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The Effect of Foreign Shocks on the Indian Economy§

ABSTRACT   The Indian economy has been increasingly exposed to external shocks with growing financial and trade integration. We examine the effects of four key international shocks: shocks to US monetary policy, oil supply, global economic policy uncertainty, and geopolitical risk. Using the external instruments strategy with Local Projections and Structural Vector Autoregression methods, we document the dynamic causal effects of these shocks on the Indian economy. We find significant effects of these foreign shocks on both macroeconomic and financial variables. Combined, these shocks explain about 15 to 35 percent of the variation in inflation, output, and financial variables at two- to four-year horizons. However, the magnitude of effects on output is lower relative to both global output and output of peer developing countries. While the oil shock behaves like a traditional supply shock, the US monetary policy and economic policy uncertainty shocks look more like domestic demand shocks. We discuss the implications for stabilization policy.

Keywords: Foreign Shocks, Indian Economy, External Instruments

JEL Classification: F4, E5, C3

1. Introduction

In recent years, increases in financial and trade linkages to the rest of the world have exposed India to global economic spillovers. This has occurred through a variety of channels, including reliance on imported oil,

exposure of financial markets to capital flows driven by the global financial cycle, and fluctuations in the exchange rate. These and other channels have contributed to the inclusion of India in the "fragile five" during the recent "taper tantrums" episode (see, e.g., Shin 2014).

While there has been much work studying the transmission of foreign shocks to emerging economies, there has been surprisingly little research that specifically answers these questions for the Indian macroeconomy. In this paper, we document the impact of foreign shocks on the Indian macroeconomy. Our contribution is divided into two parts. First, we focus on estimating the dynamic causal effects of international shocks using the recently developed method of identification through external instruments. Second, we consider a comprehensive set of external shocks that are likely to have played a role in driving economic fluctuations in India.

A key challenge in estimating dynamic causal relationships boils down to finding random variation in the treatment of interest. To address this issue, we rely on the recent progress made in the empirical macroeconomics literature in identifying exogenous macroeconomic shocks using a variety of new methodological innovations (see Ramey 2016 for an excellent recent survey). We incorporate these measures of identified exogenous shocks in a structural framework using both the Local Projections (LP) and Structural Vector Autoregression (SVAR) frameworks. Within these frameworks, we follow the recent modeling innovation of the external instruments approach, where the methodology involves using information outside (or external to) the core model to achieve the restrictions required for estimating causal relationships; see the work of Stock and Watson (2002), Mertens and Ravn (2013), Ramey and Zubairy (2018), and Jordà et al. (2020). Stock and Watson (2018) provide a survey of this literature focusing on the two main techniques of LP Instrument Variables (LP-IV) and SVAR Instrumental Variables (SVAR-IV). Based on the relevance for the Indian economy, our focus is on a core set of shocks that includes US monetary policy, oil supply, commodity prices, uncertainty, and geopolitical risk.

As documented by Miranda-Agrippino and Rey (2018), there is a global financial cycle that is important for driving international flows, and the source of this cycle is the US Federal Reserve. Additionally, new work by Lakdawala (2018) shows that the spillover effects of US monetary policy on Indian financial markets have increased since the early 2000s. We incorporate US monetary shocks into our analysis by using high-frequency changes in future rates around the policy announcements of the Federal Open Market Committee (FOMC). The futures rates incorporate market expectations and, thus, any change in these futures rates within a narrow

window around the FOMC announcement is likely due to unexpected changes in the monetary policy announcement. This approach has been widely used in the recent literature studying US monetary policy; see, for example, Gertler and Karadi (2015).

According to the International Energy Agency, as of 2018, India was the third largest importer of crude oil. Hence, another important source of foreign shocks for the Indian economy is the fluctuations in the global price of oil. Since India accounts for a large share of total global oil consumption, changes in India's demand for oil are likely to be an important driver of the global price of oil, making causal identification of oil price shocks problematic. However, India's contribution to global oil production is less than 1 percent and, therefore, supply disruptions in India are unlikely to be a contributor to changes in the global price of oil. Thus, we use an exogenous measure of oil supply shocks to identify the causal effect of disruptions in the global oil market on the Indian economy. While there is a long literature on distinguishing oil demand from oil supply shocks (see, e.g., Kilian 2009), we use the recently developed measure of oil supply shocks in Baumeister and Hamilton (2019). They use a Bayesian approach to rigorously incorporate prior information about supply and demand elasticities to identify oil supply shocks.

Our final two measures of baseline foreign shocks involve uncertainty. In a recent speech, the Bank of England Governor, Mark Carney (2016), outlined an "uncertainty trinity" composed of economic, policy, and geopolitical uncertainty as important factors for economic activity. Recent work has also highlighted the importance of uncertainty and risk aversion for international asset prices and capital flows; see, for example, the work of Rey (2015) and Bruno and Shin (2015). There is also evidence of the substantial effects of US uncertainty on emerging economies; see Bhattarai et al. (2017). For recent work exploring the impact of US uncertainty on the Indian economy, see Ghosh et al. (2017). We proxy uncertainty with two measures that are constructed from newspaper analyses by counting the relative frequency of certain key terms. The first measure proxies for global economic policy uncertainty, constructed by Baker et al. (2016), and the second measure is a proxy for geopolitical risk, constructed by Caldara and Iacoviello (2018).

Our main empirical analysis builds on the recent work of Mishra et al. (2016), who identify monetary policy shocks in India in a SVAR setting.[1]

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1. They find that shocks to the policy rate do transmit to bank lending rates in India, albeit imperfectly. However, the predicted bank lending rates do not seem to drive aggregate demand in their estimation.

Specifically, we use the Index of Industrial Production (IIP) as a proxy for output and the Consumer Price Index (CPI) to measure inflation. In addition to these macrovariables, we consider a variety of financial market variables. For our measure of interest rates, we use the 10-year Indian government bond rate. While there are a number of short-term rates that could have helped us better assess the response of the Reserve Bank of India (RBI) to foreign shocks, we found that data availability and non-variation over time were issues for several of these measures. Our qualitative results do not change if the short-term repo rate is used instead of the 10-year government bond rate. Moreover, since we want to focus on the aggregate economic effect of foreign shocks, we concluded that a higher interest rate was the best option. We use the nominal exchange rate of the Indian rupee with the US dollar as our baseline measure of exchange rates. We found that using real and nominal effective exchange rates, which are constructed with a broader set of countries, gave similar results. Finally, we also include indicators for the aggregate stock market index and total foreign reserves (excluding gold) measured in US dollars. We believe that total foreign reserves and the 10-year government bond rate indirectly capture the policy stance of the RBI, which uses various tools in its conduct of monetary policy.

Reassuringly, we find similar results using either the LP or SVAR estimation strategy. Here are the key findings. US monetary policy, economic policy uncertainty, and oil supply shocks have substantial disruptive effects on both economic activity and financial markets in India. But the geopolitical risk shock does not have a major discernible effect. Overall, US monetary policy and economic policy uncertainty have effects similar to those of a domestic demand shock, while the oil shock has effects similar to those of a supply shock. From a stabilization policy perspective, this means that there is a trade-off involved in responding to oil shocks but not to US monetary policy or economic policy uncertainty shocks.

For the monetary policy shock, our results corroborate Rajan's (2015) findings that US monetary policy indeed has important financial spillovers to the Indian economy. In response to a contractionary monetary policy shock to US policy rates, the Indian rupee depreciates, and the domestic stock market index and total foreign reserves held by the government decline. While the financial market response is striking, the effect on inflation and output is relatively smaller. The real effects are consistent with the global spillovers of US monetary policy. The peak drop of India's monthly industrial production is –0.3 percent. To benchmark these effects, the peak drop in world industrial production is –0.4 percent, and the peak drop in BRICS (excluding India, 'BRCS' henceforth) industrial production is –0.3 percent.

Second, surprise increases in policy uncertainty, measured with the global Economic Policy Uncertainty Index (EPU) of Baker et al. (2016), negatively affects real activity as well as financial market indicators. Industrial production exhibits a persistent drop, which peaks at –0.3 percent at 16 quarters, and becomes statistically indistinguishable from zero subsequently. The stock market index, government bond rate, and total reserves also decline significantly while the rupee depreciates.

Third, geopolitical risk shocks lead to a delayed appreciation of the rupee, increase in total foreign reserves held by the government, and expansion in the stock market. The effect of this geopolitical risk shock is muted on prices and output. One way to understand these results is a flight to safety story: when global geopolitical risk goes up, the Indian economy becomes an attractive destination.

Finally, oil supply shocks act as textbook adverse supply shocks. After an adverse supply shock, there is a simultaneous drop in output and an increase in prices. Moreover, the effect is persistent. Relative to the BRCS benchmark, we find that Indian output is more adversely affected by oil supply shocks. The shock also causes a general worsening of financial conditions with a reduction in total reserves, depreciation of the rupee, and a fall in stock prices.

Overall, the exposure of Indian output to these shocks is lower relative to an index of advanced economies, but it is comparable to the index of BRCS economies. To better understand how India performs among peer developing countries, we compare the response of Indian output on its own to that of China, Russia, Brazil, and South Africa. We find that, with the exception of China, the Indian economy reacts less to these foreign shocks relative to its counterparts. This suggests that in facing an adverse international shock, the Indian economy is more resilient than the economies of other developing countries. But on the flip side, since the estimated model's effects are symmetric, it implies that the Indian economy may also miss out on the positive effects of beneficial international shocks.

With the growing integration of India into the world economy, one might expect that the responsiveness of the Indian economy to international shocks has changed over time. To test this, we estimate the impulse responses for India by splitting our sample into two halves (pre- and post-December 2005). But for most of the variables (including output), we do not find statistically significant differences in the responses. What explains this phenomenon? A comprehensive analysis of this question would investigate any structural changes in the Indian economy and the response of policymakers. While this exercise lies outside the scope of this paper, our results provide some suggestive evidence on the role that monetary policymakers might have played.

Central banks can respond to international shocks primarily by changing their policy interest rates or intervening in foreign exchange markets, at least in terms of conventional policy tools. A common pattern that also emerges in the analysis is the modest response of the 10-year government bond rate to these adverse global shocks. This has potentially important implications from a policy stabilization perspective. For example, policymakers may consider easing interest rates in response to adverse international shocks. For the oil supply shock, the central bank faces a clear trade-off as output falls while prices rise. Thus, if the central bank is worried more about higher inflation, then it may want to refrain from lowering rates and accept the downturn in economic activity. But the US monetary policy and uncertainty shocks have effects that look like domestic demand shocks. In this case, there is no longer a trade-off and optimal monetary policy from conventional models dictates the central bank to lower rates.

In light of this, we think there are two different ways to interpret our results of the relative nonresponsiveness of the 10-year interest rate. First, it is possible that the RBI is not responding strongly with interest rate changes to international shocks, either because it fails to identify the shocks in a timely manner or because it perceives the trade-off is too costly. Alternatively, the RBI is indeed responding to these shocks by changing interest rates, but the transmission mechanism of monetary policy in India is weak and, thus, there are no substantial effects on the long rate.

But the RBI has also intervened in the foreign exchange market in response to international events. Our results from the split-sample estimation show that in response to adverse monetary and oil shocks, the Indian rupee depreciates less in the more recent sample. One potential factor could be the actions (or anticipated actions) of the RBI becoming stronger in the last decade or so. Our results highlight that disentangling these different channels is important to understand the role of monetary policy in overall stabilization policy.

Finally, we consider what each shock implies about the contribution to the forecast error variance of the core Indian macro variables. Overall, we find that the oil supply shock is the most important shock for explaining variations in industrial production. Specifically, oil shocks appear to create the most disruption in output around a year or two after impact. For inflation, we find that the two uncertainty shocks and the oil supply shocks are important contributors to its variation. For the US monetary policy shock, we find more modest effects on both financial market variables and output and prices. Overall, when we sum up the contributions of the four main shocks that we consider, we find

that just these four shocks can explain 15–35 percent of the variation in Indian financial and macro variables at two- to four-year horizons. We discuss some caveats to this analysis and recommend viewing these numbers as an upper bound. Nevertheless, the overall picture that emerges is that these four shocks combined account for a significant source of international fluctuations that are important for the Indian economy.

Our objective is to bring a new set of facts to the macro policy debate in India. Understanding the quantitative response of the Indian economy to previous international shocks is an important first step in preparing the policy response to future shocks. Moreover, our hope is that the econometric tools we have used can be readily applied by researchers in policy institutions to broaden our understanding of the Indian macroeconomy. Finally, the new facts that we document can guide economic modelers in building structural economic models relevant for the Indian economy.

2. Methodology

To estimate dynamic causal effects, we will consider a structural framework that relies on both the LP framework and the SVAR framework. For both these approaches, we will either directly incorporate exogenous measures of shocks or use the instrumental variables framework.

The first strategy is to use a SVAR framework. Consider the SVAR, where y_t is an $n \times 1$ vector of macroeconomic variables and α_i and A are $n \times n$ parameter matrices.

$$Ay_t = \alpha_1 y_{t-1} + \ldots + \alpha_p y_{t-p} + \varepsilon_t \tag{1}$$

The components of the error terms ε_t are assumed to be uncorrelated with each other and interpreted as structural shocks. Pre-multiply by A^{-1} to get the reduced form VAR

$$y_t = \delta_1 y_{t-1} + \ldots + \delta_p y_{t-p} + u_t \tag{2}$$

where

$$u_t = B\varepsilon_t \tag{3}$$

and $A^{-1} = B$. Also note that $E[u_t u_t'] = BB' = \Sigma$. This reduced form of VAR can be estimated in a straightforward manner. However, identification of the impulse responses to structural shocks requires an estimate of the matrix $B = A^{-1}$. This requires further identifying restrictions. If the structural shock of interest is directly observable, we will order it first in the vector y_t and

use a Cholesky ordering to identify the structural impulse responses. If we do not directly observe the structural shock but have an instrument for it (Z_t), we will use the external instruments procedure developed by Stock and Watson (2002), as well as Mertens and Ravn (2013). In the external instruments methodology, the key requirements are to find instruments that are (a) correlated with the shocks of interest and (b) uncorrelated with the other structural shocks. Denote the structural policy shocks as ε_t^p and the structural nonpolicy shocks as ε_t^q. The reduced-form residuals from the corresponding policy and non-policy equations are denoted as u_t^p and u_t^q, respectively. For a given set of instruments Z_t, these two conditions can be formally stated as

$$E[Z_t \varepsilon_t^{p'}] = \phi \qquad (4)$$

$$E[Z_t \varepsilon_t^{q'}] = 0 \qquad (5)$$

With these conditions, it can be shown in a straightforward manner how to identify structural impulse responses; see, for example, Mertens and Ravn (2013).

Jordà (2005) introduced the LP method for directly estimating impulse responses without relying on the assumption that the vector auto regression (VAR) is correctly specified. In an analogy with forecasting, this method involves forecasting future values of a variable using a horizon-specific regression rather than iterating one period ahead on the estimated model. Estimating impulse responses using VAR is analogous to iterated forecasting, while the LP method is analogous to direct forecasting. With a correctly specified VAR and standard assumptions on invertibility, Stock and Watson (2018), and with some generality Plagborg-Møller and Wolf (2019) prove that the impulse responses estimated using SVARs and LP are identical. However, in small samples, it is possible to reach different conclusions using the two different methods. Thus, we explore both of them in this paper.

For incorporating instruments variables into the LP framework, we will follow the recent literature (Jordà et al. 2020; Ramey and Zubairy 2018). This strategy is appropriate if the direct shocks are measured with error or if they capture only part of the shock. We treat the measured macroeconomic shocks e_t as proxy for the true shocks ε_t. Here, we describe the estimation strategy with the LP-IV technique and relegate the discussion of SVAR-IV to the Appendix. In the first stage, we instrument a policy indicator (e.g., the federal funds rate) with the relevant proxy. In the second stage, we run a sequence of predictive regressions of the dependent variable on the instrumented policy indicator for different prediction horizons. The estimated sequence of regression coefficients of the instrumented policy indicator are then the impulse responses.

More specifically, we estimate the following second-stage LP specification for horizons $h \in 0, \dots H$:

$$y_{t+h} = \alpha^h + \beta^h \hat{x}_t + \Sigma_p \theta^{ph} Z_{t-p} + \nu_{t+h} \tag{6}$$

$\hat{x}_t$ is the predicted policy instrument from the first-stage regression using instruments for the measured macroeconomic shocks e_t. The set Z_t includes lags of the dependent variable, the policy indicator, the policy instrument, and the current and lagged conditioning variables which identify exogenous fluctuations in the instrument and improve precision of standard errors (see Stock and Watson 2018). The dynamic coefficients of interest are, therefore, the estimates of β^h for h = 0, 1, ..., H. We compute standard errors based on heteroskedasticity and autocorrelation robust covariance matrix (Newey–West) estimators. We report one standard deviation confidence bands in our estimated impulse responses.

3. Data

3.1. Indian Macroeconomic Data

We consider the impact of external shocks on industrial production, CPI, holdings of foreign reserves, exchange rates, the 10-year government bond rate, and stock prices. We use the data for nominal exchange rate of the Indian rupee with respect to the US dollar, stock price index (measured in constant US dollars), and total foreign reserves from the Global Economic Monitor database of the World Bank, and the International Financial Statistics of the IMF. We use the Index of Industrial Production (seasonally adjusted) from the OECD database, and obtain non-seasonally adjusted CPI from the St Louis Fed's database.

Historically, Indian monetary policy has been conducted using multiple instruments: price-based and quantity-based. Starting from April 3, 2001, the RBI used the repo rate as the price-based instrument. For the preceding years, we follow the BIS in using the bank rate as the price-based policy instrument. Quantity-based instruments such as the Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR) have also been used regularly. Nonetheless, we measure the overall stance of monetary policy using the price-based instruments.[2] In the main text, we only report the impulse

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2. In terms of other interest rates and policy indicators, we also looked at the commercial bank lending rate. The results reported here are robust to including the series for the commercial bank lending rate.

FIGURE 1. Indian Interest Rates: Repo Rate and the 10-year G-Sec
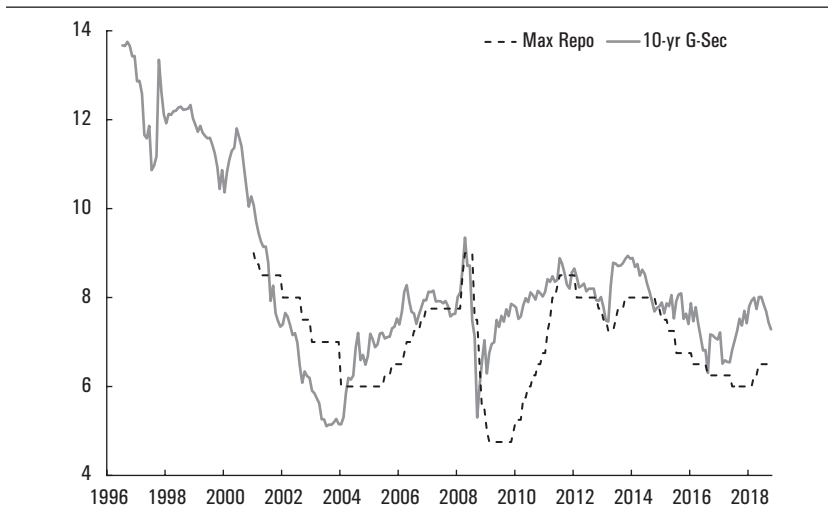
Source: Authors' calculations. RBI data.
Notes: This figure compares the evolution of the repo rate with the interest rate on 10-year bonds issued by the Government of India. Sample: February 1996–December 2018. See text for details.

responses for the 10-year government bond rate. Data for this series are available for the longest duration and exhibit considerable time variation relative to short-term interest rate set by the RBI, as shown in Figure 1. Moreover, the RBI uses a variety of instruments in its conduct of monetary policy. Market-driven variation in the 10-year bond yields would serve as a proxy for variation in other instruments used by the central bank. Impulse responses for other policy indicator variables are available upon request.

We also looked at the responses of nominal and real effective exchange rates. The results are similar to the US dollar/Indian rupee nominal exchange rate. The data for these series came from the Global Economic Monitor database of the World Bank and the International Financial Statistics of the IMF.

Next, we provide the details for our four baseline shock measures that we use in the analysis.

3.2. US Monetary Policy Shocks

For measuring exogenous changes in the stance of US monetary policy, we follow the external instruments (proxy-SVAR) strategy developed by Mertens and Ravn (2013), and Stock and Watson (2002). This methodology involves finding instruments that are correlated with the structural

shock of interest (US monetary policy shock here) but uncorrelated with the other structural shocks. We follow the work of Gertler and Karadi (2015) and use changes in futures contracts in a narrow window around FOMC announcements as instruments to identify a structural US monetary policy shock within a standard SVAR. We use both federal funds futures and Eurodollar futures contracts. Specifically, we use the current month's and next month's fed funds futures contracts and the 2, 3, and 4 quarters ahead Eurodollar futures contracts. Following Nakamura and Steinsson (2018), we take the first principal component of the change in these contracts in a 30-minute window around the FOMC announcement. Recent work in the literature has highlighted a potential issue with this approach by finding counter-intuitive effects of monetary policy shocks based on information effects (see, e.g., Lakdawala 2019; Nakamura and Steinsson 2018). To overcome this problem, we take two steps. First, we cleanse the instrument from information effects using real GDP forecasts from a market-based measure of survey forecasts (*Blue Chip*). Specifically, we regress the instrument on four lags of itself, the *Blue Chip* real GDP forecast for the previous quarter, the current quarter, the next quarter, two quarters ahead, and three quarters ahead. Second, we use this instrument to estimate the SVAR model of Gertler and Karadi (2015), and then we use the estimated structural shocks from this SVAR as our baseline measure of monetary policy shocks. This approach ensures that the information contained in the survey forecasts and the SVAR considers any predictability and information effects. Specifically, the SVAR model that we use for the US includes monthly data on industrial production, the CPI, the excess bond premium of Gilchrist and Zakrajek (2012), and the one-year treasury rate as the monetary policy tool. The estimated monetary policy shock is plotted in Figure 2A.

3.3. Economic Policy Uncertainty Shocks

We will use the measure of Baker et al. (2016) of economic policy uncertainty (EPU). This measure is constructed by analyzing newspaper coverage and measuring the relative frequency of words that capture "… a trio of terms pertaining to the economy (E), policy (P) and uncertainty (U)." We use the Global EPU variable that captures economic policy uncertainty for 20 major economies. This measure is plotted in the Figure 2B. To identify the dynamic causal effects of changes in economic policy uncertainty, Baker et al. (2016) use a SVAR with a Cholesky identification strategy by ordering the EPU index first. Recent work by Carriero et al. (2015) has pointed out

FIGURE 2. **Foreign Shocks**
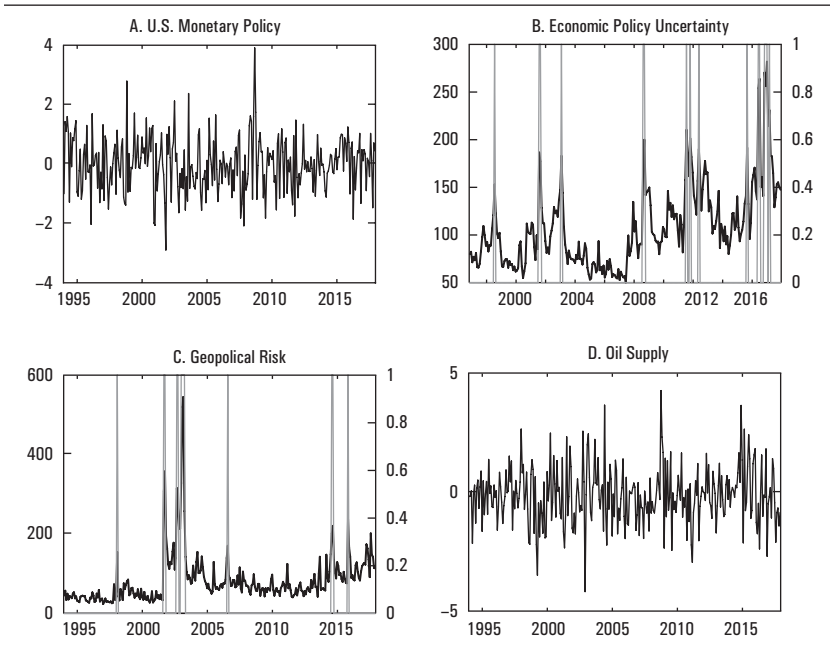
Source: Authors' calculations.
Notes: This figure plots the four main shock measures. The sources for data series are described in the text. The sample is for January 1994 to December 2017, except for the EPU shock for which the sample starts in February 1997 because the EPU measure started only in January 1997. See text for details of the 0-1 dummy variables in Figures 2B and 2C depicted in grey, with the y-axis shown on the right side.

that this approach can lead to attenuation bias due to measurement error. They advocate using a SVAR approach with external instruments. This approach has also been used recently by Caballero and Kamber (2019). Specifically, we construct a dummy indicator that takes the value 1 when the EPU index exceeds 1.65 times the unconditional standard deviation of the Hodrick–Prescott (HP) filtered data. The indicator is also plotted in Figure 2B (y-axis shown on the right side). This dummy indicator is used as an instrument for the structural shock to the EPU index in both the SVAR and LP frameworks.

3.4. Geopolitical Risk Shocks

We will use the geopolitical risk measure of Caldara and Iacoviello (2018). They use a methodology that is similar to Baker et al. (2016), which involves counting the frequency of newspaper articles related to geopolitical risk. They define geopolitical risk as "… risk associated with wars, terrorist acts, and tensions between states that affect the normal and peaceful course of

international relations." This measure (GPR) reflects both the risk of these adverse events occurring together and the actual realization of these events. Again, to identify the causal effects of geopolitical risk shocks, Caldara and Iacoviello (2018) use a SVAR identified with Cholesky ordering. Since the same caveat about measurement error and attenuation bias applies, we follow the same approach as above to construct a 0-1 dummy variable. Both the GPR index (y-axis shown on the left) and the dummy indicator (y-axis shown on the right) are plotted in Figure 2C.

3.5. Oil Shocks

Given India's reliance on imported oil, a potentially important source of shocks to the Indian economy involves changes in the price of crude oil. Of course, oil price dynamics are driven by shocks to both oil supply and oil demand. Since India is the world's third largest consumer of oil (after the USA and China), oil demand shocks can be expected to be driven in part by changes in India's economic conditions. On the other hand, India contributes to less than 1 percent of the total global oil production and thus oil supply disruptions originating in India are unlikely to move the global price of oil. Thus, to study the causal effect of changes in oil prices, we rely on an exogenous measure of oil supply shocks. Specifically, we use the newly developed measure of oil supply shocks by Baumeister and Hamilton (2019). They use an SVAR framework to disentangle oil supply shocks from oil demand shocks. While the existing literature has made some strong assumptions about relevant elasticities, their Bayesian framework allows them to incorporate uncertainty about these elasticities in a transparent manner. The estimated oil shock is plotted in Figure 2D.

4. Results

4.1. Benchmark: World and BRCS Industrial Production

We first document the responses of both the world's and BRCS countries' industrial production to external shocks. We believe this is useful for at least two reasons. First, these responses will be helpful to understand the nature of the foreign shock, for example, whether it is contractionary and expansionary, or the persistence of the effects of the shock. Second, it will help us place a benchmark on the quantitative magnitudes we should have in mind when we are looking at India-specific macro and financial variables.

Our sample uses monthly data from January 1994 to December 2017. For the economic policy uncertainty shock, the sample starts in February

FIGURE 3. **Response to One Standard Deviation Shock: World Index of Industrial Production**

A. Monetary Policy Shock

B. Economic Policy Uncertainty Shock

C. Geopolitical Risk Shock

D. Oil Supply Shock
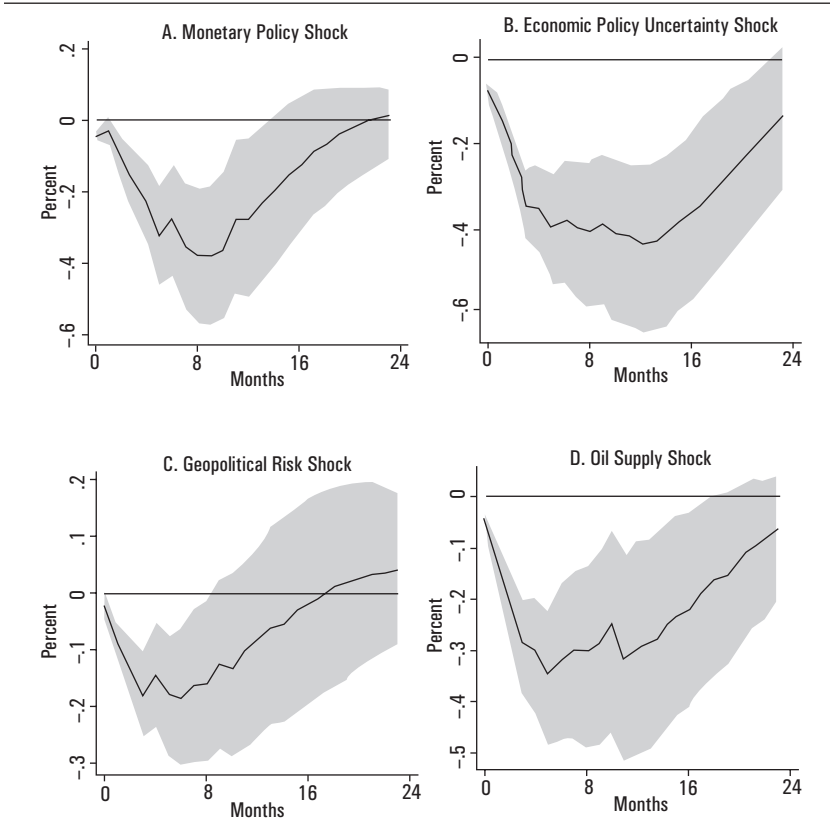
Source: Authors' calculations.

Notes: SVAR estimated response of world industrial production (OECD + BRICS + Indonesia) region to a one standard deviation shock. The shaded areas represent confidence intervals of one standard deviation. Standard errors are bootstrapped as in Gertler and Karadi (2015). The World Index of Industrial Production (WIIP) is an extended version of the OECD's index of monthly industrial production in the OECD and six major other countries developed by Baumeister and Hamilton (2019). The sources for shocks are described in the text. The sample is from January 1994 to December 2017, except for the EPU shock for which the sample starts in February 1997 because the EPU measure started only in January 1997. See text for details.

1997. Figure 3 plots the impulse responses of world industrial production to our four measures of shocks, namely, shocks to US monetary policy, economic policy uncertainty, geopolitical risk, and global oil supply. This measure of industrial production includes all OECD countries plus the six major non-member economies (Brazil, China, India, Indonesia, Russia, and South Africa). As mentioned above, the impulse responses are computed by using a combination of putting our shocks directly in the SVAR

or LP framework and using them as instruments in the SVAR-IV or LP-IV framework. Specifically, for monetary policy and oil supply shocks, we use these measures of exogenous shocks directly. For the responses to economic policy uncertainty and geopolitical risk shocks, we use the dummy indicators described above as instruments. Figure 3 displays the responses to a one standard deviation shock from a bivariate SVAR framework, which includes the log of the industrial production index and the relevant shock. The impulse responses from the LP framework are similar and have been included in the Appendix. The shaded areas in the figures represent one standard deviation confidence bands, where standard errors are computed using a bootstrap algorithm.

Figure 3A shows the response to a contractionary US monetary policy shock, or an unexpected increase in short-term interest rate by the Federal Reserve. The response of world industrial production displays an inverse hump-shaped response, with a trough of about –0.4 percent at the one-year mark. The effects of the shock have faded by the two-year horizon. These results are consistent with the hypothesis of the global financial cycle (Miranda-Agrippino and Rey 2018), which finds substantial global effects of US monetary policy. Figure 3B shows the response to an increase in economic policy uncertainty. World industrial production falls on impact, reaching a peak fall of –0.4 percent in around six months; the response stays around this level for about a year before reverting. Figure 3C shows a one standard deviation increase in geopolitical risk. The effects of this shock are also contractionary but somewhat smaller with a peak effect of almost –0.2 percent. Finally, Figure 3D shows the response to an adverse supply shock in the oil market. As expected, we see a contractionary effect on world industrial production with a peak fall of about –0.3 percent. In addition to having quantitatively meaningful effects, for all four shocks the peak effect of roughly around the one-year mark is also statistically significant as indicated by the confidence intervals.

Figure 4 plots the impulse responses of industrial production for the BRCS countries (Brazil, Russia, China, and South Africa). The broad pattern of responses for these countries is similar to that of world industrial production qualitatively. Quantitatively, the responses are slightly smaller. For both the US monetary policy shock and the economic policy uncertainty shock, the peak fall is around –0.25 percent (relative to roughly –0.4 percent for the world index). We do see a notable difference in response to the geopolitical risk shock. After this shock, BRCS industrial production actually rises slightly on impact before falling. However, the magnitude of the fall is quite small and statistically insignificant. Thus, while GPR shocks had a clear adverse effect on OECD countries, they do not appear to have

FIGURE 4. **Response to One Standard Deviation Shock: Index of Industrial Production for BRCS Countries**
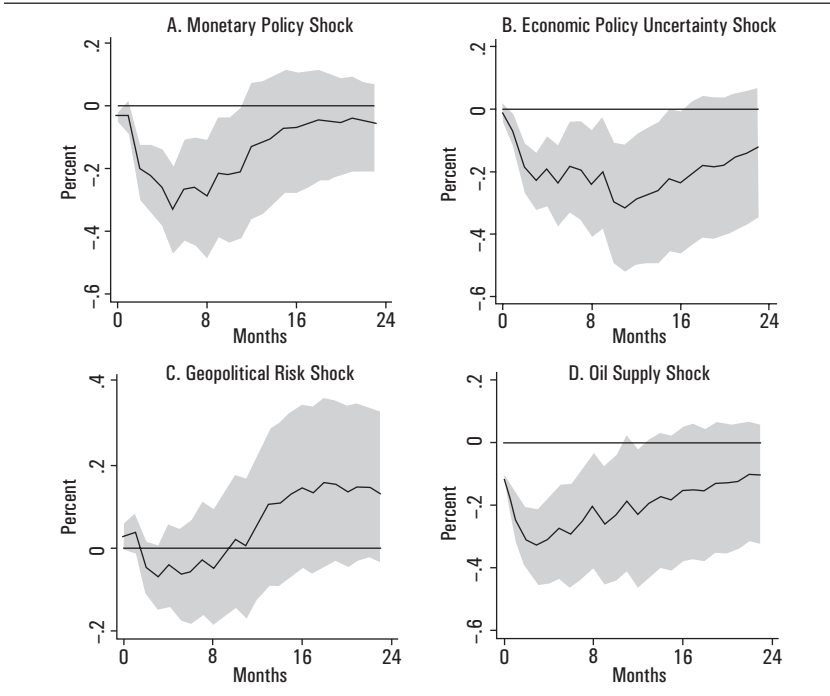
Source: Authors' calculations.
Notes: SVAR estimated response of the monthly seasonally adjusted industrial production in the four-country BRCS (BRICS excluding India) region to a one standard deviation shock. The shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler and Karadi (2015). The BRICS industrial production data are from the World Bank Global Economic Monitor. The sample is for January 1994 to December 2017, except for the EPU shock for which the sample starts in February 1997 because the EPU measure started only in January 1997. The sources for shocks are described in the text.

had much of an effect on the BRCS countries. Finally, the response to oil supply shocks is quite similar to the case of world industrial production.

In summary, we have established that adverse increases in our four shock measures have had a substantial and statistically significant effect on world industrial production and a somewhat smaller effect on industrial production in the BRCS countries. This establishes a simple benchmark for comparing the response of Indian economic activity, which we undertake next.

4.2. Impulse Responses for the Indian Economy

In this section, we present the impulse responses for the Indian macro-economic and financial market variables. We have done the estimation using both the SVAR and LP frameworks outlined above. The results are

consistent with both methods. From an econometric perspective, SVAR and LP should give similar results as long as certain conditions about the sufficiency of the information set are met. Overall, we find similar results using both approaches, which is reassuring. For the rest of this section, we present results using the SVAR framework, and the LP results are presented in Appendix A.1, A.2, A.3, and A.4.

We estimate impulse response functions (IRF) for the following six Indian macro and financial variables available at monthly frequency: industrial production, CPI, nominal exchange rate of US dollar/Indian rupee, yields on 10-year government bonds, stock market index, and US dollar value of total foreign reserves (minus gold) as a measure of international liquidity (coded as RAXG_USD in IMF/IFS). Following the recent trend in the empirical macroeconomics literature (see, e.g., Gertler and Karadi 2015), we run the SVAR in log levels. Specifically, we put the 10-year bond rate in levels (percentage points) and for all the other variables we take the log of the variable and then multiply it by 100. We also check the robustness of our results using a "gaps" specification. In this case, we de-trend the seasonally adjusted industrial production using an HP filter with a monthly frequency smoothing parameter of 14,400. Further, we take the year-over-year percentage change in the CPI price index to calculate the inflation rate. This specification is similar to the one used recently by Mishra et al. (2016). We find that the results are similar using this approach and thus do not report these impulse responses in the main draft.

The SVAR is estimated with 12 lags. All figures are presented as responses to a one standard deviation "adverse" shock. This means that based on the responses shown for the world and BRCS industrial production, these shocks are expected to lower economic activity, for example an increase in US interest rates or an increase in the global price of oil. One standard deviation confidence intervals constructed using a bootstrap algorithm are reported on all the impulse response figures.

4.2.1. Monetary Policy Shocks

Figure 5 presents the impulse response to a contractionary monetary policy shock. On impact the rupee depreciates and reserves and the stock market fall as has been documented in the literature; see, for example, Lakdawala (2018). These variables take about a year to a year and a half to recover from this shock. Overall, these effects are statistically significant and sizeable for reserves and the stock market with a peak fall of around –1.5 percent and –0.75 percent, respectively. The responses of prices, output, and the government bond rate are not significant on impact, but all three variables display a fall at around the 6-month to 1-year mark. The peak fall in Indian

F I G U R E   5 .   **SVAR Response of the India Economy to Monetary Policy Shock**
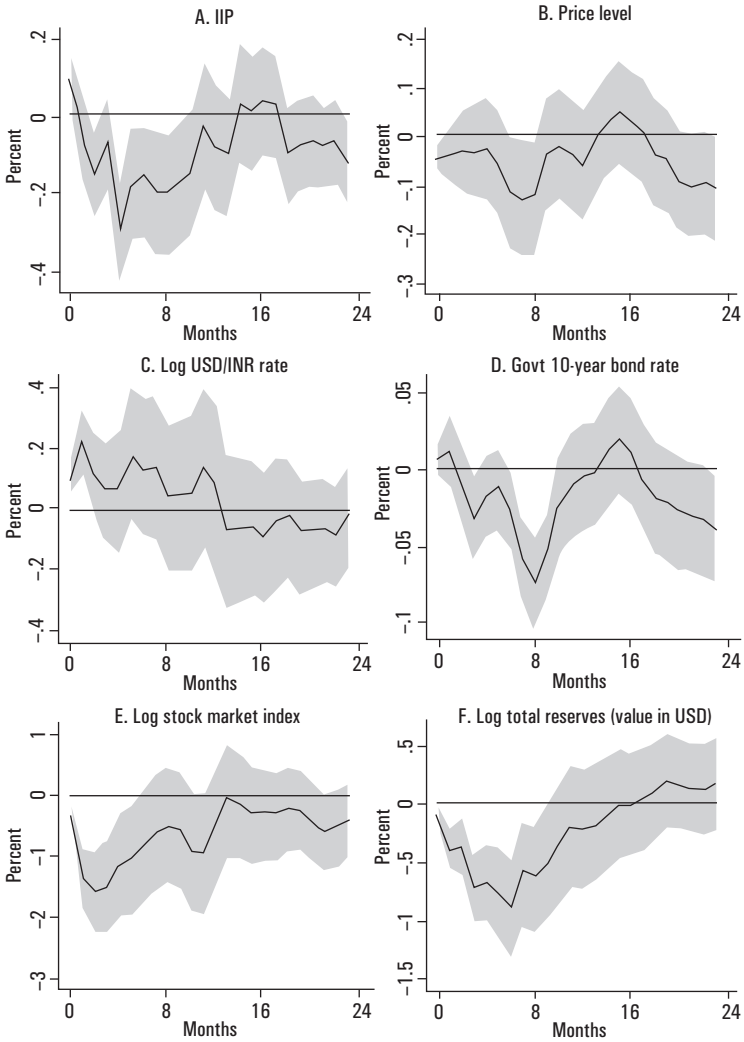
Source: Authors' calculations.

Notes: SVAR estimated response of monthly industrial production, CPI, USD/INR nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding for India to a one standard deviation identified US monetary policy shock. The shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler and Karadi (2015). The sources for data series are described in the text. Sample: February 1994–December 2017. See text for details.

industrial production is around –0.3 percent, which is quite similar to the fall in BRCS industrial production displayed above and slightly smaller than the peak fall in world industrial production. However, Indian industrial production does not display the inertial and persistent response and has almost recovered around the 15-month mark.

These results are consistent with the story of the global financial cycle. Monetary policy shocks originating in the US are propagated throughout the world through the global financial cycle. However, we should note that relative to the size of the effect on the stock market and dollar reserves, the effect on prices and thus, Indian economic activity is, to some extent, shielded from the global financial cycle.

4.2.2. ECONOMIC POLICY UNCERTAINTY SHOCKS

The impulse responses to a one standard deviation shock that increases the economic policy uncertainty are shown in Figure 6. Industrial production has a sustained fall for over two years of around 0.2 percent. The size of this effect for Indian industrial production is very similar to the size of the fall in BRCS industrial production. This shock has a larger impact on the financial markets that are persistent as well. The rupee depreciates and dollar reserves and stock market fall. Quantitatively, the stock market index falls more than 1 percent on impact and the peak effect is more than –2 percent after a couple of months. Reserves fall by 0.25 percent on impact and gradually fall to trough at –0.75 percent, staying lower for over a year. The rupee depreciates on impact and then returns around the six-month mark. The government bond rate heads slightly lower around the six-month mark before recovering. Thus, an increase in global economic policy uncertainty is clearly detrimental to the Indian economy, both immediately on impact and in the medium term.

### 4.2.3. GEOPOLITICAL RISK SHOCKS

Figure 7 presents the impulse responses to a one standard deviation increase in the geopolitical risk shock. With this shock, the SVAR results do not show a clear discernible pattern. The responses of both industrial production and CPI are quantitatively small and statistically insignificant. Thus, the response of Indian industrial production is consistent with the response of BRCS industrial production seen above: neither appears to be substantially affected by the geopolitical risk shock. Even for financial market variables, we notice that the responses are mostly near zero and insignificant. The one exception is the stock market, which falls on impact. Overall, for financial variables, if anything, this adverse shock represents some beneficial effects with an

FIGURE 6. **SVAR Response of the India Economy to Economic Policy Uncertainty Shock**
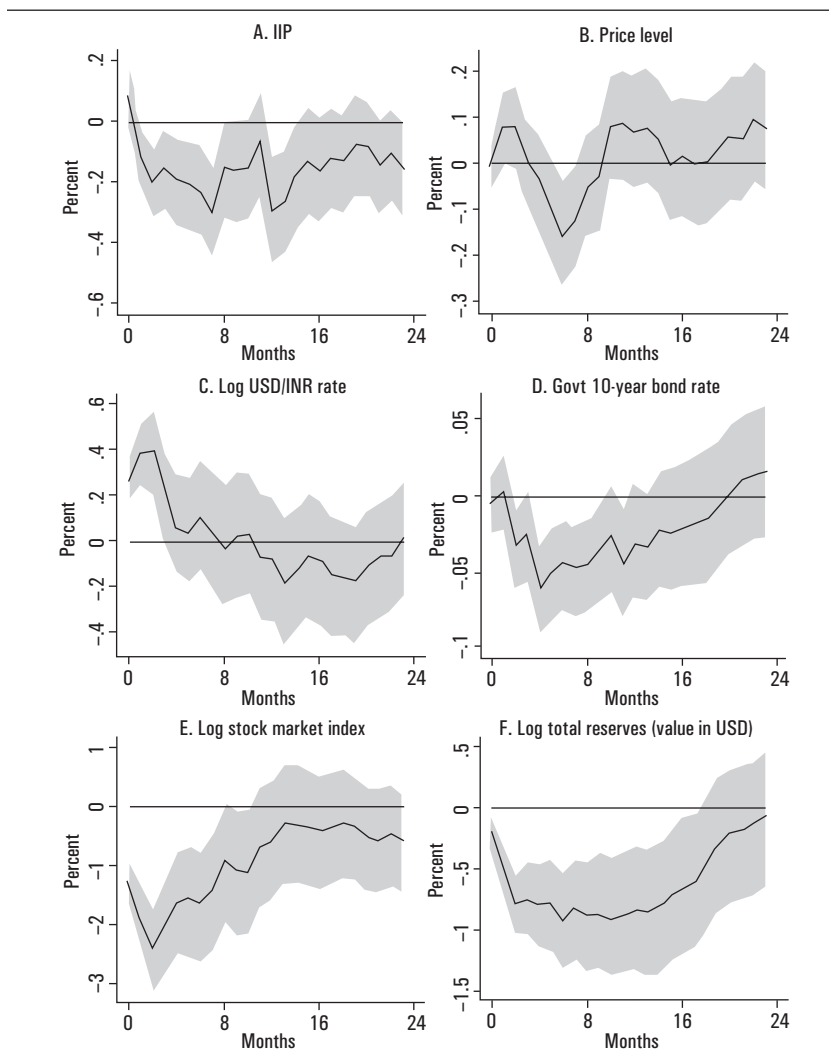
Source: Authors' calculations.

Notes: SVAR estimated response of monthly industrial production, CPI, USD/INR nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to global EPU. The shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler and Karadi (2015). The sources for data series are described in the text. Sample: February 1997–December 2017. See text for details.

F I G U R E   7 .   **SVAR Response of the India Economy to Geopolitical Risk Shock**
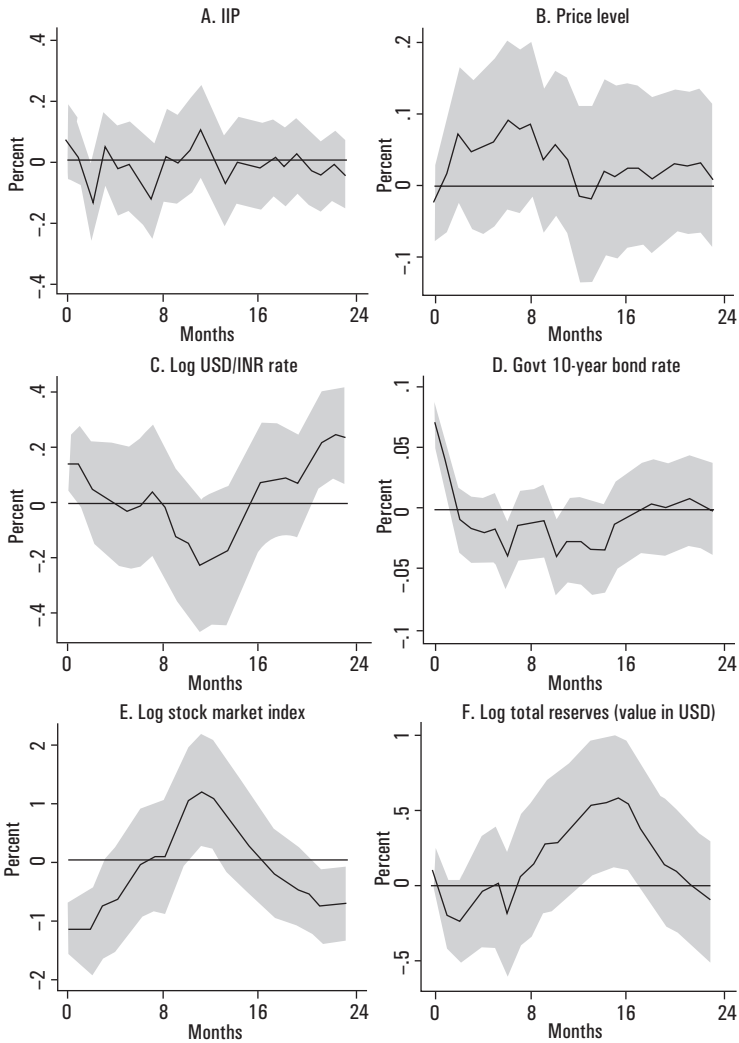
Source: Authors' calculations.

Notes: SVAR estimated response of monthly industrial production, CPI, USD/INR nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to GPR measure. The shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler and Karadi (2015). The sources for data series are described in the text. Sample: February 1997–December 2017. See text for details.

increase in dollar reserves and a delayed rise in the stock market. Thus, in contrast to the other shocks, while the geopolitical risk shock does have a significant effect on OECD countries, its impact is mostly insignificant for India, as with the BRCS countries in general.

4.2.4. Oil Supply Shocks

Figure 8 shows the impulse response to the oil supply shock. Industrial production falls on impact by 0.3 percent. Relative to the world and BRCS industrial production, this contemporaneous response of Indian industrial production is larger. Moreover, this response stays negative and significant even at the two-year mark. Thus, among the four shocks we have considered, the oil shock has the largest and most persistent effects on Indian economic activity. Consistent with expectations, the oil supply shock responses look like a textbook "supply shock." Output goes down while at the same time prices go up. The CPI rises on impact and is still higher at the two-level horizon. The rupee depreciates on impact and the peak effect is almost half a percent. This is larger than in response to other three shocks. Moreover, this effect is persistent with the rupee being lower even at the two-year horizon. Dollar reserves also fall on impact and stay about 0.5 percent lower at the two-year horizon. The stock market and the 10-year government bond yield fall on impact but recover somewhat faster. Thus, an adverse oil supply shock overall has large effects on both macroeconomic and financial market variables. Moreover, these effects are felt contemporaneously and persist over the medium term.

One common theme emerges from the four shocks about the response of the 10-year government bond rate. In response to these adverse shocks, which cause disruption in financial markets and lower economic activity, the typical response of monetary policymakers would be to ease interest rates to help the economy recover. While we do see that typically the government bond rate tends to decline, the magnitude of the fall is quite small. We think this is an important point that needs to be explored more. There are two reasons why this could be happening. First, it could be the case that the RBI is not responding enough to offset these shocks. But even if the RBI is recognizing these shocks and responding appropriately by changing policy rates, it could be the case that the monetary transmission mechanism is not effective. Indeed, there is corroborating evidence for the latter explanation. For a prominent paper, see the recent work of Mishra et al. (2016).

4.3. Discussion: Resilience versus Integration

Our results suggest that the exposure of Indian output to foreign shocks is lower relative to an index of advanced economies but comparable to an index of BRCS economies. In the Appendix, we make direct comparisons of the

FIGURE 8.   SVAR Response of the India Economy to Oil Supply Shock
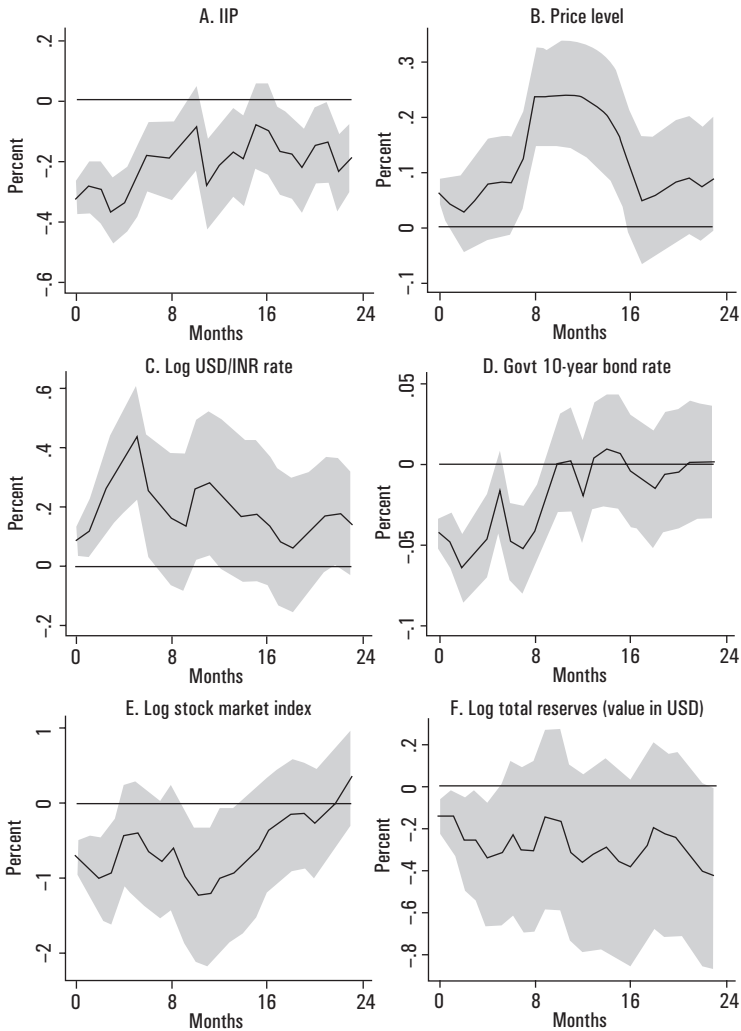
Source: Authors' calculations.
Notes: SVAR estimated response of monthly industrial production, CPI, USD/INR nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to oil supply. The shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler and Karadi (2015). The sources for data series are described in the text. Sample: February 1994–December 2017. See text for details.

responsiveness of the Indian economy to that of China, Russia, Brazil, and South Africa (see Figure 15 in Appendix A.4). We also evaluate how the responsiveness of the Indian economy may have changed over time (see Figures 16–20 in Appendix A.4). Given the increased financial integration in the later sample, this sub-sample analysis is suggestive evidence for assessing the role of resilience and the lack of integration in the estimated responsiveness of the Indian economy. In order to keep the discussion focused here, the graphs are presented in Appendix A.4. We only summarize the results with the goal of drawing broad policy lessons.

We find that, with the exception of China, the Indian economy reacts less to these foreign shocks relative to these counterpart countries (Figure 15 in Appendix A.4). This suggests that in facing an adverse international shock, the Indian economy is more resilient than those of other developing countries. But on the flip side, since the estimated model's effects are symmetric, it implies that the Indian economy may also miss out from the positive effects of beneficial international shocks.

The word *resilience* is a broad term that may capture a variety of reasons for the attenuated responsiveness of the Indian economy to foreign shocks. For example, lack of financial or trade integration could explain subdued responsiveness. To a first order, we use 'resilience' to denote forces, structural or policy-initiated, which are distinct from the lack of integration. This is done because we can conduct sub-sample analysis to provide suggestive evidence of whether increased integration has implied greater responsiveness or not.

With the growing integration of India into the world economy, one might expect that the responsiveness of the Indian economy to international shocks has changed over time. To test this, we estimate the impulse responses for India by splitting our sample into two halves (pre- and post-December 2005). But for most of the variables (including output), we do not find statistically significant differences in the responses (Figures 16–20 in Appendix A.4). What explains this phenomenon? A comprehensive analysis of this question would investigate any structural changes in the Indian economy and the response of policymakers. While this exercise lies outside the scope of this paper, our results provide some suggestive evidence of the role that monetary policymakers might have played.

Central banks can respond to international shocks primarily by changing their policy interest rates or intervening in exchange rate markets, at least in terms of conventional policy tools. A common pattern that also emerges in the analysis is the modest response of the 10-year government bond rate to these adverse global shocks. This has potentially important implications from a policy stabilization perspective. For example, policymakers may consider easing of interest rates in response to adverse international shocks.

For the oil supply shock, the central bank faces a clear trade-off as output falls, but prices rise. Thus, if the central bank is worried more about higher inflation, it may want to refrain from lowering rates and accept the downturn in economic activity. But the US monetary policy and uncertainty shocks have effects that look like domestic demand shocks. In this case, there is no longer a trade-off and optimal monetary policy from conventional models dictates that the central bank lower rates.

In light of this, we think there are two different ways to interpret our results of relative non-responsiveness of the 10-year interest rate. First, it is possible that the Reserve Bank is not responding strongly with interest rate changes to international shocks, either because they fail to identify the shocks in a timely manner or because they perceive the trade-off as too costly. Alternatively, the Reserve Bank is indeed responding to these shocks by changing interest rates, but the transmission mechanism of monetary policy in India is weak and thus there are no substantial effects on the long rate.

However, the RBI has also intervened in the exchange rate market in response to international events. Our results from the split-sample estimation show that in response to adverse monetary and oil shocks, the Indian rupee depreciates less in the more recent sample. One potential factor could be the actions (or anticipated actions) of the RBI becoming stronger in the last decade or so. Our results highlight that disentangling these different channels is important to understand the role of monetary policy in the overall stabilization policy.

4.4. Variance Decomposition for the Indian Economy

We now consider what each shock implies about the contribution to the forecast error variance of the core Indian macro variables. In principle, these quantities can be calculated from the LP framework. However, we found that in practice, the estimates implied that the total contribution of the shocks would add up to more than 100 percent. This is a finding that is common in the literature; see, for example, Ramey (2016). Thus, we use the SVAR framework to compute the forecast error variance decompositions. We include all four shocks at the same time in the following order: (a) economic policy uncertainty shock, (b) geopolitical risk shock, (c) monetary policy shock, and (d) oil supply shock. While the total share of the forecast error variance to these four shocks is not affected by the ordering, the relative contribution of each shock can be affected by the ordering. We found that, in practice, the relative shares are similar regardless of the ordering that we choose. The baseline sample runs from January 1997 to December 2017.

Table 1 presents these variance decompositions. Panel A in the table shows the contribution of the US monetary policy shock. On impact, this shock has

T A B L E 1. Individual Shock Contribution to the Forecast Error Variance 1 to 48 Months After the Shock

Months →	A. Monetary Policy Shock					B. Economic Policy Uncertainty Shock				
	1	6	12	24	48	1	6	12	24	48
Stock market	1.800	3.913	12.282	10.164	9.199	3.103	5.560	4.651	4.879	5.078
USD/INR	0.843	0.654	1.650	2.082	2.568	1.972	1.153	0.746	1.371	5.219
10-year bond	2.572	0.447	8.494	11.728	7.327	0.078	4.169	5.085	3.190	2.516
Dollar reserves	2.013	0.670	8.938	6.387	4.113	0.011	3.938	10.007	13.408	7.207
Inflation	1.835	0.724	3.160	3.680	5.066	0.000	1.557	1.804	1.597	1.046
Ind. Prod.	1.738	0.027	13.506	13.817	12.286	0.080	3.239	4.441	5.066	8.928

Months →	C. Geopolitical Risk Shock					D. Oil Supply Shock				
	1	6	12	24	48	1	6	12	24	48
Stock market	0.679	1.074	1.865	2.058	2.770	1.926	3.044	5.380	6.854	6.189
USD/INR	0.665	0.337	0.565	1.635	1.791	0.497	10.290	10.209	12.324	9.143
10-year bond	1.208	0.633	0.429	0.493	5.498	2.295	9.044	6.500	4.257	4.032
Dollar reserves	0.005	0.160	1.712	2.414	6.543	2.038	2.504	2.002	2.471	3.028
Inflation	0.260	6.009	8.654	9.319	10.237	0.668	0.311	6.475	5.415	3.520
Ind. Prod.	0.003	0.580	0.944	0.953	0.742	4.814	15.524	13.663	16.504	13.027

Source: Authors' calculations.

a small contribution, explaining about 1–2 percent of the movement in macro and financial variables. At longer horizons, we see a substantially bigger effect, explaining 13 percent of the variation in output at the one- to four-year horizon. The US monetary policy shock also has a similar long-term impact on the stock market and the 10-year bond rate, explaining roughly 10 percent at longer horizons. Somewhat surprisingly, the contribution of the monetary policy shock to the exchange rate is smaller. We also note that the shock does not explain much of the contribution to prices.

Panel B of Table 1 shows the contributions of the economic policy uncertainty shock. This shock also does not explain much of the contemporaneous contribution to output or inflation. But it has a more substantial amount of contribution at the one-year horizon, explaining 4 percent of the variation in output and 2 percent in inflation. At longer horizons, the effect on output is even bigger, explaining close to 9 percent of the variation. This shock also has relatively bigger effects on the dollar reserves. At the one-year horizon, it explains 10 percent of the impact on dollar reserves. Finally, this shock also explains around 5 percent of the long-term variation in the exchange rate and stock market.

The geopolitical risk shock is shown in panel C of Table 1. Similar to the policy uncertainty shock, it has small effects on output and inflation at shorter horizons. The peak contribution to output is less than 1 percent. However, this shock has a bigger effect on prices. For inflation, the peak effect in the long run (four years out) is at around 10 percent. This shock also contributes significantly to the long-term variation in dollar reserves and the 10-year government bond rate, with contributions of 7 percent and 5 percent, respectively.

Finally, panel D of Table 1 shows the oil supply shock. Here, we see substantially larger effects for output, even at the short and medium horizons. At the six-month horizon, oil supply shocks explain 15 percent of the variation in output. At longer horizons, the contributions remain sizeable, with 16 percent explained at two years and 13 percent explained at four years. The effects of inflation are largest around the one- to two-year mark, explaining around 5 to 7 percent of the variation. The oil supply shock is also the highest contributor to the US dollar–Indian rupee exchange rate from all the four shocks we have considered, explaining 12 percent of the variation at the two-year horizon.

Table 2 shows the sum of the contributions of the four shocks. They explain around 32 percent of the variation in output at the one-year horizon and over 34 percent of the variation at the four-year horizon. For inflation, these numbers are lower at 20 percent at the one-year and two-year horizons.

T A B L E 2 .   **Sum of Contributions of Four Shocks to the Forecast Error Variance 1 to 48 Months After the Shock**

Months →	1	6	12	24	48
Stock market	7.507	13.592	24.179	23.955	23.236
USD/INR	3.977	12.435	13.170	17.412	18.721
10-year bond	6.154	14.292	20.509	19.667	19.372
Dollar reserves	4.066	7.272	22.659	24.681	20.891
Inflation	2.763	8.600	20.094	20.011	19.869
Ind. Prod.	6.636	19.370	32.553	36.340	34.983

Source: Authors' calculations.

In the long run, the four shocks combine to explain close to 20 percent of the financial market variables as well. The overall picture emerges that these four shocks form a substantial component of the variation in output and inflation for the Indian economy, especially the monetary policy and oil price shocks.

We think that these numbers should be interpreted as representing an upper bound of the effects of these shocks. As mentioned earlier, we also ran our SVAR and LP estimation by using the IIP gap and year-over-year inflation rate, rather than the log-level specification presented in the baseline results. When we redo the variance decomposition calculations using the "gap" specification for the macro variables, we find that the contribution of the shocks is somewhat diminished. This is especially true for output. The total contribution to industrial production from the four shocks drops to 16 percent at the one-year horizon and 18 percent at the four-year horizon. While still sizeable, these numbers are definitively smaller than the 35 percent range for the baseline specification. The reduction in the contribution comes primarily from the monetary policy and oil supply shocks.

Further, there are two more qualifiers that we should mention with this analysis. First, the usual disclaimer about omitted variable bias about vector autoregressions applies here. In other words, if there are important variables that we are missing, the variance decompositions numbers have the potential to be overstated. We address this concern in the Appendix and show that our results are similar when we include a variety of other Indian macro variables. Second, this analysis looks at the net aggregate effects of these foreign shocks. If there are distributional effects of these shocks, it is possible that those effects cancel out and we are missing important transmission mechanisms. While we do not undertake this disaggregated analysis, we believe it to be a promising area for future research.

5. Conclusion

Recently, there have been increasing concern about the resilience of the Indian economy to international developments. This paper is an attempt to understand the quantitative relevance of foreign shocks for the Indian economy and to shed some light on the transmission mechanisms.

Our analysis finds substantial effects of three main foreign shocks to the macroeconomy: US monetary policy, economic policy uncertainty, and oil. We do not find a major role for geopolitical risk shocks. The spillovers associated with US monetary policy as well as the increase in global economic uncertainty have quantitatively significant bearings on Indian financial markets consistent with the global financial cycle narrative. The effects of these shocks are similar to what we would expect with domestic demand shocks. On the other hand, oil shocks act as textbook adverse supply shocks. After an adverse supply shock, there is a simultaneous drop in output and an increase in prices, and this effect is persistent. The shock also causes a general worsening of financial conditions with a reduction in total reserves, a depreciation of the rupee, and a fall in stock prices. Among the external shocks considered, consumer price inflation is largely driven by uncertainty shocks and oil supply shocks.

These four shocks combined can explain up to 35 percent of the variation in Indian output at business cycle frequencies. Thus, while the size of the effect is substantial, the response of Indian output is lower relative to the response of an index of global output and also lower relative to the output of peer developing countries. This suggests that the Indian economy is relatively more resilient to international shocks. However, this resilience potentially comes at the cost of India not reaping the gains from beneficial global shocks. Our results also highlight an important implication about counter-cyclical policy responses to stabilize the business cycle. In response to adverse foreign shocks, which cause disruption in financial markets and lower economic activity, the main tool of monetary policymakers would be to lower interest rates to help the economy recover. While the government bond rate tends to decline in response to these shocks, the magnitude of the fall is modest. Given that the foreign shocks are quantitatively relevant, our analysis suggests that quantifying the role of counter-cyclical policy should be an important agenda for further research.

We conclude with an important caveat. Our analysis provides insights for the transmission of four key foreign shocks. Since our aim is to use the instrumental variables strategy to guide our analysis, we were limited in the choice of instruments available and, hence, in the nature of foreign shocks that we could investigate. We believe, and have hopefully convinced the reader, that these are quantitatively relevant shocks. Yet there are important

transmission mechanisms, particularly through the banking system, variations in foreign currency denominated debt issuances by the private sector, and trade linkages that have not been explored here. We leave it to future research to bring more data and novel econometric techniques that can guide us in understanding the resilience of the Indian macroeconomy.

A. Appendix: Results from Local Projections Estimation Strategy

A.1. Baseline Results for India from LP-IV Estimation

We directly estimate the impulse response functions for six Indian macro variables available at monthly frequency: industrial production, CPI, nominal exchange rate US dollar/Indian rupee, yields on 10-year government bonds, stock market index, and US dollar value of total foreign reserves (minus gold) as a measure of international liquidity (coded as RAXG_USD in IMF/IFS). Following Mishra et al. (2016), we de-trend seasonally adjusted industrial production using an HP filter with a monthly frequency smoothing parameter of 14,400. In the SVAR-IVs, we directly use seasonally adjusted monthly industrial production from the IMF/IFS database along with linear time trends.

One advantage of using LP-IVs instead of SVARs is that we do not need to have a balanced sample across all horizons. We can use more information for estimating the IRFs at shorter horizons. Our sample starts in April 1994 and extends up to December 2017.

The IRFs are computed from the second-stage LP estimation method described in Equation 6. The graphs plot the β^h at each horizon. While the US Federal Reserve has a legal mandate to focus explicitly on three domestic variables, shocks identified for the US economy may be predictable by foreign economy's conditions (Obstfeld 2019). As such, we control for 12 lags of the industrial production gap, consumer price level-based inflation, and the instrument/external shock. Because of the shorter sample length, we only add six lags for the other variables, namely, nominal exchange rate US dollar/Indian rupee, yields on 10-year government bonds, stock market index, US dollar value of total foreign reserves (minus gold), and global industrial production index obtained from Baumeister and Hamilton (2019). The countries included in this index account for 79 percent of the global petroleum product consumption and 75 percent of the IMF World Economic Outlook estimate of global GDP. When estimating IRFs for oil supply shocks, we also control for six lags of global oil production (millions barrels/day), changes in oil inventories as a ratio of last year's global oil production, and the real spot price of West Texas Intermediate oil.

Figures 9–13 report the LP-IV estimated impulse responses to the four main shocks of interest. A caveat with LP estimation is the irregular shape of the impulse responses compared to relatively smooth IRFs obtained with VAR estimation. One could potentially smooth out these IRFs using methods developed in the literature (Barnichon and Brownlees 2018). That requires taking a stand on which turning points are the truth and which are noise. As a result, we chose to report the LP-IV-based IRFs.

A.1.1. Monetary Policy Shocks

Figure 9 reports the LP-IV-estimated impulse responses to US monetary policy shocks. Consistent with the global financial cycle hypothesis, we find that US monetary policy has important spillovers to the Indian economy. The rupee depreciates on impact and exhibits a persistent depreciation with respect to the US dollar. The Indian stock market index gradually falls, and the stock of foreign reserves declines. The 10-year Indian government bond yields and the consumer price level fall.

A.1.2. Economic Policy Uncertainty Shocks

Figure 10 reports the LP-IV-estimated impulse responses to increase in global economic policy uncertainty. Industrial production falls, the rupee depreciates, and consumer prices fall. The stock market initially falls to recover after one year.

Since the economic policy uncertainty measure only starts in 1997, we also estimate the IRFs with respect to one standard deviation in VIX (the Chicago Board of Trade's Volatility Index) orthogonalized to past Indian macro variables as well as world industrial production. Figure 11 reports the LP-IV estimated impulse responses to an increase in the VIX measure of uncertainty in global financial markets. The effects are more pronounced with this shock, while we do not claim identification of the exogenous shock in this case. The impulse responses are similar to global economic policy uncertainty shocks, largely because of a high correlation between the two series.

A.1.3. Geopolitical Risk Shocks

Figure 12 reports the LP-IV-estimated impulse responses to the increase in geopolitical risk in the rest of the world. There is no significant effect on industrial production, while the price level falls in response to the global geopolitical risk. Somewhat surprisingly, we find an increase in industrial production roughly 14 months after the shock. However, the financial variables seem to move in India's favor with improvement in the value of foreign reserve holdings. This would be consistent with India being a relatively safe option when there is increase in geopolitical risk in the rest of the world.

A.1.4. Oil Supply Shocks

Figure 13 reports the LP-IV estimated impulse responses to the increase in oil prices because of a reduction in supply. The industrial production gap falls and recovers eight months after the shock. Reliance on oil imports implies that consumer prices go up in India, the rupee depreciates, and foreign reserves go down.

A.2. Comparison to the World and BRCS

We next document the responses of world industrial production and industrial production in the BRCS block to external shocks. We believe this is useful for at least two reasons. One, the response of WIIP and BRCS-IP is helpful to understand the nature of the foreign shock, whether contractionary or expansionary. Two, it can help place a benchmark on the quantitative magnitudes one should expect when we look at India-specific macrovariables.

Our measure of WIIP is an extended version of the OECD's index of monthly industrial production in the OECD and six major other countries developed by Baumeister and Hamilton (2019). The countries included in this index account for 79 percent of global petroleum product consumption and 75 percent of the IMF World Economic Outlook estimate of global GDP. Our measure of BRCS-IP is the average of industrial production obtained for Brazil, China, Russia, and South Africa from the World Bank's *Global Economic Monitor*. Further, we control for past 12 lags of the instrument and world industrial production in our regression to account for the predictability of these shocks to past lags as well as to improve the precision of our estimates. In addition, we control for 12 lags of the US federal funds rate, US industrial production, and US CPI inflation. When estimating the IRFs for oil supply shocks, we also control for 12 lags of global oil production (millions barrels/day), changes in oil inventories as a ratio of last year's global oil production, and the real spot price of West Texas Intermediate oil. This is important to identify oil supply shocks from oil demand and other confounding factors.

Figure 14 plots the impulse responses to the shocks described earlier, namely, shocks to US monetary policy, economic policy uncertainty, geopolitical risk, and global oil supply shocks.

Consistent with the hypothesis of the global financial cycle (Miranda-Agrippino and Rey 2018), we find that contractionary surprises in the US federal funds rate indeed have contractionary effects on world industrial production and BRCS industrial production. Similarly, surprise increases in economic policy uncertainty and global oil prices cause a reduction in world industrial production.

The magnitude of responses of Indian industrial production is comparable to the average response of Brazil, China, Russia, and South Africa.
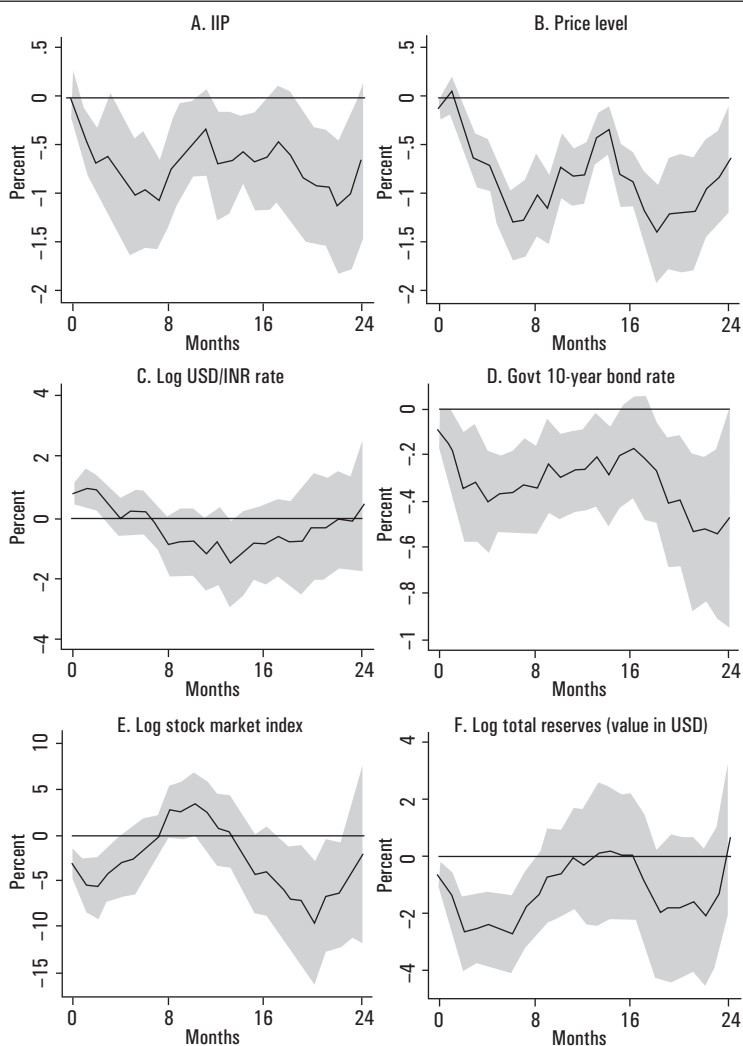
A.3. Figures for Local Projections Estimation

F I G U R E   9 .   LP Baseline Responses of the India Economy to One Standard Deviation Monetary Policy Shock
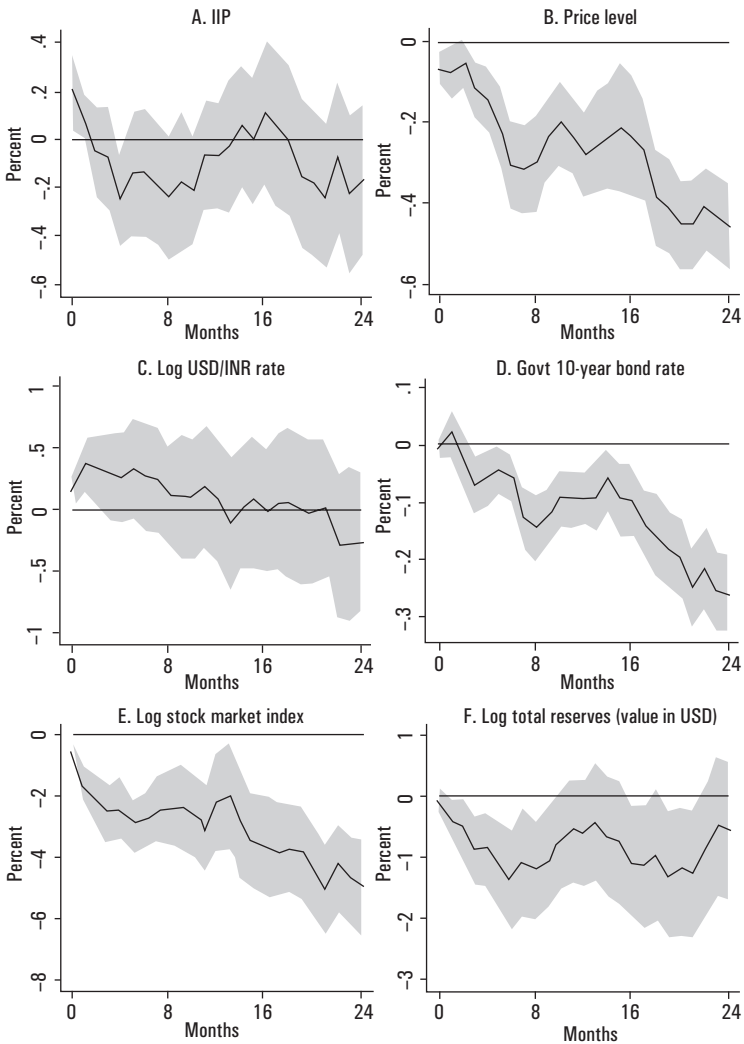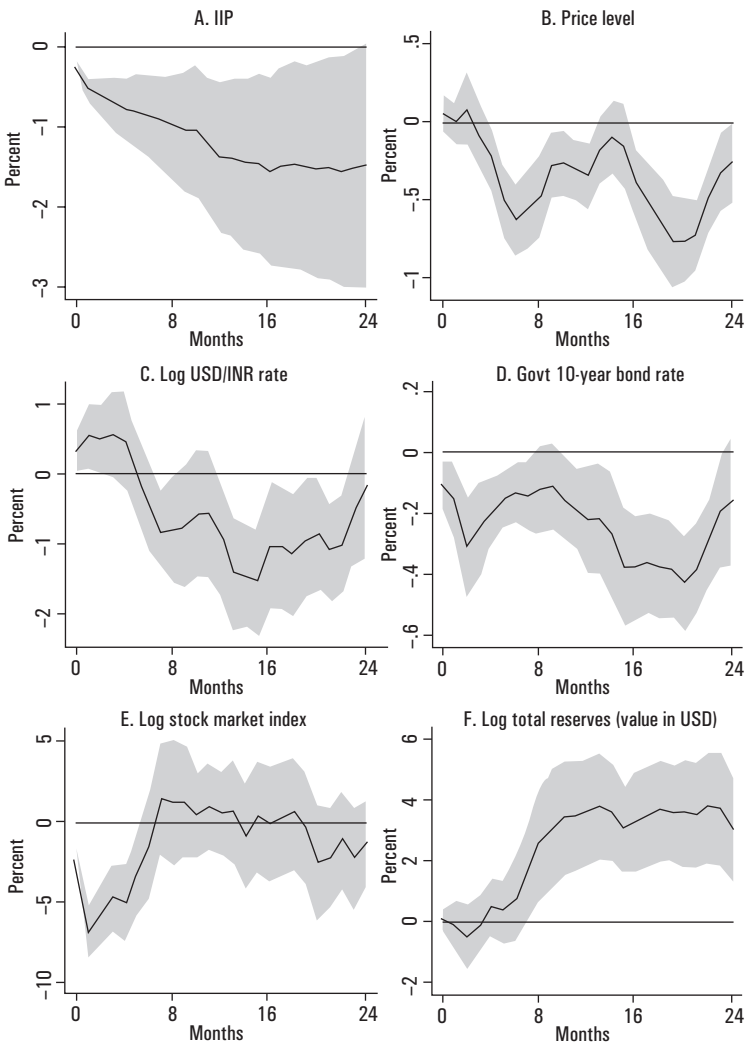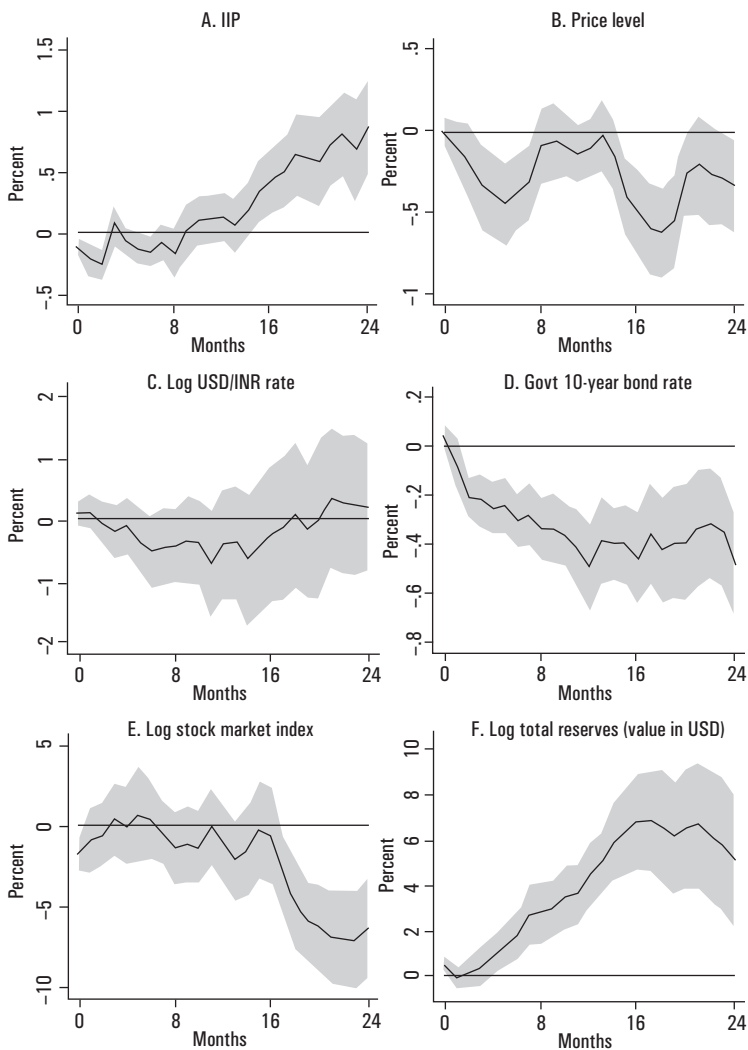

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to the US monetary policy rate. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. Sample: April 1994–December 2017. See text for details.

FIGURE 10. **LP Baseline Responses of the India Economy to One Standard Deviation Economic Policy Uncertainty Shock**
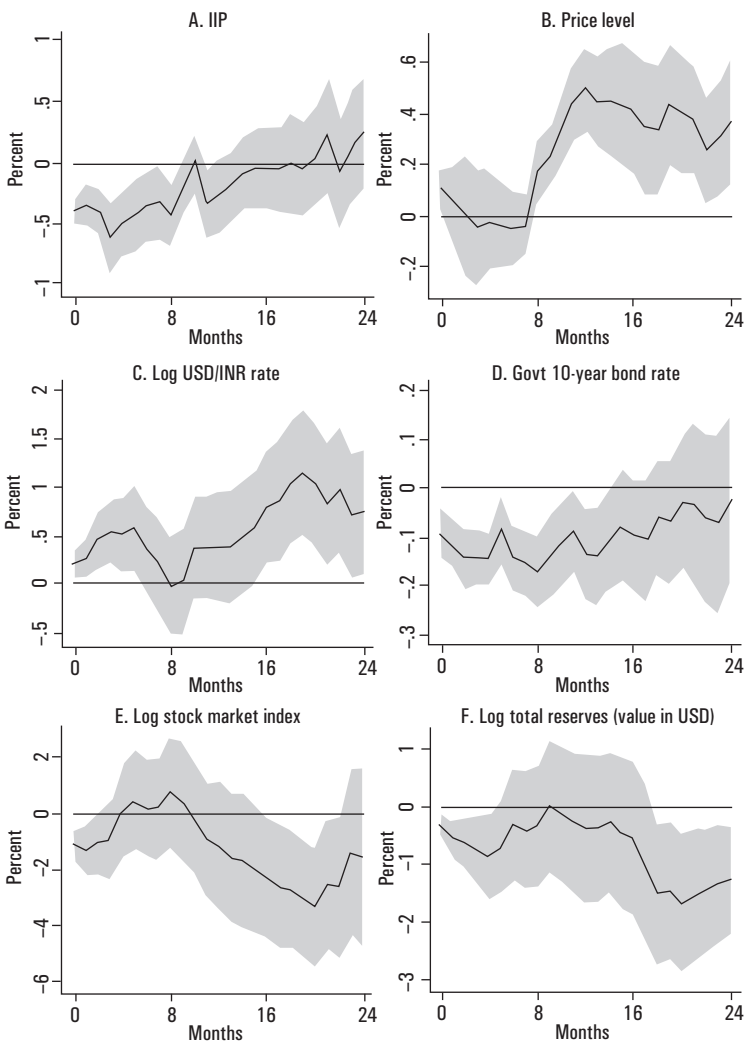

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to global EPU. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. Sample: February 1997–December 2017. See text for details.

F I G U R E 1 1 .   **LP Baseline Responses of the India Economy to One Standard Deviation Movement in VIX**

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation change in VIX. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. Sample: April 1994–December 2017. See text for details.

F I G U R E   1 2 .   **LP Baseline Responses of the India Economy to One Standard Deviation Geopolitical Risk Shock**

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to GPR measure. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. Sample: April 1994–December 2017. See text for details.

FIGURE 13. **LP Baseline Responses of the India Economy to One Standard Deviation Oil Supply Shock**

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to oil supply. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. Sample: April 1994–December 2017. See text for details.

F I G U R E 1 4 .   **Industrial Production Responses for India, World and BRICS excluding India ("BRCS") to One Standard Deviation Shock**
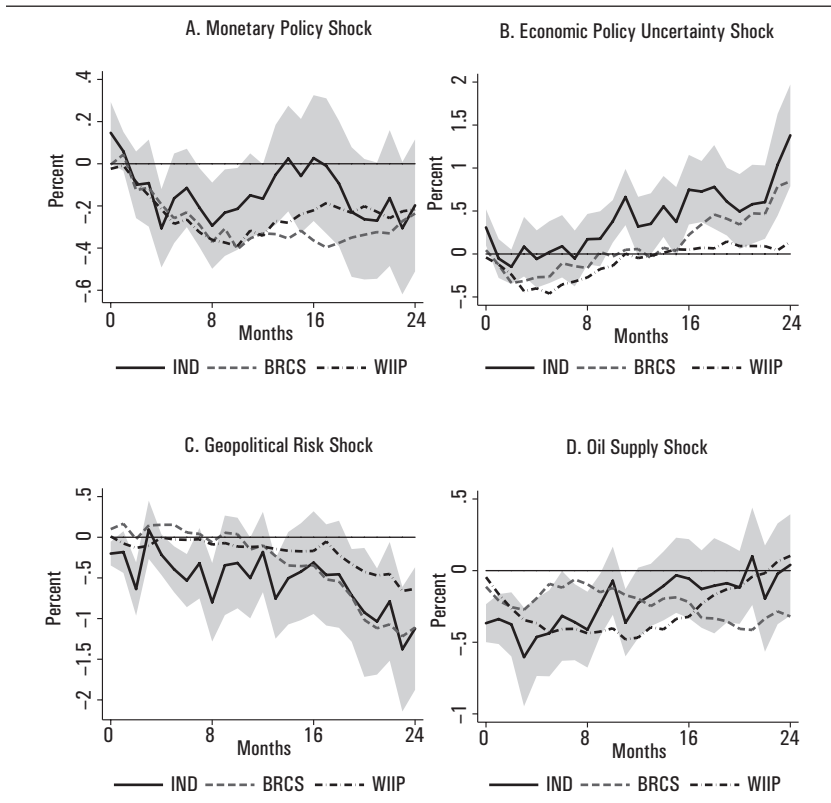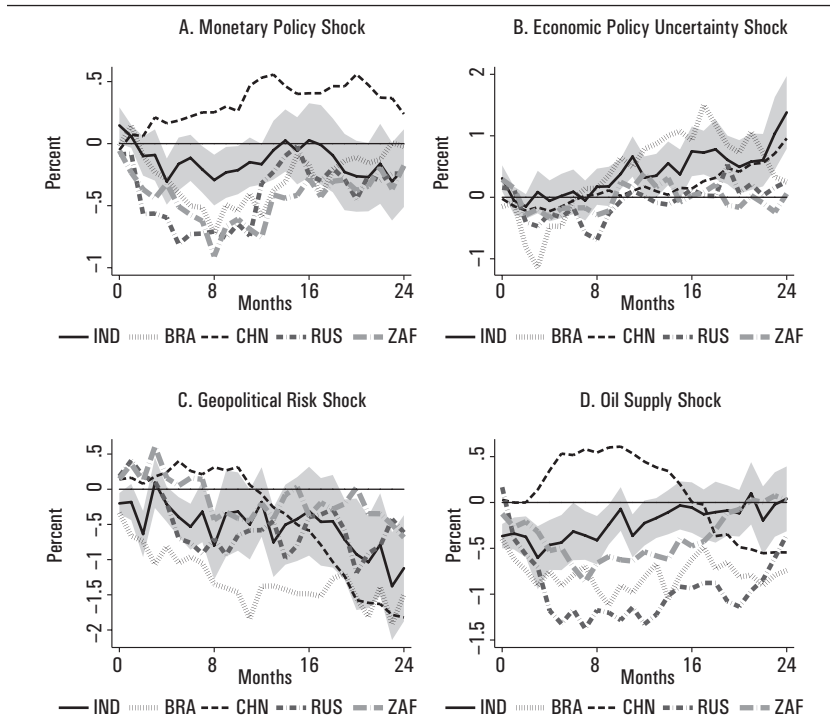

Source: Authors' calculations.

Notes: The response of industrial production of World (OECD + BRICS + Indonesia) region, BRCS region and India to a one standard deviation shock. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. WIIP is an extended version of the OECD's index of monthly industrial production in the OECD and six major other countries developed by Baumeister and Hamilton (2019). The BRICS industrial production data are from World Bank Global Economic Monitor. The sources for shocks are described in the text. Sample: April 1994–December 2017. See text for details.

A.4. Additional Figures: BRICS Country Comparisons and Sub-period Analysis

F I G U R E   1 5 .   **Industrial Production Responses for India, Brazil, China, Russia and South Africa to One Standard Deviation Shock**
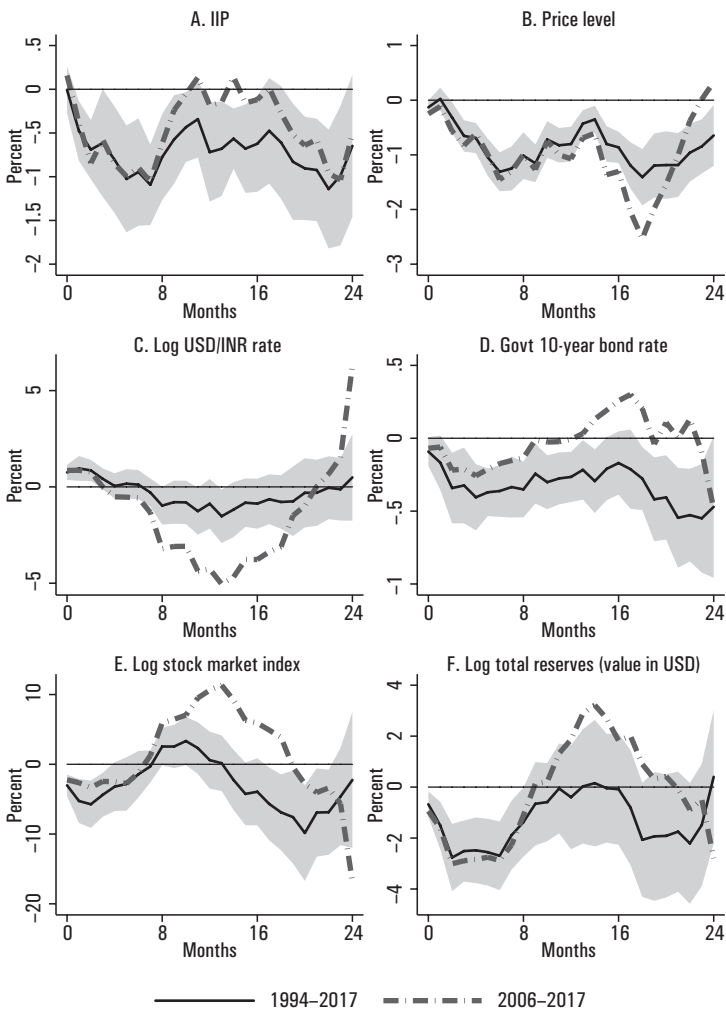

Source: Authors' calculations.

Notes: The response of industrial production of BRICS countries to a one standard deviation shock. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The BRICS industrial production data are from the World Bank Global Economic Monitor. The sources for shocks are described in the text. Sample: April 1994–December 2017.

FIGURE 16. **LP Sub-period Responses of the India Economy to One Standard Deviation Movement in Monetary Policy Shock**
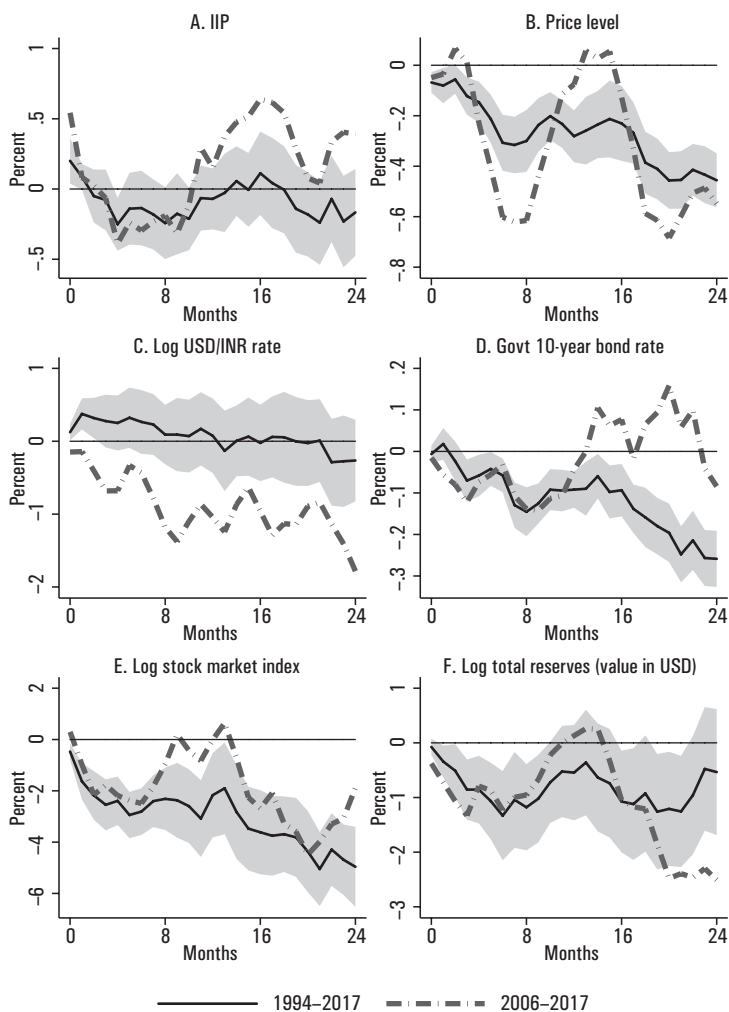
Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to US monetary policy rate. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. The solid line plots the estimated IRF for full sample from April 1994 to December 2017. The dashed line plots the estimated IRF for post-2005 sample from January 2006 to December 2017.
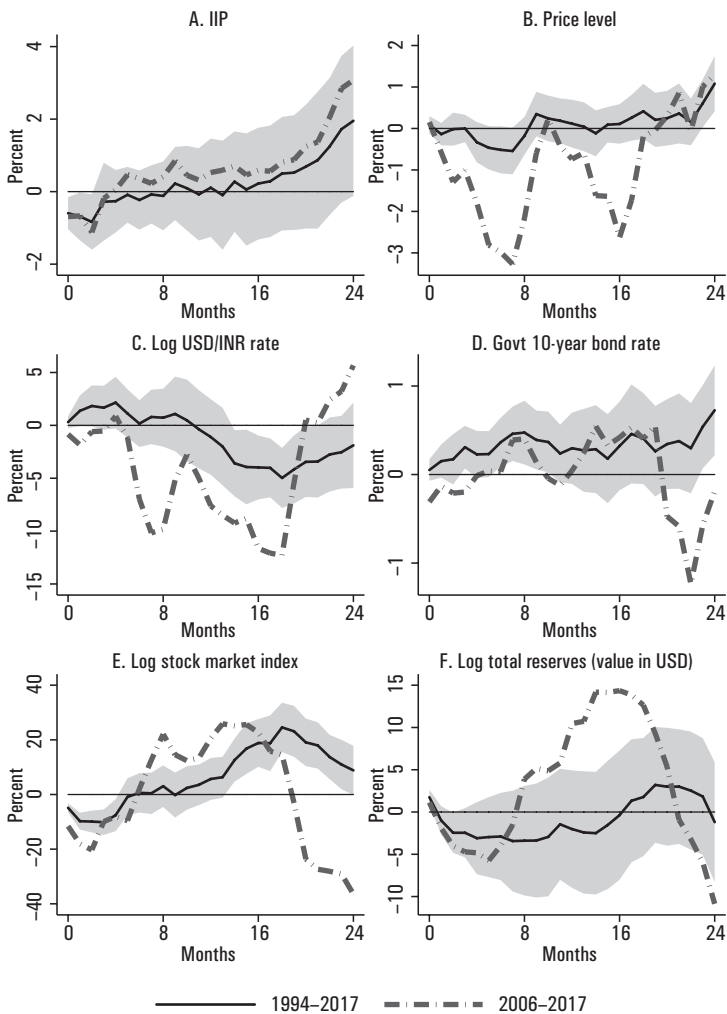
F I G U R E 1 7 .   LP Sub-period Responses of the India Economy to One Standard Deviation Movement in Economic Policy Uncertainty Shock

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to global EPU. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. The solid line plots the estimated IRF for full sample from April 1994 to December 2017. The dashed line plots the estimated IRF for post-2005 sample from January 2006 to December 2017.
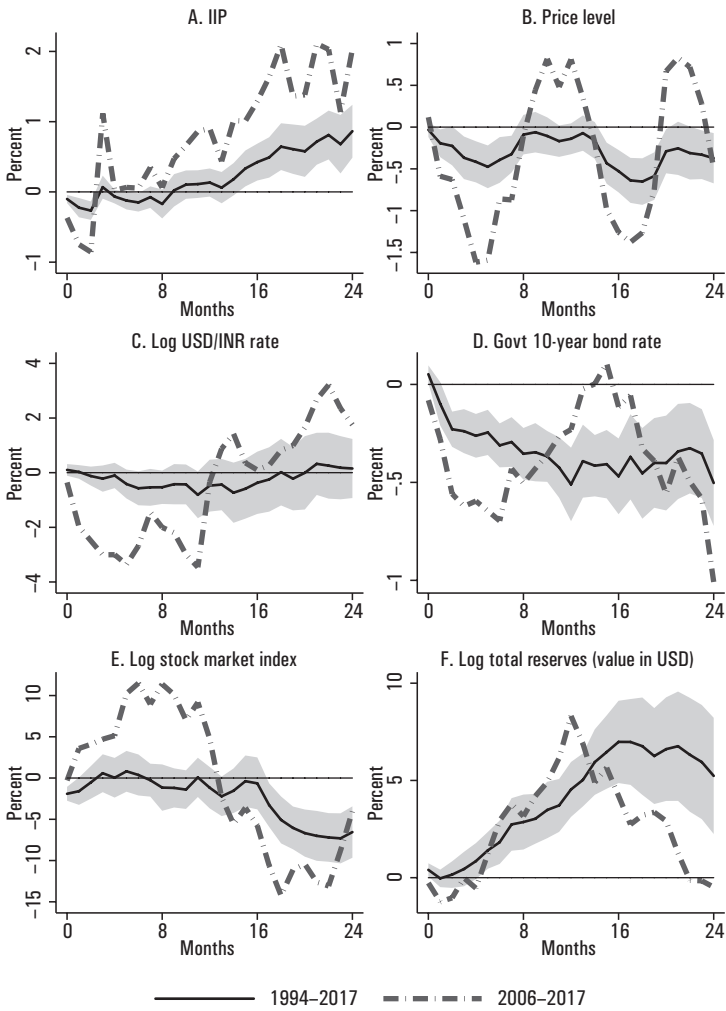
FIGURE 18. LP Sub-period Responses of the India Economy to One Standard Deviation Change in VIX
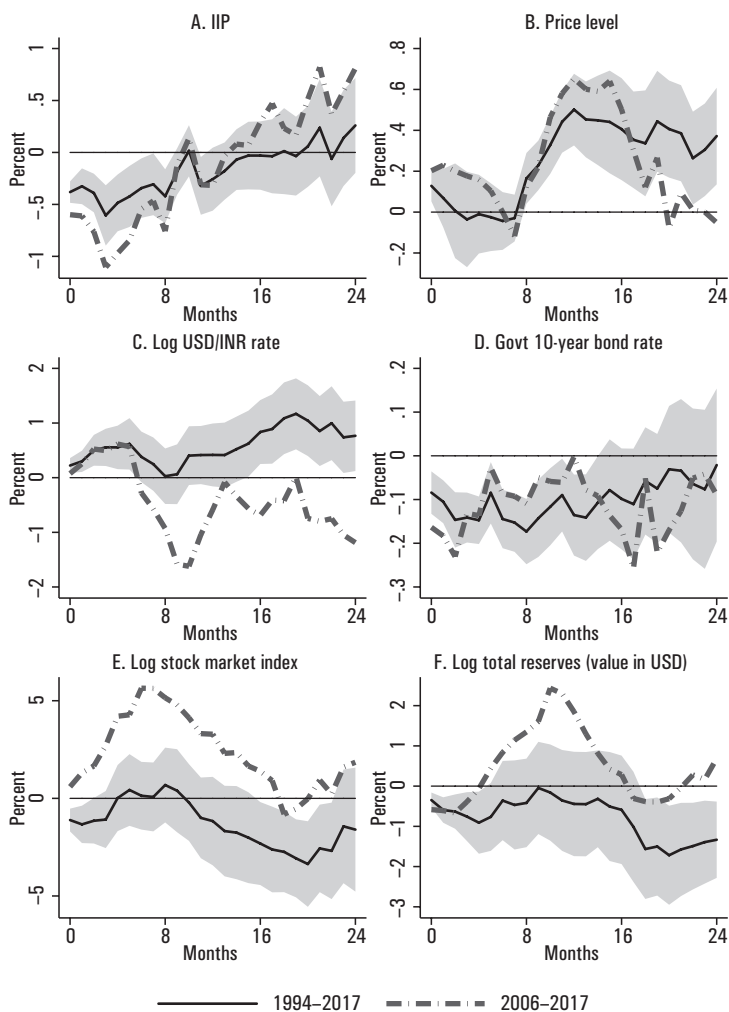

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation change in VIX. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. The solid line plots the estimated IRF for full sample from April 1994 to December 2017. The dashed line plots the estimated IRF for post 2005 sample from January 2006 to December 2017.

FIGURE 19. **LP Sub-period Responses of the India Economy to One Standard Deviation Movement in Geopolitical Risk Shock**

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to GPR measure. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. The solid line plots the estimated IRF for full sample from April 1994 to December 2017. The dashed line plots the estimated IRF for post-2005 sample from January 2006 to December 2017.

F I G U R E   2 0 .   **LP Sub-period Responses of the India Economy to One Standard Deviation Movement in Oil Supply Shock**

Source: Authors' calculations.

Notes: The response of monthly industrial production, CPI, US dollar/Indian rupee nominal exchange rate, 10-year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a one standard deviation identified shock to oil supply. The shaded areas in the figure represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey–West standard errors. The sources for data series are described in the text. The solid line plots the estimated IRF for full sample from April 1994 to December 2017. The dashed line plots the estimated IRF for post-2005 sample from January 2006 to December 2017.

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Comments and Discussion*

Chair: **Anne Krueger**
SAIS, Johns Hopkins University

Mihir Desai
Harvard Business School

I really enjoyed this paper. I have a couple of fairly straightforward quick thoughts about this. Karthik mentioned different models for IPF papers, including the grand synthesis, which is a great model. What we have here is the other kind of IPF paper, which is the 'big facts' kind of paper. So this is an effort to bring together state-of-the-art methods, a big question which is the effect of foreign shocks, and hopefully some big facts. In that sense, the paper is incredibly simple and straightforward. There are four big shocks—US monetary policy, oil supply, economic policy uncertainty, and certainly geopolitical risk—and there is a whole bunch of outcome variables. There is underneath this a sense of having some real variables and then having some prices and some financial markets. I think the paper could benefit from being more distinct and thinking about real versus financial variables in a more concrete way. Then, there is up to a third of the variance in some of these outcome variables over 2–4-year horizons.

Some of my comments are a bit about tone and a bit about content. First, I think the paper might benefit from being reorganized more specifically around real versus financial variables. I would be more interested in some sense in diving more deeply into the elements of industrial production as opposed to doing the kitchen sink on a bunch of financial variables.

The way the paper is written is that the world and the BRCS pictures raise the question, "Are the shocks valid?" We should think about it as a relative measure of Indian vulnerability, which is not really done in the paper currently. I came in with a prior that actually the Indian economy is highly levered to the global economy. It is actually a lot more resilient, and hence the talk about how GDP of 8 percent is possible regardless of what the global economy is going to do.

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* To preserve the sense of the discussions at the India Policy Forum, these discussants' comments reflect the views expressed at the IPF and do not necessarily take into account revisions to the conference version of the paper in response to these and other comments in preparing the final, revised version published in this volume. The original conference version of the paper is available at www.ncaer.org.

Second, in terms of these actual shocks, the pictures need to be highly annotated and elaborated. I want to know what is going on inside these pictures. As regards US monetary policy, I would blow it out, annotate it, and make sure that the periods being highlighted are actually the interesting periods. I would also want to know a lot more about the relationship between the outcome variables and the geopolitical risk and economic policy uncertainty variables.

The monetary policy uncertainty variable has been carefully constructed. It has futures prices and seems interesting when the innovations in the future prices are regressed against its lags and other possibilities. In contrast, I am skeptical about the economic policy uncertainty and geopolitical risk variables as they do not seem rigorous. I found the risk measure of the oil price shock to be amorphous and unsatisfying, and I am not sure what it is really trying to capture. I think the paper would benefit if this were explained more.

I would also like to see something about time trends and regimes in the paper. I think one of the underlying themes would be that we would become less exposed, and understanding that over time would be really helpful. It is also important to assess if the headline of the paper is substantiated by the underlying data. For instance, the shocks on monetary policy and oil do not necessarily seem large in terms of the magnitudes. In fact, I came away thinking that monetary policy innovations do not reflect a very significant change. I also did not see any large changes in prices and stock market levels, or at least changes I might have expected with a one standard deviation change in these measures. So, to me, the shocks delineated in the paper do not seem nearly as disruptive as one would have expected, and the recoveries have been quick. However, oil supply is an exception. I think the shock pertaining to oil supply on the industrial production is interesting and real but, otherwise, I am not sure if the shocks are big.

I would organize the paper in terms of the world, BRICS, and India, on monetary policy shocks. The big surprise to me is that the world is the most sensitive, the BRCS less so, and India even less so. It is not clear to me why that should be so. Second, these are baskets of countries, but India is a single country, which makes it even more surprising. Also, to cite one example on BRCS, Russia figures in the oil supply shock, which has left me puzzled. If we were to use these as benchmarks, as opposed to just validation that the shocks are real, then it needs to be done at the single-country level: I would want to see what Brazil looks like, what Malaysia looks like, what some of the other countries look like, and then we can talk about the relative resilience or fragility of the Indian economy. Similarly, on the oil supply shock, I would have expected India to be much more sensitive than other parts of

the world, but that is not really showing up. We see some sensitivity but not in a significant way. Again, this is more surprising as these are bundles of countries, and not a single country.

So, altogether, I think the headline of the paper should be about the resilience of the Indian economy as opposed to the headline currently given. Finally, I confess that the variance decomposition is hard to interpret. I think, as the authors acknowledge in the paper, that is an extreme upper bound on what these effects are. So when we add them all up, more than a third of the variance at four-year horizons in industrial production is being accounted for by these four shocks. We know that when we do this analysis, they can easily add up to more than a 100 percent. So it is a bit of an unsatisfactory analysis as I, in some sense, reach the opposite conclusion. My instinct is to conclude more about the resilience of the Indian economy than its fragility. However, it is a really interesting paper.

Pami Dua
Delhi School of Economics

In the backdrop of increasing globalization, the susceptibility of the Indian economy to external shocks is expected to rise. In this context, the authors examine the impact of external shocks, including US monetary policy, oil supply, uncertainty in global economic policy, and geopolitical risks on the Indian economy. They analyze the dynamic causal effects of these shocks on the Indian economy, namely, output, inflation, foreign exchange reserves, exchange rate, government bonds, and stock prices. The estimation consists of an external instrument strategy with LP-IVs and SVAR-IVs (Gertler and Karadi 2015). The results highlight the impact of these global shocks on the economy and financial markets of India.

I congratulate the authors for a competent piece of work and for using state-of-the-art econometric techniques. I will divide my comments into three parts. The first has to do with the data that are used and construction of variables. The second part has to do with the estimation methodology, and lastly I will look at the results.

Comments on data and construction of variables

1. In the introduction section, the authors mention that since India accounts for a large share of total world oil consumption, a change in India's demand for oil is likely to be an important driver of the

global price of oil, and so on. The data published by the US Energy Information Administration suggests that India is a significant but small player relative to the USA, which has a 20 percent share, China, with a 13 percent share, and the European Union, with about 15 percent share in the oil market, while India imports only about 5 percent of the total oil production. Therefore, changes in India's demand for oil may not be major drivers of the global price of oil.

2. My second comment is on the construction of the economic policy uncertainty and geopolitical risk measures. Since these are based on news events, these are media perceptions about policy uncertainty and political risks, and it is not very clear whether these indices measure the true underlying uncertainties. The authors recognize that there is a measurement error, and they correct for that using dummy variables. Still, one needs to bear in mind that we are measuring perceptions, and I am not sure whether this correction of the measurement error fixes the problem. My suggestion is that one could try out an alternate measure of uncertainty as a robustness check of the main results.

3. The authors utilize the 10-year government bond rate as an indicator of monetary policy. Normally, studies use rates at the shorter end, such as the call money rate, three-month T-bill rates, or the repo rate, for the monetary policy indicator. The problem with using the 10-year bond is that it is possible to think of cases where the central bank's policy only moves the short end of the yield curve and, therefore, the 10-year bond will not be able to capture this. This might be a possible reason behind weak transmission of monetary policy in the results.

Comments on estimation

4. For constructing the monetary policy instrument, the authors follow Nakamura and Steinsson (2018) by using the first principal component of the change in contracts. However, Gürkaynak et al. (2005) show that monetary policy is captured by two separable dimensions: change in the federal funds rate and change in forward guidance. The Cragg–Donald (1997) test (presented in Gürkaynak's paper) suggests that the two factors should be included in the model. These two factors certainly explain more variation in the surprises than a single factor. It may be useful to see whether these two factors might improve results.

5. The authors utilize an HP filter, but it is known that the filter may create spurious cycles and, therefore, the robustness of results may be checked using alternate filters.
6. The identification strategy for the SVAR is not described in the paper. The authors may also look into the issue of puzzles emerging from the results. The authors use the Cholesky decomposition, and what should be noted are the drawbacks from this decomposition. In particular, these results are order dependent.

Comments on results

7. There is a positive impact of a monetary policy shock on the Indian IIP at t = 0 and then it is negative in the long run, while for other countries it is positive. It would be interesting to understand why the Indian IIP displays this reversal.
8. If we want to study the impact of shocks on the Indian economy, then one could use benchmarks like the episodes of slowdowns or recessions. One can then measure the impact of these shocks against that of these slowdown episodes. One may also utilize the US business cycle/growth rate cycle for this purpose. This will provide a better idea of the impact of the shocks.
9. The results indicate a positive impact of the shocks on the stock and bond markets. However, stock markets do not typically show sensitivity to any shocks in the long run. In the near or medium term, there may be an impact, but it is difficult to explain the sensitivity in the long run for stock markets. As regards bond markets, one can argue that monetary policy can have an effect. A minor point about the bond market is to consider whether the bonds are in the primary or secondary markets. This might also make a difference to the analysis.

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General Discussion

Anne Krueger, the chairperson, asked whether the effect of domestic shocks would be larger or smaller in an open economy as opposed to a closed economy. She thought that the monsoons were probably the source of the largest domestic shocks, but cyclones had also caused large damage in previous years. How should policymakers respond to reduce output variability in such situations? Would that involve a greater focus on irrigation? She also noted that the government had often acted to stabilize oil prices, but those actions often involved granting greater subsidies. Hence, the economic impact involved both a price effect and the impact of a greater fiscal deficit.

Rajeswari Sengupta focused on the effect of a tightening of monetary policy originating in the US. It would involve a capital outflow from emerging markets, including India, to the US and a depreciation of the rupee. She thought that the role of capital flows as the primary transmission mechanism was missing from the SVAR model. She also noted that the capital outflow and exchange rate depreciation would lead the RBI to increase the interest rate; hence, the repo rate should also be included in the model. Second, she agreed with Pami Dua that the persistence of the effect on financial markets was surprising, given the evidence of a very quick effect on bond and equity markets. Finally, she was concerned that the measure of reserve changes may be affected by valuation changes. She preferred a focus on the RBI's interventions in the exchange market.

Rakesh Mohan pointed to the surprising result that India's economy was more resilient to shocks than the other BRICS countries. He thought it would be interesting to explore further the reasons for that result. Could it be related to measures of capital market or trade openness? He also agreed with Rajeswari Sengupta about the need to incorporate measures of domestic policy responses.

Devesh Kapur argued that the analysis should include the impact of global agricultural prices. Indian farmers gained substantially from the surge in prices between 2006 and 2012. Conversely, they have been very badly hit by the fall in prices in recent years.

Karthik Muralidharan asked if the model could address the question of whether the impacts of shocks were symmetric. He was also concerned that many would draw the conclusion that vulnerability against foreign shocks could best be achieved by not being integrated with the world economy, but that would come at the cost of not benefiting from the upside gains of integration.

Abhijit Banerjee noted that large portions of the Indian economy are largely unconnected to the global economy. A counter-example is provided

by oil prices. He suggested that the government often responded to oil price shocks by changing the composition of government expenditures rather than changing the overall budget balance. In effect, the government was sacrificing long-term investment to achieve short-run stability.

Banerjee and Montek Singh Ahluwalia were both concerned about the extent to which the model's coefficients already embodied typical or average policy responses. Thus, they thought it would be difficult to use the model to infer superior policy actions.

Rajnish Mehra expressed a desire to introduce an element of welfare analysis in evaluating the fluctuations in output and the costs of countervailing policy actions. A cost–benefit analysis would be useful to evaluate the net gains of hedging against shocks.

The session video, the paper, and all presentations for this IPF session are hyperlinked on the IPF program available on the NCAER website by scanning this QR code or going to the URL:
https://www.ncaer.org/IPF2019/Agenda/Agenda_IPF_2019.pdf