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Monetary and fiscal policies' effect on agricultural growth: GMM estimation and simulation analysis

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ABSTRACT

The concept of sustainable economic growth is closely linked with the agricultural growth. This is especially true in the context of under-developed countries. Pakistan is a typical under-developed country that has huge labor force employed in conventional rural economy and more than half of the population relies on agriculture for subsistence. The study examines the agricultural growth through developing a model using the data from agricultural sector of Pakistan for the period 1972–2010. The model is primarily based on input–output reduced form structural equations approach. It is then estimated by GMM, validated and used for deterministic simulation analyses. Finally the validated model is used to critically analyze the impact of fiscal, monetary and energy policies on the agricultural output. We conluded that recent fiscal and monetary policies should be continued, while the energy policy needs to be modified in order to improve the agricultural GDP and reduce the rural poverty situation in the country.

1. Introduction

Growth in agricultural productivity is central to overall economic development and poverty reduction (see, for example, Fare et al., 2008; Gollin et al., 2002; Irz et al., 2001; Machethe, 2004; Matsuyama, 1992; Pauw and Thurlow, 2011; Thirtle et al., 2003; Timmer, 1988). The use of inputs such as fertilizers and better seeds has been achieved considerably during the Green Revolution in 1980s. Moreover, the growing interest in national food security especially in South Asian countries stirred by recents supply shortages and restricted international trade during short supply periods boosts the importance of domestic agricultural sectors. Production of adequate amounts of agricultural output is essential for food security, which has been a major concern since the mid-1990s spanning a spectrum from the individual to the global levels (FAO, 2010; World Hunger, 2011). Growing agricultural sector ensures the employment and sustenance of masses living in rural areas in the agrarian economies.

Although agriculture is operated entirely by private sector yet public policy plays an important role in the sectoral growth of developing countries due mainly to resource constrainted farming communities. Historically, public sector influenced domestic agriculture directly through fiscal measures and setting price of output low to ensure the availability of inexpensive food for the masses as well as indirectly through monetary policy. Subsidized fertilizers were made available to ensure optimal inputs use for increasing productivity and such subsidies were a major component of Public Sector Development Plan of Pakistan during 1980s and 1990s. Recently, the public influence on agricultural prices and fertilizers subsidy has gradually been reduced. Moreover, public expenditures on research and its dissemination also contribute to the agricultural growth in Pakistan. Many previous studies observed that both public agricultural research and extension have positive and significant impacts on productivity (for example, Eyo, 2008; Huffman and Evenson, 2006; McCarl et al., 2009). Direct monetary policy impact is limited and credit requirement of farmers are mainly met through informal setting where broker (*Arhti*) provides input on credit. However, inflationary measures taken by the State Bank of Pakistan may affect indirectly the demand of inputs and output in agricultural sector.

The discourse in literature on development economics focuses the agricultural productivity and various factors affecting its growth in developing countries (see, for example, Ahmad and Martini, 2000; Chang and Zepeda, 2001; Dayal, 1984; Fan and Pardey, 1997; Fare et al., 2008; Fernandez-Cornejo and Shumway, 1997; Huang and Rozelle, 1996; Jensen et al., 2001). Gollin et al. (2002) shows that improvements in agricultural productivity accelerate industrialization and, have large effects on relative income. Therefore, a greater understanding of the determinants of agricultural growth may be helpful in understanding the development process for underdeveloped nations.

The impact of monetary policy on agricultural sector is rarely analyzed in the context of less develop countries. Few studies check the impact of monetary policy variables on commodity prices in agricultural sector (see, for example, Frankel, 2006; Hye, 2009; Orden and

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Fackler, 1989). In a recent study, Eyo (2008) finds that the exchange rate regime has not encouraged agricultural export while, agricultural credit is insignificant in affecting agricultural output growth. In recent years, monetary authorities have been adjusting interest rate after every three months in Pakistan keeping in view the economic conditions. On the fiscal side, energy subsidies have been reduced gradually due to contraints resulting in successive increases in energy prices during the last few years.[2] The impact of energy policy on agricultural sector is an ignored area and we could not find any study examining this issue. This study contributes in many ways to the existing literature. We develop an econometric model of Pakistan based on input–output framework using reduced form structural approach. Later, we conduct simulation to analyze the impact of interest rate shocks and various increases in energy price index on agricultural sector. Our study extends to previous literature on policy role in agricultural sector modeling both in breadth (*i.e.* consideration sub-sectors) and analytical scope (i.e. model estimation through the recent econometric methodology).

The development of agricultural sector models and identifying interactions with other macroeconomic variables has long history. Byerlee and Halter (1974) develops a simple simulation model for Nigeria built on an input–output framework that enables interactions in the product and labor markets. The study illustrates through linkage with an agricultural simulation model and evaluate alternative agricultural policies. Roop and Zeitner (1977) also develops agricultural sector model integrated into a larger macroeconomic model in order to identify the relationship between agriculture and rest of the economy. Some studies focus on the price formation of agricultural output while examining the relationship between agricultural sector and macroeconomic environment and finds significant bilateral causal relationship between macroeconomic variables and those refering to price formation in the sector. It shows that the macroeconomic policies and decisions strongly affect the agricultral sector and price stability (see, Dritsakis, 2003; Eckstein, 1984; Hye, 2009).

In spite of long history of such econometric modeling for policy making, partial equilibrium model construction is less frequent in developing countries. The problem with scattered commodity level models is that these are poorly integrated with national or agricultural systems, severely limiting their uses in practical work. This leads to the so-called traditional paradox of “meaningful parts forming meaningless whole” in agricultural model research (Chen, 1977).

The remainder of the paper is organized as follows. In the Section 2, we provide the structure of agricultural sector in Pakistan. Section 3 presents the specification of the model and methodology and data is described in Section 4. Sections 5 and 6 put forward respectively the estimation results and validation of the model. The simulation analysis is presented at Section 7 while Section 8 concludes.

2. Structure of agricultural sector in Pakistan

The agricultural sector has played an important role in Pakistan's economy. It accounts for over 21% of GDP, and remains by far the largest subsistence provider sector that absorbs 45% of the country's labor force. Nearly 60% of the rural population relies directly or indirectly on agriculture for their livelihood. The sector is the primary supplier of primary goods to downstream manufacturing industry, high proportional share in exports and a market for many industrial and energy products such as fertilizer, pesticides, machinery, oil and electricity. Pakistan agricultural sector enjoys substantial growth during the Green Revolution particularly in the crops sub-sector. The decade-wise cumulative average agricultural growth rates are given in Table 1 showing the impact of Green Revolution in terms of subsequent growth achievements.

Table 1
Historical decade-wise agriculture growth performance.

Period	Growth (%)
1960s	5.1
1970s	2.4
1980s	5.4
1990s	4.4
2000s	3.2

Source: Federal Bureau of Statistics, Government of Pakistan.

Agricultural sector remains a key sector in economic development despite the relatively fast growing industrial and services sectors. It is due to its ability to produce food and source of livelihood. The food security concerns are worldwide but South Asia is among the most vulnerable regions where large number of people are food insecure. World Food Programme (WFP) declared that more than 48% people in Pakistan are food insecure (Khan, 2011). The agricultural sector is a source of susvival for millions of rural households and accounts for relatively huge share in national income and total employment in most agrarian economies.

The agricultural sector output especially crops has been volatile in nature. The major crops (wheat, rice, cotton, and sugarcane) contribute 1/3rd of agricultural GDP in Pakistan. The minor crops account for 11% of the value added in overall agriculture. Livestock contributes 53.2% to agricultural output—more than the combined contribution of crops while the share of fishery in total agricultural output remains 2–3%. Livestock have rather stable growth trend. Fisheries share in GDP is relatively low but it contributes substantially to the national income especially through export earnings. The fourth component of agricultural sector in Pakistan is forest that has contracted significantly in the recent past. Pakistan is among few countries where highest rates deforestation is taking place (Shahbaz et al., 2007).

To clearly appreciate the linkages between public policy and agricultural growth in Pakistan, the causal relationships are given below at Figs. 1 and 2. It shows that agricultural output at aggregate and sub-sectoral levels has causal relationships as the graphical representations show same trend in the long-run. However, public investment only remained driver of agricultural growth upto early 1990s and later private sector investment became self sustained. Therefore, the trend of public investment in agricultural sector does not match with the agricultural growth beyond 1995. Government agricultural investments prior to early 1990s was mainly focused to mechanization of the sector. During 1990s and 2000s, the public general investment keep on rising that indirectly affected agricultural growth especially through better water and energy infrastructure and access to markets. Hence fiscal policy affects agricultural growth directly as well as indirectly.

There are two important monetary policy channels affecting agricultural growth, i.e. interest rate channel and credit channel. Fig. 2 shows that inter-bank call money rate and weighted average rate of return on bank advances have cointegration. Graphical analysis shows poor causal relationship between agricultural output and interest rate. However, credit to agricultural sector shows causal relationship with the output. These relationships are further elaborated through an econometric model.

3. Specification of the model

The disposition of agricultural sector in Pakistan is carried out by constructing a simultaneous equation model in an input–output framework. It focuses on identifying the likages of the agricultural sector with fiscal and monetary policy and a number of other interacting variables. The role of fiscal policy is limited to government investment expenditures

[2] There are two main energy regulatory bodies namely; Oil and Gas Regulatory Authority (OGRA), which regulates the natural gas, LPG and oil products in Pakistan and National Electric Power Regulatory Authority (NEPRA), which regulates the electricity in the country.

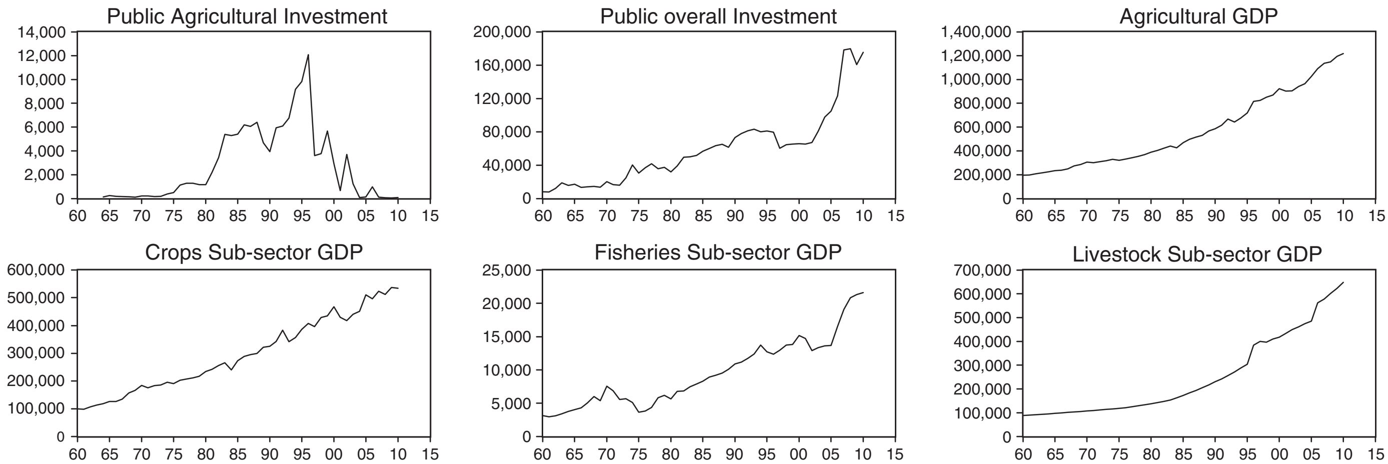

Fig. 1. Causal relationships between Fiscal Policy and Agricultural Output.

since agricultural sector is exempted from taxes. There are two instruments of fiscal policy; public investment in agricultural sector, and general government investment on infrastructure such as expenditure on roads, canals, dams, etc.

Economic literature discusses on various channels including the interest rate channel, the credit channel, the exchange rate channel and the asset price channel through which monetary policy affects real sector of the economy. However, the relative importance of each channel may differ from one country to another depending on the structure of financial markets, central bank's credibility and the degree of openness of the economy. According to a recent study on monetary transmission channels in the context of Pakistan, monetary policy transmits mainly through interest rate and credit channels (Aleem, 2007, 2010). We concentrate only these two channels in this study. The interest rate channel is considered as the most important monetary policy channel in conventional macroeconomic models especially in the Neo Keynesian context. The interest rate channel affects agricultural growth through private investment, agricultural credit and capital stock whereas credit channel operates through private investment. The exchange rate regime of Pakistani rupee is characterized as the managed floating exchange rate and hence, the study does not contain the exchange rate channel. The asset price channel is also not considered due to low market capitalization of listed companies.

The model assumes that the economy comprises of an agricultural and a non-agricultural sector. Aggregate output or GDP at facor cost is decomposed into agricultural output and non-agricultural output.

$$Y_t^{FC} = Y_t^A + Y_t^O \tag{1}$$

Non-agricultural output is treated as exogenous here and derived simply by subtracting agricultural output from overall GDP. Agricultural output is represented for agricultural subsectors i.e. crops, livestock, fisheries and forestry.

$$Y_t^A = Y_t^C + Y_t^L + Y_t^F + Y_t^{For} \tag{2}$$

We follow Akbar (2011) for constructing reduced form output functions from supply and demand functions for all sub-sectors. The underlying production functions, the output supply and sectoral demand functions and demand functions for variable inputs are assumed to be of Cobb–Douglas form. It follows that the reduced form functions for the sectoral outputs also take the Cobb–Douglas form. Input demand functions for agricultural sector are specified at aggregare level. Supply function for output in crop sector is assumed to depend on the price of output in crops sector, prices of inputs (i.e. agricultural wage rate, energy price index, and fertilizer price index), capital stock, domestic credit

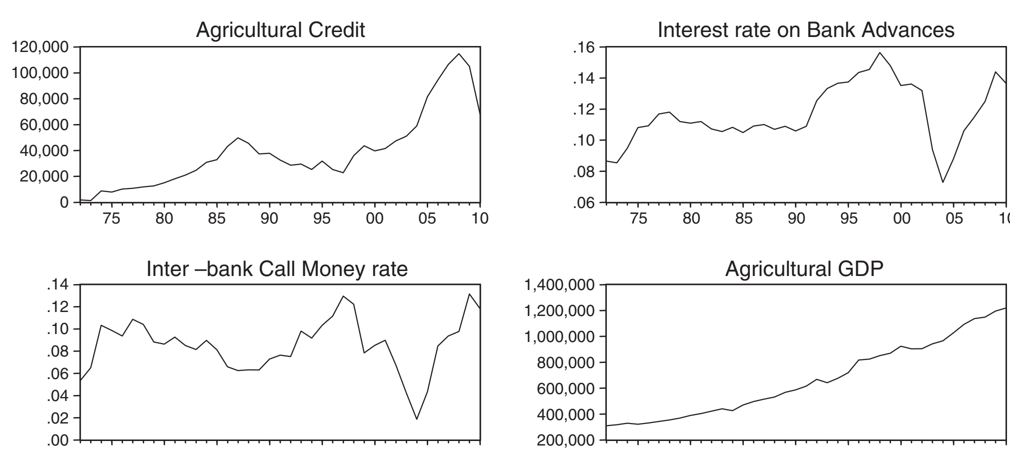

Fig. 2. Causal relationships between Monetary Policy and Agricultural Output.

to agricultural sector and rainfall. Although rainfall does not have any linkage to the impact of monetary and fiscal policies upon agricultural growth yet, we have included it as an explanatory variable that may explain the energy requirements of agricultural sector .

$$Y_t^{CS} = Y^{CS}\left(P_t^C, W_t^A, P_t^{EN}, P_t^{FR}, K_t^A, DC_t^A, RF_t\right) \tag{3a}$$

Demand for output of crops sub-sector depends on the output price, size of population, per capita income and price index of exports.

$$Y_t^{CD} = Y^{CD}\left(P_t^C, N_t, Y_t^{PC}, P_t^{EX}\right) \tag{3b}$$

The reduced form output function for the crops sector is obtained by solving Eqs. (3a) and (3b) to eliminate the output price index of crops. Hence, the output function for the crops sub-sector is specified as follows.

$$Y_t^C = Y^C\left(W_t^A, P_t^{EN}, P_t^{FR}, K_t^A, DC_t^A, RF_t, N_t, P_t^{EX}, Y_t^{PC}\right) \tag{3}$$

Similarly, reduced form functions of output for livestock and fishery are obtained. Output supply in livestock and fishery depends upon output price, agricultural wage rate, energy price index, capital stock, credit to agricultural sector and rainfall. Output demand is determined by output prices, size of population, per capita income and price index of exports.[3] By eliminating the output prices, reduced form output functions for these two sectors takes the form,

$$Y_t^L = Y^L\left(W_t^A, P_t^{EN}, K_t^A, DC_t^A, RF_t, N_t, P_t^{EX}, Y_t^{PC}\right) \tag{4}$$

$$Y_t^F = Y^F\left(W_t^A, P_t^{EN}, K_t^A, DC_t^A, N_t, P_t^{EX}, Y_t^{PC}\right) \tag{5}$$

For simplicity, we consider the output in forestry as exogenous due to its negligible share in overall agricultural output (less than 1%). The demand functions for labor, energy and fertilizer are derived as the cost minimizing conditional input demand functions given the level of output which depends on output, capital stock and input prices.

$$L_t^A = L^A\left(Y_t^A, K_t^A, W_t^A, P_t^{EN}, P_t^{FR}\right) \tag{6}$$

$$E_t^A = E^A\left(Y_t^A, K_t^A, W_t^A, P_t^{EN}, P_t^{FR}\right) \tag{7}$$

$$F_t^A = F^A\left(Y_t^A, K_t^A, W_t^A, P_t^{EN}, P_t^{FR}\right) \tag{8}$$

Capital stock in the sector is derived from private investment and public investment in agricultural sector by using the following identities.

$$\begin{aligned} K_t^A &= \frac{I_t^{PA} + I_t^{GA}}{\delta + g^A} \qquad ; t = 1 \\ K_t^A &= (1-\delta)K_t^A + \left(I_t^{PA} + I_t^{GA}\right); t > 1 \end{aligned} \tag{9}$$

where δ denotes annual depreciation rate of fixed capital in agricultural sector while g^Adenotes annual compound growth rate of output in agricultural sector. The role of fiscal policy represents in the model through public fixed agricultural investment. Public investment decisions to achieve growth tergets depends on public revenue. Hence, functions for public fixed investment expenditure and general government investment expenditure are specified as follows.

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

$$I_t^{GG} = I^{GG}(R_t) \tag{11}$$

Private fixed investment expenditure in agricultural sector depends on the user cost of capital, lagged value of agricultural output, public investment expenditures and domestic credit.

$$I_t^{PA} = I^{PA}\left(P_t^{KA}, Y_{t-1}, I_t^{GA}, DC_t^A, I_t^{GG}\right) \tag{12}$$

User price of capital for agricultural sector is obtained as the sector-specific price index of capital goods multiplied by interest rate on bank advances plus depreciation rate less rate of inflation in the price index of capital goods.

$$P_t^{KA} = P^{MA}\left(r_t^A + \delta - \left(\frac{P_t^{MA}}{P_{t-1}^{MA}} - 1\right)\right) \tag{13}$$

Demand function for agricultural credit depends on interest rate and agricultural output thereby, allowing impact of monetary policy on agricultural output through agricultural credit function.

$$DC_t^A = DC^A\left(r_t^{ib}, Y_t^A\right) \tag{14}$$

The wage rate in the sector depends on general price level, sectoral output and unemployment rate.

$$W_t^A = W^A\left(P_t, Y_t^A, UR_t\right) \tag{15}$$

Energy price index and fertilizer price index are exogenous in the model as prices of these inputs are set exogenously. Interest rate (inter bank call money rate) is also taken as exogenous because it is also fixed exogenously by the central bank. Overall price level of the economy is modeled as it has a significant impact on prices of agricultural outputs. Moreover, monetary policy also affects agricultural sector through this channel and many recent studies presented the discourse on this relationship rigorously (see, for example, Dahmardey et al., 2010; Moorthy and Kolhar, 2011; Price and Nasim, 1999). General price level in the economy is represented by GDP deflator (at factor cost), which is determined by both the supply side as well as demand side factors. GDP deflator is assumed to depend on aggregate output of the economy, money supply, exchange rate, international oil prices and energy price index. International oil price and energy price index are considered as separate regressors because prices of different energy forms are set by in the country exogenously. Hence, price function is specified as follows.

$$P_t = P\left(Y_t^{FC}, M2_t, ER_t, P_t^{WO} \times ER_t, P_t^{EN}\right) \tag{16}$$

where exchange rate, energy price index and international oil prices are exogenous variables because these are not affected by agricultural output. However, we model the behaviour of money supply. Money supply is adjusted equal to money demand in the economy and the quantity of money is set equal to liquidity demand, which depends on nominal aggregate demand and nominal interest rate.

$$M2_t = L\left(P_t \times Y_t, r_t^{ib}\right) \tag{17}$$

Sectoral price levels are determined by the interaction of supply and demand forces. In the absence of explicit sectoral demand functions, an

[3] Most of the output in fishery sector depends on marine fisheries and hence, rain fall does not have much effect on fishery sector.

approximate procedure is adopted to determine the sectoral price levels. Price level in sector j is assumed to be a function of general price level and the sectoral outout. Thus output price levels in crops, livestock, fishery and overall agricultural sector separetly are determined as follows.

$$P_t^j = \left(P_t, Y_t^j\right) \text{where} j = C, L, F, A \tag{18–21}$$

Finally, the per capita income and inflation rate are specified in the model as follows.

$$Y_t^{\rm PC} = \frac{Y_t^{\rm FC}}{N_t} \tag{22}$$

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{23}$$

4. Data and Methodology

Annual data of Pakistan for the period 1972–2010 is used to estimate the model. All the variables are used in real terms (at base 1999–2000) except exchange rate, wage rate, money supply and interest rates. The economic variables are obtained from *Pakistan Economic Survey* 2010–11 and various previous issues and *Statistical Year Book*, 2009 while the agricultural data is obtained from *Agricultural statistics* 2010. Data on energy consumption is obtained from various issues of *Pakistan Economic Survey* 2010–11 and *Pakistan Statistical Year Book* 2009. The different energy sources consumed in agricultural sector are converted into similar unit that is, tones of oil equivalent.[4] Agricultural energy consumption variable is obtained by adding these different sources. Price indices for sectoral output are constructed by dividing the sectoral real output to sectoral nominal output. Agricultural wage rate data is not available in the published sources hence, we have used the same generated by Akbar (2011).

Annual compound growth rates of agricultural output are used to derive the initial period data figures of capital stock. Annual depreciation rate of fixed capital is used as 0.05. Some dummy variables are also constructed and used in order to measure various shocks and shifts in various regression equations due to policy changes or any other event that leaves a significant impact on the economy. These dummy variables are treated as exogenous variables in the model and are explained at Appendix-B.

All the variables except rates are transformed into their natural logarithms. Besides regressors specified above, first and second order autoregressive schemes,[5] lag values of regressands, time trend and some dummy variables are also added in most of the equations at estimation stage to capture the effects of some additional aspects. Generalized Method of Moments (GMM) is used for estimation of each equation separately by 2SLS consistent estimates in EViews 5. GMM method is considered superior to the alternatives in handling many econometric problems including endogeneity, heteroscedasticity, serial correlation and identification. It uses weighting matrix to account for serial correlation and heteroscedasticity of unknown form and for nonlinearities (see, Hansen, 1982; Newey and West, 1987; White, 1984). Hsiao (1997) proves that conventional 2SLS inference procedure gives consistent estimates hence, GMM estimator based on 2SLS consistent estimates is considered as valid estimation technique. Furthermore, cointegrating relations due to non-stationarity of variables in structural equations are found.

GMM estimation technique requires moment conditions. A set of population moment conditions is specified on the regression errors. These moment conditions set the expected value of the errors and the expected values of the products of errors with exogenous instrumental variables equal to zero. These population moments are then replaced by the sample moments to derive the parameter estimates. Identification in GMM requires that there should be at least as many instruments (including the intercept) and, hence, the moment conditions in each equation as the number of parameters to be estimated. An equation may be under-identified, exactly identified or over-identified depending on whether the number of instruments and, hence the moment conditions in that particular equation are respectively less than, equal to or greater than the number of parameters to be estimated. In this study, number of instruments in each equation is greater than the number of parameters to be estimated hence, all the equations are over-identified and GMM gives unique estimates of the parameters in over-identified equations.

After estimation, the model is deterministically solved as a system of equations by using Gauss-Seidel to get dynamic solutions for different simulation experiments. Historical simulation experiment is conducted by solving the model for the period 1975 to 2010 and the results are used to check validity of the model. Other simulation experiments are conducted on the basis of forecasting horizon consisting of five years from 2011 to 2015. For this purpose, exogenous variables are forecasted using best fitted Auto Regressive (AR) model. Various experiments are performed by conducting deterministic simulations and the model is solved dynamically for the period 1975–2015 using Gauss-Seidel technique in all the experiments.

5. Results and discussion

There are 17 behavioral equations and 105 slopes to be estimated in the model. Table 2 gives results of estimated equations and the results of diagnostic tests indicating reasonably good fit and none shows any symptoms of econometric problem. Values of Breusch-Godfrey LM test statistic show that all the equations are free from the problem of serial correlation up to two lags. Values of F-statistic show that explanatory variables explain a significant amount of variability in the dependent variable of each equation. Values of Adjusted R^2 are high in all the equations. Moreover, 72 out of 105, that is, 69%, of the estimated slops are significant and the signs of almost all the estimated parameters in the model are either according to theoretical expectations or somehow can be justified. This indicates that there is not a problem of at least severe incidence of multicollinearity in the estimated model.

White test shows that all the equations are free from the problem of heteroscedasticity. Moreover, low level of standard errors and high level of $\bar{R}^2$ in most of the estimated equations show reasonably good fit of the estimated model. In all the equations, number of instruments is set greater than the number of parameters to be estimated. Moreover,

Table 2
Diagnostic test statistics for behavioral equations.

Regressand	Durbin Watson	*Adj.R*^{2}	S.E.	J-Stat. (*p*-value)	F-Stat.	GB-Stat.	White test (*p*-value)
Y_t^C	1.81	0.99	0.04	0.69	215.47	0.44	0.45
Y_t^L	2.16	1.00	0.04	0.87	809.85	0.48	0.53
Y_t^F	1.11	0.93	0.13	0.76	48.45	5.39	0.12
L_t^A	2.08	0.98	0.03	0.72	221.72	0.18	0.27
E_t^A	2.32	0.90	0.10	0.36	49.34	1.24	0.31
F_t^A	1.20	0.99	0.08	0.58	402.44	4.55	0.25
I_t^{GG}	2.12	0.93	0.14	0.33	135.83	4.80	0.43
I_t^{GA}	1.88	0.67	0.94	0.40	12.25	4.15	0.24
I_t^{PA}	2.41	0.70	0.20	0.50	16.06	3.85	0.66
DC_t^A	2.20	0.84	0.38	0.96	42.03	4.72	0.99
P_t^A	2.28	1.00	0.02	0.63	13644.20	1.08	0.16
P_t	2.08	1.00	0.03	0.58	4497.29	0.54	0.32
W_t^A	2.15	1.00	0.05	0.67	2601.93	0.62	0.60
P_t^C	1.67	1.00	0.06	0.13	1882.89	0.85	0.17
P_t^L	1.27	1.00	0.05	0.51	3301.00	4.61	0.50
P_t^F	2.29	0.99	0.08	0.72	858.77	3.85	0.71
$M2_t$	1.97	1.00	0.05	0.99	11379.70	0.23	0.61

[4] Unit conversion factors have been taken from www.onlineconversion.com.
[5] Autoregressive schemes are used to control the problem of autocorrelation in the equations.

values of J statistic show that the chosen instruments are exogenous and satisfy orthogonality conditions in all the estimated equations. We may conclude the above discussion that our estimated model is free from any severe econometric problem.

Estimation results of estimated equations are given in Appendix A. Agricultural wage rate shows positive relationship with output of all three sectors indicating that wage increase improves efficiency of the labor employed. Energy price index and export price index have significant adverse impact on output, which implies that increase in energy prices has negative effect on output supply and increase in export price lowers the demand for agricultural exports. Impact of fertilizer price is negative but insignificant on crops output. The extensive fertilizer subsidy in the past may cause insignificant coefficient of fertilizer price. Capital stock, population size and credit to agricultural sector directly affect output in all sub-sectors. Amount of rainfall has positive but insignificant impact on agricultural output as most of the agricultural output depends on canal water (almost 70%) or tube wells and arid agricultural output constitutes only 10% in Pakistan.

Physical inputs considered are labor, energy, and fertilizer. All these three inputs capture significant adverse impact from their own prices. Energy price has significant direct relationship with labor demand which shows that energy is substituted by labor with increase in its price. But on the other hand, wage rate is insignificant in determining energy demand. Fertilizer price and wage rate have negative but insignificant coefficients in input demand functions. It means that increase in fertilizer price has negative impact on output which results in decline of labor demand and increase in wage rate raises efficiency of labor which results in decline of fertilizer demand. Fertilizer price index and energy price index have significant positive coefficients in energy demand and fertilizer demand respectively which implies that both the inputs are substitutes. Capital stock significantly affects all the three inputs demand. However, its negative coefficient in labor demand equation implies that an increase in capital stock lowers the demand for labor while its positive coefficients in energy and fertilizer demand equations show that capital stock raises the demand for energy and fertilizer. Higher capital stock implies mechanization which results in expansion of cultivable land and increased farming activity therefore higher demand of energy and fertilizers. Agricultural output has direct impact on all three input demands. Our results are similar to Ali et al. (2009), that the input intensification is inevitable for agricultural output growth in Pakistan. Hazell and Rosegrant (2000) however, suggest that the new investments in agricultural sector need to be directed towards increasing productivity and efficient use of inputs. In view of the resources scarcity, it is important for agricultural growth to depend on production efficiency improvement to achieve sustainability (also see, Jensen et al., 2001; Hu and McAleer, 2005).

Inputs related to public policy are public investment expenditures and agricultural credit. Public fixed investment in agricultural sector is negatively and significantly affected by agricultural output. It shows that government raises its investment expenditure in agricultural sector when agricultural output growth falls short of growth targets. This is especially due to poor investing capability of private sector and market structure, that the government bears the burden of investing in R & D activities in agriculture in the country.

However, public fixed investment in agricultural sector has a significant crowding-out effect, while general government investment expenditure has a positive and significant impact on private investment. It indicates that government expenditures and investments on social and physical infrastructure are more beneficial than investment expenditure on agricultural sector. Moreover, data for public fixed investment in the agricultural sector shows downward trend during the recent decade and a little amount is invested in this sector now as shown by Fig. 1. On the other hand, general government investment expenditure has upward trend which indicates that recent fiscal policy pertaining to agricultural sector is on right track.

The agricultural output of previous years contains negative and significant coefficient in the equation of private investment. It shows that agriculturist increases investment expenditure if they observe the decline in output and vise versa. User cost of capital has adverse but insignificant relationship with private investment in agricultural sector. Agricultural output has a direct and significant impact on domestic credit. Interest rate has negative but insignificant impact on domestic credit to agricultural sector. It shows from estimation results that changes in interest rate has less influence in determining credit and investment expenditure to agricultural sector signifying the importance of institutional factors in determining the credit to the sector.

Sectoral output prices and wage rate are linked to overall price level and monetary policy instruments. Overall price level represented by GDP deflator is directly affected by money supply, exchange rate and energy price index while aggregate output has negative relationship with overall price level. International crude price has direct but insignificant impact in determining the aggregate price level. Nominal demand has significant direct and interest rate significant negative effect on money demand and hence money supply in the economy. Overall price level and agricultural output directly and significantly affect while impact of unemployment rate is insignificant on agricultural wage rate. Overall price level has direct while sectoral output has negative relationship with output prices of crops, livestock, fisheries and overall agricultural sector.

Signs of all dummy variables are according to our expectations and can be justified with respect to impact of the phenomena represented by the dummies. D_t^{8085}shows significant positive impact of first Afghan war on output of crops sub-sector, public fixed investment expenditure and credit to agriculture sector due to heavy foreign aid during that period. Positive sign and significance of the parameters of D_t^{8900} in the equations of GDP deflator, output deflator of crops sub-sector show adverse impact of successive changes in governments during 1990s. Estimated parameter of D^{9296} in the equation of public investment in agricultural sector shows that government raises investment expenditure in agriculture sector after the devastating flood in 1992. D^{9407}captures adverse impact of privatization process on general government investment. D^{9901} shows positive impact of the event of atomic explosion in 1999. Dummy variable D^{0207} representing the effects of 9/11 and subsequent events contains significant positive sign in the equation of general government investment expenditure due to increase of foreign capital and foreign aid. D^{0407} representing the impact of oil price hike and food price hike shows significant direct impact on output and price level of crops and fisheries sub-sectors indicating rise in food production due to rise in food prices.

6. Validation of the model

The model is deterministically solved as a system of equations by using Gauss-Seidel technique, which gives predicted values by dynamic solution for the period 1975–2010. Theil inequality coefficients, root mean square percentage errors and mean absolute percentage errors are presented in Table 3. The predicted values of the model and actual

Table 3
Validation statistics for within-sample prediction.

Variables	TIC	RMSPE	MAPE	Variables	TIC	RMSPE	MAPE
Y_t^A	0.028	0.047	0.033	I_t^{PA}	0.072	0.125	0.099
Y_t^C	0.055	0.097	0.066	DC_t^A	0.119	0.260	0.177
Y_t^L	0.029	0.045	0.025	P_t^A	0.069	0.109	0.078
Y_t^F	0.053	0.077	0.048	P_t	0.064	0.097	0.070
L_t^A	0.032	0.057	0.038	W_t^A	0.088	0.129	0.100
E_t^A	0.056	0.096	0.059	P_t^C	0.069	0.116	0.088
F_t^A	0.043	0.062	0.044	P_t^L	0.067	0.112	0.088
I_t^{GA}	0.138	9.166	3.517	P_t^F	0.070	0.115	0.076
I_t^{GG}	0.063	0.091	0.063	$M2_t$	0.072	0.131	0.096

Note: TIC, RMSPE and MAPE denote respectively the Theil inequality coefficient, Root mean square percentage error and Mean absolute percentage error.

values are close to each other as the values of almost all statistics are within acceptable range. The graphical projections of actual and predicted values of key variables in Fig. 3 indicate that the deterministic dynamic solution of the model tracks the actual time paths and the turning points of the actual historical data reasonably well.

7. Simulation analysis

After establishing validity of the estimated model, it can now safely be used for forecasting and simulation analyses to analyze the model's properties. The study contains an analysis of the impact of interest rate shock and multiplier analysis of energy price index.

7.1. Interest rate shock

Three experiments are conducted to see the impact of interest rate shock on the agricultural output. In the baseline experiment, growth rate of interest rate is adjusted as 1% for five forecasting years. Growth rate of interest rate in the second experiment is taken as 20% for the year 2012 and 1% for rest of the forecasting years, i.e. an interest rate shock is given that sustained in the forecasting period i.e. 2011–2015. In the third experiment, growth rate of interest rate is adjusted as 20% in 2012 but growth rates for the following three financial years are adjusted as −10%, −5% and −2%; i.e. level of interest rate is decreased in the following years after interest rate shock. The resulting growth rates under these three experiments are reported for comparison in Table 4. Graphical projection of the shocks is also presented in Fig. 4.

The results show that interest rate shock adversely affects agricultural output, employment, fertilizer demand, private investment and wage rate but it significantly lowers prices of sectoral output. Interest rate shock negatively affects domestic credit to agricultural sector, private investment and wage rate whose direct impact goes to sectoral output of agriculture. As overall price level declines due to interest rate shock, therefore, sectoral output price levels and, hence, overall agricultural output prices also decline. This decline is significant while adverse impact on agricultural output is not too much severe. Hence, it may be concluded that interest rate shock does not have much adverse impact on agricultural sector in Pakistan but it is useful to control inflation in agricultural

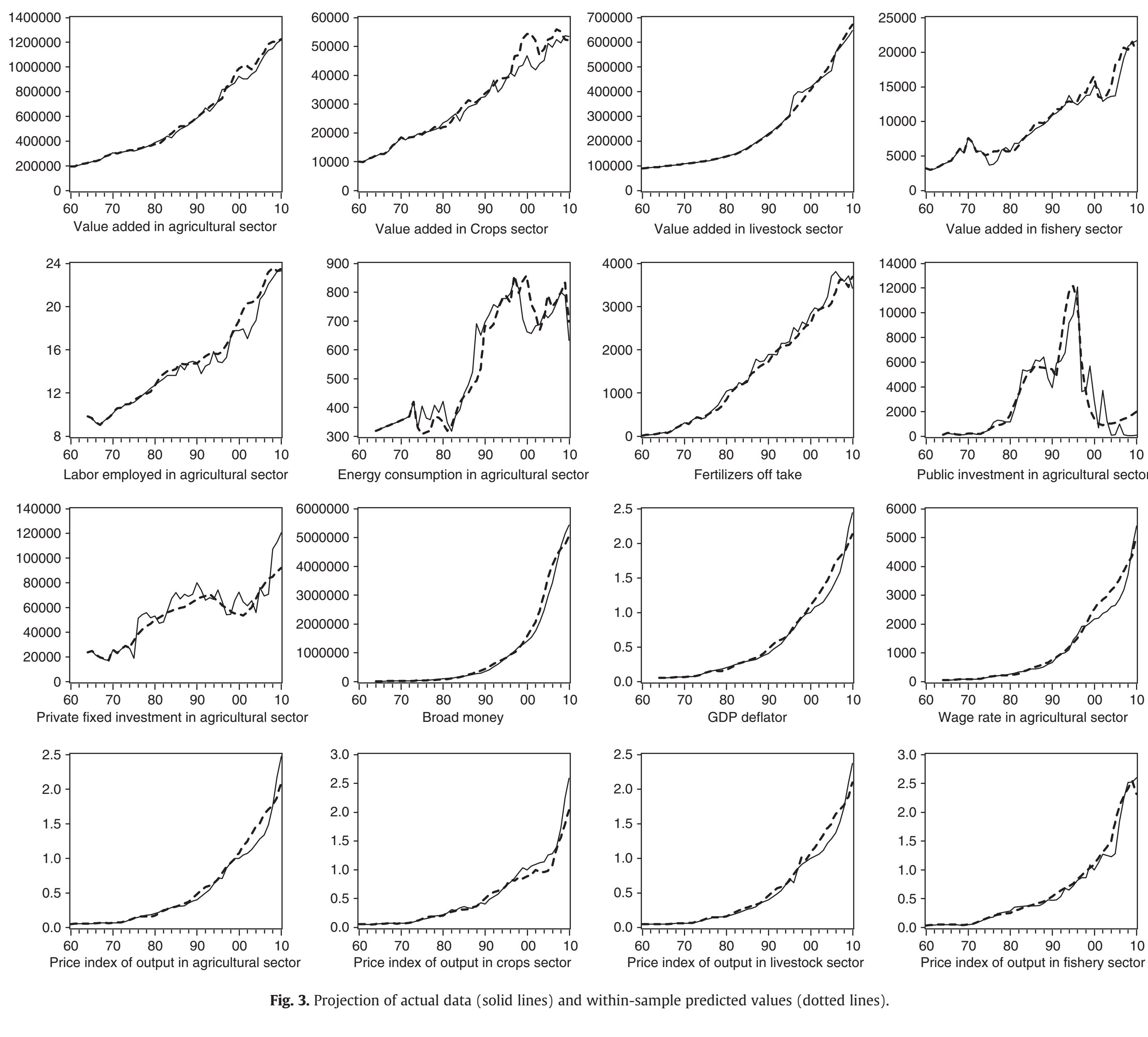

Fig. 3. Projection of actual data (solid lines) and within-sample predicted values (dotted lines).

Table 4
Numerical projection of interest rate shock (growth rates).

Variables	First (Baseline) experiment					Second experiment					Third experiment				
	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015
r_t^{ib}	1	1	1	1	1	1	20	1	1	1	1	20	−10	−5	−2
Y_t^A	6.65	3.63	3.72	4.18	4.61	6.65	3.46	3.45	3.74	4.07	6.65	3.46	3.57	3.98	4.50
Y_t^C	8.57	2.01	2.07	2.86	3.51	8.57	1.70	1.59	2.07	2.58	8.57	1.70	1.80	2.51	3.35
Y_t^L	4.61	4.76	4.90	5.10	5.37	4.61	4.70	4.80	4.94	5.13	4.61	4.70	4.84	5.02	5.29
Y_t^F	19.04	3.91	3.89	4.83	5.88	19.04	3.40	3.16	3.63	4.47	19.04	3.40	3.51	4.31	5.64
L_t^A	3.52	1.88	0.68	0.96	1.33	3.52	1.83	0.59	0.82	1.15	3.52	1.83	0.62	0.90	1.28
E_t^A	11.65	9.54	9.59	6.68	6.51	11.65	9.55	9.99	7.34	7.24	11.65	9.55	9.98	7.05	6.63
F_t^A	8.91	2.47	0.79	2.63	2.77	8.91	2.46	0.76	2.58	2.71	8.91	2.46	0.77	2.61	2.75
I_t^{GG}	4.97	5.03	5.02	4.99	4.95	4.97	5.03	5.02	4.99	4.95	4.97	5.03	5.02	4.99	4.95
I_t^{GA}	6.98	6.52	5.93	4.64	2.90	6.98	6.81	6.59	5.87	4.70	6.98	6.81	6.40	5.32	3.60
I_t^{PA}	6.40	0.83	1.26	0.56	2.42	6.40	0.49	1.02	0.43	2.35	6.40	0.49	1.26	0.68	2.58
DC_t^A	10.5	5.58	5.72	6.46	7.16	10.5	0.56	5.24	5.69	6.23	10.5	0.56	8.86	7.80	7.77
P_t^A	2.73	3.29	3.94	3.90	3.81	2.73	2.30	1.67	1.14	1.52	2.73	2.30	2.35	3.04	4.39
P_t	5.94	4.64	4.08	4.03	4.07	5.94	3.60	1.91	1.45	1.87	5.94	3.60	2.62	3.29	4.58
W_t^A	7.37	3.82	3.64	5.12	6.85	7.37	3.35	2.29	2.88	4.21	7.37	3.35	2.61	3.98	6.33
P_t^C	2.88	3.36	3.02	2.19	1.37	2.88	2.75	1.35	0.04	−0.5	2.88	2.75	1.77	1.38	1.62
P_t^L	2.25	4.60	3.98	3.92	3.94	2.25	3.49	1.67	1.16	1.60	2.25	3.49	2.42	3.13	4.49
P_t^F	12.46	7.98	5.47	4.05	3.20	12.46	7.56	4.35	2.45	1.56	12.46	7.56	4.63	3.35	3.10
$M2_t$	8.95	9.72	9.55	9.11	8.70	8.95	6.64	5.68	5.25	5.25	8.95	6.64	7.78	8.97	9.75

commodities which are considered basic necessities of life. It is also concluded that it is not necessary to maintain the previous level of interest rate after a shock as there is not much difference in the growth rates of output or employment level between the second and third experiment. However, output prices increase with decreasing the level of interest rate.

7.2. Multiplier analysis of energy price index

Estimation results capture only direct impact and show that increase in energy prices has adverse impact on output as well as inputs demand. In order to capture direct as well as indirect impact of increases in energy prices on all sectoral outputs, input demands and output prices, we conduct six simulation experiments by adjusting various growth rates of energy price index for five years of forecasting period. In the baseline experiment, growth rate of energy price index is fixed as 1% for all five forecasting years. In the second experiment, 2% growth rate of energy price index for all five forecasting years is taken. Similarly, 4%, 8%, 13% and 21% growth rates of energy price index are considered for third, fourth fifth and sixth experiments respectively (Table 5).

For each experiment, the model is solved as a system of equations and resulting average growth rates of five forecasting years for key variables are calculated. For the baseline experiment, average growth rates of forecasting years are presented while deviations of average growth rates of forecasting years from baseline experiment are presented for all other experiments.

It appears from the results of multiplier analysis that one percentage point increase in energy price index results in 0.12, 0.04, 0.10 and 0.07 percentage points decrease in output of crops, livestock, fishery sub-sectors and overall agricultural sector respectively. Firstly, it implies that increase in energy price index has a strong adverse impact on output of all agricultural sectors. Secondly, crops sector is the strongest victim of increase in energy price index. That perhaps is why, most of the agricultural imports are of crops category. Successive increases in energy price index results in severe decline of crops output and government has to import to meet internal demand.

One percentage point increase in energy price index results in 0.92 percentage point decline in energy demand and hence, labor demand and fertilizer demand increase by 0.19 and 0.46 percentage points respectively as these two inputs are used as a substitute for energy in agricultural sector. Along with increase in employment level, wage rates are also increased due to increase in inflation. Another adverse impact of increase in energy price is that prices of agricultural output increase and hike in both energy prices together with food prices creates a situation of higher inflation. One percentage point increase in energy price index results in 0.67, 0.51, 0.36 and 0.50 percentage point increases in output prices of crops, livestock, fishery and overall agricultural sector.

According to above multiplier analysis, for every increase of almost 15 percentage points in energy price index results in loss of one percentage point growth of agricultural output, 7.5 percentage points increase in food inflation and 7 percentage points increase in overall inflation in the economy. In a nutshell, analysis establishes the fact that recent policy of successive increases in energy prices harms agricultural sector growth. The government will have to revise recent energy policy in order to make improvement in agricultural growth rate and employment level as well as to control food inflation.

8. Conclusion

Agricultural sector is essential to provide livelihood to masses in developing countries. Previous studies illustrate the potential of agricultural sector in economic growth and poverty reduction. The study develops a simple simulation model built on an input–output framework thereby, attempts to achieve two objectives. Firstly, it specifies, estimates and validates an econometric model that can be used in evaluating the policy effects targeting the agricultural sector of Pakistan. Secondly, the study applies the model in evaluating the possible effects of macroeconomic policies on agricultural sector.

The model covers disaggregated output at three sub-sectors, input demands, sectoral output prices, monetary and fiscal sector variables and overall price level in the economy. Behavioural equations are estimated separately by using GMM. Overall the estimated equations provide reasonably good fit. The model is then deterministically solved as a system of equations by using Gauss-Seidel technique to get dynamic solution of the model for different simulation experiments. Historical simulation experiment establishes validity of the model. Other simulation experiments are conducted to analyze

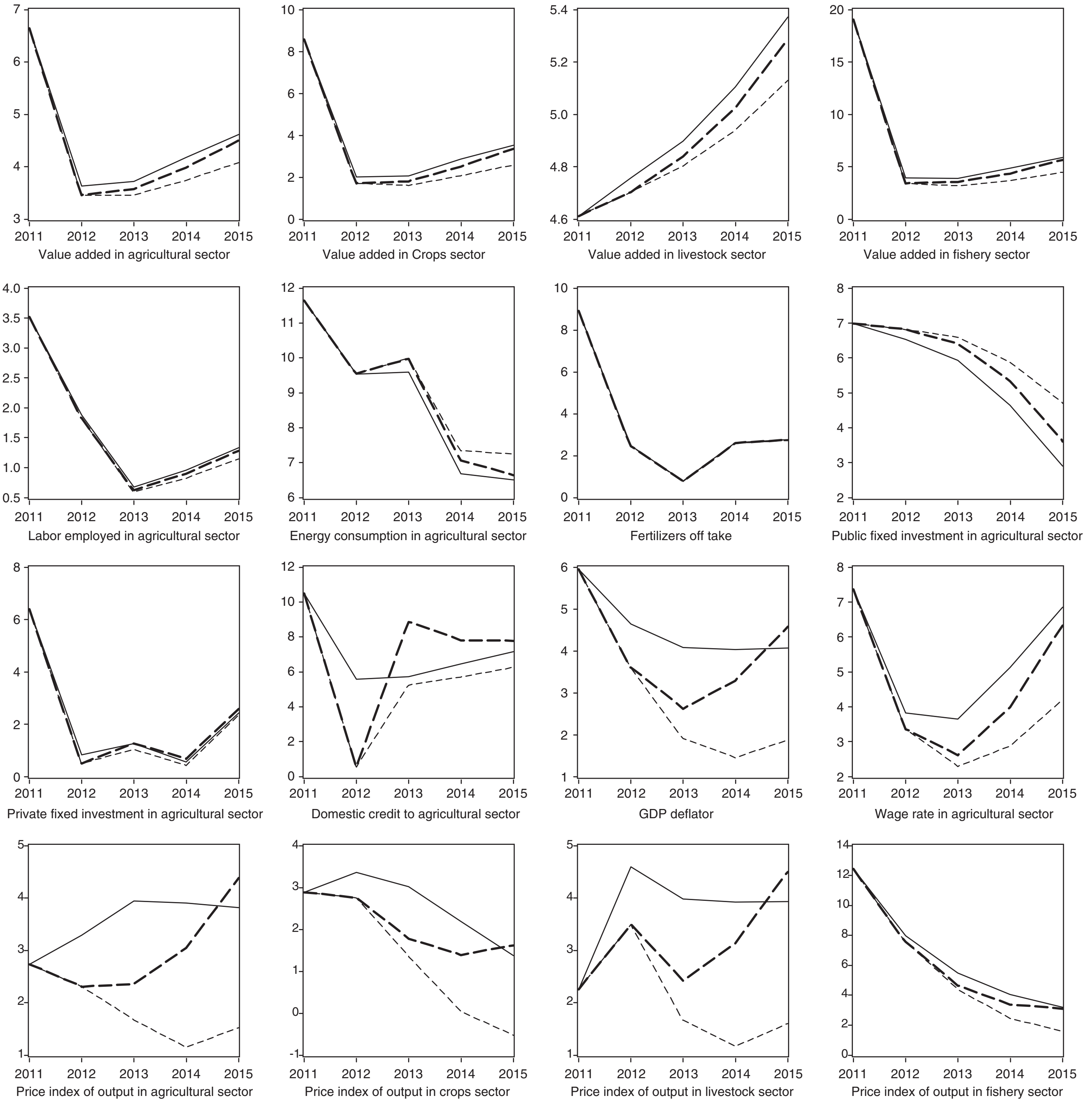

Fig. 4. Graphical projection of interest rate shock*. *Solid lines represent resulting growth rates of baseline experiment while dotted lines and dotted as well as bold lines represent resulting growth rates from second and third experiments respectively.

impact of interest rate shocks and to conduct multiplier analysis of energy price index.

Three policy recommendations can be derived from the study. First, the government should focus on general infrastructural investment instead of public investment in agricultural sector to due its crowding-out effect in Pakistan. Recent fiscal policy matches to our findings. Second, interest rate shock does not have much influence on agricultural growth. However, it is a useful instrument to control food inflation in the economy. Therefore, recent policy of higher level of interest rate will be helpful to control inflation in the economy without hurting agricultural sector. Third, multiplier analysis of energy price index clearly establishes that increase in energy prices exerts significant adverse impact on agricultural sector. For every increase of 15 percentage points in energy prices results in loss of one percentage point growth of agricultural output and 7.5 percentage points increase in food inflation. Agricultural sector is found a victim of recent increases in energy prices. The energy policy may be reviewed to help this under-privileged sector and to solve the livelihood issues of farming community in Pakistan. The developed model may also be used for conducting various other simulation experiments. Further improvements of the model are expected with its continued application to the analysis of agricultural sector of Pakistan.

Table 5
Multiplier analysis of Energy Price Index.

Variables	Experiment No.					
	Baseline	2	3	4	5	6
P_t^{EN}	1	1	3	7	12	20
Y_t^A	5.21	−0.07	−0.21	−0.48	−0.80	−1.27
Y_t^C	4.87	−0.12	−0.34	−0.79	−1.31	−2.09
Y_t^L	5.29	−0.04	−0.11	−0.26	−0.43	−0.69
Y_t^F	8.70	−0.10	−0.29	−0.67	−1.11	−1.76
L_t^A	0.58	0.19	0.58	1.33	2.25	3.65
E_t^A	13.82	−0.92	−2.71	−6.07	−9.90	−15.25
F_t^A	0.79	0.46	1.36	3.15	5.34	8.73
I_t^{GA}	3.08	0.27	0.82	1.87	3.15	5.08
I_t^{PA}	2.43	0.01	0.03	0.06	0.10	0.16
DC_t^A	9.45	−0.12	−0.35	−0.79	−1.32	−2.10
P_t^A	1.92	0.50	1.49	3.44	5.84	9.58
P_t	3.03	0.47	1.41	3.26	5.54	9.08
W_t^A	4.81	0.26	0.78	1.81	3.06	5.00
P_t^C	−0.59	0.67	2.02	4.69	7.99	13.20
P_t^L	2.09	0.51	1.51	3.51	5.96	9.78
P_t^F	5.12	0.36	1.08	2.48	4.20	6.86

Appendix A. Estimated equations[6]

$$LOG\left(Y_t^C\right) = 1.673 + 0.029^*LOG\left(K_t^A\right) + \underline{\mathbf{0.326}}^*LOG\left(W_t^A\right) - \underline{\mathbf{0.183}}^*LOG\left(P_t^{EN}\right) + \underline{\mathbf{0.464}}^*LOg(N_t) - 0.022^*LOG\left(P_t^{FR}\right) + \underline{\mathbf{0.029}}^*LOG(DC_t^A - \underline{\mathbf{0.126}}^*LOG\left(P_t^{EX}\right) + \underline{\mathbf{0.567}}^*LOG\left(Y_t^{PC}\right) + 0.006^*LOG(RF_t) + \underline{0.041}^*D^{0407} + \underline{\mathbf{0.072}}^*D^{9901} + \underline{\mathbf{0.053}}^*D^{8085}$$

$$LOG\left(Y_t^L\right) = -\underline{\mathbf{1.028}} + 0.028^*LOG\left(K_t^A\right) + \underline{0.025}^*LOG\left(W_t^A\right) - \underline{0.015}^*LOG\left(P_t^{EN}\right) + 0.005^*LOG(N_t) - \underline{\mathbf{0.018}}^*LOG\left(P_t^{EX}\right) + 0.007^*LOG\left(DC_t^A\right) + \underline{\mathbf{0.142}}^*LOG\left(Y_t^{PC}\right) + 0.005^*LOG(RF_t) + \underline{\mathbf{0.916}}^*LOG\left(Y_{t-1}^L\right) + \left[AR(2) = -\underline{\mathbf{0.219}}\right]$$

$$LOG\left(Y_t^F\right) = -\underline{\mathbf{6.656}} + 0.002^*LOG\left(K_t^A\right) + \underline{\mathbf{0.481}}^*LOG\left(W_t^A\right) - \underline{0.192}^*LOG\left(P_t^{EN}\right) + 0.049^*LOG\left(DC_t^A\right) - \underline{0.311}^*LOG\left(P_t^{EX}\right) + 0.513^*LOG(N_t) + 0.934^*LOG\left(Y_t^{PC}\right) - 0.054^*D^{9296} + \left[AR(1) = \underline{\mathbf{0.305}}\right] + 0.1117^*D^{0407} - 0.056^*D^{0207}$$

$$LOG\left(L_t^A\right) = 0.873 - \underline{\mathbf{0.261}}^*LOG\left(K_t^A\right) - 0.016^*LOG\left(W_t^A\right) + \underline{\mathbf{0.147}}^*LOG\left(P_t^{EN}\right) - 0.086 * LOG\left(P_t^{FR}\right) + \underline{\mathbf{0.322}}^*LOG\left(Y_t^A\right) + \underline{\mathbf{0.595}}^*LOG\left(L_{t-1}^A\right) - 0.129^*LOG\left(L_{t-2}^A\right)$$

$$LOG\left(E_t^A\right) = -\underline{\mathbf{34.692}} + \underline{\mathbf{1.612}}^*LOG\left(K_t^A\right) - 0.691^*LOG\left(W_t^A\right) - \underline{\mathbf{0.604}}^*LOG\left(P_t^{EN}\right) + \underline{\mathbf{0.368}}^*LOG\left(P_t^{FR}\right) + \underline{\mathbf{1.767}}^*LOG\left(Y_t^A\right) + \left[AR(1) = \underline{\mathbf{0.424}}\right] + 0.0787^*D^{0407}$$

$$LOG\left(F_t^A\right) = -\underline{\mathbf{4.97}} + \underline{\mathbf{0.606}}^*LOG\left(K_t^A\right) - 0.026^*LOG\left(W_t^A\right) + \underline{\mathbf{0.376}}^*LOG\left(P_t^{EN}\right) - 0.308^*LOG\left(P_t^{FR}\right) + 0.174^*LOG\left(Y_t^A\right) + 0.285^*LOG\left(F_{t-1}^A\right) + \left[AR(2) = -\underline{\mathbf{0.326}}\right]$$

$$LOG\left(I_t^{GA}\right) = \underline{6.856} + 0.907^*LOG(R_t) - \underline{1.603}^*LOG\left(Y_t^A\right) + 0.419^*LOG\left(I_t^{GG}\right) + \underline{\mathbf{0.776}} * LOG\left(I_{t-1}^{GA}\right) + \underline{0.2208}^*D^{8085} + 0.04^*D^{8688} + \underline{0.273}^*D^{9296}$$

$$LOG\left(I_t^{GG}\right) = -0.336 + \underline{\mathbf{0.338}}^*LOG(R_t) - \underline{\mathbf{0.147}}^*D^{9407} + \underline{\mathbf{0.139}}^*D^{0207} + \underline{\mathbf{0.645}}^*LOG\left(I_{t-1}^{GG}\right)$$

$$LOG\left(I_t^{PA}\right) = \underline{\mathbf{2.601}} - \underline{\mathbf{0.021}}^*LOG\left(I_t^{GA}\right) + \underline{\mathbf{0.274}}^*LOG\left(I_t^{GG}\right) - 0.049^*\left(P_t^{KA}\right) - 0.204 * LOG\left(Y_{t-1}^A\right) + 0.019^*LOG\left(DC_t^A\right) + \underline{\mathbf{0.7335}}^*LOG\left(I_{t-1}^{PA}\right)$$

$$LOG\left(DC_t^A\right) = -\underline{\mathbf{10.787}} - 2.027^*r_t^{ib} + \underline{\mathbf{1.588}}^*LOG\left(Y_t^A\right) + [AR(1)] = \underline{\mathbf{0.836}} + \underline{\mathbf{0.560}}^*D^{8085}$$

$$LOG\left(W_t^A\right) = -\underline{\mathbf{3.110}} + \underline{\mathbf{0.367}}^*LOG(P_t) + \underline{\mathbf{0.497}}^*LOG\left(Y_t^A\right) - 0.012^*UR_t + 0.913 * LOG\left(W_{t-1}^A\right) - \underline{\mathbf{0.389}}^*LOG\left(W_{t-2}^A\right) + \left[AR(1) = -\underline{0.35}\right] + 0.0328^*D^{9407} - \underline{0.086}^*D^{0407}$$

$$LOG(P_t) = 1.536 - \underline{\mathbf{0.478}}^*LOG\left(Y_t^{FC}\right) + \underline{\mathbf{0.355}}^*LOG(M2_t) + 0.0229^*LOG\left(P_t^{WO*}ER_t\right) + \underline{\mathbf{0.109}}^*LOG(ER_t) + \underline{\mathbf{0.1673}} * LOG\left(P_t^{EN}\right) + \underline{\mathbf{0.858}}^*LOG(P_{t-1}) - \underline{\mathbf{0.53}}^*LOG(P_{t-2}) + \underline{\mathbf{0.0471}}^*D^{8900}$$

$$LOG(M2_t) = -0.4926 + \underline{\mathbf{0.325}}^*LOG(P_t{}^*Y_t) - \underline{\mathbf{1.109}}^*\left(r_t^{ib}\right) + \underline{\mathbf{1.018}}^*LOG(M2_{t-1}) - \underline{0.32}^*LOG(M2_{t-2})$$

$$LOG\left(P_t^C\right) = \underline{\mathbf{10.805}} + \underline{\mathbf{0.855}}^*LOG(P_t) - \underline{\mathbf{0.833}}^*LOG\left(Y_t^C\right) + \underline{\mathbf{0.382}}^*LOG\left(P_{t-1}^C\right) + \underline{\mathbf{0.063}}^*D^{8900}$$

$$LOG\left(P_t^L\right) = 0.995 + \underline{\mathbf{1.073}} * LOG(P_t) - 0.079 * LOG\left(Y_t^L\right) + \left[AR(2) = \underline{\mathbf{0.664}}\right] - \underline{\mathbf{0.036}} * D^{0407}$$

$$LOG\left(P_t^F\right) = 1.259 + 0.454^*LOG(P_t) - 0.126^*LOG\left(Y_t^F\right) + 0.520^*LOG\left(P_{t-1}^F\right) + 0.162^*D^{0407}$$

[6] The bold and underlined values of estimated coefficients are statistically significant at 1% or 5% level. The values which are only underlined but not bold, represent the coefficients which are significant at 10% level while the values which are neither underlined nor bold represent insignificant coefficients.

Appendix B. Variables identification

Variable	Description	Source
DC_t^A	Domestic credit to Agriculture sector	*Pakistan Statistical Yearbook*
D^{8085}	Dummy variable representing period of 1st Afghan war	Constructed
D^{8688}	Dummy variable representing policy change after Marshal Law regime	Constructed
D^{8900}	Dummy representing uncertainity due to frequent changes in government	Constructed
D^{9296}	Dummy variable representing effects of flood	Constructed
D^{9407}	Dummy variable representing privatization policy	Constructed
D^{9901}	Dummy variable representing effects of atomic explosion in Pakistan	Constructed
D^{0207}	Dummy variable representing effects of 9/11 and subsequent events	Constructed
D^{0407}	Dummy variable representing oil price hike and food price hike	Constructed
ER_t	Nominal exchange rate (Rupees per US dollar)	*Pakistan Economic Survey*
E_t^A	Energy consumption in agricultural sector	*Pakistan Economic Survey and Pakistan Statistical Yearbook*
F_t^A	Fertilizer off-take	*Pakistan Economic Survey*
g^A	Annual compound growth rate of output in agricultural sector used to construct initial period capital stock	Constructed
I_t^{GA}	Expenditure on public fixed investment in agricultural sector	*Pakistan Economic Survey*
I_t^{GG}	General government investment expenditure	*Pakistan Economic Survey*
I_t^{PA}	Expenditure on private fixed investment in agricultural sector	*Pakistan Economic Survey*
K_t^A	Capital stock in agricultural sector at the beginig of period t	Constructed
L_t^A	Labor employed in agricultural sector	*Pakistan Economic Survey*
$M2$	Broad money	*Pakistan Economic Survey*
N_t	Population size	*Pakistan Economic Survey*
P_t	GDP deflator (based on GDP at factor cost)	Derived from nominal GDP divided by real GDP
P_t^A	Price index of agricultural output	Derived
P_t^C	Price index of output in crops sector	Derived
P_t^{EN}	Price index of energy	*Pakistan Economic Survey*
P_t^{EX}	Exports price deflator	Derived
P_t^F	Price index of output in fishery sector	Derived
P_t^{FR}	Price index of fertilizers	*Pakistan Economic Survey*
P_t^{KA}	User cost of capital in agricultural sector	Construced
P_t^L	Price index of output in livestock sector	Derived
P_t^{MA}	Price index of capital goods for agricultural sector	Derived
P_t^{WO}	Internationald average Oil spot Price (US $ per barrel)	*World Economic Outlook*
RF_t	Amount of rainfall	
R_t	Total government revenues	*Pakistan Economic Survey*
r_t^A	Nominal interest rate on bank advances	*Handbook of Statistics on Pakistan Economy 2010*
r_t^{ib}	Inter bank call money rate (nominal interest rate)	*Handbook of Statistics on Pakistan Economy 2010*
U_t	Urbanization rate	*Pakistan Economic Survey*
UR_t	Unemployment Rate	*Pakistan Economic Survey*
W_t^A	Wage rate in agricultural sector	Taken from a Ph.D. thesis
Y_t	GDP at market prices	*Pakistan Economic Survey*
Y_t^A	Value added in agricultural sector	*Pakistan Economic Survey*
Y_t^C	Value added in Crops sector	*Pakistan Economic Survey*
Y_t^{CD}	Demand of crops output	
Y_t^{CS}	Supply of crops output	
Y_t^F	Value added in fishery sector	*Pakistan Economic Survey*
Y_t^{FC}	GDP at factor costs	*Pakistan Economic Survey*
Y_t^{For}	Value added in forestry sector	*Pakistan Economic Survey*
Y_t^L	Value added in livestock sector	*Pakistan Economic Survey*
Y_t^O	Value added in non-agricultural sectors	Derived
Y_t^{PC}	Per capita income	Derived
δ	Annual depreciation rate of fixed capital in agricultural sector	0.05
π_t	Inflation rate based on GDP deflator	Derived

$$LOG\left(P_t^A\right) = \underline{0.983} + \underline{\mathbf{0.9814}}*LOG(P_t) - \underline{0.073}*LOG\left(Y_t^A\right) + 0.170* LOG\left(P_{t-1}^A\right) - 0.127*LOG\left(P_{t-2}^A\right) + [AR(2) = -0.263] - \underline{\mathbf{0.036}}*D^{0407}$$

References

Agricultural Statistics, 2010 and various previous issues. Ministry of Food and Agriculture, Government of Pakistan. Islamabad.

Ahmad, S., Martini, R.P., 2000. Agricultural Policy Analysis in Pakistan: Illustrations in the use of the Policy Analysis Matrix. CMER Working Paper No. 00–27. Lahore University of Management Sciences, Lahore (May).

Akbar, M., 2011. *Modeling and Econometric Analysis of Pakistan Economy*, Ph.D. Dissertation (Unpublished Manuscript), Department of Statistics, Quaid-i-Azam University, Islamabad, Pakistan.

Aleem, A., 2007. *Monetary transmission mechanism, core inflation and monetary policy rules: Evidence from India and Pakistan*. PhD Dissertation (Unpublished Manuscript), Centre d'Economie de l'Université Paris Nord, Université Paris XIII, 99.

Aleem, A., 2010. Transmission mechanism of monetary policy in India. Journal of Asian Economics 21, 186–197.

Ali, A., Mushtaq, K., Ashfaq, M., Raza, M.A., 2009. An analysis of productivity growth of agriculture in Pakistan: 1971–2006. Journal of Agricultural Research 47, 439–450.

Byerlee, D., Halter, A.N., 1974. A macroeconomic model for agricultural sector analysis. American Journal of Agricultural Economics 56 (3), 520–533.

Chang, H.S., Zepeda, L., 2001. Agricultural productivity for sustainable food security in Asia and the Pacific: the role of investment. In: Zepeda, L. (Ed.), Agricultural investment and productivity in developing countries: FAO Economic and Social Development Paper, 148. ISBN 92–5–104553–4, Publishing and Multimedia Services, FAO, Rome.

Chen, D.T., 1977. The Wharton agricultural model: structure, specification, and some simulation results. American Journal of Agricultural Economics 59, 107–116.

Dahmardey, M., Piri, I., Dahmardey, M., 2010. Determination of factors affecting investment in agricultural sector of Iran. Journal of Food, Agriculture and Environment 8, 519–523.

Dayal, E., 1984. Agricultural productivity in India: a spatial analysis. Annals of the Association of American Geographers 74, 98–123.

Dritsakis, N., 2003. The agricultural sector in the macroeconomic environment: an empirical approach for EU. Agricultural Economics Review 4 (1), 37–46.

Eckstein, Z., 1984. A rational expectations model of agricultural supply. Journal of Political Economy 92 (1), 1–19.

Eyo, E.O., 2008. Macroeconomic environment and agricultural sector growth in Nigeria. World Journal of Agricultural Sciences 4 (6), 781–786.

Fan, S., Pardey, P.G., 1997. Research, productivity and output growth in Chinese agriculture. Journal of Development Economics 53, 115–137.

FAO, 2010. The State of Food Insecurity in the World 2010. Food and Agriculture Organization, http://www.fao.org/docrep/013/i1683e/i1683e.pdf.

Fare, R., Grosskopf, S., Margaritis, D., 2008. U.S. productivity in agriculture and R&D. Journal of Production Annals 30, 7–12.

Fernandez-Cornejo, J., Shumway, C.R., 1997. Research and productivity in Mexican agriculture. American Journal of Agricultural Economics 79 (3), 738–753.

Frankel, J.A., 2006. The effects of monetary policy on real commodity prices. NBER WP-12713. December.

Gollin, D., Parente, S., Rogerson, R., 2002. The role of agriculture in development. The American Economic Review 92 (2), 160–164.

Hansen, L.P., 1982. Large sample properties of generalized method of moments. Econometrica 50, 1029–1054.

Hazell, P., Rosegrant, M., 2000. Transforming the Rural Asian Economy: The Unfinished Revolution. Oxford University Press, Hong Kong.

Hsiao, C., 1997. Statistical properties of the two stage least squares estimator under cointegration. The Review of Economic Studies 64, 385–398.

Hu, B., McAleer, M., 2005. Estimation of Chinese agricultural production efficiencies with panel data. Mathematics and Computers in Simulation 68, 475–484.

Huang, J., Rozelle, S., 1996. Technological change: rediscovering the engine of productivity growth in China's rural economy. Journal of Development Economics 49, 337–369.

Huffman, W.E., Evenson, R.E., 2006. Do formula or competitive grant funds have greater impacts on state agricultural productivity. American Journal of Agricultural Economics 88 (4), 783–798.

Hye, Q.M.A., 2009. Money supply and agricultural prices a causality analysis for Pakistan economy (quarterly data analysis). Journal of Agricultural Research 47 (1), 193–199.

Irz, X., Lin, L., Thirtle, C., Wiggins, S., 2001. Agricultural productivity growth and poverty alleviation. Development Policy Review 19 (4), 449–466.

Jensen, J.D., Andersen, M., Kristensen, K., 2001. A regional econometric sector model for Danish agriculture. Report No. 129. Danish Institute of Agricultural and Fisheries Economics, Kobenhavn. December.

Khan, I., 2011. Rising inflation causing food insecurity in Pakistan. The News Daily, http://www.thenews.com.pk/TodaysPrintDetail.aspx?ID=62936&Cat=3 (August).

Machethe, C.L., 2004. Agriculture and poverty in South Africa: can agriculture reduce poverty? Presented at Conference on the Overcoming Underdevelopment in Pretoria (October).

McCarl, B., Villavicencio, X., Wu, X., 2009. The Effect of Climate Change over Agricultural Factor Productivity: Some Econometric Considerations. Agricultural & Applied Economics Association Annual Meeting. Milwaukee, Wisconsin, USA, Milwaukee, Wisconsin, USA, pp. 26–29.
Matsuyama, K., 1992. Agricultural productivity, comparative advantage, and economic growth. Journal of Economic Theory 58 (2), 317–334.
Moorthy, V., Kolhar, S., 2011. Rising food inflation and Indian monetary policy. Indian Growth and Development Review 4 (1), 73–94.
Newey, W.K., West, K.D., 1987. A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica 55 (3), 703–708.
Orden, D., Fackler, P.L., 1989. Identifying monetary impacts on agricultural prices in VAR models. American Journal of Agricultural Economics 71 (2), 495–502.
Pakistan Economic Survey, 2010–2011. Ministry of Finance. Government of Pakistan, Islamabad.
Pauw, K., Thurlow, J., 2011. Agricultural growth, poverty, and nutrition in Tanzania. Food Policy 36, 795–804.
Price, S., Nasim, A., 1999. Modelling inflation and the demand for money in Pakistan: cointegration and the causal structure. Economic Modelling 16, 87–103.
Roop, J.M., Zeitner, R.H., 1977. Agricultural activity and the general economy: some macromodel experiments. American Journal of Agricultural Economics 59 (1), 117–125.
Shahbaz, B., Ali, T., Suleri, A.Q., 2007. A critical analysis of forest policies of Pakistan: implications for sustainable livelihoods. Mitigation and Adaptation Strategies for Global Change 12 (4), 441–453.
Statistical Yearbook, 2009. Federal Bureau of Statistics. Government of Pakistan, Islamabad.
Thirtle, C., Lin, L., Piesse, J., 2003. The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America. World Development 31 (12), 1959–1975.
Timmer, C.P., 1988. The agricultural transformation. In: Chenery, H., Srinivasan, T.N. (Eds.), Handbook of Development Economics, Vol. I. Elsevier Science Publishers, Amsterdam, pp. 275–331.
White, H., 1984. Asymptotic Theory for Econometricians. Academic Press, Orlando Fla.
World Hunger, 2011. 2011 World Hunger and Poverty Facts and Statistics, http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm.