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Assessing the effect of monetary policy on agricultural growth and food prices

Zulfiqar Ali WAGAN[1*], Zhang CHEN[1], Hakimzadi SEELRO[2], Muhammad Sanaullah SHAH[1]

[1]School of Management, Hefei University of Technology, Hefei, Anhui, China
[2]Faculty of Social Sciences, Sindh Agriculture University, Tando Jam, Sindh, Pakistan

*Corresponding author: zulfiwagan@yahoo.com

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Abstract: Agricultural growth is closely associated with sustainable economic development. This is especially true from the perspective of developing countries, such as India and Pakistan, where significant portions of the labour force are dependent on agriculture for their livelihood. This study analysed the impact of macroeconomic policy (i.e. monetary policy) on employment, food inflation, and agricultural growth by analysing to what extent monetary policy is effective in controlling food price inflation, the effect of contractionary monetary policy on the agricultural sector's employment and productivity, and the extent of monetary policy transmission to money market rates and 10-year interest rates. We did so by applying a factor-augmented vector autoregressive model proposed by Bernanke et al. (2005) to agricultural data from 1995 and 1996 to 2016 for India and Pakistan, respectively. We found that tight monetary policy significantly reduced food inflation and agricultural production while increasing the rural unemployment rate. Short-term and 10-year interest rates increased owing to the contractionary monetary policies pursued by both countries. An inclusive monetary policy whereby policymakers work alongside governments to achieve price stabilisation and reasonable employment rates is recommended.

Keywords: agricultural growth, food inflation, monetary policy

Increased agricultural production is vital to the reduction of poverty and the growth of the overall economy (Thirtle et al. 2003; Färe et al. 2008; Christiaensen et al. 2011; Pauw and Thurlow 2011; Pauw and Thurlow 2012; Baldos and Hertel 2014; Dorosh and Thurlow 2016)

Moreover, a recent surge in international food prices (concentrated primarily in South Asian countries) has stirred discussion about the importance of domestic agricultural production to national food security. While growth in the agricultural sector is necessary to sustain the rural population, food security requires availability of sufficient amounts of food at reasonable prices.

India's economy is primarily based on agriculture, which provides a livelihood to about 58% of the labour force. The agricultural sector's share of gross domestic product (GDP) growth declined from 54.56% in the early years (1951–1952) after independence to 27.87% in 1999–2000. There has been a decline of the agricultural sector's share of GDP growth about 50% (Joshi 2015). Similarly, the agricultural sector comprises 21% of Pakistan's GDP and employs 45% of its workforce (Akbar and Jamil 2012). Monetary policy plays a major role in agricultural development both directly (e.g. providing resources) and indirectly (e.g. decreasing food prices). Through interest rates, monetary policy affects the availability of money and, consequently, the level of demand for agricultural output. Alagh (2011), for example, found that monetary policy effects rise/fall in money income and significantly affected India's agricultural sector. Akbar and Jabbar (2017) examined the effect of decisions relating to macroeconomic policy on domestic food inflation and production in Pakistan. Their study suggested a considerable increase in terms of public expenditure to undertake the development of infrastructure; in addition, it found that lowering energy prices would bring a significant improvement in terms of accessibility and availability

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within the theme of providing food security in the country. For a limited period, tight monetary policy may help in reining in food inflation; however, it could also have a few adverse impacts with regard to food production. Over the years numerous studies have contributed to the field of agricultural productivity and these studies provide those working in the sector such as business forecasters, economists for decision analysis with additional information on which to make decisions (Huffman and Evenson 2006; Eyo 2008; McCarl et al. 2009; Akbar and Jamil 2012; Traboulsi 2013; Siftain et al. 2016). Measures taken by central banks to control inflation may indirectly affect output and employment in this sector. Although a small number of researchers (Frankel 2006; Hye 2009) have studied the impact of monetary policy on the price of goods in developing economies, the effect of tight policy on agricultural sector productivity has hardly been analysed. Recently, Indian and Pakistani monetary authorities have frequently adjusted interest rates keeping economic conditions in view.

Vector autoregression (VAR) has been used to analyse policy transmission and its impact on macroeconomic variables for decades. Over the past 35 years, there has been a great deal of advancement in the area of stationary VARs[1] (Giordani 2004; Brissimis and Magginas 2006; Castelnuovo and Surico 2010; Krusec 2010; Jääskelä and Jennings 2011; Rusnák et al. 2013). Despite this, there are limitations to the practical use of VAR models. In addition to the identification problem, one of their most apparent shortcomings is their use of an insufficient number of variables (usually three or four, but occasionally more than ten).[2] While monetary policy makers use more variables than those normally used in VAR models. As their predictions are not based on formal methods, replicating these is not possible. This has two consequences. Firstly, monetary policy forecasting is no longer considered an entirely scientific process (Orphanides 2003). Secondly, VAR models have little impact on everyday monetary policy decisions (Rudebusch 1998).

To answer the questions of interest to them and others, macro econometricians work with hundreds of time series variables and have to rely on just a few hundred observations for every variable; however, when VAR has to estimate a large number of parameters, the lack of data cannot be overlooked. This is especially true when accurately modelling macroeconomic relationships, where the number of dependent variables can be more than the two or three usually found in VAR models. The main challenge faced by the researchers is to build an empirically appropriate model that can not only capture the key characteristics of the data but also not be over-parameterised.

Building a model by using hundreds of time series variables is a challenging task, raising problems related to the potential proliferation of parameters and the need for methods to reduce the dimensionality of the model. Factor methods provide a solution by analysing the information contained in hundreds of variables and replacing them by a few factors.

Later on, static factor models were developed into dynamic factor models (DFMs) to resolve the issue of identification. With the help of DFMs, researchers can explain the changes in a large set of cross-sectional data with the help of only a few common shocks, such as monetary policy, news, technology, fiscal policy, and oil shocks, which depict the key dynamics. The pioneering work was done by Geweke (1977), and the applications were suggested by Stock and Watson (1999, 2002). Combining factor methods with VARs leads to factor-augmented VARs (FAVARs), which were introduced by Bernanke et al. (2005). The basic idea was to resolve the dimensionality problem by imposing restrictions derived from the DFM.

In general, the FAVAR approach is superior to VAR because it provides a comprehensive view of the effects of monetary policy, and may be more intuitive for policy makers due to the following reasons. First, standard VAR requires an explicit connection between the variable used and the theoretical concept it represents. For example, it is common practice to use industrial production or GDP as the measure of 'economic activity'. However, there may be a mismatch between the variable for which data are available and the theoretical construct it measures or represents. Hence, some variables need to be treated as unobserved at the time of deciding monetary policy interventions. The FAVAR approach allows this. Second, it allows central bankers to analyse the rich data set at the time of

[1]VAR was initially proposed by Christopher Sims (Sims 1980) three decades ago to address four macro-econometric tasks: data description and summarisation, macroeconomic forecasting, structural inference, and macroeconomic policy analysis.

[2]A study by Bańbura et al. (2009) that used a Bayesian VAR with up to 130 variables is an exception.

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monetary policy making. Third, standard VAR allows the observation of impulse responses for only the limited variables included in the model, whereas in the FAVAR approach, one can work with hundreds of the variables and observe the impulse response functions for each of them. To date, the effect of tight policy on agricultural growth and employment in South Asia has been neglected by researchers. Although food insecurity is a global concern, South Asia is particularly susceptible. For example, about 48% of people in Pakistan are food insecure (Khan and Ahmed 2011). Additionally, food is the primary driver of persistent inflation in India, which has resulted in widespread food insecurity. Food accounts for 47.6% weight in India's consumer price index (Anand et al. 2014).

In this study, we have employed FAVAR to analyse the effects of public policy on inflation, rural employment, and agricultural productivity in India and Pakistan. Five factors interest rates (long and short-term interest rate), employment, food inflation, and agricultural production were considered in our benchmark model.

We were primarily interested in answering the following questions:

– How does agricultural productivity react to contractionary monetary policy shocks?

– To what extent is monetary policy effective in controlling inflation to the price of food?

– What is the extent of monetary policy transmission to money market rates and 10-year interest rates?

– How does contractionary monetary policy affect the level of agricultural employment?

This study contributes to the existing literature in several ways. Firstly, by extending the analytical scope of our study using a FAVAR model. Secondly, we have documented the effect of monetary policy shocks on a broad range of variables, including employment, food inflation, and agricultural productivity. Finally, we have described the effect of contractionary monetary policy on agricultural sector productivity in India and Pakistan.

EMPIRICAL MODEL

Data and description

The data for this analysis were taken from the Reuters EcoWin database (2016), the Pakistan Bureau of Statistics (2016), the Food and Agriculture Organization of the United Nations (2016), the Asian Development Bank (2016), and Organization for Economic Cooperation and Development, General Statistics (OECD 2016). We have examined similar variables for both India and Pakistan. Eighty variables for each country were included in X_t, all of which were stationary and subject to transformation. All data were standardised (i.e. every variable had zero mean and unit standard deviation).

The following transformations were conducted: four represents (logarithm) and one (levels). We divided the variables into fast- and slow-moving groups (represented by *). Further details regarding the transformation and variable categories used are provided in Table 1.

FAVAR model

We used the FAVAR approach introduced by Bernanke et al. (2005). Let $\mathbf{Y}_t$ be a $(M \times 1)$ vector of observable time series macroeconomic variables assumed to have persistent effects on the economy. However, in many instances additional information is required to depict the dynamics of the series not fully explained by $\mathbf{Y}_t$. As $\mathbf{Y}_t$ contained the policy instrument and it can be considered a subset of $\mathbf{X}_t$. A

Table 1. Data description and transformation

Serial number	Description	Data span		Code
		India	Pakistan	
1	agricultural GDP*	1995:1–2016:12	1996:1–2016:12	4
2	employment rate in the agricultural sector*	1995:1–2016:12	1996:1–2016:12	1
3	short-term interest rates	1995:1–2016:12	1996:1–2016:12	1
4	long-term interest rates	1995:1–2016:12	1996:1–2016:12	1
5	consumer prices: food indices*	1995:1–2016:12	1996:1–2016:12	4
6	central bank rates	1995:1–2016:12	1996:1–2016:12	1

*the variables were divided into fast- and slow-moving groups (represented by *); codes – four (logarithm), one (levels)

Source: described in chapter Empirical model

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limited number of variables (normally four to eight) is usually used for estimation in VAR analyses, and additional variables are required to depict the dynamics, which can be written as $\mathbf{F}_t$, where $\mathbf{F}_t$ is the $(K \times 1)$ vector of unobserved factors. To identify monetary policy shocks, we employed the following FAVAR approach:

$$\begin{bmatrix} \mathbf{F}_t \\ \mathbf{Y}_t \end{bmatrix} = \phi(L) \begin{bmatrix} \mathbf{F}_t - 1 \\ \mathbf{Y}_t - 1 \end{bmatrix} + \nu_t \qquad (1)$$

where $\phi(L)$ is a lag polynomial of finite order d and the error term ν_t is identically and independently distributed with mean zero and covariance matrix Q.

It is possible to reduce the above system to standard VAR if the terms of $\phi(L)$ that relate $\mathbf{Y}_t$ to $\mathbf{F}_t$ are zero. The system described above enabled us to assess the marginal contribution of additional information in $\mathbf{F}_t$. Unlike the FAVAR models, the standard VAR suffers from omitted variables bias; hence, FAVAR is a more realistic depiction of economic dynamics and produces better results than the VAR model. The results were analysed as impulse response functions. The responses were considered significant at horizons where the median and percentile bands of the impulse response functions of selected variables did not fall on the baseline.

RESULTS AND DISCUSSION

Our results are presented in Figures 1–10, for India and Pakistan for major agricultural variables encompassing our broad dataset. We used five factors for each country in the form of impulse responses in order to investigate the effects of monetary policy on interest rates, employment, food inflation, and agricultural production. As the data were collected monthly, we used twelve lags; however, eight lags provided the same results. In the figures below, the dotted lines represent the 10th and 90th percentiles and the posterior median is given by the solid line. Innovations in central bank rates were standardised to one standard deviation; the figures were therefore interpreted in terms of standard deviation units.

Our principle component analysis employed Gibbs's 16 000 related iterations from which we rejected the initial 5 000 to draw for the accuracy of outcomes. In our FAVAR framework, we considered $\mathbf{Y}_t$ to contain only central bank rates, which means that it was the only variable that had an effect on the economy. The results showed that under the five-factor FAVAR framework, 100 basis points tightening of monetary policy in each country led to an initial decline to output in India. According to conventional wisdom, the effects of a monetary policy shock to output commence within months. However, the most significant negative impact on agricultural output was noted during the fifth and seventh months in India and Pakistan, respectively. There was a persistent decline to the GDP of both countries over the medium term, which is evident in Figures 1–2.

Our finding is in line with the theoretical constructs and qualitatively supports the findings of Kazi et al. (2013), who found that the negative response in output is because it is a slow-moving variable. This finding can be supported by the relationship between the high interest rates and a reduction in employment rate and level of agriculture production in these countries.

While Figures 3–4 show that agricultural sector employment decreased in both countries, the impact was more persistent in Pakistan. Previous research emphasises the government support to increase efficiency, output and employment in agriculture sector in India. Epstein and Yeldan (2009) study different

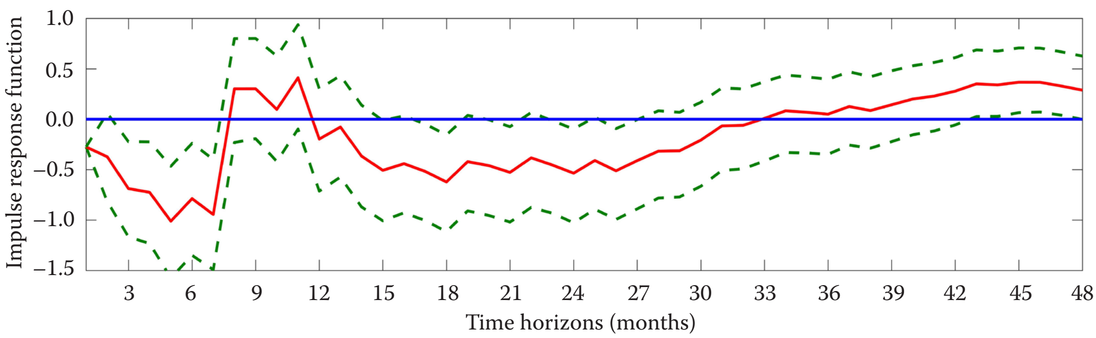

Figure 1. Impulse response function of India's agricultural GDP to India's monetary policy shock

Source: authors' own calculation

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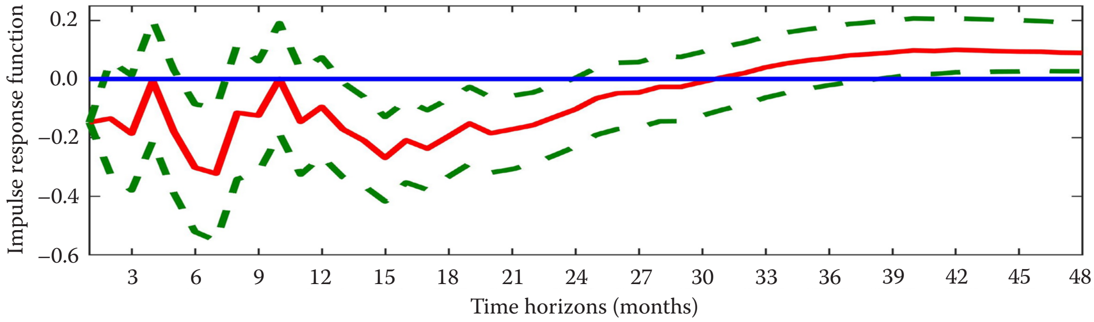

Figure 2. Impulse response function of Pakistan's agricultural GDP to Pakistan's monetary policy shock

Source: authors' own calculation

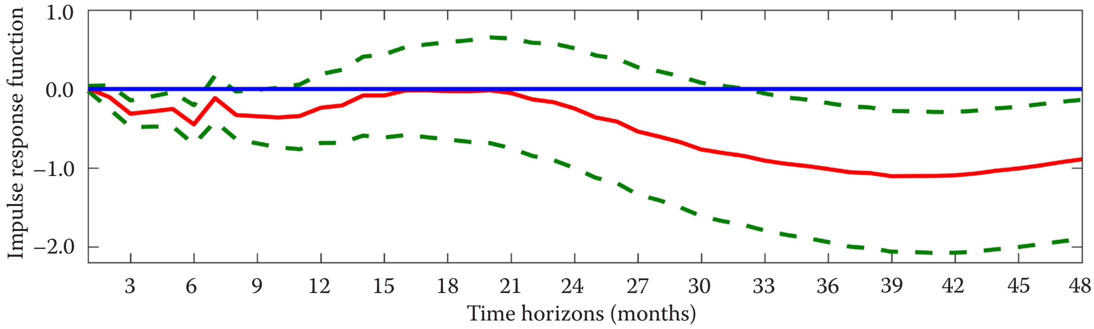

Figure 3. Impulse response function of India's employment rates in agricultural sector to India's monetary policy shock

Source: authors' own calculation

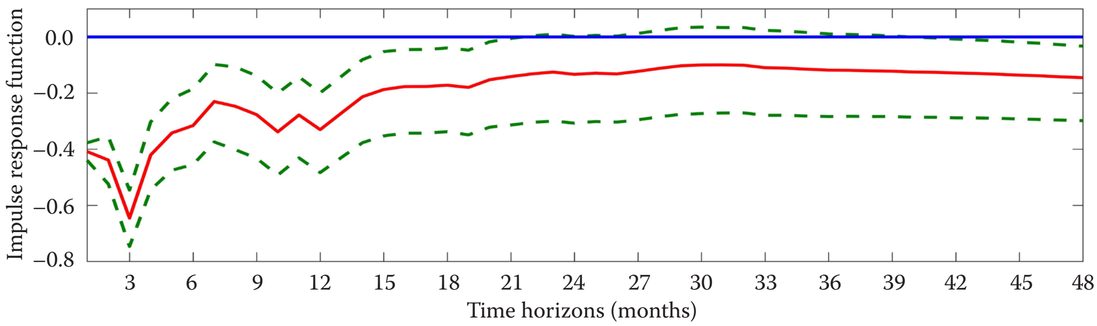

Figure 4. Impulse response function of Pakistan's employment rates in agricultural sector to Pakistan's monetary policy shock

Source: authors' own calculation

economies of Asia including India and supports the view that central banks target should be beyond inflation targeting. Felipe (2009) proposes holistic approach of monetary policy beyond inflation targeting post global financial crisis in Pakistan.

Figures 5–8 demonstrate that short-term interest rates tend to rise when monetary authorities raise policy rates. This is because money market rates closely follow policy rates. Although money market rates immediately increased by 100% in both countries, this was nullified after 19 months, which affirms the effectiveness of recent monetary policy in both India and Pakistan. Das (2015) found slow transmission of loose monetary policy and quick transmission of tight monetary policy to bank rates in India. Long-term interest rates increased as a result of increases to short-term interest rates, and increases to borrowing costs resulted in a decline in investment demand for agricultural output. Hence it confirms that long- and short-term interest rates have risen significantly in response to contractionary monetary policy shocks in both countries.

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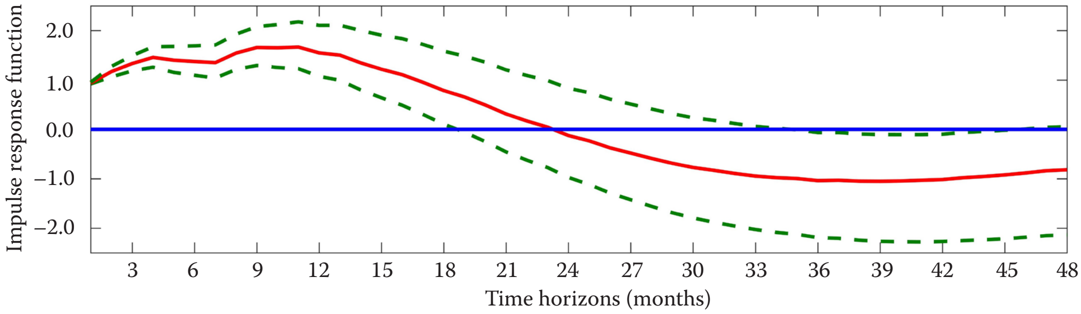

Figure 5. Impulse response function of India's short-term interest rate to India's monetary policy shock

Source: authors' own calculation

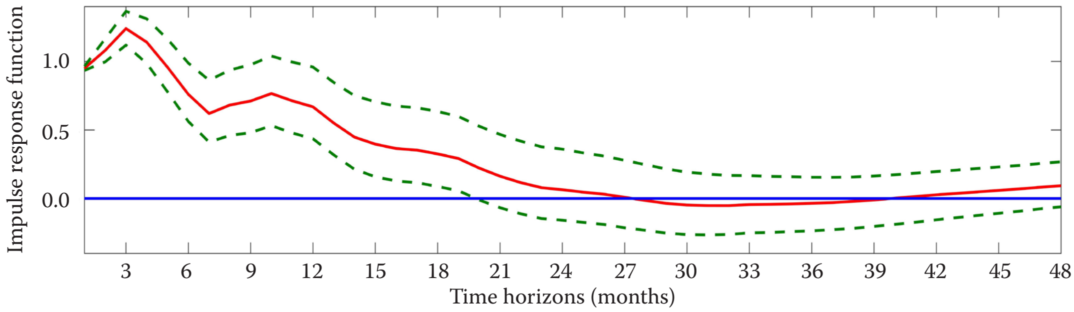

Figure 6. Impulse response function of Pakistan's short-term interest rate to Pakistan's monetary policy shock

Source: authors' own calculation

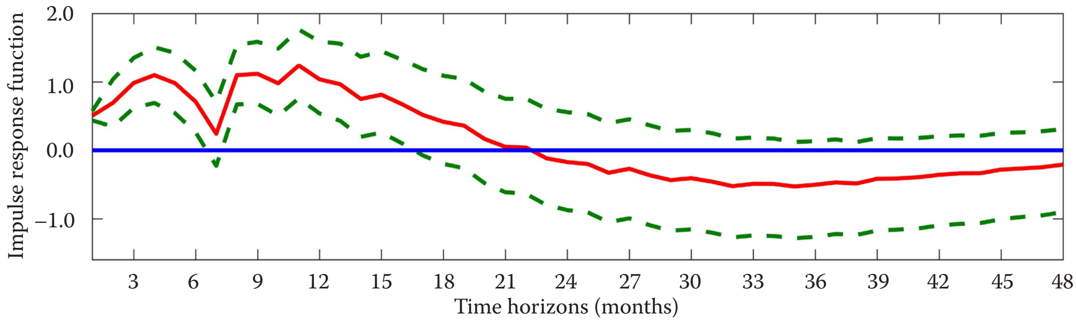

Figure 7. Impulse response function of India's long-term interest rate to India's monetary policy shock

Source: authors' own calculation

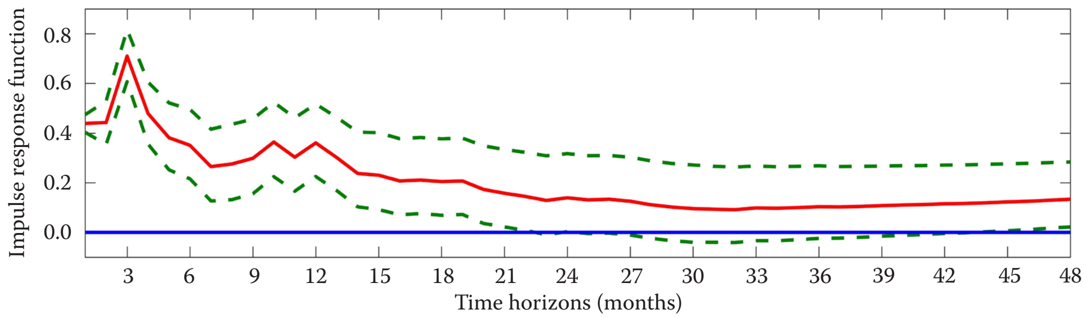

Figure 8. Impulse response function of Pakistan's long-term interest rate to Pakistan's monetary policy shock

Source: authors' own calculation

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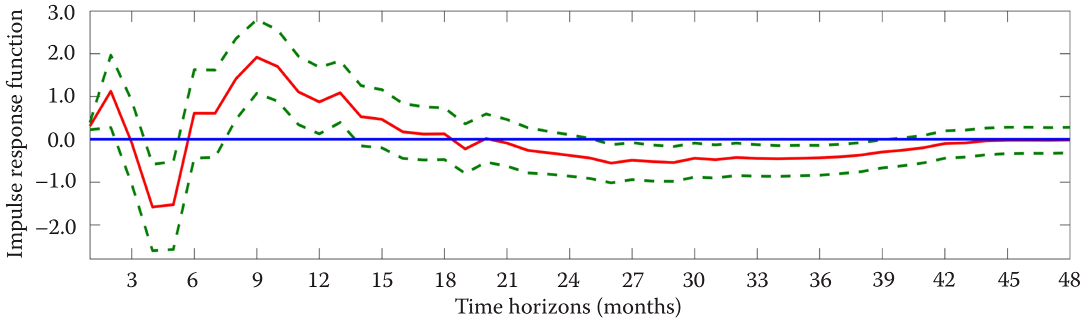

Figure 9. Impulse response function of India's consumer prices (food indices) to India's monetary policy shock

Source: authors' own calculation

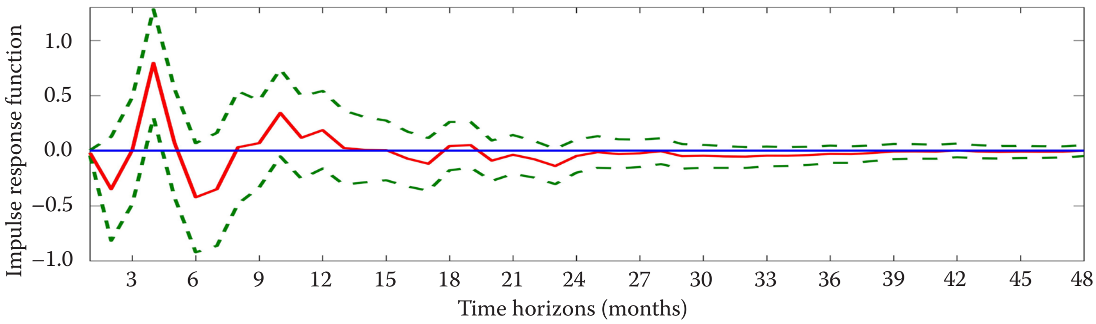

Figure 10. Impulse response function of Pakistan's consumer prices (food indices) to Pakistan's monetary policy shock

Source: authors' own calculation

Additionally, we estimated the impulse response function of food inflation to contractionary monetary policy shocks. It took India and Pakistan four and six months, respectively, to fully pass through to prices (Figures 9–10). Furthermore, there is evidence of a price puzzle during the first three months in India.

Many studies (Romer and Romer 2004; Primiceri 2005) have found that inflation has a persistent positive response to monetary policy shocks in which it takes several years for permanent aggregate shocks to affect prices fully. Our findings present a challenge to existing explanations for the persistence of inflation and contradict Lustig (2009), who argued that real and monetary dynamics played an important role in rising food inflation post-2007. The impulse response functions discussed above provide an overview of the effects of monetary policy shocks on major agricultural and macroeconomic policy variables and demonstrate the effectiveness of FAVAR methodology at capturing additional information. It provides a comprehensive view of the effects of monetary policy, which may prove more intuitive for policy makers as they attempt to expedite growth in the agricultural sector.

CONCLUSION

In this study, we examined the effects of monetary policy shocks by applying the FAVAR model proposed by Bernanke et al. (2005) to a broad range of variables, including employment, food inflation, and agricultural productivity and employment in India and Pakistan. In addition, we described the effect of contractionary monetary policy on agricultural sector productivity in both countries.

The agricultural sector is the most important source of employment for most developing countries, including India and Pakistan. However, food inflation has surged in both countries over the past several years. Monetary policy may be used cautiously to contain this inflation so long as its impact on agricultural productivity and the employment rate is considered. Governments should invest in the agricultural sector

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owing to the crowding out effect of tight monetary policy to control food inflation.

We demonstrated that the FAVAR approach could account for important changes in the responses of employment, food inflation, agricultural output, and interest rates to monetary policy shocks. Our findings suggest that factor models could play an important role in analysing monetary policy transmission mechanisms in the agricultural sector. It was found that tight monetary policy reduced food inflation and agricultural production significantly, but simultaneously increased the rural unemployment rate. There was an increase in both short-term and 10-year interest rates owing to the contradictory monetary policies of both nations.

Currently, the trend of rising food prices is posing a serious threat to monetary policy. This is particularly the case in low-income and middle-income countries. If contractionary money policy was enacted, it would be ineffective, particularly in the face of exogenous shock comparable to relative prices (International Monetary Fund 2013). Within this context, it is plausible to suggest that such a policy might be the cause of prevailing food price inflation. Moreover, if a government were to tighten monetary policy, it would negatively affect agricultural output and slow down growth, especially in countries experiencing high energy and food prices. On the other hand, if a government were to enact expansionary monetary policy owing to the need to manage real exchange rate appreciation and capital inflows, it would more likely negatively affect agricultural output and eventually exacerbate the prevailing agricultural situation (International Monetary Fund 2013).

To that end, it is recommended that governments pursue inclusive monetary policy wherein policymakers work with governments to achieve price stabilisation and reasonable employment rates.

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