doi: 10.17221/96/2016-AGRICECON

Impact of macroeconomic policies on national food security in Pakistan: simulation analyses under a simultaneous equations framework

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Akbar M., Jabbar A. (2017): **Impact of macroeconomic policies on national food security in Pakistan: simulation analyses under a simultaneous equation framework.** Agric. Econ. – Czech, 63: 471–484.

Abstract: The UN's Vision 2050 regarding food security emphasizes a doubling of food production by 2050 to ensure sufficient food availability. It should also be considered that economic accessibility to food depends mainly on food prices in developing countries. Vision 2050 requires proper planning at the national level to ensure that targets are met in the coming years. This study was conducted to analyse the impact of macroeconomic policy decisions on domestic food production and food inflation in Pakistan. A simultaneous equations model, estimated using the generalized method of moments (GMM) with annual data from 1963–1964 to 2013–2014, was developed. Simulation analyses were conducted by using the model to analyse the impact of monetary policy, fiscal policy and energy price policy; policy recommendations are also given. A significant increase in public expenditure for the development of infrastructure and the lowering of energy prices would significantly improve the availability and accessibility parameters of food security in Pakistan. The recent fall in energy prices will also be advantageous for both the availability as well as economic accessibility to food. Tight monetary policy for a limited time period may be helpful to control food inflation, but may also exert some minor adverse effects on food production. Moreover, monetary policy decisions must be taken while considering all sectors of the economy. The results of the study provide some important guidelines for national food security policy that may help in realising the UN's Vision 2050.

Keywords: food security, macroeconomic policies, simultaneous equations, simulation analyses, Pakistan

Food insecurity has reached alarming proportions: the number of malnourished people around the world has reached more than 900 million (FAO 2009).[1] Moreover, the situation is worsening in the developing countries of Asia and Africa where more than 800 million undernourished people live. The latest UN projections predict that the world's population will reach 9.1 billion (i.e., 34% higher than today) by 2050 shows, and indicate that most of the increase in population is likely to occur in developing countries. According to Rijsberman (2012), "FAO estimates that we have to double food production by 2050 to feed the expected 9 billion people, knowing that one billion people are already going to bed hungry every day." Hence, proper planning at all levels, i.e., household level, national level as well as the global level, is imperative if we are to overcome food insecurity around the world.

Four dimensions of food security are considered, namely, availability of food, access to food, food utilization/absorption as well as the stability of all these three components of food security. Among these dimensions, availability of and accessibility to food have emerged as the most important and basic factors for ensuring food security in any country. For developing countries, food availability is strictly dependent

[1]Malnourishment exists when the household's calorie intake falls below the minimum requirements of dietary energy (FAO 2010).

doi: 10.17221/96/2016-AGRICECON

on sufficient domestic food production, as these countries have limited resources to imported food items. Moreover, most of these developing countries have high rates of population growth and, therefore, a continuous growth in food production that is higher than population growth is imperative for these countries in order to achieve food security also at a global level. Otherwise, the demand of these countries may cause a shortage of food on international markets and the Vision 2050 of the UN that sets the goal of doubling food production at a global level would not be achievable. Accessibility of food can be categorized into physical access and economic access. Physical access requires efficient market infrastructure. Long-term government policies aimed at improving the services sector play a vital role in physical accessibility. On the other hand, economic access depends on the purchasing power of households, which, in turn, depends upon income and food prices. Since the growth of household income is slow in developing countries, economic access to food items is dependent of effective policies controlling food inflation. Hence, food inflation due to a supply and demand gap in the competitive markets for food items, may significantly hinder economic access in developing countries. Domestic food production represents supply and access to food represents demand. Both of these factors are highly linked with food prices, which depend on the supply and demand gap in competitive markets of food items. Hence, availability and access components of food security are interlinked with each other (Andersen 2009). Thus, domestic food production and food prices play a vital role in ensuring availability of and accessibility to food, and, thus, national food security in developing countries.

Pakistan is a developing South Asian country whose huge population of 200 million representing 2.5% of all the people on earth. The food security situation in Pakistan is not any better than in other developing countries of the region. Moreover, the number of malnourished people is also increasing day by day. This will ultimately result in chronic food security problems in the country, which may negatively affect other countries in the region as well as the regional food market. When we consider the above-mentioned two aspects of food security, i.e., domestic food production and food prices, the following picture emerges with respect to Pakistan. Food production is actually growing with the passage of time but its growth is much slower compared to population growth. Figure 1 shows that the average calorie supply per capita is increasing, but that its rate of increase is too low because the population growth rate is higher than the rate of growth of food production. Even after improvements in agricultural production, Pakistan is lagging behind the average calorie supply per capita of developing as well as developed countries. This implies that Pakistan will not be able to maintain a status of self-sufficiency in food production in the coming years until proper planning and policies are adopted at national level to raise food production rapidly. Hence, a sufficient increase in food production is imperative in the coming years in order to ensure food availability. A high level of food inflation also represents a hindrance to economic access as indicated in Figure 2. This figure shows a markedly rising trend in the food price index over the last ten years, while the increase in per capita income remains much too low. This rising trend of food inflation is of major concern to food policy makers as it has severe adverse effects on poor households. Taken together, the growth of domestic food production must be accelerated in order to ensure the availability of food, while economic accessibility can be improved by controlling food inflation in Pakistan.

Considering food security at a national level, macroeconomic policy decisions that alter certain crucial macroeconomic parameters can have both a direct and indirect impact on a country's rate of food production and food inflation. Macroeconomic policies include monetary policy, fiscal policy and energy price policy. These policy steps are decided on by the government, which determines the macroeconomic environment. There must be a clear understanding of how macroeconomic policy decisions affect the different dimensions of food security in a country. Such an understanding of macroeconomic policy decisions may be used to raise domestic food production

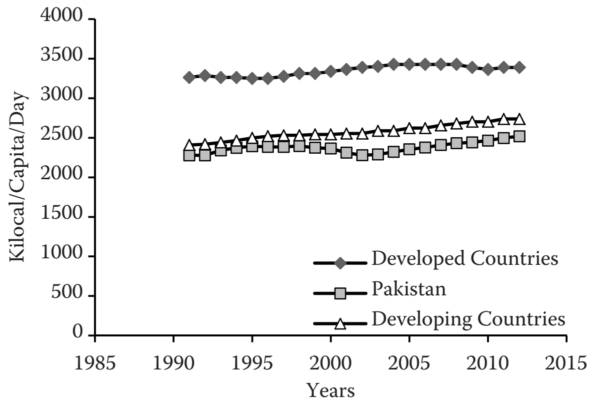

Figure 1. Average calorie supply per capita per day

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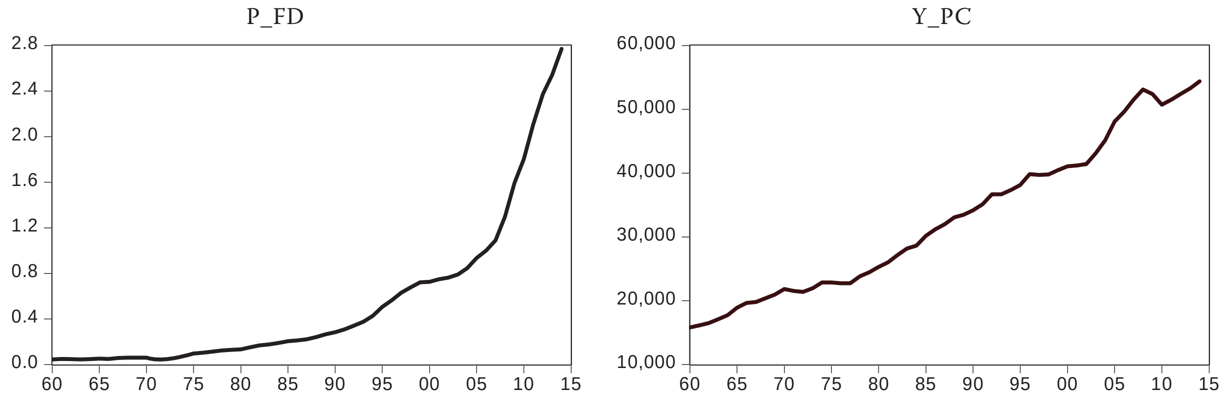

Figure 2. Graphical projection of food price index and per capita income

and to control food inflation in order to achieve food security at the national level. Most of the research related to food security in Pakistan has been conducted at the micro level. All of these studies have made significant contributions to the literature and have highlighted causes and cures for food security. However, we could not find any study that analyses the impact of macroeconomic policies on the different dimensions of food security at the national level. Hence, the focus of this study was to analyse the role of government in choosing the appropriate combinations of monetary, fiscal and energy policies to create a macroeconomic environment that is conducive to the attainment of food security.

REVIEW OF THE LITERATURE

The issue of food security has been analysed from different dimensions. Food security is a multidimensional, complicated phenomenon and the factors affecting it are different at various levels, i.e., international, national and household level. George (1994) and Timmer (2000) analysed the food security problem in South Asian countries and concluded that eradicating poverty by making large investments in human capital would help to improve the accessibility of food. Singh (2002) suggested a sustainable development of the agricultural sector to improve the food security situation in South Asia. Kargbo (2005) determined the factors affecting food security at the national level and concluded that monetary policy, exchange rate and trade policies have a significant impact on food prices and per capita domestic food production. Ringler et al. (2011) engaged in a theoretical discussion and concluded that food security and energy security are interlinked and together determine global food security. According to Devadoss (1991), Barnett (2000) and Orden (2010), monetary policy measures affect food inflation, either actively or passively. Eckstein and Heien (1978) identified monetary policy actions by both the US and foreign governments, along with some other factors such as world economic conditions, devaluation of the US dollar, and rapid income growth, as the main causes of food inflation in USA. However, Lapp (1990) found that the growth rate of money supply does not affect prices received by farmers relative to other prices in the economy. Capehart (2008) identified higher commodity and energy costs as the key determinants of food inflation in the USA. Moreover, that study argued that low investment in agricultural technology and infrastructure reduces the supply of food crops which widens the gap between supply and demand and raises food inflation worldwide. Naim (2008) stated that rising energy prices, non-food hedging policies against drought years and corn ethanol policy are the causes of food inflation in the USA. Trostle (2008) analysed world food prices and identified the rapid growth of demand for food together with the slower growth of production as the major causes of food inflation. That study further identified adverse weather conditions, rising energy prices, increasing costs of production and national trade policies as significantly affecting food security. Arshad and Hameed (2010) concluded that a decline in agricultural production, underinvestment in the agricultural sector and rising demand due to population growth as well as bio-fuel demand as the major factors causing food inflation in Malaysia.

There are a number of studies analysing food security in Pakistan. Ahmed and Siddique (1995) pointed out the negative impact of continuous population growth, sharp increases in urbanization, changing patterns of income distribution, increases in the irrigation

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expenditures, debt burden, the lack of technology and inadequate food distribution systems on food availability. Iram and Butt (2004) described a significant positive effect of a mother's age and the household income in ensuring adequate average calorie intake at the household level. Hussain and Akram (2008) concluded that agricultural production, in particular, the production of wheat, rice and maize, can be increased by adopting effective policies to eliminate food insecurity. Shahid and Siddiqui (2010) argued that the food security situation in Pakistan needs drastic development in all dimensions. Mushtaq et al. (2011) concluded that money supply, trade openness and exchange rate significantly affect wheat prices in Pakistan but Abdullah and Kalim (2009) argued that money supply does not determine food prices. Mushtaq et al. (2011) analysed the impact of monetary as well as macroeconomic factors on wheat prices by employing Johansen's co-integration test. The results revealed that the real money supply, real exchange rate as well as trade openness significantly affect the long run real wheat prices. Akbar and Jamil (2012) concluded that the prices of all inputs including energy significantly and negatively affect crop production. Khan et al. (2012) examined three dimensions of food security in rural areas and concluded that 80 districts out of 120 are food-insecure in rural areas and that more than 21 million people from urban populations are food-insecure. According to Arshad and Shafqat (2012), gender inequality, poverty, health and environmental conditions, availability of water, natural calamities, population growth, and urbanization cause food insecurity. Amir et al. (2013) analysed household food security in Northern Pakistan on the basis of a survey and concluded that the lack of irrigation water, inadequate access to markets and increasing cost of fertilizer are the production constraints causing a decline in food production and access in these areas.

On the basis of the above studies, we may conclude that Pakistan is a food-insecure country and that food insecurity is increasing with the passage of time, e.g., Ahmad and Siddique (1995), Farkhanda et al. (2009), Shahid and Siddique (2010), Bashir et al. (2012), Hussain and Routray (2012), Khan et al. (2012) and Amir et al. (2013). Most studies have emphasized the growth of the agricultural sector and of food production as being important for improving the food security situation, e.g., Anderson (2001), Singh (2002), Kargbo (2005), Hussain and Akram (2008), Joël et al. (2012) and Arshad and Shafqat (2012). Moreover, a number of studies show that food inflation is the major hindrance of the accessibility of food; see Naim (2008), Capehart (2008), Arshad and Hameed (2010), Mushtaq et al. (2011) and Khan et al. (2012). However, the impact of macroeconomic policies upon different dimensions of food security in Pakistan has not yet been analysed. Hence, the present study may be a useful contribution to the literature of food security.

MODEL SPECIFICATIONS

The availability of food is considered to be the central element of any model for food security and has been the only indicator of food security for a long time. The availability of food can be achieved by domestic production, stocks and import of food items. However, Pakistan is a developing country with an agricultural-based economy and, hence, has very limited resources for imports. Therefore, food supply depends upon domestic production and, hence, the food production function is focused on in this study. As discussed above, food price is the most important factor determining economic accessibility to food in developing countries. Hence, second equation is concerned with food prices. These two equations are linked to tools of macroeconomic policy through a simultaneous equations framework. The model assumes two sectors, that is, the agricultural and non-agricultural sectors in the economy. Thus, GDP at factor cost can be disintegrated into agricultural output and non-agricultural output. Agricultural output is further disintegrated into food and non-food output; thus,

$$Y_t^{FC} = Y_t^{FP} + Y_t^{NF} + Y_t^{O} \quad (1)$$

Non-food output and other output can be taken as exogenous in the study, allowing us to construct a food production function for domestic food output. A number of studies have used the Cobb-Douglas production function to analyse the impact of inputs on crop production, such as Singh et al. (1998, 2002) and Yilmaz et al. (2005). Thus,

$$Y_t = A \times F(K_t, N_t)$$

This equation shows how output (Y) relates to the use of capital stock (K), the number of workers (N) and productivity level (A). However, we also consider other inputs such as energy and fertilizer off-take. Hence, we use the Cobb-Douglas production function with four major inputs: capital, labour, fertilizer off-

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take and energy consumption. The specified model is as follows.

Domestic food production is determined by the quantity of inputs, i.e., capital stock, labour, energy and fertilizer. Besides, domestic credit to the agricultural sector and total population as a demand component are also used as regressors. Hence, an economy's capacity for food production is given by the following food production function.

$$Y_t^{FP} = Y^{FP}(K_t^A, L_t^A, E_t^A, F_t^A, DC_t^A, N_t) \quad (2)$$

Food prices are determined by demand as well as supply side variables. Demand side factors which determine the quantity demanded for food items are food prices, money supply and per capita income, while supply side factors that affect the quantity of supplied food items are food prices, food production and inflation in the economy. Thus,

$$Q_F^D = f(P^{FD} M2, Y^{PC})$$

$$Q_F^S = f(P^{FD} \pi, Y^{FP})$$

The price of food items is determined by equating quantity demanded to quantity supplied and, hence, the food price equation would be as follows:

$$Q_F^D = Q_F^S$$

$$P_t^{FD} = P^{FD}(M2, Y_t^{PC}, Y_t^{FP}, \pi_t) \quad (3)$$

$$\text{where } \pi_t = \left(\frac{P_t - P_{t-1}}{P_{t-1}}\right) \times 100 \quad (4)$$

Domestic credit to the agricultural sector and population are taken as exogenous. The demand functions for labour, energy and fertilizer can now be derived as the (variable cost minimizing) conditional input demand functions given the level of output, which depend on agricultural output, capital stock and input prices. Thus,

$$E_t^A = E^A(K_t^A, P_t^{EN}, P_t^{Fr}, W_t^A, Y_t^{FP}) \quad (5)$$

$$F_t^A = F^A(K_t^A, P_t^{EN}, P_t^{Fr}, W_t^A, Y_t^{FP}) \quad (6)$$

$$L_t^A = L^A(K_t^A, P_t^{EN}, P_t^{Fr}, W_t^A, Y_t^{FP}) \quad (7)$$

The prices of energy and fertilizer are taken as exogenous as they are fixed by the government. Wage rate in the agricultural sector depends on general price level, agricultural output and unemployment rate. Thus,

$$W_t^A = W_t^A(P_t, Y_t^A, UR_t) \quad (8)$$

Capital stock in the agricultural sector can be derived by using the following formula for private and public investment in the agricultural sector.

$$K_t^A = \frac{I_t^{PA} + I_t^{GA}}{\delta + g^A}; t = 1$$
$$K_t^A = (1-\delta) K_t^A + \left(I_t^{PA} + I_t^{GA}\right); t > 1 \quad (9)$$

Here, δ denotes the annual depreciation rate of fixed capital in the agricultural sector, while g^A denotes annual the compound growth rate of output in the agricultural sector.

The role of fiscal policy is incorporated into the model through public fixed investment expenditures in the agricultural sector. The government makes investment decisions to achieve a targeted growth rate in agriculture. However, public investment depends on public revenue, while general government investment also affects public investment in the agricultural sector. Most public investment, such as that pertaining to canals, dams and roads, in infrastructure directly relates to the agricultural sector. General government investment expenditures are determined by public revenue. Thus,

$$I_t^{GA} = I^{GA}\left(R_t, Y_t^A, I_t^{GG}\right) \quad (10)$$

$$I_t^{GG} = I^{GG}\left(R_t\right) \quad (11)$$

Here, public revenue can be taken as exogenous, as agricultural income is tax-free in Pakistan. Determinants of private investment in the agricultural sector are public investment, interest rate, agricultural output, and domestic credit. Thus,

$$I_t^{PA} = I^{PA}(R_t, I_t^{GA}, I_t^{GG}, Y_t^A, DC_t^A) \quad (12)$$

Overall inflation in the economy significantly affects food inflation. Moreover, monetary policy decisions also affect food inflation through this channel. Aggregate output (GDP at factor cost), nominal money supply, exchange rate and energy prices are considered as the determinants of general price levels in the economy. Hence, a function for general price level containing supply side as well as demand side variables is specified as follows:

$$P_t = P(M2_t, Y_t^{FC}, P_t^{EN}, ER_t) \quad (13)$$

Treating the exchange rate as exogenous, the behaviour of money supply is modeled due to its im-

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portance with respect to monetary policy. Money supply is adjusted to be equal to money demand in the economy and, hence, the quantity of money is set as equal to liquidity demand, which, in turn, depends on nominal interest rate, aggregate demand and general price level in the economy. Thus,

$$M2_t = M2(r_t, P_t, Y_t) \quad (14)$$

The rate of interest, aggregate demand and per capita income are taken as exogenous. Hence, the structure of the model is completed.

DATA AND ECONOMETRIC METHODOLOGY

Annual data from 1963–1964 to 2013–2014 from the Pakistan economy were used to construct the specified model.[2] We used real data for all variables except for interest rate, energy demand, money supply, wage rate and exchange rate. The data were sourced from various issues of Pakistan Economic Survey, Pakistan Statistical Year Book and Pakistan Agricultural Statistics and the obtained real data for variables were converted at same base year of 2005–2006. The unit of the variables is million of rupees. However, the unit of energy consumption is tonnes of oil as gas; electricity and coal used in the agricultural sector are converted into tonnes of oil equivalent. The rate of depreciation of fixed capital is taken as 0.05.

All equations of the model are estimated separately using the generalized method of moments (GMM). According to Hansen (1982), Newey and West (1987) and White (1984), GMM is superior to other methods in handling econometric problems like heteroscedasticity, endogeneity and nonlinearities of unknown form. However, conventional GMM gives spurious results if the variables are non-stationary.[3] Therefore, we used a two-step estimation strategy described by Ogaki (1999, 2009) as applied by Akbar (2011) and Akbar and Jamil (2012). In the first step, cointegration is tested for using the Engle-Granger method. In the second step, efficient GMM is applied for estimation by plugging in consistent 2SLS point estimates, provided cointegration exists. Otherwise, conventional GMM is applied by using stationary variables in the equation. Identification in GMM requires that there should be at least as many instruments and, hence, moment conditions in each equation as the number of parameters to be estimated. The number of valid instruments in each equation is set as greater than the number of parameters to be estimated. Therefore, valid moment conditions are greater than the parameters in each equation implying that all the equations are over-identified. The *J*-statistic of Hansen (1982) is used to test the validity of over-identifying restrictions in each equation. Besides, the Breusch-Godfrey serial correlation LM test, White's test for heteroscedasticity and *F*-test of overall significance test are computed. *F*-test statistics together with standard error and adjusted R^2 are used as a test to check goodness of fit of each estimated equation.

After estimation, all the equations including identities are put together in order to solve the model deterministically as a system of equations; the Gauss-Seidel method is used to compute dynamic solutions for different simulation experiments. The historical simulation experiment is conducted by solving the model from 1970–1971 to 2013–2014 and predictions are used to assess the performance of the model. Other simulation experiments are conducted by solving the model from 1970–1971 to 2018–2019. For these experiments, exogenous variables are forecasted using a best-fitting AR model. Then, various experiments are performed by conducting deterministic dynamic simulations using the Gauss-Seidel method and the results of forecasting periods, i.e., 2014–2015 to 2018–2019 are compared to derive conclusions in these experiments. The whole program is written in a program file of EViews 8.1 which conducts estimation, validation and simulation analyses of the model.

RESULTS AND DISCUSSION

Following the standard practice at the estimation stage, all the variables (except rates) were transformed into natural logarithm form to obtain stationarity in the variance-covariance matrix (Chang et al. 2001; Fatai et al. 2004). Besides specified regressors, first- and second-order autoregressive schemes[4], and dummy variables representing some additional aspects are also added at the estimation stage. There are 11 be-

[2]The financial year in Pakistan begins on the 1st July and ends on the 30th June of the following year. Hence, 1963–1964 denotes the financial year that started on the 1st July 1963 and ended on the 30th June 1964.

[3]The ADF test was applied to test the stationarity of all variables and showed that all variables were non-stationary at level but stationary at first difference.

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Table 1. Results of diagnostic test statistics of behavioral equations

Eq. NO/ Variable	DW	$\bar{R}^2$	S.E.	*J*-Stat (*P*-value)	*F*-Stat.	BG_Stat.	White Stat (*P*-value)
01/FP_t	1.512359	0.990399	0.011725	0.1869	496.1631	2.303809	0.867489
02/E_t^A	1.895318	0.927419	0.093150	0.7472	137.2312	0.148406	0.320926
03/L_t^A	1.788680	0.982410	0.038648	0.6914	447.7966	1.153967	0.130434
04/F_t^A	1.841263	0.988242	0.117834	0.3075	687.4161	4.781488	0.125798
05/W_t^A	1.961544	0.979208	0.036190	0.3408	322.8335	0.510324	0.126471
06/I_t^{GA}	1.956242	0.699440	0.541898	0.7980	19.88066	0.090595	0.561284
07/I_t^{PA}	2.009413	0.893061	0.173700	0.9689	72.19995	0.781415	0.973971
08/ I_t^{GG}	1.899311	0.959017	0.150712	0.8322	598.9901	0.218359	0.262296
09/$M2$	1.988982	0.999537	0.042878	0.8075	20 808.44	0.209526	0.394608
10/P_t	2.035906	0.999146	0.035768	0.1496	11 239.07	0.038484	0.708432
11/P_t^{FD}	2.243176	0.997541	0.060737	0.3868	2 840.960	1.361947	0.600471

havioural equations and 74 slopes to be estimated in the model. The results of diagnostic test statistics presented in Table 1 show no symptoms of severe econometric problems in the estimated equations. The Breusch-Godfrey LM test shows that all estimated equations are free from the problem of autocorrelation. The results of the White test show homoscedasticity in all the estimated equations. *P*-values of the *J*-statistic are greater than 0.10. This implies that the null hypotheses representing orthogonality conditions for the equations are accepted and, hence, over-identification of all the behavioural equations is established. Moreover, all the instruments consist of lag terms. Non-stationarity of the variables implies a high degree of correlation between the current terms and the lag terms used for instruments. Hence, the validity of the instruments is established on the basis of the *J*-statistic where lagged terms are taken as instruments. The values of the *F*-statistic show that the deterministic part of each equation explains a significant amount of variability in the dependent variables. Standard error values are low and $\bar{R}^2$ are high in most of the estimated equations. Moreover, 60 out of 74, that is, 81%, of the estimated slopes are significant, and all the estimates of parameters can be justified. This indicates that the estimated equations are, at the very least, free from severe problems of multicollinearity. Hence, the validity of the estimated equations is established.

Estimation results of the model in the form of estimated equations are given in Appendix (in electronic supplementary material (EMS); for the supplementary material see the electronic version). All estimates of food production function are significant except for the coefficient's estimates of domestic credit to the agricultural sector. All inputs except labour have a positive effect, while labour and population show adverse effects on food production in Pakistan. This implies that the agricultural sector is over-employed and that any increase in labour employment in this sector will cause a decline in food production. A trend towards an increase in the population causes a significant decline in food production as agricultural lands become converted into residential areas. The insignificance of domestic credit to the agricultural sector for food production reflects the inefficient and highly inequitable distribution of agricultural loans by government agencies. Most of the disbursed credit is directed towards the large landholding families, which hold political influence, instead of small framers. A significant positive trend in food production is observed in the estimated food production function. Significant determinants of food price are food production, money supply and rate of inflation in the economy, while per capita income is insignificant to food prices. Money supply and inflation rate are directly related while food production is inversely related to food prices. This implies that the supply-demand gap of food is the key determinant of food prices in Pakistan. Hence, food production plays a key role in two dimensions of food security, namely, availability and accessibility.

Fertilizer price and the wage rate of the agricultural sector do not affect energy demand, while energy price significantly and negatively affect energy demand in the agricultural sector. Capital stock and

[4]Autoregressive schemes are used to control for the problem of autocorrelation in the equations.

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food production have significant positive effects on energy demand in the agricultural sector, which implies that increases in food production entails a higher use of energy by farmers and that increases in the capital stock of the agricultural sector, such as machinery and tube wells, raises energy demands. The wage rate plays an insignificant role in determining labour demand in the agricultural sector, because labour supply is larger than labour demand. Indeed, there is a surplus of untrained labour supplied to the agricultural sector. Fertilizer price significantly and negatively affects labour demand. This is because a rise in fertilizer price causes a decline in fertilizer demand which in turn lowers food production. A decline in food production causes a decline in the wage rate. The energy price is significant for labour demand and its positive sign implies that energy is considered as a substitute for labour in the agricultural sector. The significant positive impact of food production on labour demand shows that the use of labour as an input depends on return. Capital stock exerts a negative impact on labour demand, which implies that capital used in the agricultural sector reduces the demand for labour. Fertilizer price inversely affects, while energy price and wage rate directly affect fertilizer demand in the agricultural sector. Food production and capital stock are insignificant for fertilizer demand. Agricultural output and unemployment rate are determinants of the agricultural wage rate, while inflation rate is insignificant in this regard.

Public revenue and agricultural output are insignificant, while general government investment directly affect public investment in the agricultural sector. This implies that decisions regarding direct public investment in the agricultural sector should be based neither on agricultural performance nor on the available resources. However, general government investment expenditure is determined by public revenue and, hence, the available revenue directly affects decisions about government investment in infrastructure development. Private investment in the agricultural sector is directly affected by public investment expenditure in the agricultural sector, general government investment and domestic credit to the agricultural sector. Interest rates negatively affect, while agricultural output is insignificant for private investment in the agricultural sector. Thus, public investment exerts crowding in effects and monetary policy decisions have a significant effect on private investment in the agricultural sector. Money demand is directly affected by aggregate demand and price level in the economy, while the rate of interest negatively affects demand for money in the Pakistan economy. Money demand, exchange rate and energy price have direct impacts, while aggregate output negatively affects the overall price level in the economy. Estimation results can be concluded with reference to the effect of macroeconomic policy variables on food production and food prices as follows.

Table 2. Validation statistics for within-sample prediction

Variables	*TIC*	*MAPE*
FP_t	0.010418	0.017887
L_t^A	0.032072	0.047652
E_t^A	0.058600	0.093214
F_t^A	0.062517	0.091766
I_t^{GA}	0.185070	0.799992
I_t^{PA}	0.059073	0.119928
P_t	0.039621	0.079453
W_t^A	0.018140	0.031319
P_t^{FD}	0.046075	0.134076

Government investment in the agricultural sector and general government investment expenditure exert a positive impact on food production through capital stock. Tight monetary policy decisions cause a decline in food prices along with a decline in food production through demand for money and private investment, respectively. Increases in energy prices cause food inflation and a decline in food production.

After estimation of the behavioural equations, all the equations, including identities, were put together, and the model was solved deterministically as a system of simultaneous equations by use of the Gauss-Seidel model to give predicted values from 1971–1972 to 2013–2014. Theil inequality coefficients (*TIC*) and mean absolute percentage errors (*MAPE*) were computed and are presented in Table 2. These statistics indicate that the values predicted by the model and the actual values are close to each other, as the values of almost all statistics are within acceptable ranges. Graphical projections of actual and predicted values of endogenous variables presented in Figure 3 indicate that the deterministic dynamic solution tracks the actual time paths and the turning points of the actual historical data reasonably well. Hence, the validity of the model is established.

SIMULATION ANALYSES

After establishing validity of the estimated model, it can now be used for simulation analyses to analyse

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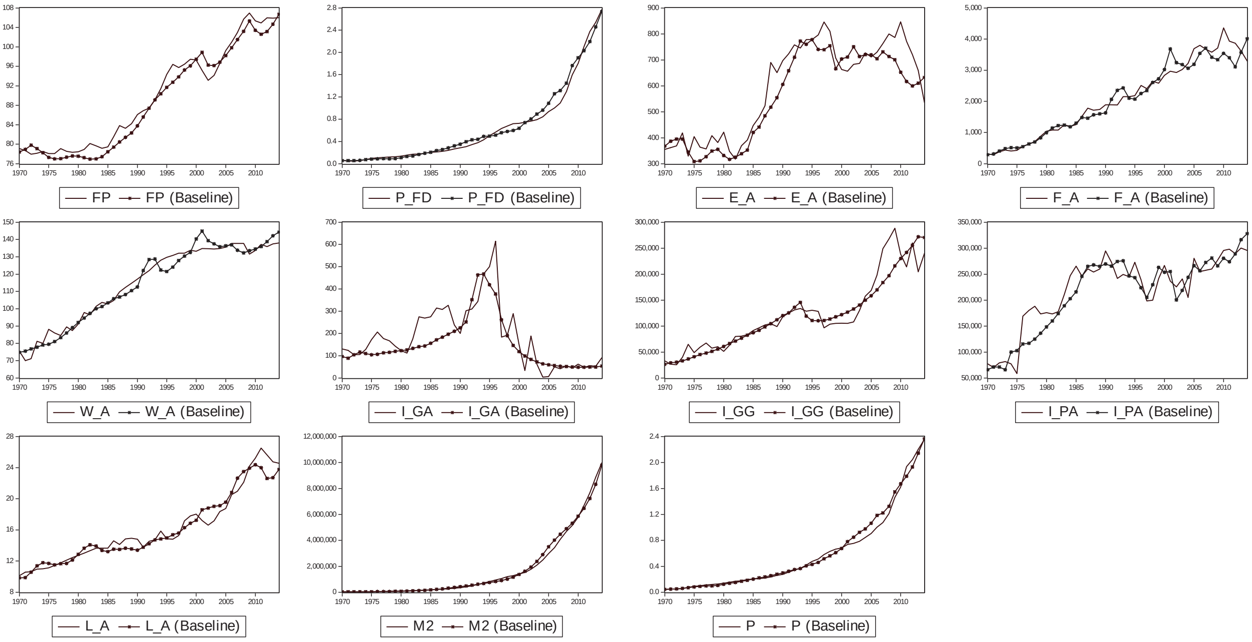

Figure 3. Projection of actual data (Solid lines) and within-sample predicted values (Dotted lines)

the impact of macroeconomic policy variables on food production and inflation. What follows is an analysis of the impact of changes in interest rate, public investment expenditure and multiplier analysis of the energy price index.

Simulation experiments of the interest rate

Monetary policy managers have long used nominal interest rate as an instrument of monetary policy. Six experiments were conducted to analyse the impact of changes in this monetary policy tool. For this purpose, interest rate was adjusted exogenously for five forecasting years and the model was solved dynamically from 1971–1972 to 2018–2019. In the baseline experiment, a 0.1% per annum increase in interest rate was adjusted for five forecasted years, while a 10% annual decrease in nominal interest rate was adjusted for five forecasted years in the first and second experiments, respectively. The third, fourth and fifth experiments model interest rate shock. In the third and fifth experiments, an interest rate shock is given that is sustained over the forecasted period, while the fourth experiment incorporates an interest rate shock that is reversed in subsequent years. An increase of 30% and a decrease of 30% in interest rates is applied for 2015–2016, while a 0.01% increase in the interest rate is considered for the other four forecasted years in the third and fifth experiments, respectively. For the fourth experiment, a 0.01% increase for 2014–2015 to 2015–2016, a 30% increase for 2016–2017 and a 10% decrease for 2017–2018 to 2018–2019 are applied to the interest rate. The results of these experiments are presented in Table 3 and Figure 4. Table 3 contains the average growth rates over five forecasted years in the baseline experiment and deviations of average growth rates for the five forecasted years for the other experiments. Figure 4 shows a graphical projection of rates of growth of the interest rate, food production index and food price index in the baseline experiment as well as in the five remaining simulation experiments.

Simulation results in Table 3 and Figure 4 show that an increase in the interest rate adversely affects food production as private investment in agricultural sector declines. However, this adverse impact

Table 3. Experiments of changes in nominal interest rate

Variables	Baseline	1	2
FP_t	2.328281	–0.050765	0.045473
L_t^A	3.448607	0.008316	–0.005196
E_t^A	4.944955	–0.421911	0.371794
F_t^A	5.212976	–0.127051	0.108916
I_t^{GG}	–0.218259	0.000000	0.000000
I_t^{GA}	9.504068	0.000000	0.000000
I_t^{PA}	1.068191	–2.338060	1.635076
P_t	10.69260	–1.485327	1.185312
W_t^A	2.305741	–0.043998	0.035746
P_t^{FD}	10.78056	–3.898499	3.299173
$M2$	18.14375	–3.577729	2.911992
r_t^{ib}	**0.100000**	**9.900000**	**–10.100000**

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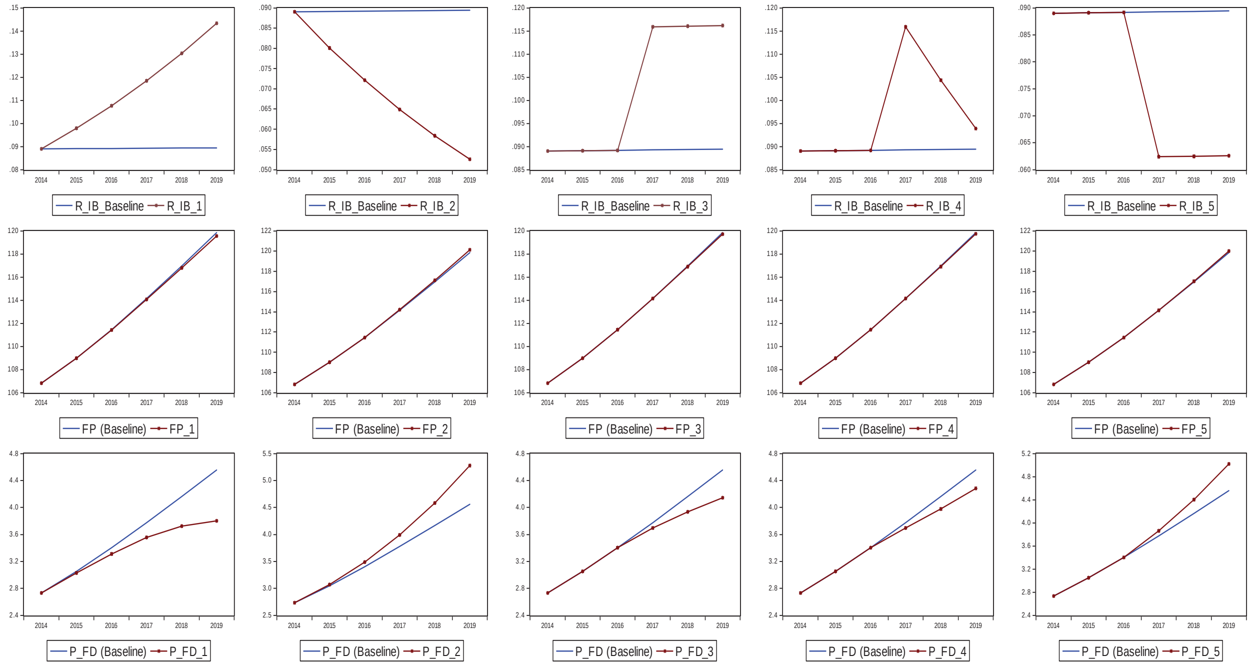

Table 4. Multiplier analysis of public investment

of monetary policy on food production is not very significant, as a 10% change in interest rate causes an approximately 0.05% change in food production. Figure 4 illustrates the significant impact of changes in interest rate on food inflation and, hence, the accessibility dimension of food security. Simulation results reveal that a 10% increase in interest rate causes an approximately 4% decline in the food price index and vice versa. Similarly, interest rate shocks have immediate inverse effects on the food price index as shown in Figure 4. The results of the fourth experiment show that the adverse impact of interest rate shock, although followed by a decline in the interest rate, seems to have long-lasting effects, as the food price index continues to decline over the following three years in spite of the decline in the interest rate. The results of the third, fourth and fifth experiments show that interest rate shocks have long-lasting and significant impacts on food inflation in the Pakistan economy. This suggests that tight monetary policy helps to control food inflation, but with a resulting small drop in food production. On the other hand, easy monetary policy helps to raise food production, but it significantly raises food prices. These results might be expected, as the interest rate on domestic credit to the agricultural sector in Pakistan is not attached to the overall interest rate in the economy. The former is set by the government at a minimum level and, hence, only a small effect of changes in the overall interest rate of the economy on food production has been observed. However, changes in interest rate significantly affect food prices due to a direct relationship with overall inflation in the economy. These results are in line with Barnett (2000), Kargbo (2005) and Orden (2010).

Multiplier analysis of public investment

Fiscal policy consists of revenue collection and public expenditure. Since the agricultural sector is exempt from taxes in Pakistan, tax policy may not have any significant effects on food production. Public expenditure is divided into current expenditure and investment expenditure. Public investment expenditure is considered as an important fiscal policy tool, as public capital formation plays a key role in economic growth. Two types of public investment expenditure can be considered as important for the agricultural sector and hence for food security. These are public investment in the agricultural sector and general government investment expenditure, i.e., development expenditure. Hence, multiplier analysis of public investment consists of seven experiments with different growth rates of the two variables of public investment. For each experiment, both variables of public investment were fixed exogenously from 2014–2015 to 2018–2019; then, the model was used to give dynamic solutions from 1971–1972 to

doi: 10.17221/96/2016-AGRICECON

2018–2019. The average growth rates for the five forecasted years for endogenous variables were computed. The baseline experiment was conducted by fixing a 1% annual increase in both types of investment for the five forecasted years. The remaining eight experiments were conducted by fixing different growth rates of public investment in the agricultural sector and general government investment. The simulation results of all eight experiments were then compared with the baseline experiment by calculating deviations in the average growth rates over the five forecasted years. The results are reported in Table 4.

Table 4 shows that changes in both types of public investment have positive impacts on food production and inverse effects on food inflation. The results of multiplier analyses reveal that a 10% increase in general government investment causes a 0.1% rise in food production along with a 0.1% decline in the food price index. On the other hand, a 10% increase in public investment in the agricultural sector causes a 0.01% rise in food production along with a 0.01% decline in food price. This suggests that general government investment is more effective than public investment in the agricultural sector in raising food production and controlling food inflation. This is because general government investment expenditure is used to develop infrastructure which helps to raise food production and, therefore, food prices began to decline in the country. Hence, fiscal policy can be used to improve the availability as well as accessibility of food by raising food production in the economy. These results are in line with Capehart (2008). Fiscal policy makers in Pakistan have drastically cut direct public investment in the agricultural sector. The results of simulation analyses suggest that this would be harmful for food production as well as food prices in the economy and, hence, the government should raise the level of investment in the sector. Moreover, fiscal policy makers should also consider raising general government expenditure for the development of agricultural technology and infrastructure. Such measures would assist in overcoming the issue of food insecurity in Pakistan.

Multiplier analysis of energy price

Four simulation experiments were conducted to analyse the impact of energy price on food production and food inflation. In each experiment, the energy price index was exogenously fixed for five forecasted years and then the model was solved for endogenous variables from 1971–1972 to 2018–2019. A baseline experiment was conducted in which 0.01% annual increases for five forecasted years were fixed in the energy price index. A 10% annual increase and a 10% annual decrease in the energy price index were fixed for the five forecasted years in the first and second experiments, respectively. The third experiment was conducted to analyse the impact of energy price shock; a 20% increase in the energy price index was fixed in 2015–2016 and 0.01% increases were fixed in the energy price index for the remaining four forecasted years. Average growth rates in the baseline experiment and deviations of average growth rates in the other experiments from the baseline are presented below in Figure 5 and Table 5. The results show that changes in energy prices have significant and direct impacts on food inflation and inverse effects on food production, and vice versa. An increase of 10% in energy prices causes a 0.7% decline in food production and raises food inflation by 9%. This is because an increase in energy prices raises the costs of production, which result in a decline in food production and an increase

Table 4. Multiplier Analysis of Public Investment

Variables	Experiments							
	Baseline	1	2	3	4	5	6	7
FP_t	**2.25**	**0.08**	**–0.11**	**0.01**	**–0.01**	**0.10**	**–0.12**	**0.07**
L_t^A	3.41	–0.01	0.01	–0.00	0.00	–0.02	0.02	–0.01
E_t^A	4.56	0.74	–0.90	0.10	–0.14	0.87	–1.02	0.58
F_t^A	5.06	0.07	–0.09	0.01	–0.01	0.08	–0.10	0.05
I_t^{PA}	**0.75**	**3.97**	**–5.13**	**0.59**	**–0.79**	**4.59**	**–5.89**	**3.14**
P_t	10.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W_t^A	2.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P_t^{FD}	**10.10**	**–0.10**	**0.12**	**–0.01**	**0.02**	**–0.12**	**0.14**	**–0.08**
$M2$	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
I_t^{GG}	**0.99**	**9.00**	**–11.00**	**0.00**	**0.00**	**9.00**	**–11.00**	**9.00**
I_t^{GA}	0.99	0.00	0.00	8.99	–11.00	8.99	–11.00	–11.00

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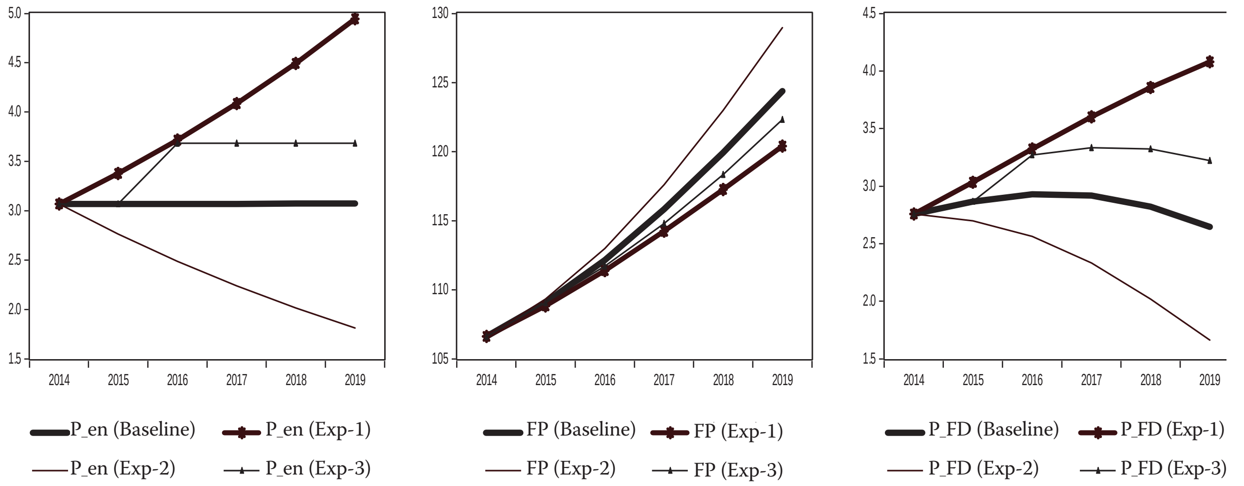

Figure 5. Graphical projection of simulation experiments for the energy price index

in food prices. Moreover, an increase in energy prices raises the overall rate of inflation in the economy and, hence, food prices also increase. These results show that energy prices and food prices move in the same direction in the Pakistan economy, in line with the results of Naim (2008) and the theoretical discussion of Ringler et al. (2011). Hence, energy price policy has much significance for the availability as well as accessibility of food in Pakistan. Therefore, food policy makers should consider controlling energy prices in order to overcome the problem of food insecurity in Pakistan. Increases in energy prices exert significant adverse effects on food availability as well as economic access to food in Pakistan. Thus, the recent decline in energy prices at the global level may contribute positively to food security in the country. However, while a significant decline in oil prices has been observed in Pakistan, prices of electricity and gas have not fallen. Policy makers should consider lowering the prices of all forms of energy and the government should contemplate introducing subsidized energy prices for the agricultural sector. All of these steps may improve the food security situation in Pakistan.

Table 5. Multiplier analysis of Energy Price Index

Variables	Baseline	1	2	3
FP_t	**3.1335**	**–0.6712**	**0.7496**	**–0.3474**
L_t^A	0.380327	2.542110	–2.74114	1.046671
E_t^A	11.67275	–5.64020	6.606896	–2.40883
F_t^A	0.571876	3.844516	–4.09037	1.300644
I_t^{GG}	–0.21825	0.000000	0.000000	0.000000
I_t^{GA}	13.90823	0.000000	0.000000	0.000000
I_t^{PA}	1.021469	0.000000	0.000000	0.000000
P_t	4.698965	4.750806	–5.01685	2.037080
P_t^{FD}	**–0.76868**	**8.921452**	**–8.70591**	**4.080006**
$M2$	13.25844	3.512355	–3.73804	1.830053
W_t^A	2.106565	0.158720	–0.17549	0.076130
P_t^{EN}	**0.010000**	**9.990000**	**–10.0100**	**3.998000**

CONCLUSIONS

Pakistan mainly relies on domestic food production to meet its food consumption needs, i.e., the availability dimension of food security. Its rising population necessitates a significant increase in domestic food production. Hence, food production must rise significantly in order to realise Vision 2050 of the UN. Moreover, high food inflation is a major concern for economic accessibility to food in Pakistan. The demand for food in Pakistan will continue to rise in the next few decades due to population pressures, which will cause food prices to grow due to a demand-supply gap. Higher food prices mainly hurt the poor, which may cause a further deterioration in the national security situation. How macroeconomic policy decisions may be used to improve these two dimensions of food security was the focus of this study.

A macroeconomic simultaneous equations framework was developed to link monetary policy, fiscal policy and energy price policy with food production and food prices. GMM was used to estimate behavioural equations separately using annual data from 1963–1964 to 2013–2014. Then, the model was deterministically solved as a system of equations by using the Gauss-Seidel method to give dynamic solutions of the model for different simulation experiments. Simulation experiments were conducted

doi: 10.17221/96/2016-AGRICECON

to analyse the impact of changes in interest rate, multiplier analysis of public investment and multiplier analysis of the energy price index. Simulation analyses revealed that changes in the interest rate have little impact on food production but have significant inverse effects on food inflation. This suggests that tight monetary policy significantly contrubutes to food inflation with minor negative impacts on food production. Monetary policy may be used to stabilize food prices and in so doing control the devastating effects of food price hikes on poor households. However, policy makers must evaluate its side-effects on other sectors of the economy. Moreover, the government should increase its expenditure for general government investment to develop agricultural technology and infrastructure. Such increased expenditure would help to increase food production and to control food inflation by reducing the supply-demand gap. Multiplier analysis of the energy price index clearly establishes that an increase in energy prices exerts significant adverse impacts on food production as well as food inflation. Every 10% increase in energy prices results in a 0.7% decline in food production along with a 9% increase in food prices. This implies that increases in energy prices may have strong adverse effects on the food security situation in Pakistan. Therefore, the government should continue its recent energy price policy to solve the problem of food insecurity in Pakistan. It may be concluded on the basis of the results that an expansionary fiscal policy of public investment and low energy prices would facilitate significantly the availability and accessibility of food in Pakistan. However, limited numbers of tight monetary policy actions may be taken to control food inflation, while considering its harmful effects on other variables.

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Received March 3, 2016
Accepted August 4, 2016
Published online June 19, 2017