The Effect of Foreign Shocks on the Indian Economy*

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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 (LP-IVs) methods and structural vector auto regressions (SVAR-IVs), we document the dynamic causal effects of these shocks on Indian macro and financial variables. We find these foreign shocks significantly affect the stock market, USD/INR exchange rate and foreign exchange reserves. The magnitude of effects on industrial production is consistent with the effects of world industrial production as well as the comparable benchmark of BRICS nations' industrial production. Oil supply shocks and economic policy uncertainty shocks have largest effects on industrial production while increased global geopolitical risk leads to an increase in foreign reserves held by the government. Combined, these shocks explain about 15% to 35% of the variation in inflation, output and financial variables at two to four year horizons. These findings shed new light on the quantitative magnitudes of effects of foreign shocks to the Indian macroeconomy

Keywords: foreign shocks, Indian economy, monetary policy, uncertainty, local projection

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1 Introduction

In recent years, increases in financial and trade linkages to the rest of the world has exposed India to global economic spillovers. This has worked though a variety of channels, including reliance on imported oil, exposure of financial markets to capital flows driven by 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.[1]

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 Indian macroeconomy. Our contribution is along two main dimensions. First, we focus on estimating 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 been important for 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 tackle this issue, we rely on the recent progress made in the empirical macroeconomic 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 and structural vector autoregression 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 & Watson (2002), Mertens & Ravn (2013), Jordà, Schularick & Taylor (2015) and Ramey & Zubairy (2018). Stock & Watson (2018) provide a survey of the this literature focusing on the two main techniques of LP-IV (local projections instrument variables) and SVAR-IV (structural vector autogression instrumental variable). Based on the relevance

[1] See, for example Shin (2014).

for the Indian economy, our main focus will be on a core set of shocks which include U.S. monetary policy, oil supply, commodity prices, uncertainty and geopolitical risk.

As documented by Miranda-Agrippino & Rey (2018), there is a global financial cycle that appears to be important for driving international flows and that 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 to Indian financial markets has increased since the early 2000s. We will incorporate US monetary shocks into our analysis by using high frequency changes in futures 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 in a narrow window around the FOMC announcement can reasonably be expected to be solely due to unexpected changes in the monetary policy announcement. This approach has been used widely in the recent literature studying US monetary policy, see Gertler & Karadi (2015) for example.

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 world 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 world oil production is less than 1% and thus 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 to the Indian economy. While there is long literature on separating oil demand from oil supply shocks, see for example Kilian (2009), we use the recently developed measure of oil supply shocks in Baumeister & Hamilton (2019). They use a Bayesian approach to 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, Bank of England Governor Mark Carney (Carney (2016)) outlined an "uncertainty trinity" composed of economic, policy and geopolitical uncertainty as being 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 & Shin (2015). There is also evidence for the substantial effects of US uncertainty on emerging economies, see Bhattarai, Chatterjee & Park (2017). For recent work exploring the impact of US uncertainty on the Indian economy see Ghosh, Sahu & Chattopadhyay (2017). Our first measure of uncertainty captures global economic policy uncertainty as measured by Baker et al. (2016). This measure has found to have important effects on a wide variety of economic factors. We discuss how the change in their global measure is a good proxy for exogenous changes to global policy uncertainty shocks. Additionally, we will also consider a similarly constructed series of geopolitical risk of Caldara & Iacoviello (2018) who show that their measure has important effects on global capital flows.

Since our shock measures are available at a monthly frequency, for our main empirical analysis we build on the recent work of Mishra et al. (2016), who identify monetary policy shocks in India in a SVAR setting using monthly data.[2] Specifically we use the index of industrial production as a proxy for output and the consumer price index to measure inflation. In addition to these macro variables 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 variety of short-term rates that could have better helped assess the response of the Reserve Bank of India to foreign shocks, we found data availability and non-variation over time to be an issue for several of these measures. Moreover, since we want to focus on aggregate economic effect of foreign shocks, we concluded that a longer interest rate was the appropriate choice. We use the nominal exchange rate of Indian rupee with US dollar as our baseline measure of exchange rates. We found that using real and nominal effective exchange rates, that are constructed with a broader set of countries, gave similar results. Finally we also include an indicator for the aggregate stock market index and total foreign reserves (excluding gold) measured in US dollars.

Using the local projection and structural vector autoregression estimation strategy, we find qual-

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

itatively similar results. Here are the key findings. First, we corroborate Rajan (2015)'s 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, domestic stock market index and total foreign reserves held by the government decline. While financial market response is marked, the effect on inflation and output is somewhat 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%. To benchmark these effects, the peak drop in world industrial production is -0.4% and in BRICS industrial production is -0.3%.

Second, surprise increases in policy uncertainty measured with global economic policy uncertainty index 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% at 16 quarters, and becomes statistically indistinguishable from zero subsequently. Stock market index, government bond rate, and total reserves also decline significantly while rupee depreciates.

Third, geopolitical risk shocks leads to a delayed appreciation of the rupee, increase in total foreign reserves held by the government and expansion in 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 the global geopolitical risk goes up, 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 BRICS 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.

A common pattern that emerges in the impulse response analysis is the relatively small response of the 10 year government bond rate to these adverse shocks. This has potentially important implications from a policy stabilization perspective. For instance in the case of monetary policy, 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 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 similar to domestic demand shocks. In this case there is no longer a tradeoff and optimal monetary policy from conventional models dictates that the central bank lower rates. In light of this, we think there are a few 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 to the international shocks. This could happen if they fail to identify the shocks in a timely manner. Alternatively, even though these shocks act as demand shocks, the Reserve Bank of India might have been concerned about the prevailing level of inflation to lower rates too much. The second explanation is that the Reserve Bank is indeed responding to these shocks by changing interest rates but that the transmission mechanism of monetary policy in India is weak and thus there are no substantial effects on the long rate. Our results highlight that disentangling these channels is important to understand the role of monetary policy in overall stabilization policy.

Next 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 contribution of the four main shocks that we consider, we find that just these four shocks can explain from 15% up to 35% of the variation in the Indian financial and macro variables at two to four year horizons. We discuss some caveats to this analysis and recommend viewing these numbers as un 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 past 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 then be readily applied by researchers in policy institutions to broaden our understanding of the Indian macro economy. 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 local projections (LP) framework and vector autoregression framework (SVAR). 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 structural vector autoregression framework. Consider the structural VAR where y_t is an n x 1 vector of macroeconomic variables and α_i and A are n x n parameter matrices

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

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

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

where

$$u_t = B\varepsilon_t \quad (3)$$

and $A^{-1} = B$. Also note that $E[u_t u_t'] = BB' = \Sigma$. This reduced form VAR can be estimated in a straightforward manner. However identification of the impulse responses to the 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 then 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), then we will use the external instruments procedure developed by Stock & Watson (2002) and Mertens & Ravn (2013). In the external instruments methodology, the key requirements are to find instruments that are i) correlated with the shocks of interest, and ii) uncorrelated with the other structural shocks. Denote the structural policy shocks as ε_t^p and the structural non-policy shocks as ε_t^q. The reduced-form residuals from the corresponding policy and non-policy equations are denoted u_t^p and u_t^q respectively. For a given set of instruments Z_t, these two conditions can be formally stated as

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

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

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

Jordà (2005) introduced the local projections method for directly estimating impulse responses without relying on 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 local projections method is analogous to direct forecasting. With a correctly specified VAR and standard assumptions on invertibility, Stock & Watson (2018) and with some generality Plagborg-Møller & Wolf (2019) prove that the impulse responses estimated using structural VARs and local projections 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 local projections framework we will follow the recent literature (Jordà et al. (2019), Ramey & Zubairy (2018), and Barnichon & Brownlees (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 local projections instrumental variables technique, and relegate the discussion of SVAR-IV to the appendix. In the first-stage, we instrument a policy indicator (for example 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,..., H:

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

$\hat{x}_t$ 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 dependent variable, the policy indicator, the policy instrument, and the current and lagged conditioning variables that identify exogenous fluctuations in the instrument and improve precision of standard errors (see Stock & 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 Macro Data

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

Historically, Indian monetary policy has been conducted using multiple instruments: *price based* and *quantity based*. Starting from 3rd April, 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.[3] In the main text, we only report the impulse responses for ten year government bond rate. Data for this series is available for the longest duration and exhibits considerable time-variation relative to other series. In reality, we believe the policy makers used variety of instruments for macro- stabilization. Market driven variation in the ten year bond yields would capture the policy responses. Impulse responses for other policy indicator variables are available on request.

We also looked at the responses of nominal and real effective exchange rates. The results are similar to the USD/INR 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.

3.2 Foreign Shocks

In this section we provide the details for our four baseline shock measures that we use in the analysis.

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

3.3 U.S. Monetary Policy Shocks

For measuring exogenous changes in the stance of US monetary policy we follow the external instruments (proxy-SVAR) strategy developed in Mertens & Ravn (2013) and Stock & 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 & 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 quarter ahead eurodollar futures contracts. Following Nakamura & Steinsson (2018) we take the first principal component of the change in these contracts in a thirty minute window around the FOMC announcement. Recent work in the literature has highlighted a potential issue with this approach by finding counterintuitive effects of monetary policy shocks based on information effects, see for example Nakamura & Steinsson (2018) and Lakdawala (forthcoming). To overcome this problem, we undertake two steps. First, we cleanse the instrument from information effects using real GDP forecasts from 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, current quarter, next quarter, two quarters ahead and three quarters ahead. Second we use this instrument to estimate the SVAR model of Gertler & Karadi (2015) and then 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 in the SVAR takes into account any predictability and information effects. Specifically, the SVAR model that we use for the US includes monthly data on industrial production, CPI price index, the excess bond premium of Gilchrist & Zakrajek (2012) and the 1 year Treasury rate as the monetary policy tool. The estimated monetary policy shock is plotted in the top left panel of Figure 1.

3.4 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 top right panel of Figure 1. 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 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 & Kamber (2019). Specifically, we construct a dummy indicator that takes the value one when the EPU index exceeds 1.65 times the unconditional standard deviation of the HP filtered data. The indicator is also plotted in the top right panel of Figure 1 (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.

3.5 Geopolitical Risk Shocks

We will use the geopolitical risk measure of Caldara & Iacoviello (2018). They use a methodology that is similar to Baker et al. (2016) and 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 with the actual realization of these events. Again to identify the causal effects of geopolitical risk shocks, Caldara & Iacoviello (2018) use a SVAR identified with Cholesky ordering. Since the same caveat about measurement error and attenuation bias applies, we follow same approach as above to construct a dummy variable. Both the GPR index (y-axis shown on left) and the dummy indicator (y-axis shown on the right) are plotted on the bottom left panel of Figure 1.

3.6 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 prices dynamics are driven by shocks to both oil supply and oil demand. Since India is the third largest consumer of oil (after U.S. and China), oil demand shocks can be expected to be driven in part by changes to India's economic conditions. On the other hand, India contributes to less than one percent of total world 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 & Hamilton (2019). They use a structural vector autoregression 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 the bottom right panel of Figure 1.

4 Results

4.1 Benchmark: World and BRICS Industrial Production

We first document the responses of both world and BRICS countries industrial production to the 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 place a benchmark on the quantitative magnitudes we should have in mind when we go to the 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 1997. Figure 2 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 shocks. 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 using a combination of putting our shocks directly in the SVAR or LP framework and using them as instruments in the SVARIV or LPIV framework. Specifically for the monetary policy and oil supply shock 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 2 displays the responses to a one standard deviation shock from a bivariate SVAR framework which include log of the industrial production index and the relevant shock. The impulse responses from the LP framework are similar and are put in the appendix. The blue dotted lines represent one standard deviation confidence bands, where the standard errors are computed using a bootstrap algorithm.

The top left panel 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% at the 1 year mark. The effects of the shock have faded by the 2 year horizon. These results are consistent with the hypothesis of global financial cycle (Miranda-Agrippino & Rey 2018), which find substantial global effects of US monetary policy. The top right panel shows the response to an increase in economic policy uncertainty. World industrial production falls on impact and the peak fall of 0.4% is reached around 6 months, The response stays around this level for about a year before reverting back. The bottom left panel 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 -0.15%. Finally, the bottom right panel 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%. In addition to having quantitatively meaningful effects, for all the four shocks the peak effect roughly around the one year mark is also statistically significant as indicated by the confidence intervals.

Figure 2 plots the impulse responses of industrial production for BRICS countries (Brazil, Russia, India, 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 economic policy uncertainty shock, the peak fall is around -0.25% (relative to roughly 0.4% for world index). We do see a notable difference in response to the geopolitical risk shock. After this shock, BRICS industrial production actually rises slightly on impact before falling. However, the magnitude of the fall is quite small and is statistically insignificant. Thus, while geopolitical risk shocks had a clear adverse effect on OECD countries, there appears not to be much of an effect on BRICS countries. Finally, the response to oil supply shocks is quite similar to the world industrial production case.

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

4.2 Impulse responses for India economy

In this section we present the impulse responses for the Indian macroeconomic 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, so we relegate the LP estimation results to the appendix. From an econometric perspective, SVARs and local projections 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 local projection results are presented in the appendix.

We estimate the impulse response functions for six Indian macro and financial variables available at monthly frequency: industrial production, consumer price index, nominal exchange rate

USD/INR, yields on ten year government bonds, stock market index and USD 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 for example Gertler & 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 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 HP filter with monthly frequency smoothing parameter of 14400. Further, we take the year-over-year percent 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 twelve lags. All figures are presented as responses to a one standard deviation "adverse" shock. This means that based on the responses shown for world and BRICS industrial production these shocks are expected to lower economic activity, for example an increase in U.S. 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 4 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% and .75% respectively. The response of prices, output and the government bond rate is not significant on impact but all three variables display a fall around the 6 month to 1 year mark. The peak fall in Indian industrial production is around 0.3%, which is quite similar to the fall in the BRICS 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 U.S. are prorogated 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 5. Industrial production has a sustained fall for over two years of around 0.2%. The size of this effect for Indian industrial production is very similar to the size of the fall in BRICS industrial production. This shock has larger on the financial markets that are persistent as well. The rupee depreciates and Dollar reserves and stock market falls. Quantitatively, the stock market index falls more than 1% on impact and the peak effect is more than 2% after a couple of months. Reserves fall by a quarter percent on impact but slowly fall more troughing at around 0.75% and staying lower for over a year. The rupee depreciates on impact and returns back 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 6 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 consumer price index is quantitatively small and statistically insignificant. Thus the response of Indian industrial production is consistent with the response of BRICS industrial production seen above: neither appear to be substantially affected by the geopolitical risk shock. Even for the 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 the financial variables, if anything, this adverse shock represents some beneficial effects with an increase in the 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, for India as with the BRICS countries in general

4.2.4 Oil Supply Shocks

Finally 7 shows the impulse response to the oil supply shock. Industrial production falls on impact by 0.3%. Relative to world and BRICS 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 from the four shocks we have considered the oil shock has the largest and 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 consumer price index 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% lower at the two year horizon. The stock market and 10 year government bond yield fall on impact but recover somewhat faster. Thus overall an adverse oil supply shock has large effects on both macroeconomic and financial market variables. Moreover these effects are felt contemporaneously and they 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 the financial markets and lower economic activity, the typical response of monetary policy makers 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 explored more. There are two reasons why this could be happening. First, it could be the case that the Reserve Bank of India is not responding enough to offset these shocks. But even if the

Reserve Bank of India 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 this latter explanation. For a prominent paper, see the recent work of Mishra et al. (2016).

4.3 Variance Decomposition for 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 local projection framework, however we found that in practice the estimates implied that the total contribution of the shocks would add up to more than 100%. This is a finding that is common in the literature, see for example Ramey (2016). Thus we use the structural vector autoregression (SVAR) framework to compute the forecast error variance decompositions. We include all four shocks at the same time in the following order: i)economic policy uncertainty shock,ii)geopolitical risk shock, iii)monetary policy shock and iv)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. The top left panel shows the contribution of the U.S. monetary policy shock. On impact, this shock has a small contribution, explaining about 1-2% of the movement in the macro and financial variables. At longer horizons we see a substantially bigger effect, explaining 13% of variation in output at the 1 to 4 year horizon. The U.S. monetary policy shock also has a similar long-term impact on the stock market and the 10 year bond rate explaining roughly 10% 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.

The top right panel 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 1 year horizon, explaining 4% of variation in output and 2% in inflation. At longer horizons the effect on output is even bigger explaining close to 9% of the variation. This shock also has relatively bigger effects on the Dollar reserves. At the 1 year horizon it explains 10% respectively of the dollar reserves. Finally this shock also explains around 5% of the long-term variation in the exchange rate and stock market.

The geopolitical risk shown in the bottom left panel. 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%. However, this shock has a bigger effect on prices. For inflation, the peak effect is in the long run (4 year) at around 10%. This shock also contributes significantly to the long-term variation in dollar reserves and the 10 year government bond rate, with contributions of 7% and 5% respectively.

Finally, the bottom right panel 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% of the variation in output. At longer horizons the contributions remain sizeable, with 16% explained at 2 years and 13% explained at 4 years. The effects of inflation are largest around the one to two year mark explaining around 5 to 7% 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% of the variation at the two year horizon.

Table 2 shows the sum of the contributions of the four shocks. They explain around 32% of the variation in output at the 1 year horizon and over 34% of the variation at the 4 year horizon. For inflation, these numbers are lower at 20% at the 1 year horizon and 2 year horizon. In the long-run the four shocks combine to explain close to 20% 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 prices 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% at the 1 year horizon and 18% at the four year horizon. While still sizeable, these numbers are definitively smaller than the 35% range for the baseline specification. The reduction in the contribution comes primarily from the monetary policy and oil supply shock.

Further, there are two more qualifiers that we should mention with this analysis. First, the usual disclaimer about omitted variable bias about vector auto-regressions applies here. In other words, if there are important variables that we are missing then the variance decompositions numbers have the potential to be overstated. We address this concern in the online 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 concerns 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 foreign shocks to the macroeconomy. The spillovers associated with US monetary policy as well as increase in global economic uncertainty have quantitatively significant bearings on Indian financial markets consistent with the global financial cycle narrative. 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 and this effect is persistent. 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. Among the external shocks considered, consumer price inflation is largely driven by the uncertainty shocks and the oil supply shocks.

Our estimations find that the magnitude of the effects of foreign financial shocks on India's industrial production is similar to the responses of world industrial production as well as a benchmark industrial production of BRICS nations. An implication is that Indian economy is significantly exposed to global business cycles. Another implication is about counter-cyclical policy responses to stabilize the business cycle. In response to adverse foreign shocks, which cause disruption in the financial markets and lower economic activity, the typical response of monetary policy makers would be to lower interest rates to help the economy recover. While the government bond rate tends to decline, the magnitude of the fall is quite small. 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 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 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.

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Table 1: Individual shock contribution to the forecast error variance

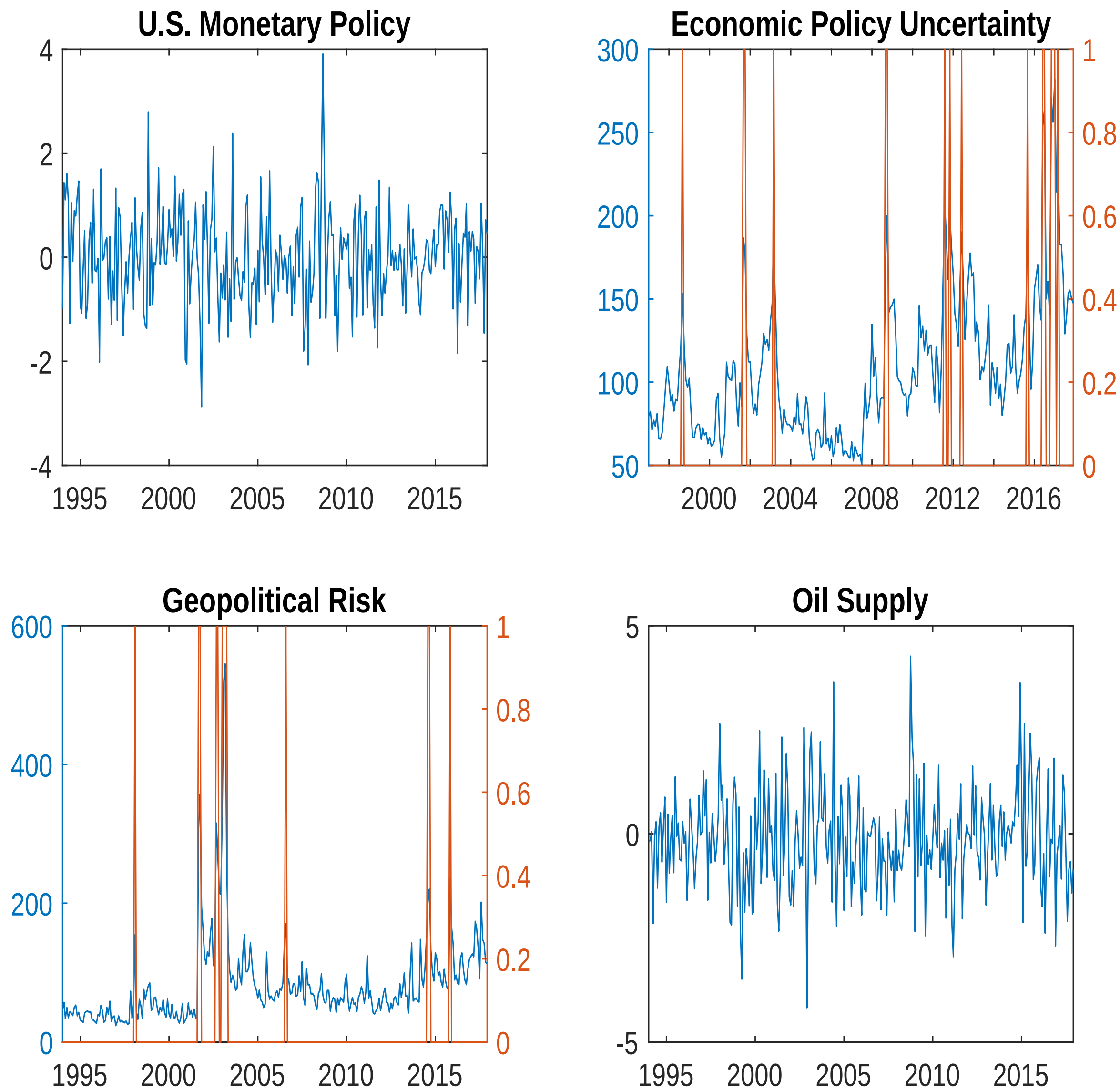
	Monetary Policy Shock					Ecoomic Policy Uncertainty Shock				
	1	6	12	24	48	1	6	12	24	48
Stock market	1.800	3.913	12.282	10.164	9.199	3.103	5.560	4.651	4.879	5.078
USD/INR	0.843	0.654	1.650	2.082	2.568	1.972	1.153	0.746	1.371	5.219
10 yr bond	2.572	0.447	8.494	11.728	7.327	0.078	4.169	5.085	3.190	2.516
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

	Geopolitical Risk Shock					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 yr 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

Table 2: Sum of contribution of four shocks to the forecast error variance

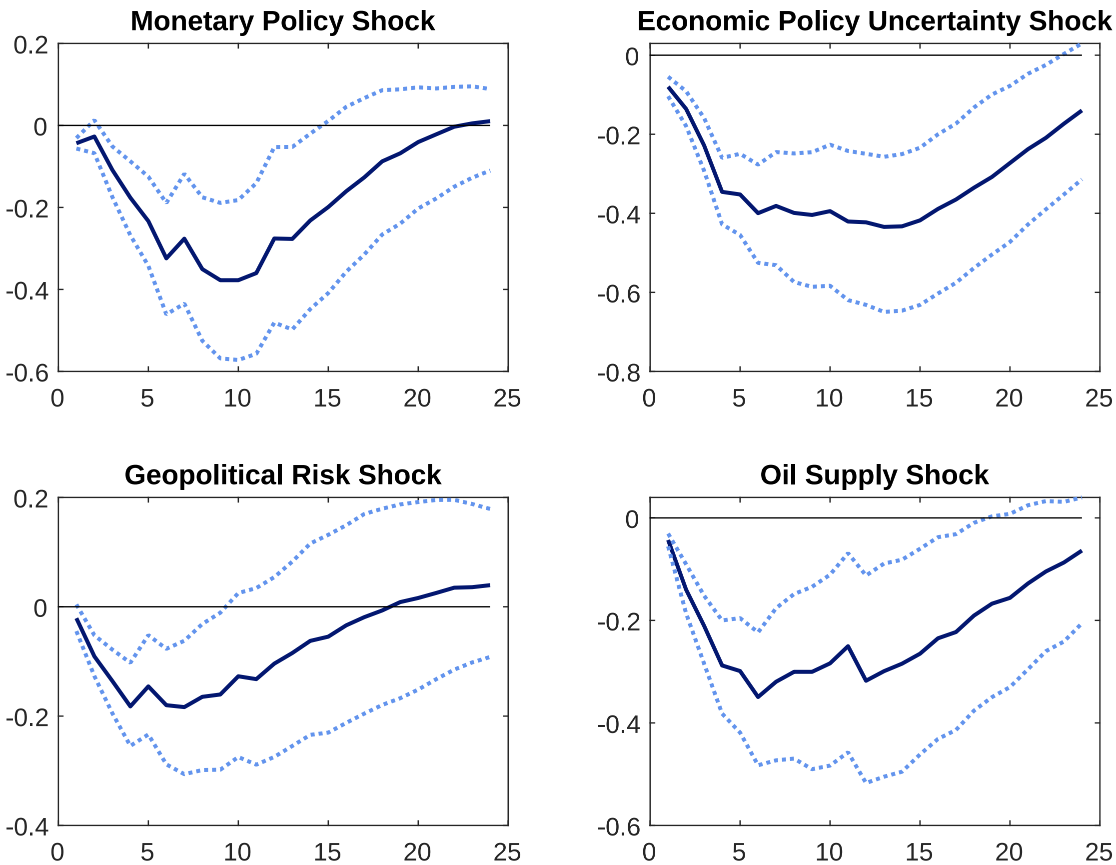
	1	6	12	24	48
Stock market	7.507	13.592	24.179	23.955	23.236
USD/INR	3.977	12.435	13.170	17.412	18.721
10 yr bond	6.154	14.292	20.509	19.667	19.372
Dollar Reserves	4.066	7.272	22.659	24.681	20.891
Inflation	2.763	8.600	20.094	20.011	19.869
Ind. Prod.	6.636	19.370	32.553	36.340	34.983

Figure 1: Foreign Shocks



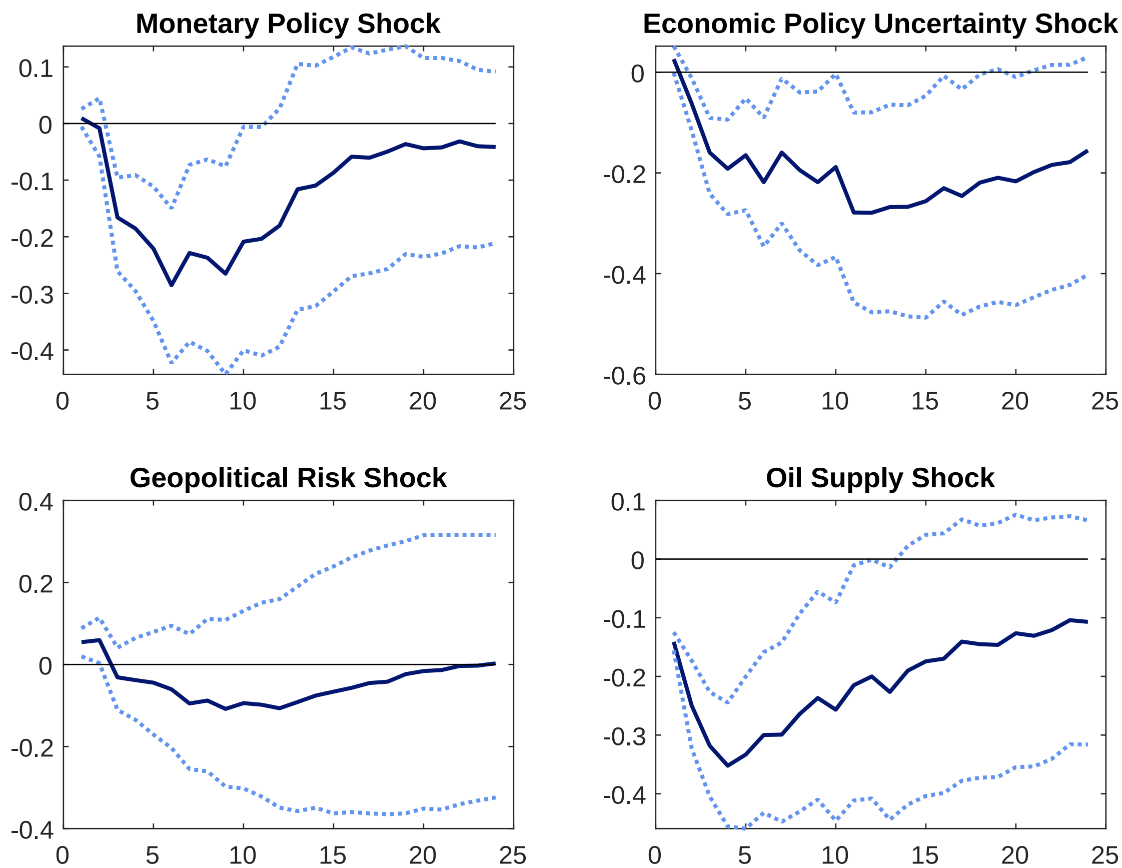
Notes: This figure plots the four main shock measures. The sources for data series are described in the text. Sample: February 1994 - December 2017. See text for details. *Authors' own calculations*.

Figure 2: Response to 1 std dev shock: WIIP



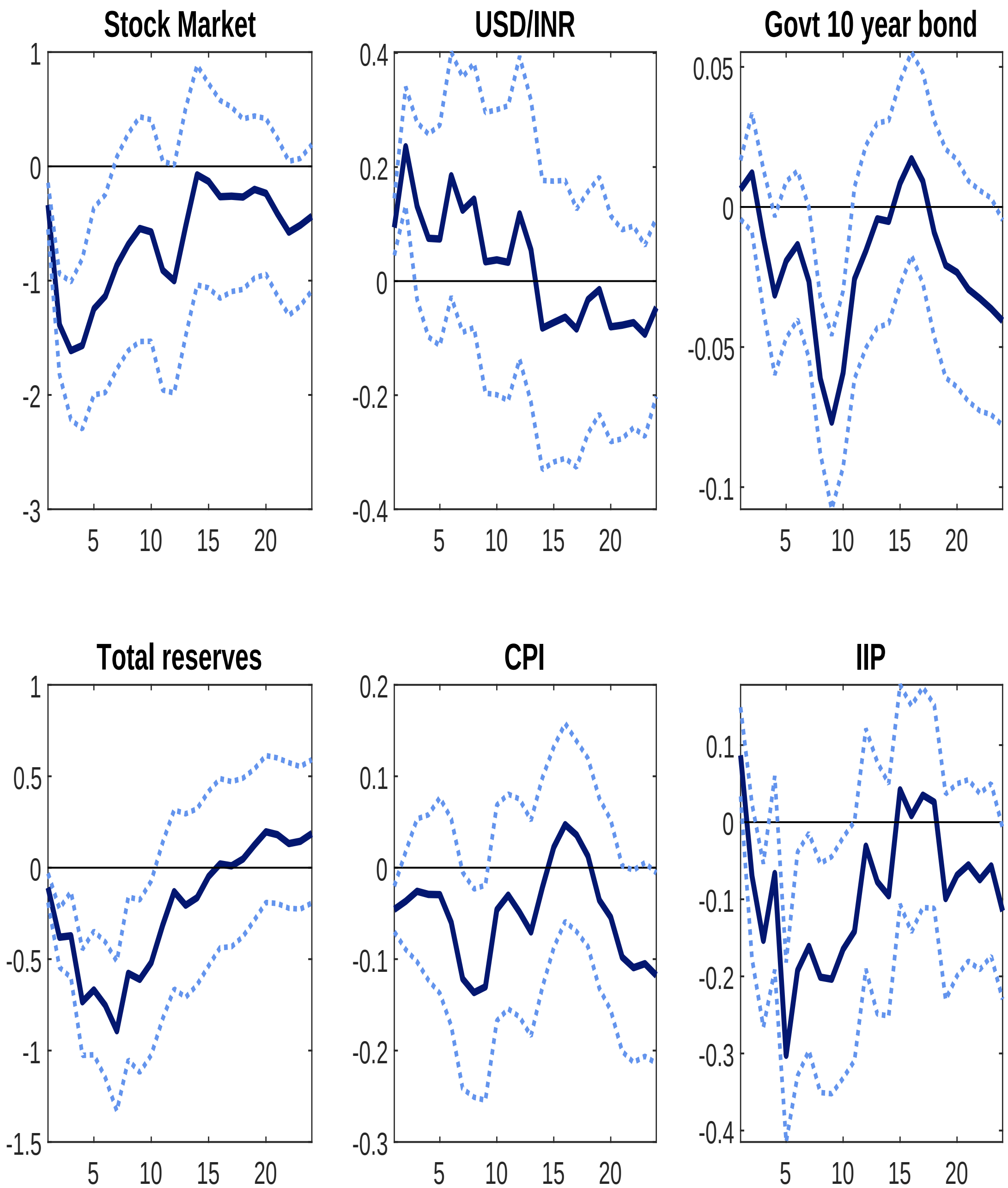
Notes: SVAR estimated response of world industrial production (OECD + BRICS) region to a 1 std deviation shock. Shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler & Karadi (2015). WIIP is an extended version of the OECD's index of monthly industrial production in the OECD and six major other countries developed by Baumeister & Hamilton (2019). The sources for shocks are described in the text. Sample: February 1997 - December 2017. See text for details. *Authors' own calculations.*

Figure 3: Response to 1 std dev shock: BRICS IIP



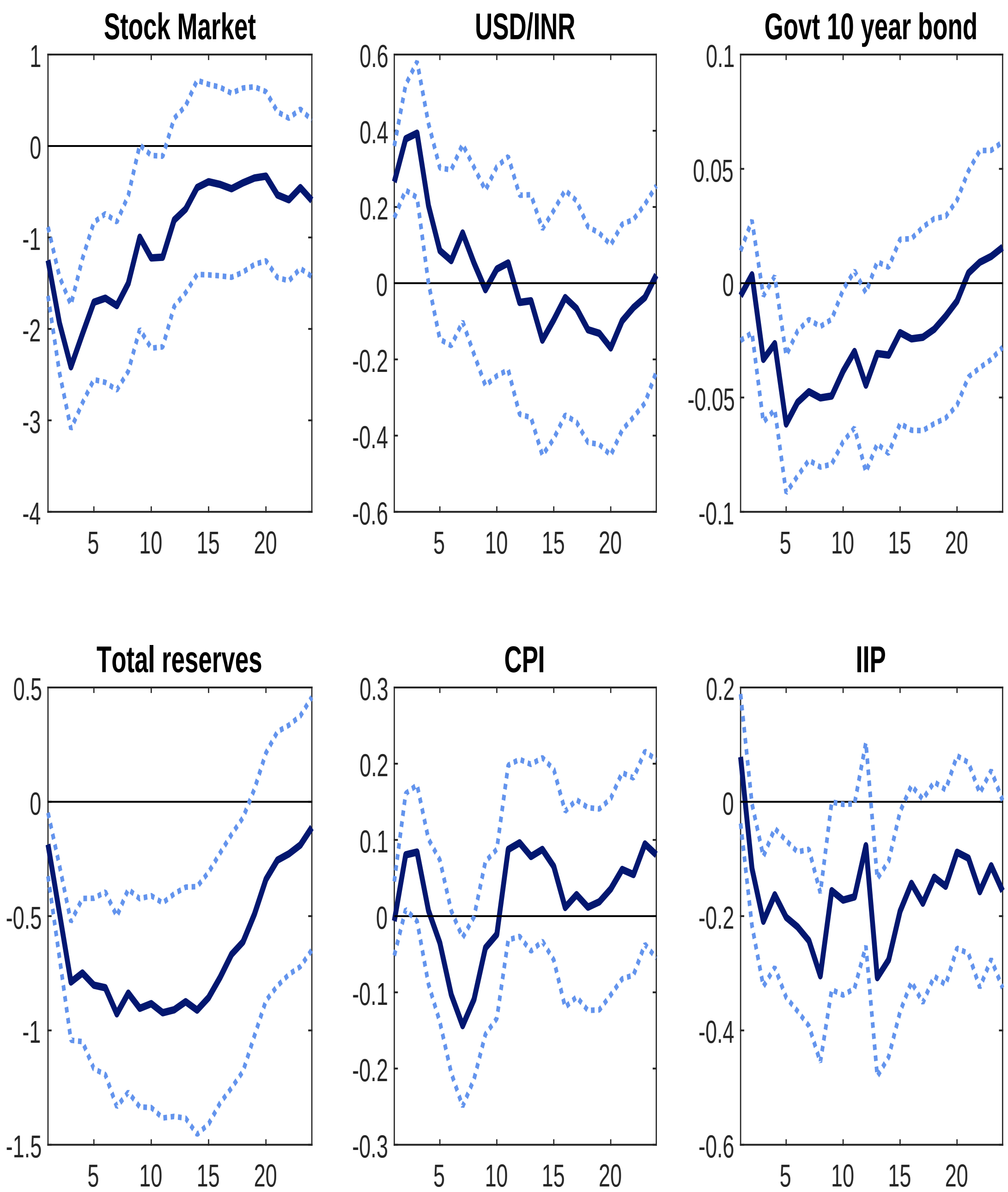
Notes: SVAR estimated response of monthly seasonally adjusted industrial production in the four BRICS region to a 1 std deviation shock. Shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler & Karadi (2015). The BRICS industrial production data is from World Bank Global Economic Monitor. Sample: February 1997 - December 2017. The sources for shocks are described in the text. See text for details. *Authors' own calculations*.

Figure 4: SVAR response to monetary policy shock



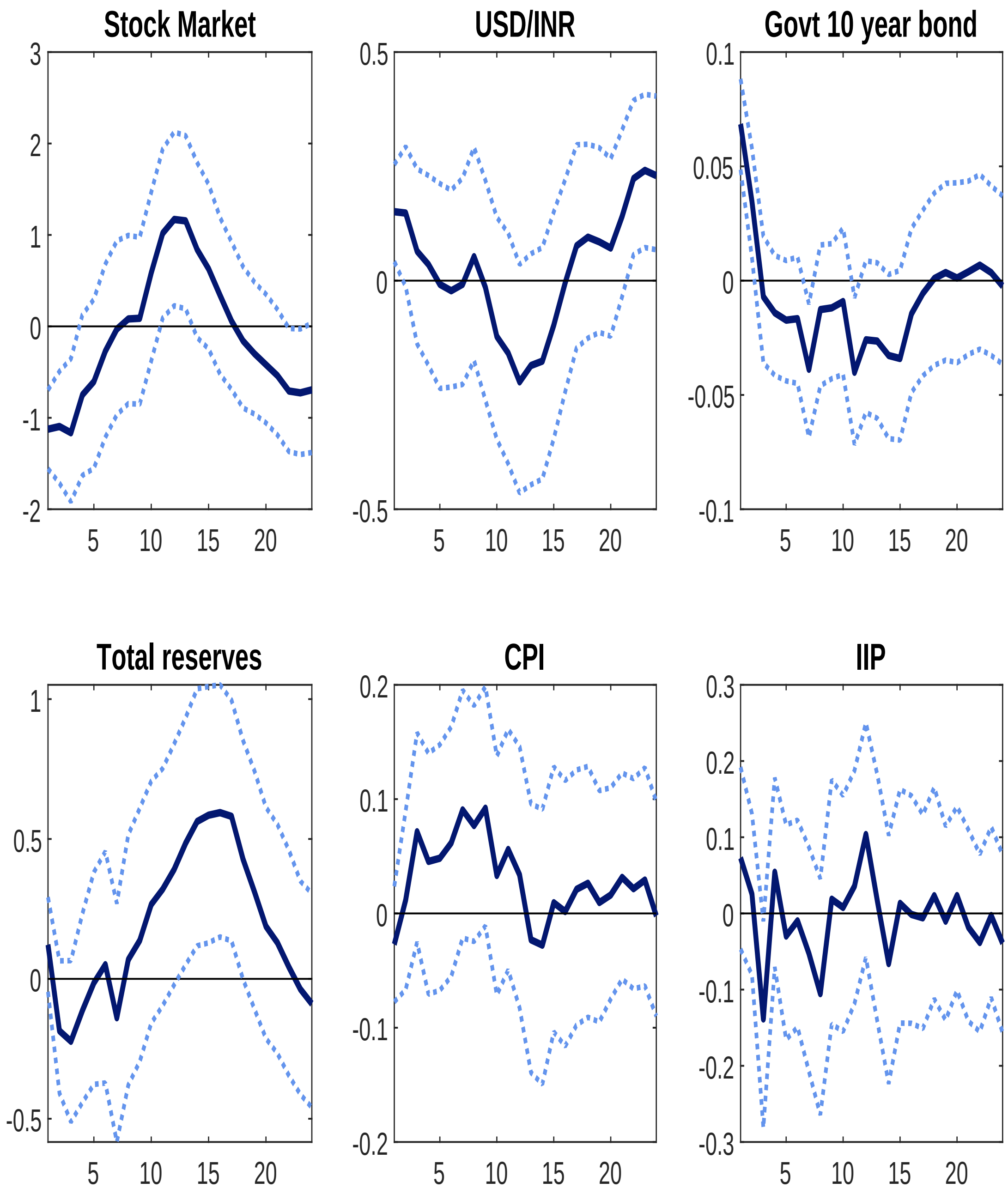
Notes: SVAR estimated response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation identified shock to global economic policy uncertainty. Shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler & Karadi (2015). The sources for data series are described in the text. Sample: February 1997 - December 2017. See text for details. *Authors' own calculations*.

Figure 5: SVAR response to economic policy uncertainty shock



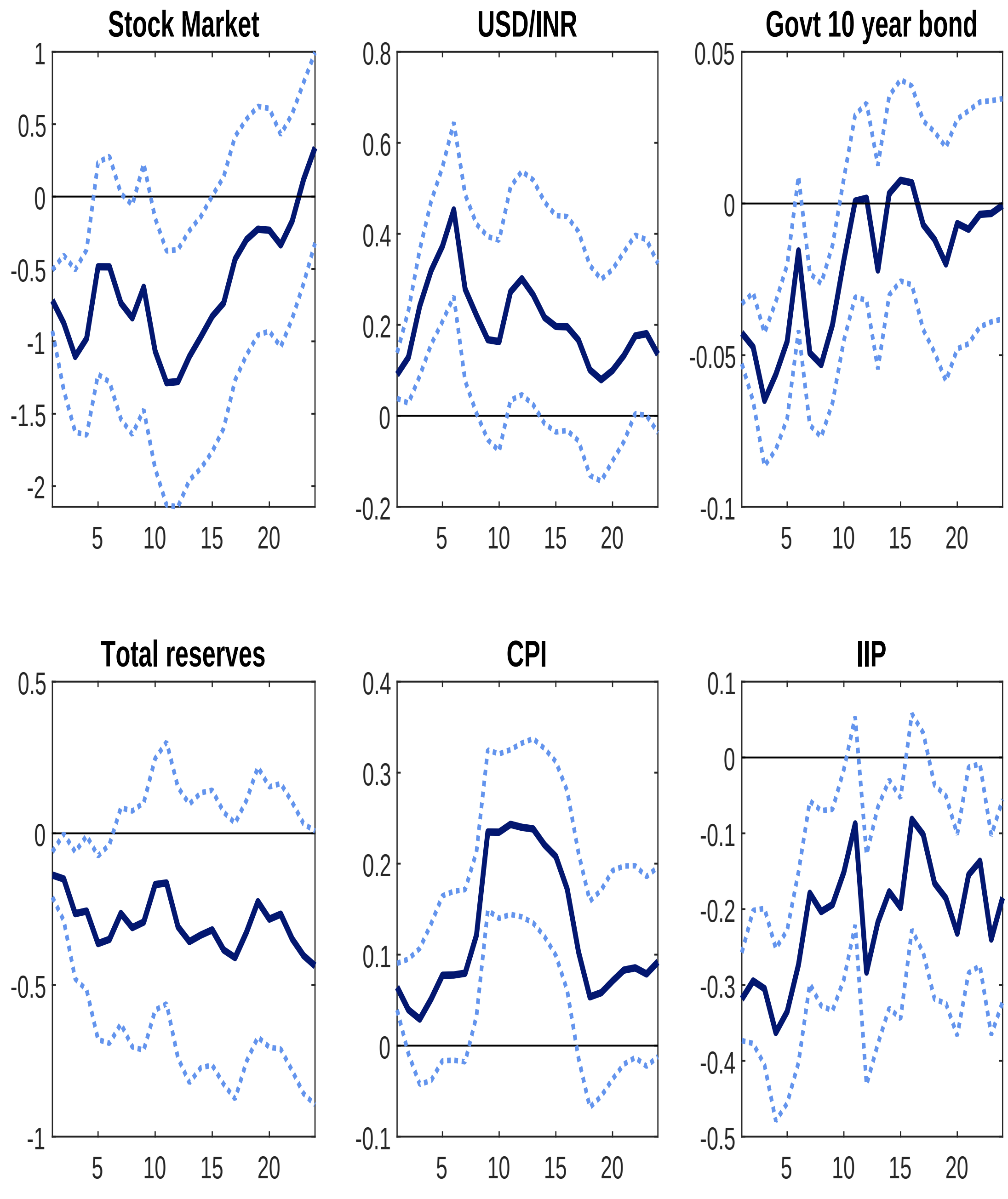
Notes: SVAR estimated response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation change in VIX. Shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler & Karadi (2015). The sources for data series are described in the text. Sample: February 1997 - December 2017. See text for details. *Authors' own calculations*.

Figure 6: SVAR response to geopolitical risk shock



Notes: SVAR estimated response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation identified shock to geopolitical risk measure. Shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler & Karadi (2015). The sources for data series are described in the text. Sample: February 1997 - December 2017. See text for details. *Authors' own calculations*.

Figure 7: SVAR response to oil supply shock



Notes: SVAR estimated response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation identified shock to oil supply. Shaded areas represent one standard deviation confidence intervals. Standard errors are bootstrapped as in Gertler & Karadi (2015). The sources for data series are described in the text. Sample: February 1997 - December 2017. See text for details. *Authors' own calculations*.

Results from local projections estimation strategy

Benchmark: World Industrial Production

We first document the responses of world industrial production to the external shocks. We believe this is useful for at least two reasons. One, the response of WIIP is helpful to understand the nature of the foreign shock, whether it is contractionary and expansionary. Second, it can help place benchmark on the quantitative magnitudes one should expect when we go to India specific macro variables.

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 & Hamilton (2019). The countries included in this index account for 79 percent of world petroleum product consumption and 75 percent of the IMF World Economic Outlook estimate of global GDP.

Figure 9 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.

The IRFs are computed from the second stage local projections 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 economies's conditions (Obstfeld 2019). As such, we control for past twelve lags of the instrument and world industrial production in our regression to account for predictability of these shocks to past lags as well as to improve precision of our estimates. In addition, we control for twelve lags of US federal funds rate, US industrial production, and US CPI inflation. When estimating the IRFs for oil supply shocks, we also control for twelve lags of global oil production (millions barrels/day), changes in oil inventories as ratio of last year's global oil production, and real spot price of West Texas Intermediate oil. This is important to identify the oil supply shocks from oil demand and other confounding factors. The shaded grey area represents one standard deviation confidence bands, where the standard errors are computed using the Newey-West heteroscedasticity and autocorrelation consistent standard errors.

Consistent with the hypothesis of global financial cycle (Miranda-Agrippino & Rey 2018), we find that contractionary surprises in US federal funds rate indeed have contractionary effects on world industrial production. Similarly, surprise increases in economic policy uncertainty and world oil prices cause a reduction in world industrial production. These exercises provide motivation for considering the effect of these shocks on the Indian economy, which we report next.

Baseline results for India from LP-IV estimation

We directly estimate the IRFs for six Indian macro variables available at monthly frequency: industrial production, consumer price index, nominal exchange rate USD/INR, yields on ten year government bonds, stock market index and USD 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 detrend the seasonally-adjusted industrial production using HP filter with monthly frequency smoothing parameter of 14400. We refer to this variable henceforth as industrial production gap (*ipgap*). In the SVAR-IVs, we directly use the seasonally adjusted monthly industrial production from the IMF/IFS database along with linear time trends.

One advantage of using LPIVs instead of SVARs is that we can 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 July 1994 and extends up to January 2018. As with estimating IRFs for WIIP, we control for twelve lags of industrial production gap, consumer price level based inflation and the instrument/external shock. Because of shorter sample length, we only add six lags of other variables namely, nominal exchange rate USD/INR, yields on ten year government bonds, stock market index, USD value of total foreign reserves (minus gold) and WIIP. 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 ratio of last year's global oil production, and real spot price of West Texas Intermediate oil.

Figures 10 - 14 report the LP-IV estimated impulse responses to the four main shocks of interest. A caveat with local projections 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 & Brownlees 2018). That requires taking a stand on what turning points are the truth or noise. As a result, we chose to report the LP-IV based IRFs. SVAR based IRFs reported in the next section can be seen as the extreme case of the IRFs obtained with structural assumptions on dimension reduction.

Monetary policy shocks

Figure 10 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 USD. The Indian stock market index gradually falls, and stock of foreign reserves gets depleted. The ten year Indian government bond yields and consumer price level falls. The industrial production gap effects are quantitatively comparable to those found in the SVAR estimations, as well similar to the numbers for WIIP and BRICS industrial production.

Economic Policy Uncertainty Shocks

Figure 11 reports the LP-IV estimated impulse responses to increase in global economic policy uncertainty. Industrial production falls, rupee depreciates, and consumer prices falls. 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 orthogonalized to past Indian macro variables as well as world industrial production. Figure 12 reports the LP-IV estimated impulse responses to increase in VIX measure of uncertainty in the 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 high correlation between the two series.

Geopolitical Risk Shocks

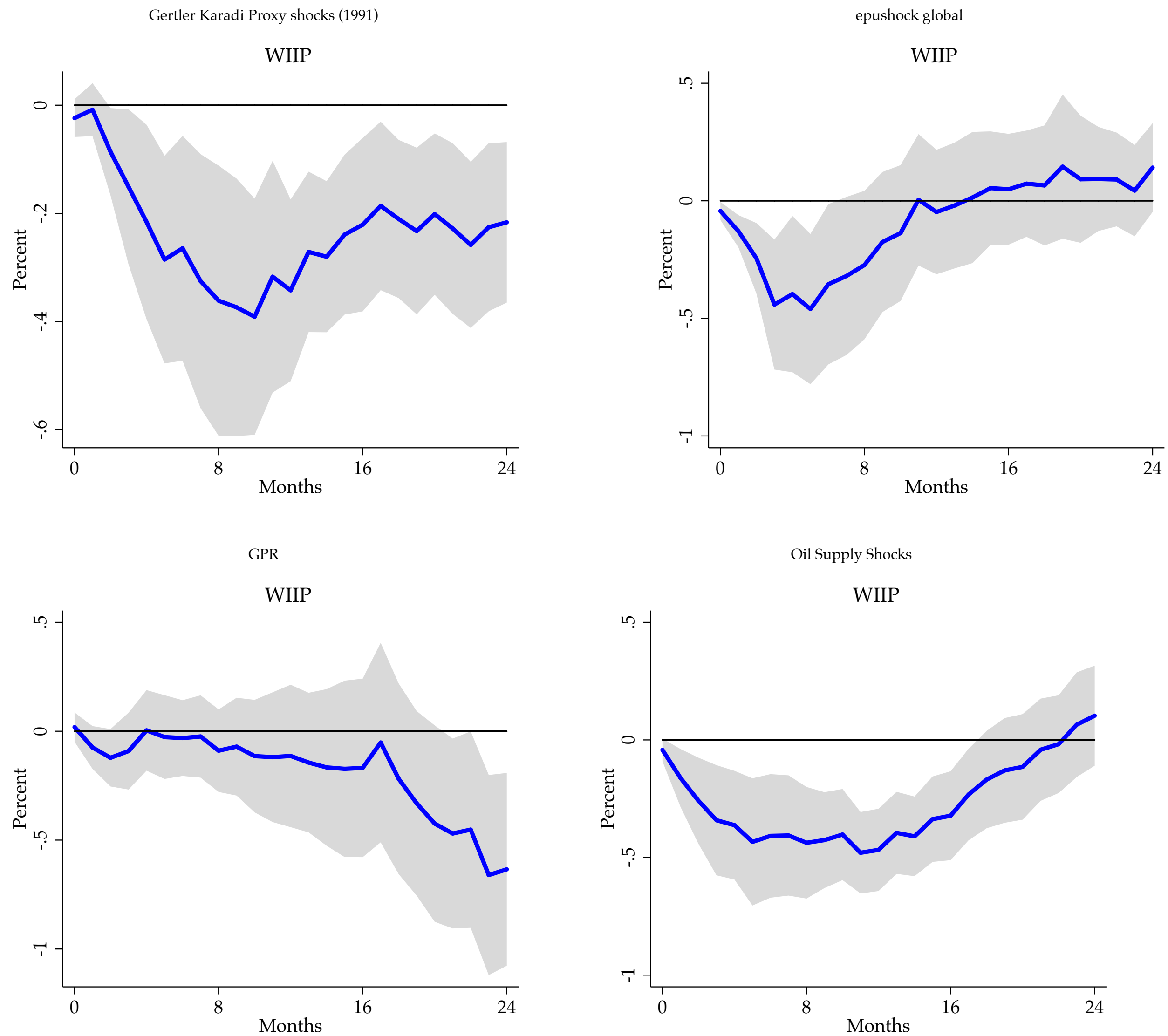
Figure 13 reports the LP-IV estimated impulse responses to increase in geopolitical risk in rest of the world. There is no significant effect on industrial production, while price level falls in response to the global geopolitical risk. Somewhat surprisingly, we find an increase in industrial production roughly 14 months after the shock. However, the financial variables seem to move in India's favor with improvement in value of foreign reserves holdings. This would be consistent with India being a relatively safe option when there is increase in geopolitical risk in rest of the world.

Oil Supply Shocks

Figure 14 reports the LP-IV estimated impulse responses to increase in oil prices because of reduction in supply. Industrial production gap falls and recovers eight months after the shock. Reliance on oil imports implies that consumer prices go up in India, rupee depreciates and foreign reserves go down.

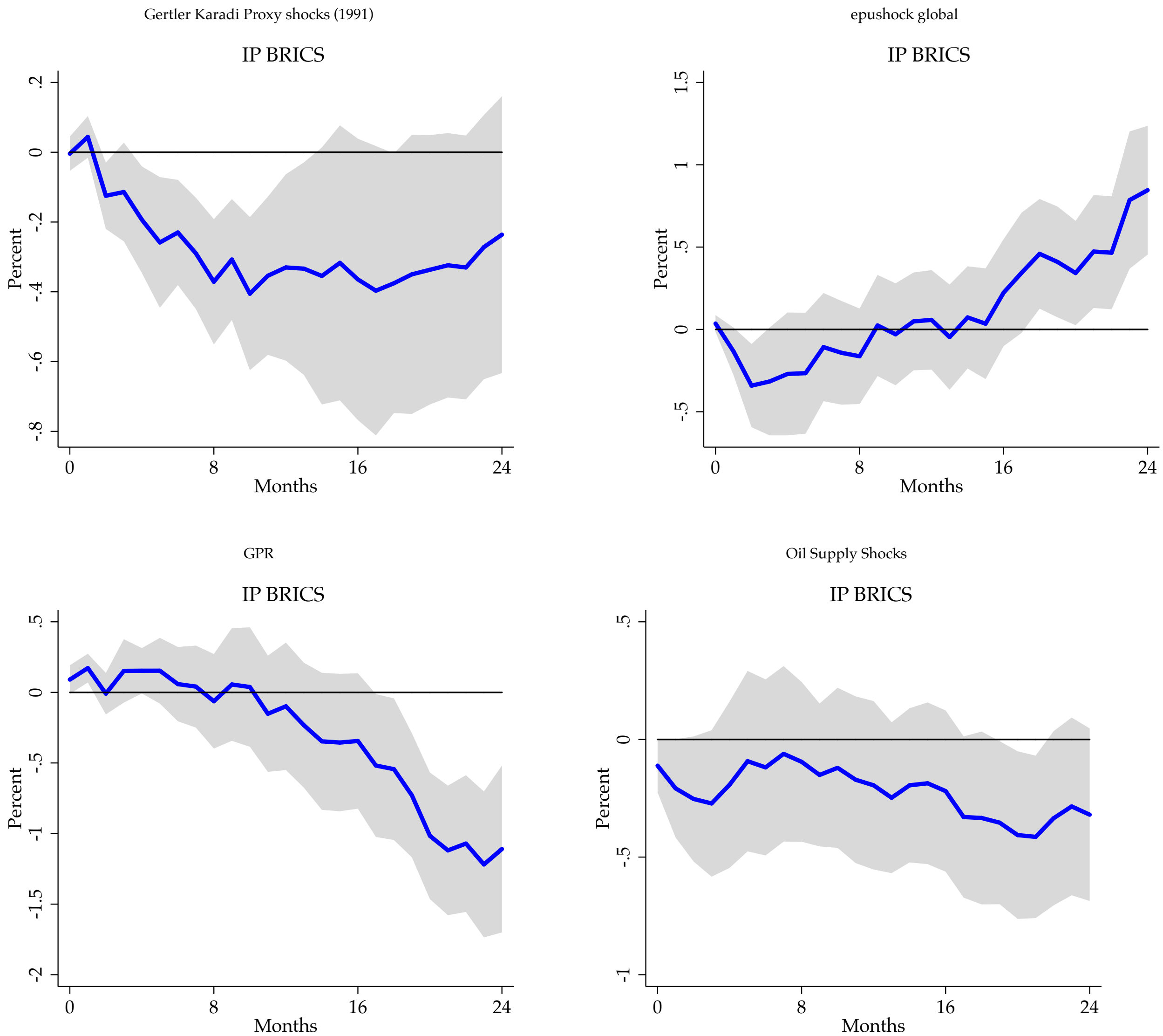
Figures for local projections estimation

Figure 8: WIIP response to 1 std dev shock



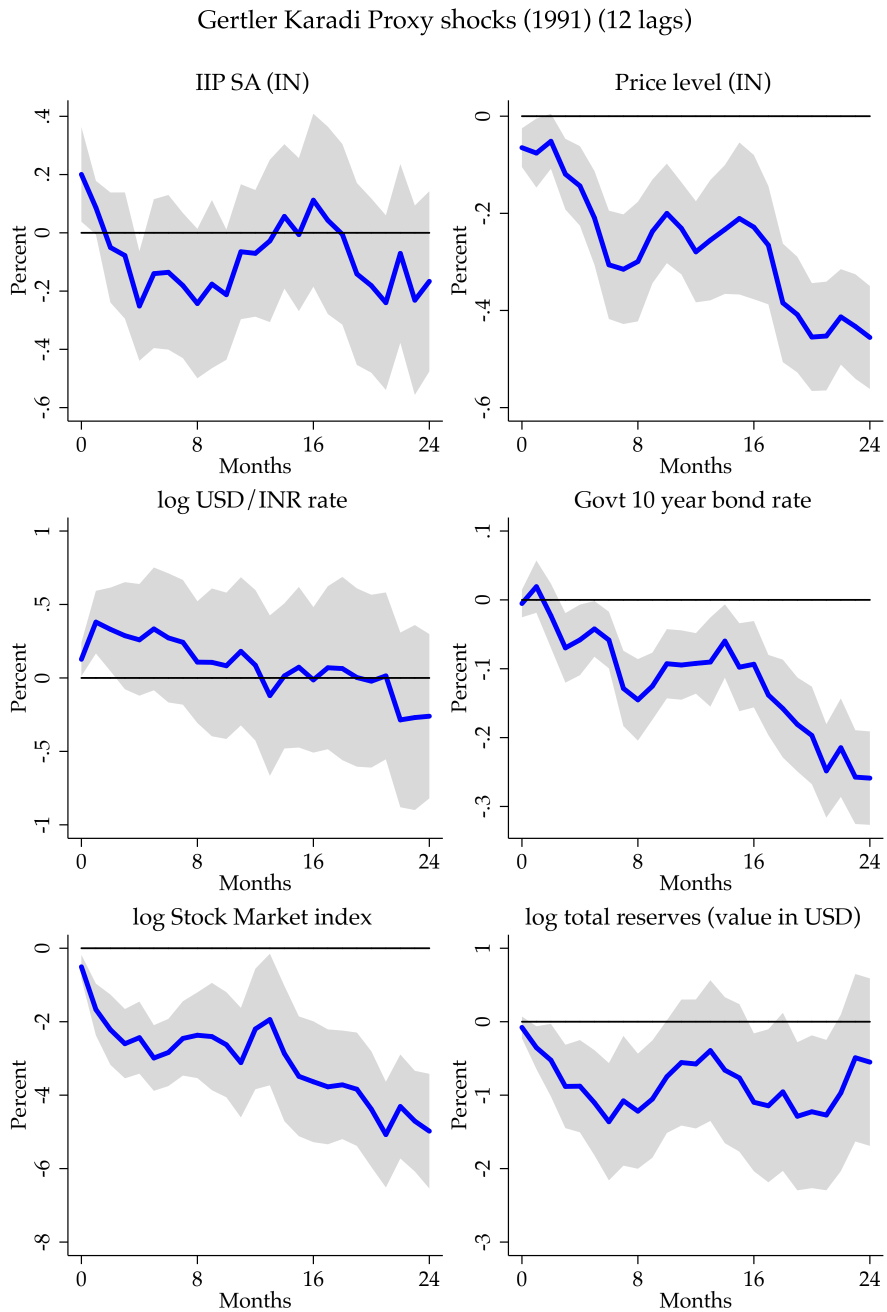
Notes: Response of world industrial production (OECD + BRICS) region to a 1 std deviation shock. Shaded areas represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey West standard errors. WIIP is an extended version of the OECD's index of monthly industrial production in the OECD and six major other countries developed by Baumeister & Hamilton (2019). The sources for shocks are described in the text. Sample: April 1994 - December 2017. See text for details. *Authors' own calculations*.

Figure 9: BRICS IP response to 1 std dev shock



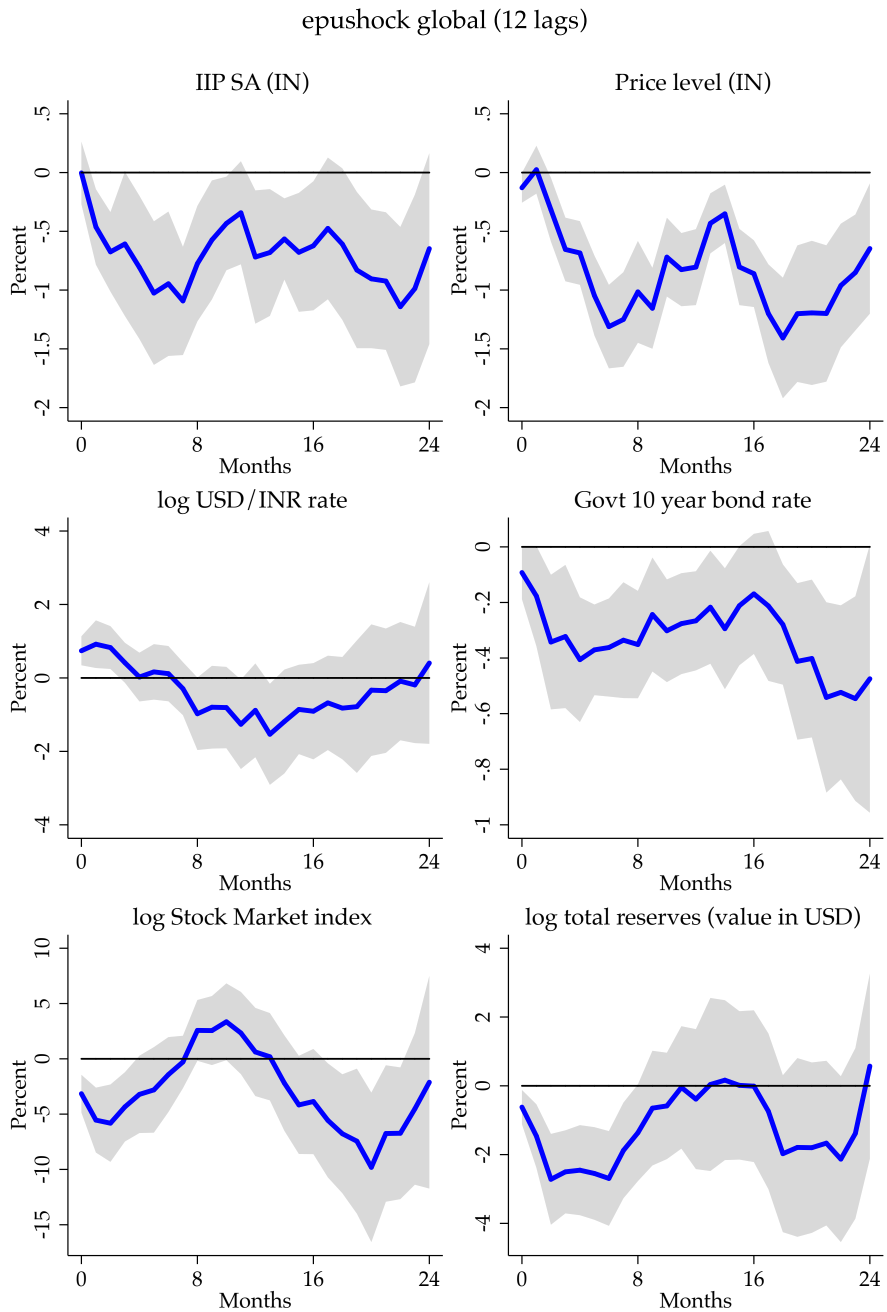
Notes: Response of monthly seasonally adjusted industrial production in the four BRICS region to a 1 std deviation shock. Shaded areas represent one standard deviation confidence intervals. Standard errors are heteroskedasticity and autocorrelation robust Newey West standard errors. The BRICS industrial production data is from World Bank Global Economic Monitor. Sample: April 1994 - December 2017. The sources for shocks are described in the text. See text for details. *Authors' own calculations*.

Figure 10: LP baseline responses to 1 std dev monetary policy shocks



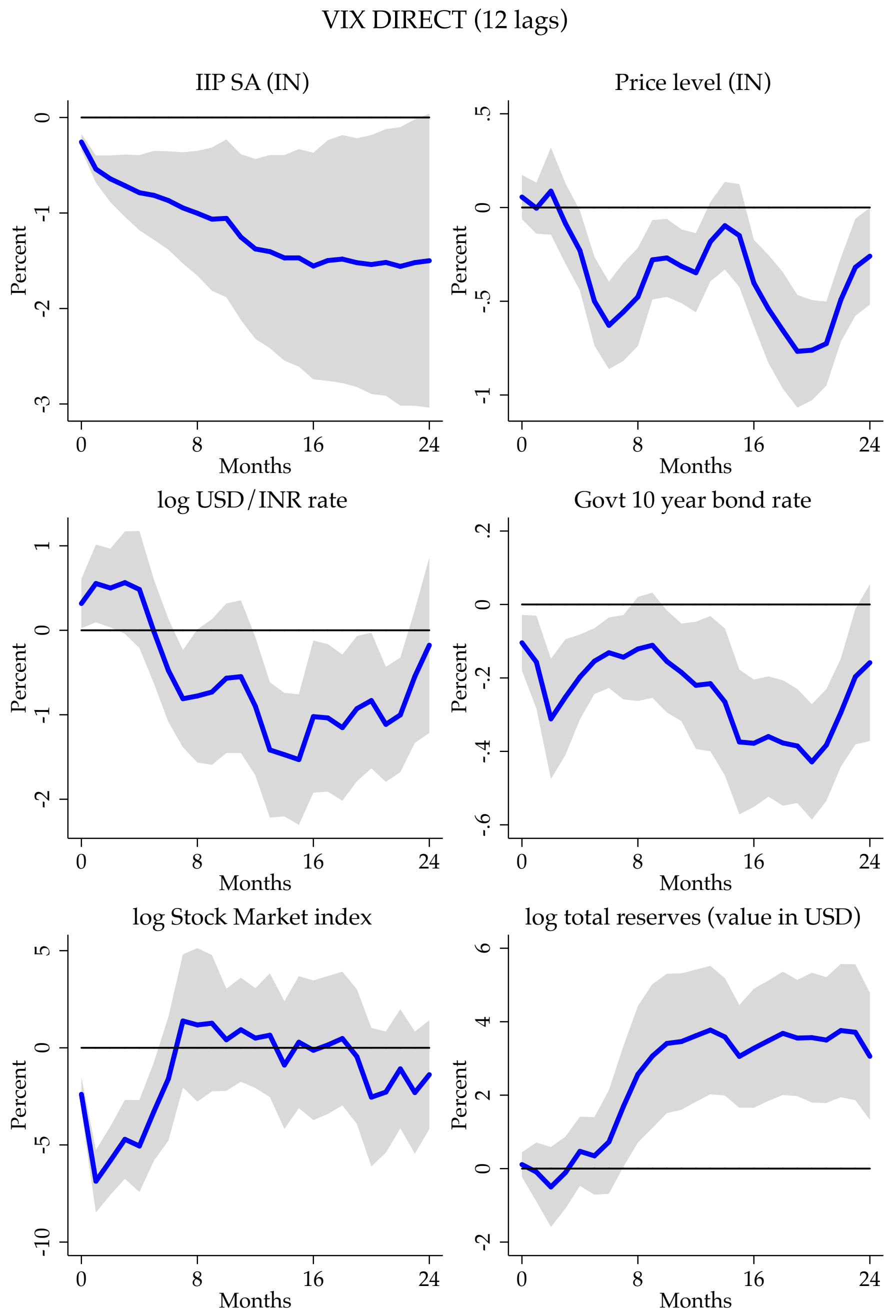
Notes: Response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation identified shock to US monetary policy rate. Shaded areas represent one standard 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. *Authors' own calculations*.

Figure 11: LP baseline responses to 1 std dev economic policy uncertainty shocks



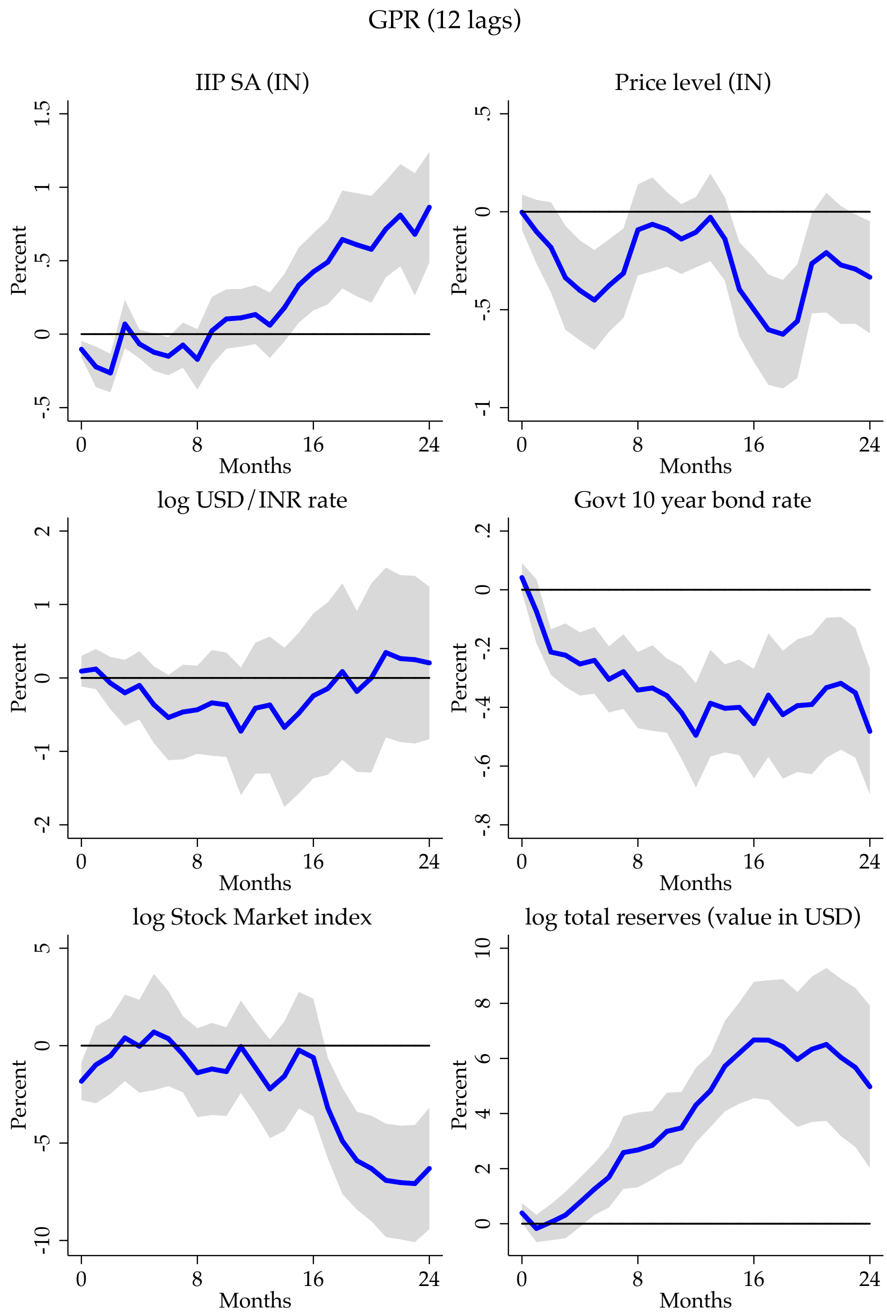
Notes: Response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation identified shock to global economic policy uncertainty. Shaded areas represent 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. *Authors' own calculations*.

Figure 12: LP baseline responses to 1 std dev movements in VIX



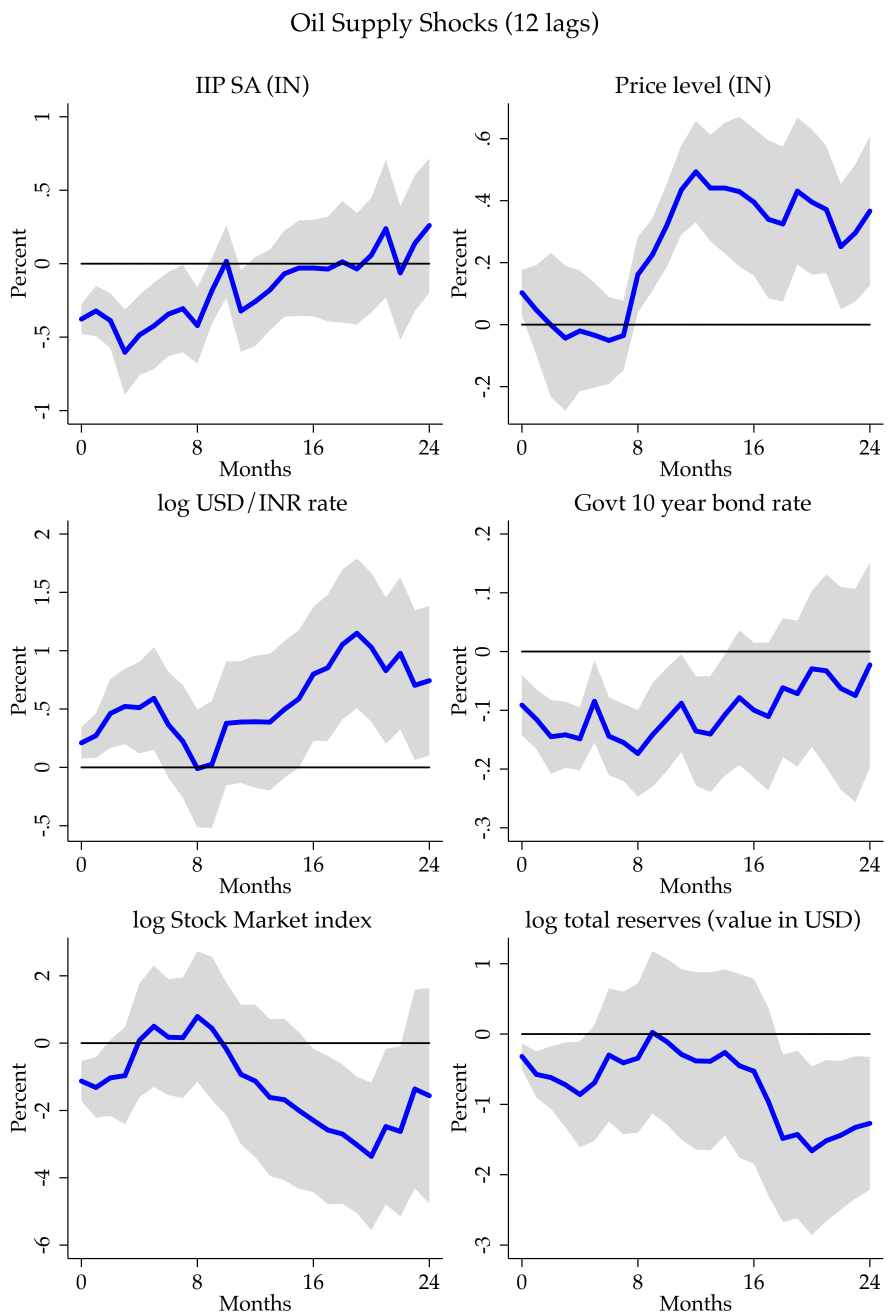
Notes: Response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation change in VIX. Shaded areas represent one standard deviation confidence intervals. 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. *Authors' own calculations*.

Figure 13: LP baseline responses to 1 std dev Geopolitical Risk Shocks



Notes: Response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation identified shock to geopolitical risk measure. Shaded areas 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. *Authors' own calculations*.

Figure 14: LP baseline responses to 1 std dev oil supply shocks



Notes: Response of monthly industrial production, consumer price index, USD/INR nominal exchange rate, ten year government bond rate, stock market index, and total reserves (excluding gold) outstanding to a 1 std deviation identified shock to oil supply. Shaded areas 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. *Authors' own calculations*.