and the Granger causality test. As shown in Figure 4 and summarized in Panel A in Table 1, the VIX, which has contemporaneous correlations with global equity price volatility, seemed to have led the other global indicators by at least 2-3 days, although the variables shared very high contemporaneous correlations to each other. This suggests that the fluctuations in uncertainty may have had significant causal impacts on the fluctuations in other financial indicators.

The Granger causality test delivers similar messages, as shown in Panel B in Table 1. The test does not reject the null hypothesis that there is *not* a causal relationship from the global indicators to the VIX, while it does reject the hypothesis that VIX does not have causal impacts on global equity volatility, global equity price, global implied inflation, and global interest rates at the one percent significance level. The only exceptions are between VIX and oil prices and between VIX and the economic surprise index where the variables do not seem to Granger-cause each other (at the ten percent significance level, VIX granger-caused oil prices). These two exercises suggest that global uncertainty shocks might have played a key role in driving fluctuations in financial markets.

4. Empirical results

In this section, I examine the FAVAR estimation results. I first discuss the impacts of global uncertainty shocks on global variables, and then on domestic variables.

Global impacts of uncertainty shocks. Figure 5 presents the impulse response of daily global indicators following a one standard deviation increase in VIX. Following the negative uncertainty shock, which increased VIX by four points, global stock market volatility increased by around 0.2 percentage points on impact and the impacts dissipated over time. Global stock prices and implied inflation were reduced by 0.8 and 0.2 percentage points, respectively, within a couple of days of

the shock, and the impact lasted for a few weeks. Global interest rates increased on impact and the impacts were maximised around ten days after the shock, while oil prices decreased over one percent by the shock. Finally, global economic surprise index responded negatively with some time lags of 2-4 weeks.

Figure 6 compares the impact of daily VIX shocks across two mutually exclusive sample periods. The results show that the impacts of the VIX shocks on global equity prices, oil prices, implied inflation, and global economic surprise index were much more sizeable than as estimated based on the pre-crisis sample period. The differences were statistically significant for global equity prices and oil prices (i.e. confidence bands do not overlap at some forecasting horizons). More interestingly, the response of global interest rates is in opposite directions, and these distinctions are statistically significant. While the increase in global uncertainty was followed by *declines* in global interest rates during the pre-crisis sample period, after the outbreak of COVID-19 pandemic, the shock led to a sizeable *increase* in global interest rates. One interpretation is that during the pre-crisis period, the uncertainty shocks reduced the future expected economic output and inflation, and thus future short-term interest rates during the crisis, the term and risk premium increased following the shock and they outweighed the decrease in future expected short-term interest rates.

The variance contribution of the uncertainty shocks seems relatively sizeable during the pandemic (Figure 7). The uncertainty shocks explained over a third of total variations in all global indicators. These contributions are three to five times as much as their contributions based on pre-pandemic sample. The higher contributions of uncertainty shocks may reflect more frequent (negative) uncertainty shocks, or alternatively, a more sensitive response of the variables during the pandemic disease.

Impact of global uncertainty shocks on domestic variables. Next, I observe the impact of global uncertainty shocks on domestic financial indicators using country-specific block of FAVAR model (Figure 8). Based on the median country, domestic stock market volatility increased by 0.2 percentage point, and the impact was maximised around a week after the shock. The shock led to a decrease in domestic stock prices by 1.5 percent and 0.4 percentage point, respectively. The shocks were associated with an increase of interest rates by 0.2 percentage points. Finally, currencies in individual countries depreciated unambiguously per US dollar by up to 5 percent. The 25^{th}-75^{th} intervals indicate that the responses of the variables are relatively consistent across countries. Although not shown here, the responses of the variables were statistically significant for most of the countries within each financial market. All in all, uncertainty shocks were transmitted to all types of asset prices and economic expectations since the outbreak of COVID-19.

Panel F presents the variance share of global uncertainty shocks on domestic financial indicators. Based on the median country, around a half of the total variations in domestic stock market volatility and stock prices were explained by the shocks. While around two fifth of total variations in implied inflation is explained by the shock, a fifth to a third of variations in interest rates and FX rates are explained by the shocks.

Put together, the exercises with daily global data suggest that global uncertainty shocks, triggered by the outbreak and the exacerbation of the COVID-19 pandemic, have played a crucial role in the

fluctuations in macroeconomic and financial variables during the period, by explaining a much higher proportion of variations in the variables. The comparison of the results with those based on the pre-pandemic sample suggests that the role of uncertainty shocks has substantially strengthened since the outbreak of pandemic. Country-specific results confirm the results based on the global variables.

Cross-country differences in the contributions of global uncertainty shocks. The foregoing results suggest that, since the pandemic, the global uncertainty shocks have accounted for a sizeable portion of domestic indicators in most of countries in the sample. To test whether there has been some heterogeneity in the impacts of the global uncertainty shocks across countries, I here examine the country-specific correlates of the contribution of the global uncertainty shocks to domestic financial indicators—stock prices, interest rates, and FX rates.[11] Based on theoretical channels of global uncertainty shocks as shown in the literature review (Appendix 1), I test six different types of country characteristics—income, trade and financial openness, central bank independence, and monetary policy and exchange rage regimes. A statistical test of mean difference across county groups of the contribution of global uncertainty shocks to domestic indicators is expected to help identify country characteristics that are most significantly correlated with greater impacts of global uncertainty shocks. Again, the data set includes the variance shares of the benchmark 47 countries (of which 17 are EMDEs), over the period of COVID-19 pandemic, as explained in Section 2. The results for each country group are reported in Table 3.

For equity prices, the variance contribution of global uncertainty shocks was sizeable, between 0.4 and 0.5, for all types of country groups considered, suggesting the global nature of the COVID-related shocks. The variance contribution was moderately greater in the median EMDE than in the median advanced economy, possibly reflecting more volatile equity prices in EMDE due to thin financial and currency markets and the sensitive movements of foreign investors. Alternative, it could be the case that for advanced economies, a quicker response of monetary or fiscal policies has somewhat compensated for the negative impacts of global uncertainty shocks.

To the contrary to the results on the equity price (or equity price volatility), the impacts of global uncertainty shocks on domestic interest rates and FX rates seem to have been closely associated with several country characteristics. More specifically, higher trade and capital openness and(or) the adoption of inflation targeting and flexible exchange rate regimes were associated with lower contribution of global uncertainty shocks to domestic interest rates. To the contrary the global uncertainty shocks have exhibited much greater effects on FX rates in the countries with flexible exchange regime or with inflation targeting, than in others, which differences were statistically significant at the one percent level.

These results collectively suggest that the external (global uncertainty) shocks triggered larger fluctuations in currency markets with flexible FX regime and(or) inflation targeting while domestic interest rates were less affected by the shocks than in other economies.[12] Similarly, the countries with fixed exchange rate regime avoided large exchange rate fluctuations but interest rates were heavily affected by the shocks. This finding is broadly in line with the predictions by

[11] I also tested the results for stock market volatility, which do not suggest any notable differences across countries.
[12] The economies with inflation targeting and(or) flexible exchange rate regime tend to be correlated with countries with greater financial and trade openness.

the classical theories (e.g. Mundell-Fleming's models as in Obstfeld et al. 2005 and Aizenman et al. 2016) that suggest that foreign exchange rates insulate domestic economy from foreign shocks and that countries with fixed foreign exchange regime may be expected to have more correlated business cycles than countries with purely domestically oriented monetary policy (see Céspedes, Chang and Velasco 2004 for instance).

5. Conclusion

The outbreak of the corona virus disease reignited the attention on the importance of economic confidence or uncertainty shocks on global macroeconomic and financial fluctuations. This paper examines the role of global uncertainty shocks that are transmitted into global financial market proxies. I estimate a Bayesian Factor-Augmented Vector Auto Regression model, by using a wide range of cross-country data on uncertainty index, equity price, implied inflation, economic surprise index, short-term interest rates, and oil prices, all based on daily frequency.

The results presented in the paper suggest that, since the outbreak of COVID-19 pandemic, global uncertainty shocks have played crucial role in daily domestic financial market fluctuations. The response of domestic equity price, inflation expectations, and interest rates is all significant following global uncertainty shocks. The contribution of global uncertainty shock to financial during the COVID-19 period are two to four times greater than what is estimated over pre-COVID period. The results are robust to alternative data transformation, alternative measures of uncertainty, and alternative global variables.

The results provide with several important policy implications. Given the broad-based importance of economic and financial uncertainty in business and financial fluctuations in world-wide countries, the uncertainty index, in particular on global uncertainty, should be closely monitored in policy making. Considering the results that the uncertainty shocks mainly reflect conditions in the demand side of the economy, a careful investigation on the role of monetary and fiscal policies should be considered in a timely manner to overcome the large negative impacts of COVID-19 pandemic.

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Table 1. VIX and other global factors

A. Cross correlations of VIX with other global indicators

Correlation	VIX is lagging			Contemporaneous	VIX is leading		
(number of days)	-3	-2	-1	0	+1	+2	+3
Global equity price volatility	0.89	0.92	0.95	**0.986**	0.97	0.96	0.92
Global equity price	-0.72	-0.76	-0.79	0.841	0.85	0.86	**0.86**
Global breakeven inflation	-0.71	-0.75	-0.78	-0.820	-0.83	**-0.84**	-0.83
Global economic surprise index	-0.02	-0.05	-0.10	-0.13	-0.16	-0.20	**-0.23**
Global interest rate	0.42	0.48	0.54	0.597	0.64	0.68	**0.70**
Oil price	-0.63	-0.67	-0.70	-0.740	-0.74	-0.75	**-0.75**

B. Granger causality test

Null hypothesis	F-statistics (p-value)	Results
VIX <≠ Global equity price volatility	1.93 (0.15)	Accept
VIX ≠> Global equity price volatility	13.0 (0.00)	**Reject**
VIX <≠ Global equity price	2.92 (0.06)	Accept
VIX ≠> Global equity price	6.94 (0.002)	**Reject**
VIX <≠ Global breakeven inflation	1.34 (0.27)	Accept
VIX ≠> Global breakeven inflation	4.93 (0.01)	**Reject**
VIX <≠ Global economic surprise index	2.94 (0.06)	Accept
VIX ≠> Global economic surprise index	1.83 (0.16)	Accept
VIX <≠ Global interest rate	5.18 (0.01)	**Reject**
VIX ≠> Global interest rate	5.58 (0.01)	**Reject**
VIX <≠ Oil price	1.95 (0.15)	Accept
VIX ≠> Oil price	2.78 (0.07)	Accept

Note: The null hypotheses are rejected at the one percent significance level.

Table 2. List of countries: FAVAR estimation

Advanced economies (30)	Australia; Austria; Belgium; Canada; Switzerland; Czech Republic; Germany; Finland; France; Greece; Hong Kong; Ireland; Israel; Italy; Japan; Korea; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Norway; New Zealand; Portugal; Slovakia; Slovenia; Spain; Sweden; Taiwan; and United Kingdom
EMDEs (17)	Brazil; Chile; Colombia; Croatia; Egypt; Ghana; Hungary; Mexico; North Macedonia; Malaysia; Peru; Poland; Romania; Russia; Thailand; Turkey; and South Africa

Note: Numbers in the parentheses indicate the number of countries in each group. "EMDEs" = emerging market and developing economies. The country classification follows that of the IMF and World Bank.

Table 3. Variance shares of global uncertainty shocks across country groups

A. Stock prices

	Variance shares		
Group	(Group A)	(Group B)	(A-B)
Income	42.1	50.5	-8.4**
Trade	46.0	44.8	1.2
KA	45.6	44.6	1.0
CBI	45.3	44.3	1.0
Peg	47.1	43.3	3.7
IT	45.6	44.9	0.7

B. Interest rates

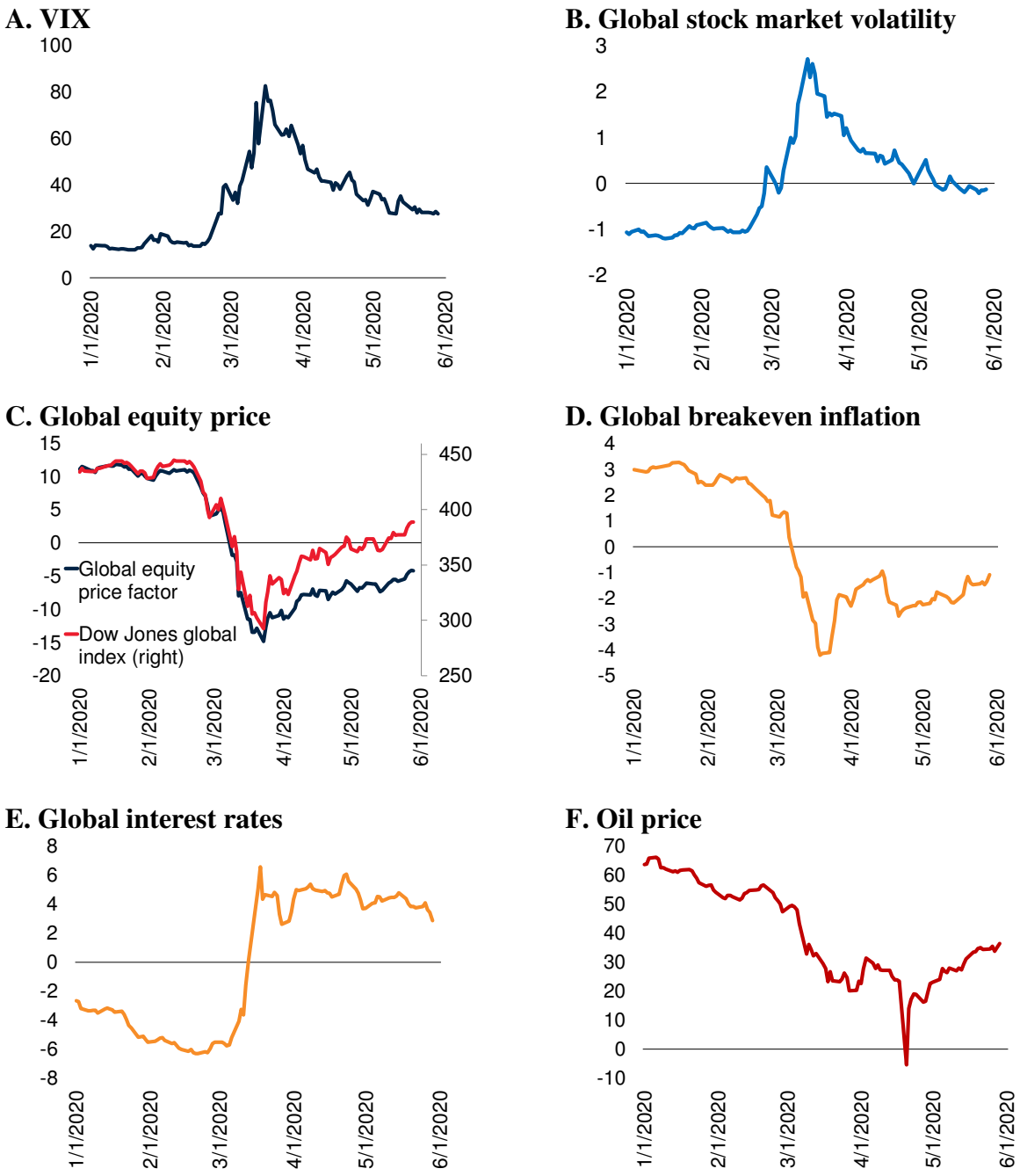
	Variance shares		
Group	(Group A)	(Group B)	(A-B)
Income	20.3	23.4	-3.1
Trade	16.6	22.6	-5.9**
KA	18.0	24.4	-6.4**
CBI	20.6	19.0	1.6
Peg	24.6	16.1	8.4**
IT	17.2	23.6	-6.4*

C. FX rates

	Variance shares		
Group	(Group A)	(Group B)	(A-B)
Income	20.2	33.2	-13.0***
Trade	26.3	24.5	1.8
KA	26.6	22.7	3.9
CBI	25.9	16.6	9.3
Peg	16.4	34.2	-17.8***
IT	35.4	15.2	20.2***

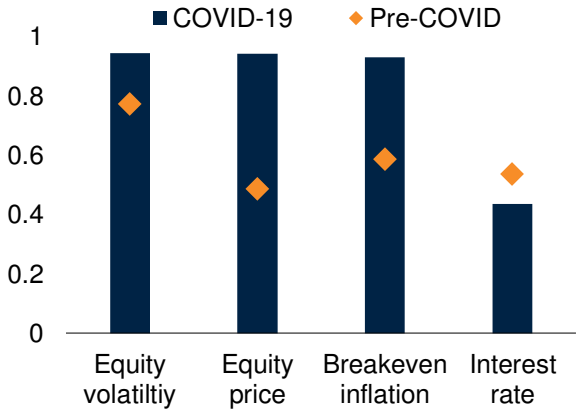
Note: The tables report mean-differences between two groups of countries on the variance contributions of global uncertainty (VIX) shocks on domestic variables, estimated with the FAVAR model described in Section 2. The countries are divided into two groups by each country characteristic; Group A includes countries with higher income, higher trade, financial openness, or central bank independence, or countries with inflation targeting or pegged exchange rate regimes, respectively, and vice versa for Group B. Inflation targeting (denoted by "IT") regimes are defined as the IMF Annual Report on Exchange Rate Regime. Exchange rate regime ("Peg") is based on Shambaugh (2004). The measures of trade ("Trade") and capital account openness ("KA") are, respectively, trade (exports plus imports)-to-GDP ratios (in percent) and the index compiled by Chinn and Ito (2006). Central bank independence and transparency (CBI) is based on Dincer and Eichengreen (2014). A higher value indicates greater central bank independence and transparency. Country-specific variables are based on values in 2015. (*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$).

Figure 1. Global financial indicators during COVID-19 pandemic



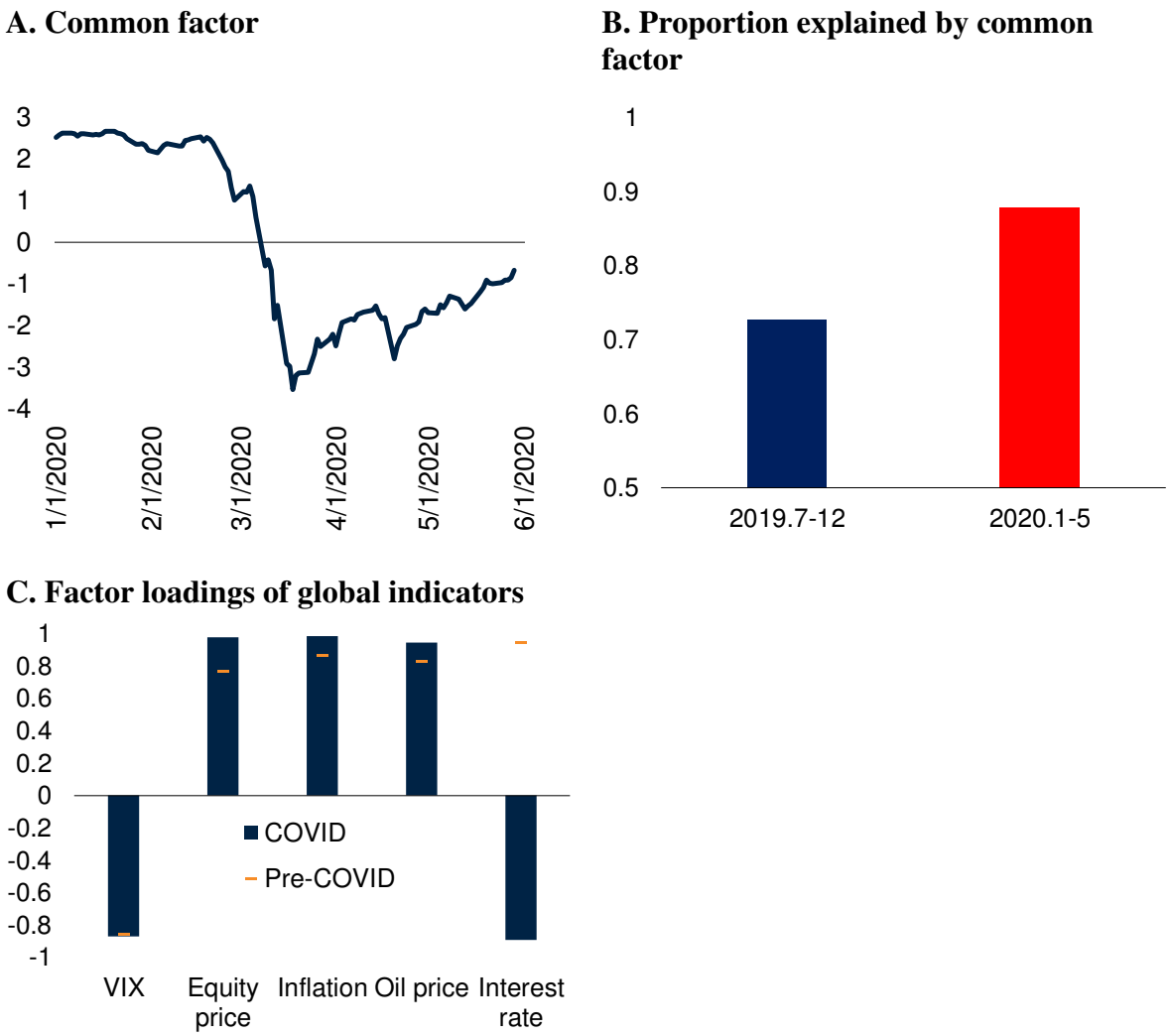
Note: B.-E. The corresponding global factors are estimated using the Principal component analysis. The vertical axis denotes normalized scales (A, B, C), percent (D, E), or US dollar per barrel (F).

Figure 2 Degree of synchronization across countries



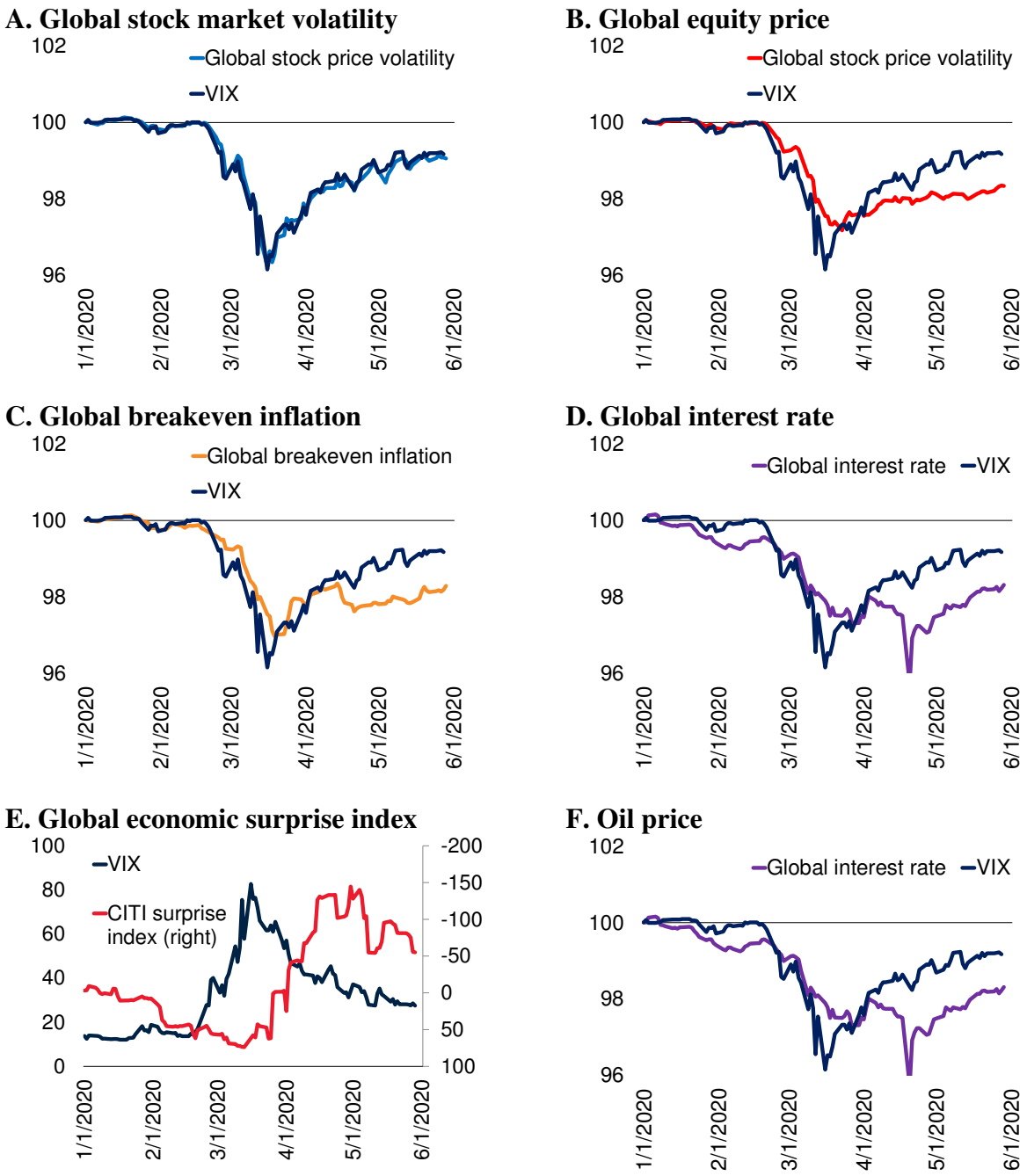
Note: Average portion of variance explained by the first principal components. Blue bars indicate the results based on the post-pandemic sample (2020.1.2.-2020.5.31) and orange diamonds indicate the results based on pre-crisis sample (2019.7.1-2019.12.31).

Figure 3 Contributions of global factor



Note: A. Common components of five global indicators (VIX, global equity price, global breakeven inflation, global interest rates, oil prices). B. Portion of variance explained by the first principal components based on 2020.1-5 (red bar) and 2019.7-12 (Blue bar).

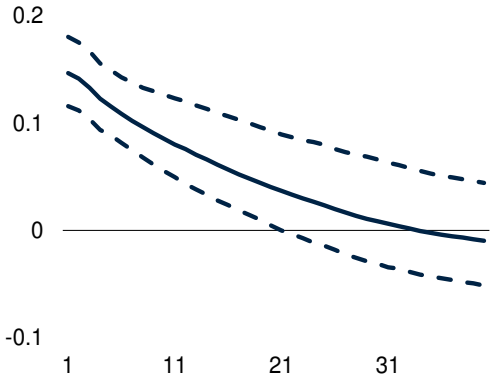
Figure 4 VIX and Global factors



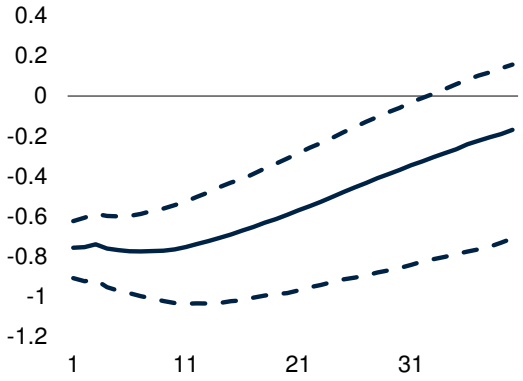
Note: A.-D. Global factors are estimated using the Principal component analysis using level variables.
E. Global economic surprise index provided by the Citi group. The index shows recent global economic data surprising to the upside.

Figure 5 Impulse response of global variables to global uncertainty shocks: VIX

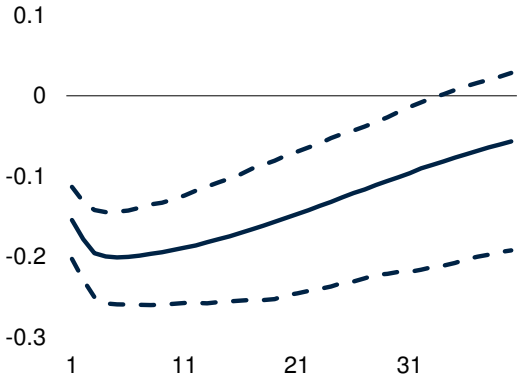
A. Global equity price volatility



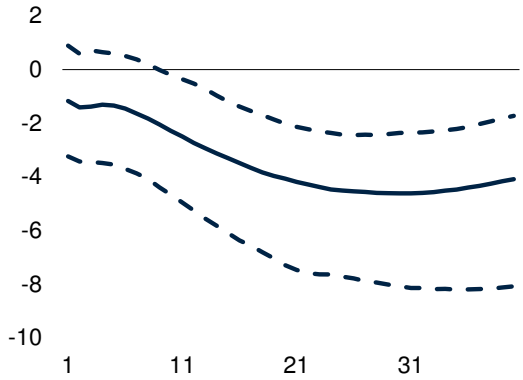
B. Global equity price index



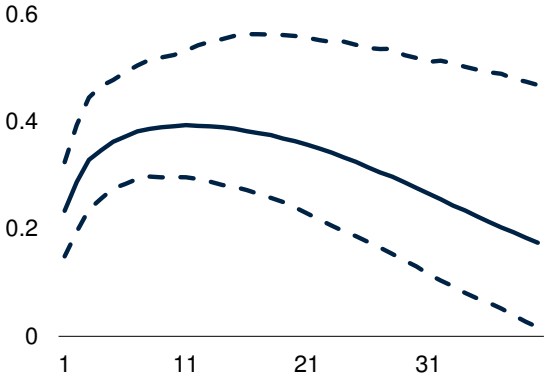
C. Global breakeven inflation



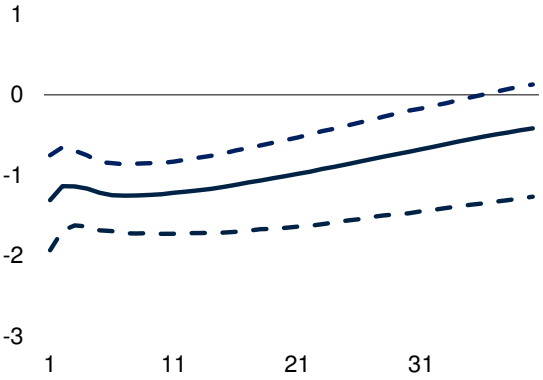
D. Global economic surprise index



E. Global interest rate



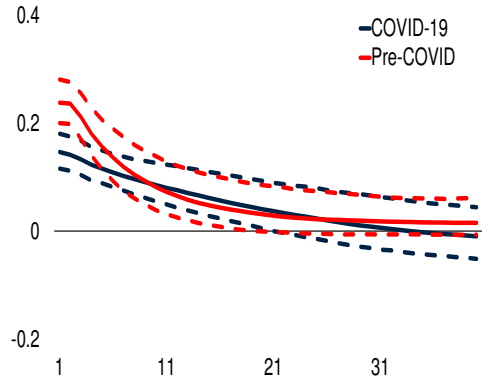
F. Oil price



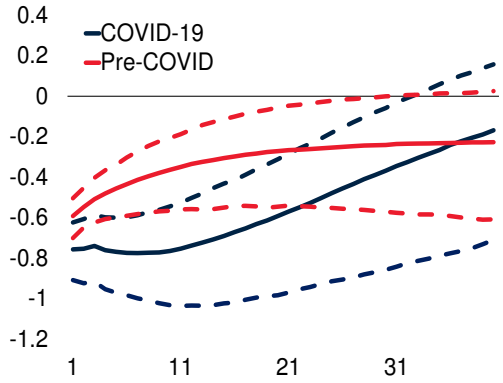
Note: The impulse response functions (IRFs) to a positive one standard deviation global uncertainty shock (measured by VIX) based global block of the factor-augmented vector autoregression models for daily data. Sample period is 2020.1.1-2020.5.29. Solid and broken lines indicate median and 5^{th}-95^{th} percentiles, respectively, based on 1000 Bayesian draws. Vertical axis indicates percentage point and horizontal axis indicates number of days.

Figure 6 Impulse response of global variables to global uncertainty shocks: VIX

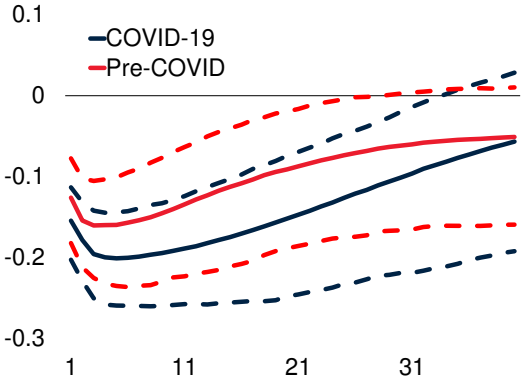
A. Global equity price volatility



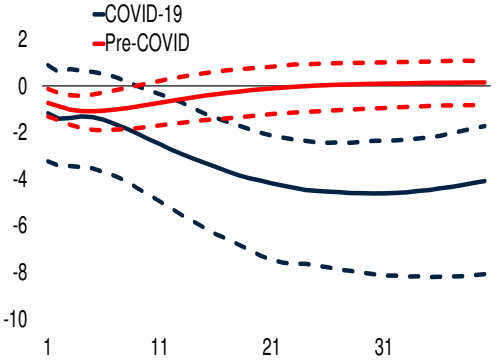
B. Global equity price



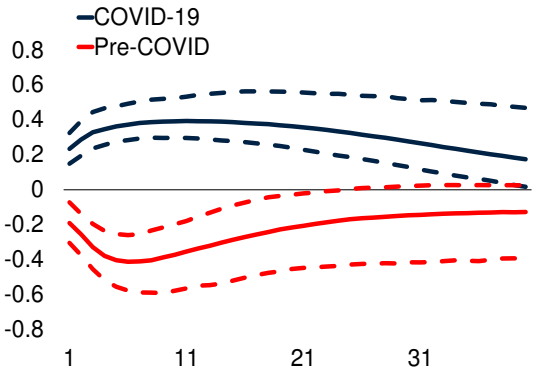
C. Global breakeven inflation



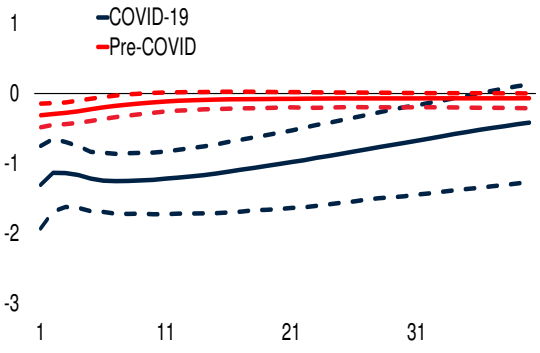
D. Global economic surprise index



E. Global interest rate

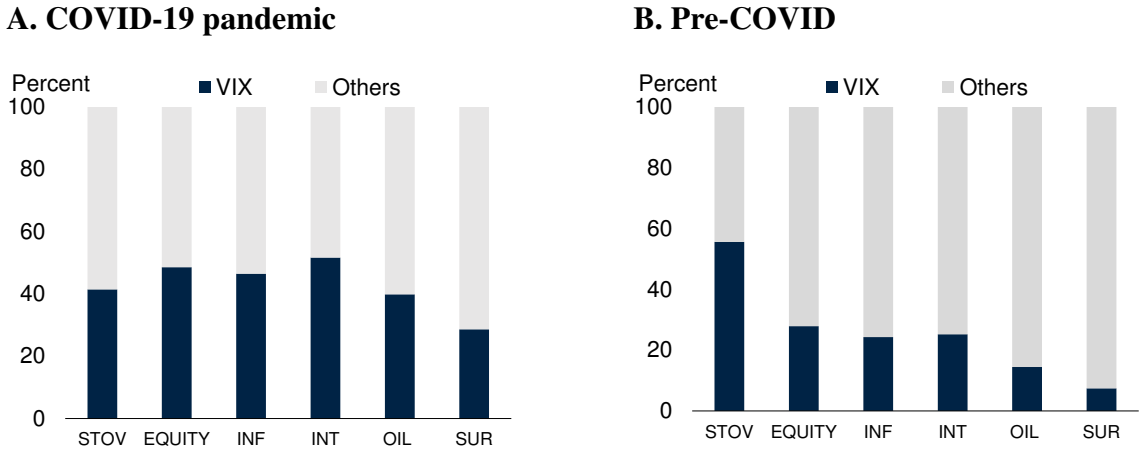


F. Oil price



Notes: IRFs to a one standard deviation increase in global uncertainty based global block of FAVAR model. Sample period is 2020.1.1-5.29 (COVID-19) and 2019.7.1-12.31 (pre-COVID). Solid and broken lines indicate median and 5th-95th percentiles, respectively, based on 1000 Bayesian draws. Vertical axis indicates percentage points or percent. Horizontal axis indicates number of days.

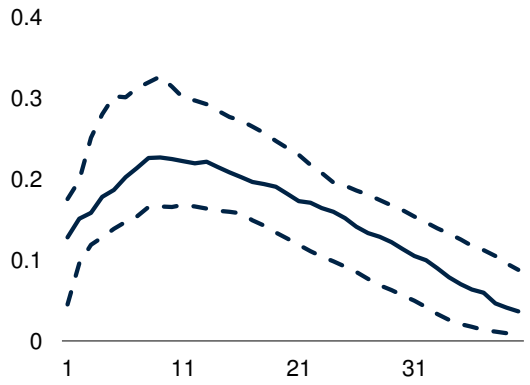
Figure 7 Variance contribution of uncertainty shocks: VIX



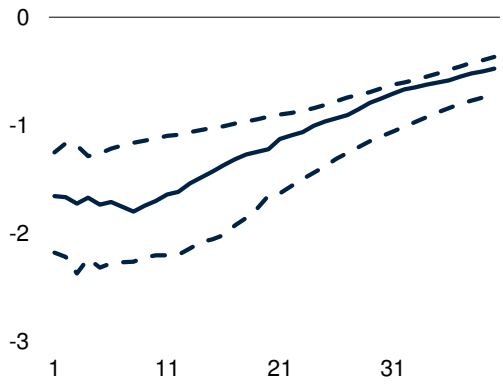
Note: Variance contribution of global uncertainty shocks to total variations in global indicators between January and May 2020 (A) or between July and December 2019 (B). “STOV”, “EQUITY”, “INF”, “INT”, “OIL”, and “SUR” indicate stock market volatility, equity price, implied inflation, interest rates, oil prices, and economic surprise index, respectively.

Figure 8 Impulse response of domestic variables to global uncertainty shocks: VIX

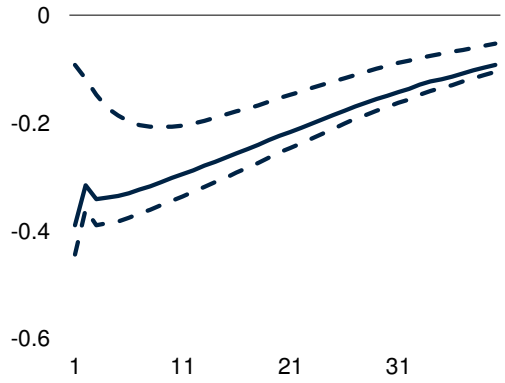
A. Domestic equity price volatility



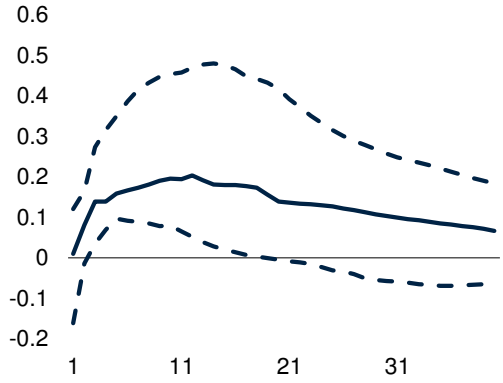
B. Domestic equity price



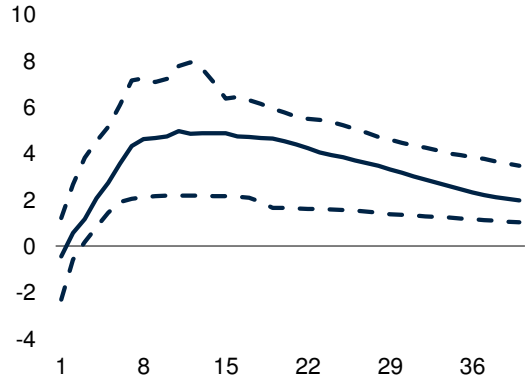
C. Domestic breakeven inflation



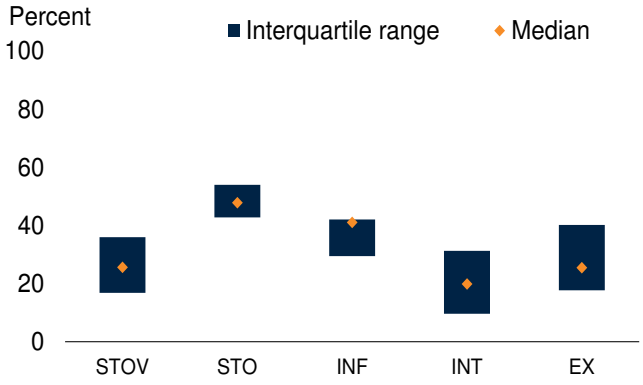
D. Domestic interest rate



E. FX rates



F. Variance contribution of uncertainty shocks



Note: A.-E. IRFs to a one standard deviation increase in global uncertainty based domestic block of FAVAR model. Sample period is 2020.1.1-5.29. Solid and broken lines indicate median and 25th-75th percentiles, respectively, of median draws across 50 countries. Vertical axis indicates percentage point and horizontal axis indicates number of days. F. Variance contribution of global uncertainty shocks to total variations in domestic indicators. “STOV”, “STO”, “INF”, “INT”, and “EX” indicate stock market volatility, equity price, implied inflation, interest rates, and foreign exchange rates per USD, respectively.

Appendix 1. COVID-19 and global uncertainty: literature review

Since the outbreak of COVID-19 pandemic, a wide range of studies has investigated the impact of uncertainty shocks on business and financial cycles using novel measures of uncertainty.

Uncertainty measures and macroeconomic impacts. Based on the SVAR model of VIX and other macro and financial variables, Leduc and Liu (2020) showed that the spikes in uncertainty induced by COVID will have significant and sizeable negative impacts on unemployment, inflation, and interest rates in near future. Caggiano, Castelnuovo, and Kima (2020) estimated a three-variate VAR using proxies of global financial uncertainty, the global financial cycle, and world industrial production to simulate the effects of the jump in financial uncertainty observed in correspondence of the Covid-19 outbreak. The study predicted that the cumulative loss in world output one year after the uncertainty shock due to Covid-19 to be about 14%. Ludvigson, Ma, and Ng (2020) quantified the macroeconomic impact of costly and deadly disasters in recent US history, and to translate these estimates into an analysis of the likely impact of covid19. The studies argued that even a conservative calibration of a 3-month, 60 standard deviation shock is forecast to lead to a cumulative loss in industrial production of 12.7% and in service sector employment of nearly 17% or 24 million jobs over a period of ten months, with increases in macro uncertainty that last five months. Kholodilina and Rietha (2020) constructed a news-based viral disease index and studied the dynamic impact of epidemics on the world economy, using structural vector autoregressions.

The studies predict that the epidemic shocks have persistently negative effects, both directly and indirectly, on affected countries and on world output and will translate into a significant fall in global trade, employment, and consumer prices. Baker et al. (2020) used text-based methods to study large daily stock market back to 1900 and overall stock market volatility back to 1985 and argued that this event is unprecedented. Baker, Bloom, Davis, and Terry (2020) constructed cross-country panel data on stock market levels and volatility and use natural disasters, terrorist attacks, and political shocks as instruments in regressions and VAR estimations. They estimated that COVID-19 will reduce US GDP by 9% in 2020 based on the initial stock market returns and volatility response.[13]

Nature of shocks. The literature has argued that the economic uncertainty is mainly a demand shock although they included a wide range of various triggers. Leduc and Liu (2020) argued that these effects on unemployment rate, inflation, and interest rate were similar to those resulting from declines in aggregate demand. Shocks. Baker, Bloom, Davis and Terry (2020) pointed out that major uncertainties surround almost every aspect in aggregate demand.[14] Ludvigson, Ma, and Ng

[13] Another group of studies have focused on the effects of confidence shocks on asset prices. On stock market effects, see Baker et al. (2020) and Toda (2020). On complexities arising from highly uneven supply-side disruptions caused by a major pandemic, see Guerrieri et al. (2020). On potential medium- and long-term macroeconomic consequences, see Barro, Ursua and Weng (2020) and Jorda, Singh and Taylor (2020).

[14] This includes the infectiousness, prevalence, and lethality of the virus; the availability and deployment of antigen and antibody tests; the capacity of healthcare systems to meet an extraordinary challenge; how long it will take to develop and deploy safe, effective vaccines; the ultimate size of the mortality shock; the duration and effectiveness of social distancing, market lockdowns, and other mitigation and containment strategies; the near-term economic impact of the pandemic and policy responses; the speed of recovery as the pandemic recedes; whether "temporary" government interventions and policies will persist; the extent to which pandemic-induced shifts in consumer spending

(2020) pointed out that unlike past natural disasters, Covid-19 is a multi-month shock that is not local in nature, disrupts labor market activities rather than destroys capital, and harms the social and physical well-being of individuals. Guerrieri et al. (2020) presented a theory of Keynesian supply shocks: supply shocks that trigger changes in aggregate demand larger than the shocks themselves. They argued that the economic shocks associated to the COVID-19 epidemic—shutdowns, layoffs, and firm exits—may have this feature. Using daily data for the period January 21–March 13, 2020 and Autoregressive Distributed Lag model, Albulescu (2020) showed that the new infection cases reported at global level, and the death ratio, and negative oil price dynamics lead to increased uncertainty and have a positive influence on the US EPU.

Policy recommendations. Based on the empirical findings, the studies overall agreed that monetary policy reactions could alleviate the negative impacts of the spikes in economic uncertainty. They argued that policy responses to the COVID-19 pandemic provide the most compelling explanation for its unprecedented stock market impact (Baker et al. 2020, Leduc and Liu 2020). Monetary policy accommodation, such as interest rate cuts, can help cushion the economy from such uncertainty shocks. Kholodilina and Rietha (2020) argued that demand-side dominate supply-side contractions and that overall, the findings indicate that expansionary macroeconomic policy is an appropriate crisis response. Guerrieri et. al (2020) discussed the effects of various policies. Standard fiscal stimulus can be less effective than usual because the fact that some sectors are shut down mutes the Keynesian multiplier feedback. Monetary policy, as long as it is unimpeded by the zero lower bound, can have magnified effects, by preventing firm exits. Turning to optimal policy, closing down contact-intensive sectors and providing full insurance payments to affected workers can achieve the first-best allocation, despite the lower per-dollar potency of fiscal policy.

patterns will persist; and the impact on business survival, new business formation, R&D, human capital investment, and other factors that affect productivity over the medium and long term.

Appendix 2. Robustness check

In this appendix, I perform several robustness checks for the baseline results explained in the main sections.

Alternative measure of global uncertainty. I observed the response of the variables following the global stock market volatility (as measures of global uncertainty) and compared the results to those with the benchmark model using VIX. The results are clearly consistent with the baseline results in the context of the impulse response and variance decompositions. As shown in Figure A1, the results were quite consistent with the baseline results with VIX as the measure of global uncertainty.

1st differenced data. In this model, the variables were included as 1st differences of level or logged levels, to obtain the stationarity of the series. Asset prices have shown clear time trends since the outbreak of the COVID-19 pandemic, declining constantly and reflecting the persistent negative shocks prompted by the spread of the pandemic disease. The model consists of, in this order, VIX, global stock price, global implied inflation, global interest rates (ten-year bond yields), and world oil prices, all based on a daily frequency. The model uses recursive restrictions and identifies the impact of uncertainty shocks proxied by VIX.

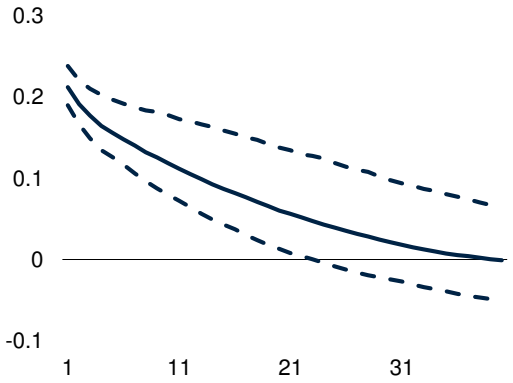
Figure A2 shows the impulse response of daily asset prices following a one standard deviation increase in VIX. Following the negative uncertainty shock, global stock prices decreased up to five percent (on a cumulative basis) within 10 days of the shock. Implied inflation also registered significant negative impacts from the shock, decreasing by around 0.5 percentage point within 10 days of the shock. Nominal interest rates decreased by 0.1 percentage point on impact, and became insignificant within a few days of the shock. The negative response of the variables, together with that of world output, is consistent with the finance-uncertainty multiplier hypothesis put of Alfaro, Bloom, and Lin (2018), who conjecture that financial stress due to uncertainty shocks might magnify the direct effects of uncertainty on output. Finally, oil prices declined by five percent following the shock but the impact is short-lived. The variance contribution of the uncertainty shocks seems quite sizeable during the period of the COVID-19 pandemic. Uncertainty shocks explained around half the total variations in global equity price and around a fifth of variations in inflation and oil prices. Again, these contributions are two to five times as much as their contributions to the corresponding variables estimated with pre-crisis data (not shown here).

Impact of COVID-19 pandemic on global uncertainty. The foregoing models implicitly assumes that the increase of VIX during the COVID-19 pandemic is mostly due to the shocks originated by the outbreak of the pandemic. To formally test this assumption, these models examine the direct impact of COVID-19 pandemic shocks on VIX and other variables. I test two types of models. The first model consists of, in this order, number of total confirmed cases of COVID-19, global equity prices, VIX, global economic activity index (proxied by CITI global economic surprise index), global implied inflation. The second model consists of the number of total confirmed cases of COVID-19, US equity prices (S&P 500 index), VIX, economic forecasts for US GDP growth, US implied inflation (10-year nominal government bond yields – 10-year real bond yields). As shown in Figure A3, a one standard deviation increase in the number of deaths in countries world-wide due to the COVID-19 pandemic, immediately increases VIX by 2.5 units, and the global equity price, global economic activity index, and inflation expectations were reduced by around one percentage point. Similar empirical results are obtained when I employ US variables instead of global variables in the second model, as shown in Figure A4.

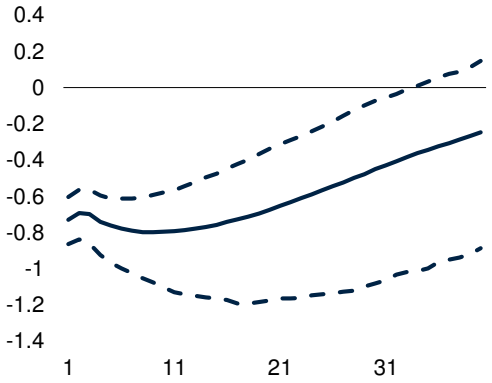
Country-specific results: balanced sample. The baseline results on the domestic block (as presented in Section 4.2) were based on the unbalanced set of 47 countries, as shown in Table 1. The robustness of the results are checked with a balanced set of 5 countries where all the data sets of five domestic variables are available or with the balanced set of 40 countries where four domestic variables but implied inflation are available. Variance share of global uncertainty shocks to domestic variables (in this order, stock market volatility, stock price, interest rates, FX rates, and implied inflation) are, based on median across countries in the first group, 40.1 percent, 14.1 percent, 9.8 percent, 31.9 percent, and 41.1 percent, respectively. Variance share of global uncertainty shocks (in this order, stock market volatility, stock price, interest rates, and FX rates) are, based on median across countries in the second alternative group, 24.1 percent, 48.2 percent, 23.9 percent, and 19.1 percent, respectively. All in all, these results are consistent with the baseline results (as shown in Figure 8) confirming the sizeable contribution of global uncertainty shocks on domestic financial fluctuations.

Figure A1 Impact of global variables to global uncertainty shocks: stock market volatility

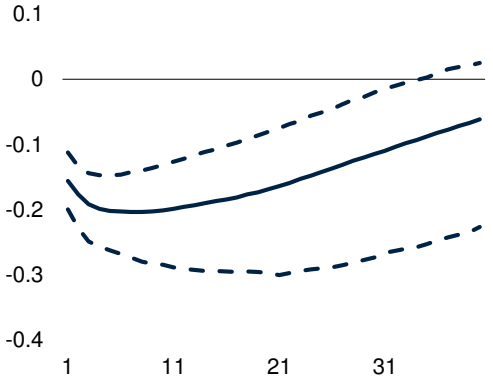
A. Global equity price volatility



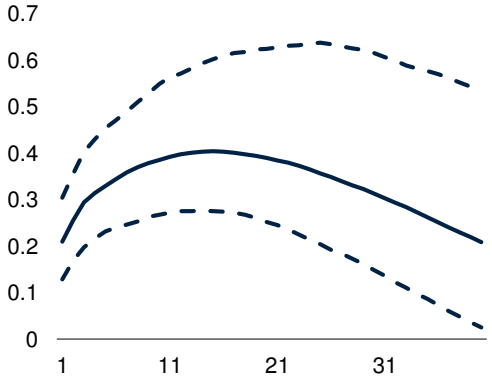
B. Global equity price



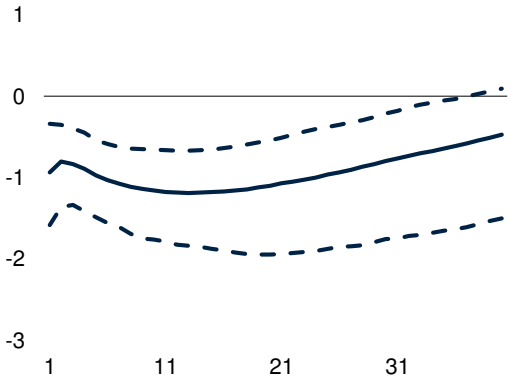
C. Global breakeven inflation



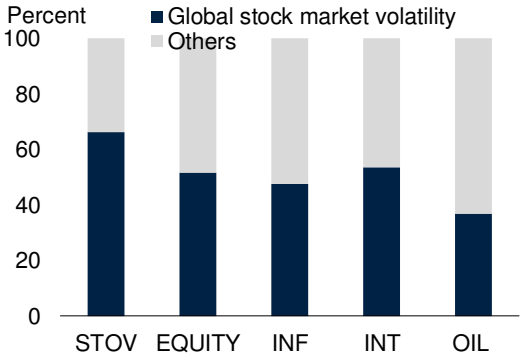
D. Global interest rate



E. Oil price



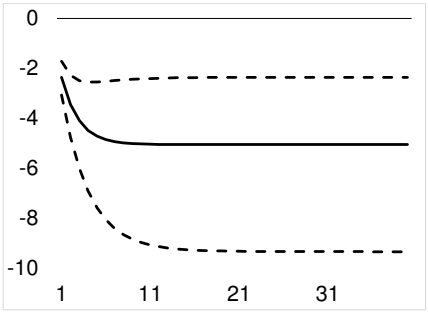
F. Variance contribution of uncertainty shocks



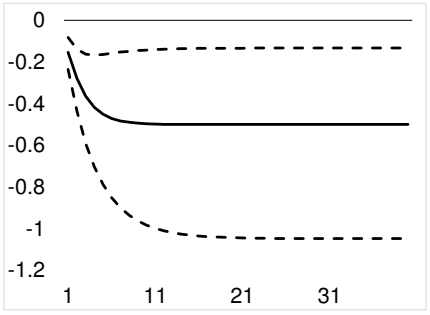
Note: The impulse response functions (IRFs) to a positive one standard deviation global uncertainty shock (measured by common equity market volatility, A-E) based global block of the factor-augmented vector autoregression models for daily data. Sample period is 2020.1.1-2020.5.29. Solid and broken lines indicate median and 5th-95th percentiles, respectively, based on 1000 Bayesian draws. Vertical axis indicates percentage point and horizontal axis indicates number of days. F. Variance contribution of global uncertainty shocks to total variations in global indicators. “STOV”, “EQUITY”, “INF”, “INT”, and “OIL”, indicate stock market volatility, equity price, implied inflation, interest rates, and oil prices, respectively.

Figure A2 Impact of global uncertainty shocks: 1st-difference data

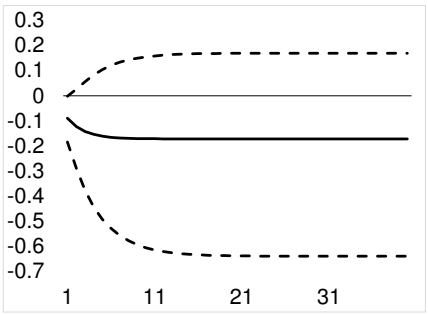
A. IRF: Equity Price



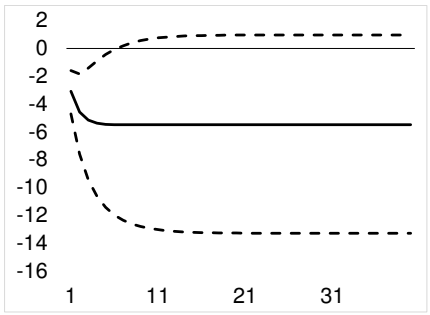
B. IRF: Breakeven Inflation



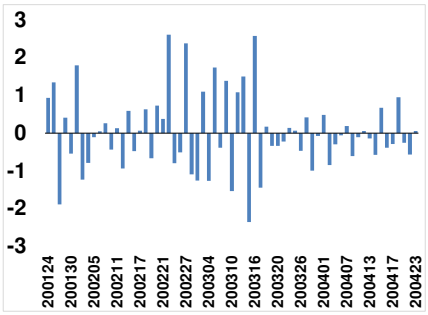
C. IRF: Global interest rate



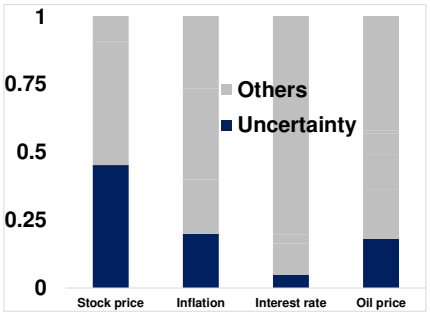
D. IRF: Oil prices



E. Structural global uncertainty shocks



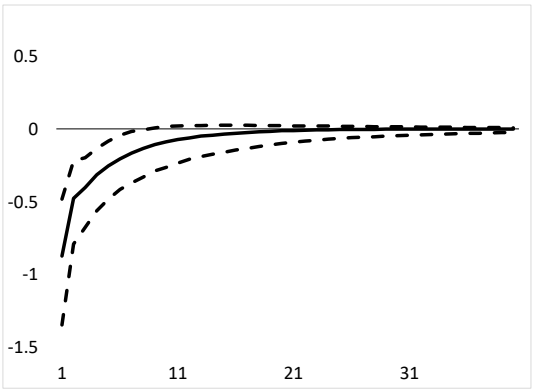
F. Forecast error variance decompositions



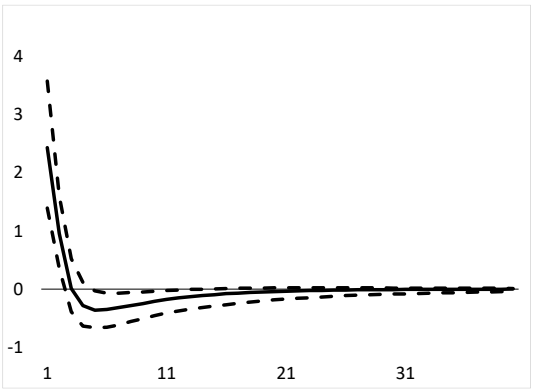
Note: A.-D. Impulse responses (IRF) following a positive one standard deviation uncertainty (proxied by VIX) shocks. The global SVAR model consists of, in this order, VIX, global equity prices, global implied inflation, global interest rates, and oil prices, all based on daily frequency and 1st difference of levels (or logged level). Solid lines and broken lines indicate median (50th) and 5th-95th percentiles, respectively, among 1,000 successful Bayesian draws. Vertical axis indicates percentage point and horizontal axis indicates months. E.F. Structural shocks (E) or forecasting error variance contribution of (F) global uncertainty shocks.

Figure A3 Impact of COVID-19 shocks on daily global variables

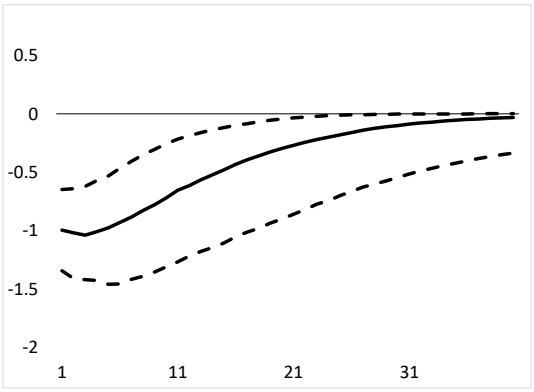
A. Global equity price



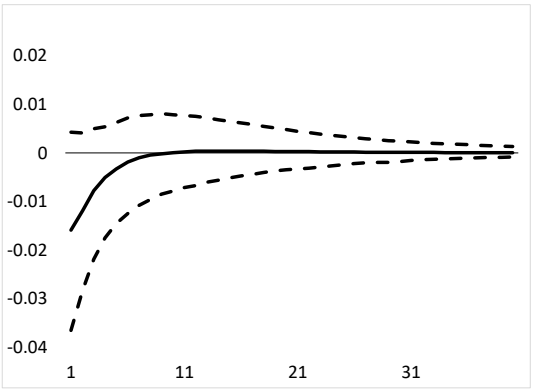
B. VIX



C. Global economic activity



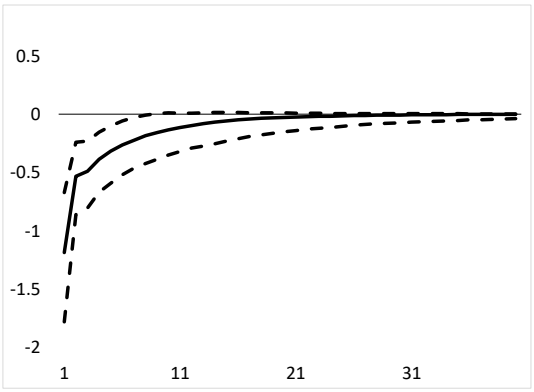
D. Inflation expectations



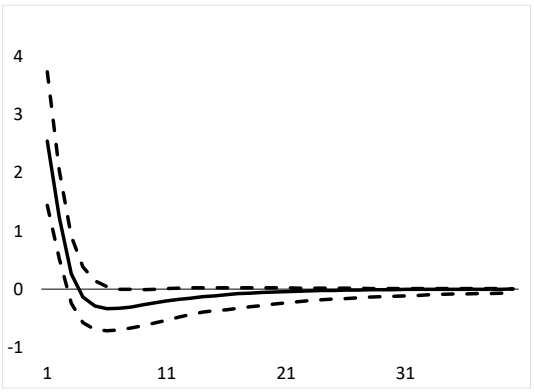
Note: The global SVAR model that consists of, in this order, number of world deaths due to COVID-19, global equity price index, VIX, global economic activity index (Citi index), and global implied inflation, all based on daily frequency and 1st difference of levels (or logged levels). Solid lines and broken lines indicate median (50th) and 5th-95th percentiles, respectively, among 1,000 successful Bayesian draws. Vertical axis indicates percentage point and horizontal axis indicates days.

Figure A4 Impact of COVID-19 shocks on US variables

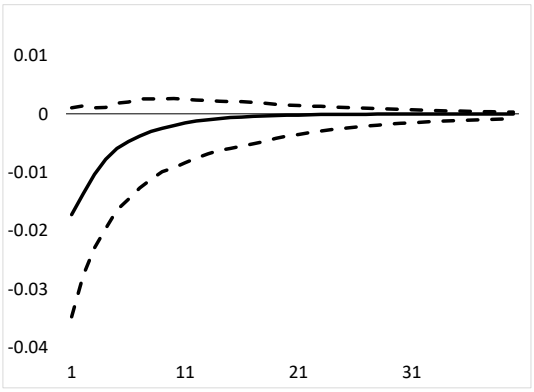
A. US equity price



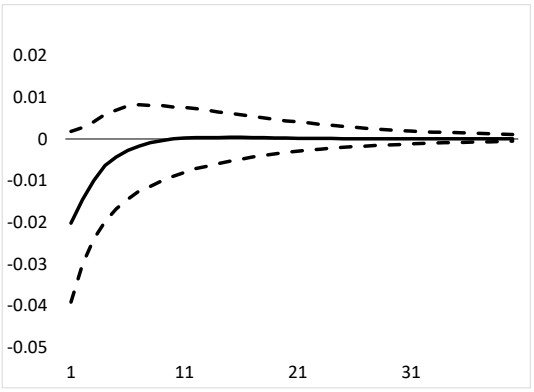
B. VIX



C. daily GDP forecasts



D. Inflation expectations



Notes: The SVAR model consists of, in this order, number of world deaths due to COVID-19, US equity price (S&P 500) index, VIX, US economic forecasts, and US implied inflation, all based on daily frequency. Solid lines and broken lines indicate median (50^{th}) and 5^{th}-95^{th} percentiles, respectively, among 1,000 successful Bayesian draws. Vertical axis indicates percentage point and horizontal axis indicates days.

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