CHAPTER FOUR

MODEL SPECIFICATION AND ESTIMATION PROCEDURE

4.1 Introduction

The main purpose of this chapter is to show how the input expenditure model developed in this study is specified and recursively integrated into the existing BFAP output model. Developing an input model basically utilises the theory of derived demand; hence, the variables from the output model largely determine the input demand. The recursive link between input and output model is also presented, using the two input prices, which are used as a proxy for the variable input costs that determine the area response equation in the BFAP output model outlined in the previous chapter. By applying the accounting relationship on all estimated aggregate variables, the two main targets of the model (gross value added and net farming income) are also computed.

The organisation of this chapter is as follows. Section two presents a schematic view of the model developed in this study and section three lists all endogenous and exogenous variables of the model. The model specifications of each equation are presented in section four and the estimation procedure of the specified models is discussed in section five.

4.2 Schematic View of the Model

A schematic view of how the input and other aggregate variables of the models are estimated is given in Figure 4.1. The arrows (⟶) in the figure indicate the direction of influence. Since all inputs are derived demand, they are largely determined by the demand for the final output. Hence, the variables from the output model or gross income components (which include area planted, commodity and animal product prices and production volumes) are the main drivers of input demand and they determine most of the input components both directly and indirectly.

The gross income components (area planted and gross income) determine rent paid directly. Together with the real interest rate, gross income also determines the gross capital formation of the sector, which in turn affects the asset values of the sector. Depreciation value is then directly influenced by the total asset value of the sector. Interest paid by the sector is determined largely by the total debt value and the real interest rate. Total debt value is also influenced by the interest rate and total asset value. Similar to the asset value, own construction of the sector is also largely influenced by the gross capital formation of fixed improvements, and labour remuneration of the sector is determined exogenously by the quantity of labour employed and real wage rate.

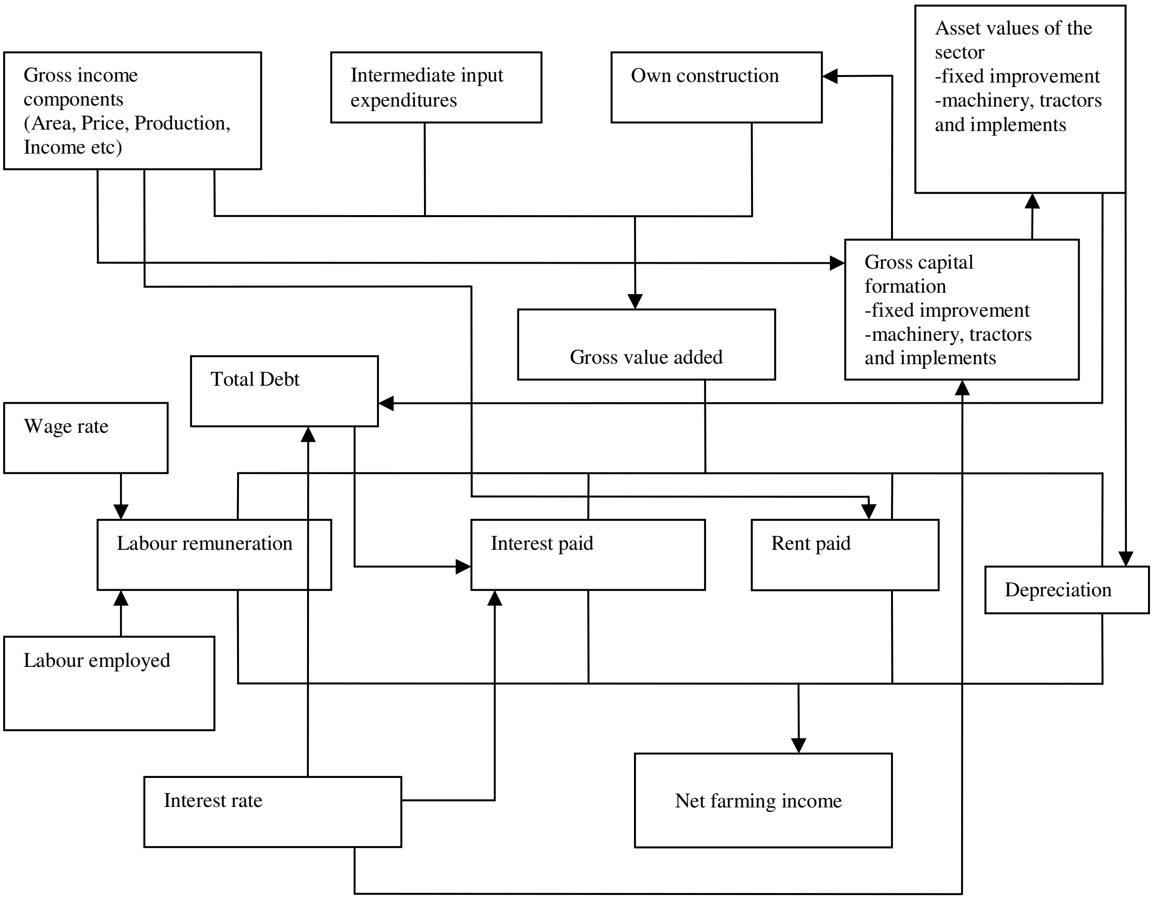

Figure 4.1: A schematic view of the behavioural equations of the model

A schematic view of how output and input models are recursively linked is presented in Figure 4.2. The figure also displays the common exogenous variables that influence both the output and input sides of the integrated model. As explained in chapter three, the proxies used for variable costs in estimating the area response by field crops are fuel and fertiliser prices. As shown in Figure 4.2, the area planted, which affects the production hence the price and income in the output model, also determines the quantity of inputs to be applied in the production process. Together with exogenous variables such as exchange rate and oil prices, the quantity of input demand also influences some of the variable costs, which subsequently determines the area planted for the next season. Thus, there is a recursive link between the output and input models where a shock introduced on one side will have a recursive effect on the other side and vice versa. Once the input demand and prices are estimated, the total input expenditure is obtained by the product of the quantity of input and costs, and the gross income of the sector is obtained from the output model by multiplying the output price, area planted and yield of the field crop.

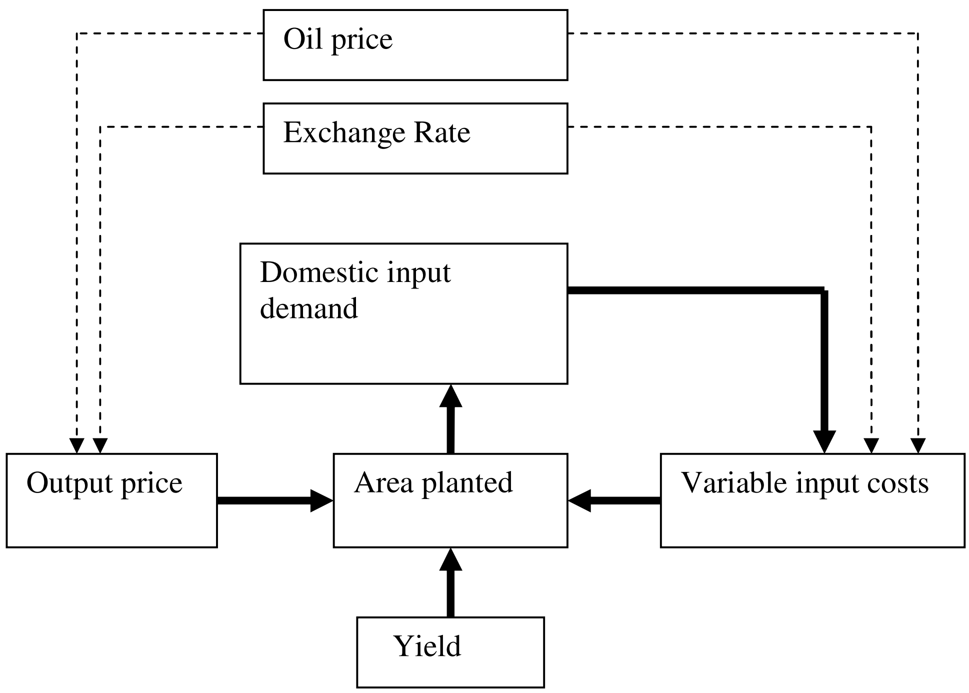

Figure 4.2: A schematic view of the recursive link between the output and input models

The general direction of the linkage between the input and agricultural output markets flows from the output side to the input markets. This arises because input demand is derived from demand that is largely dependent on the agricultural output market, particularly on changes in the gross income, output price and area planted. However, the effect of agricultural input markets on outputs in the model is largely captured by the input costs. Among the input costs that are recursively affected by the output market is the fertiliser price, which is linked with the output market through the gross income of field crops. However, the fuel price, which is regarded as a proxy for the variable cost in the area response, is not recursively linked with agricultural markets since it is determined exogenously by the international oil price and exchange rate.

For the recursively linked integrated model, therefore, the effect of a shock introduced in the integrated model is expected to be lengthened and converged slowly instead of making an abrupt halt. To compare the recursively linked and unlinked integrated model and to test the hypothesis of a lengthened and slow convergence of the effect of a shock in a recursively linked model, the recursive link between the input and output model will be 'switched off' and domestic input prices would remain exogenous so that the shock's effect could be compared in both versions of the model.

This recursive link between field crops and inputs cost introduced in this study is similar to the recursive link between animal production and field crops in the BFAP output model. Both sub-sectors in the output model are recursively linked through feed equations. Thus, a rise in the commodity price augments the feed (input) cost for animal production. As a result of a lower ratio of output price to input costs, animal production subsequently subsides. The fall in production consequently brings about a fall in the feed demand. The fall in the demand, therefore, results in lower feed consumption and domestic use of the commodity that may ultimately affect the domestic commodity prices.

Figure 4.3 illustrates the main variables that are useful to compute the main target variables of the model, which are gross value added and net farming income. The gross value added is obtained by deducting intermediate input expenditure from gross income and adding own construction and change in livestock inventory to the difference. In this model, change in livestock inventory is assumed to have a negligible effect on the gross value added, as evidenced by its average value over the past decades, which is close to zero. These variables, which are useful in computing the gross value added, are given in the top block of Figure 4.3. Similarly, four expenditure variables are deducted from the gross value added to produce net farming income. These variables are labour remuneration, interest paid, rent paid and depreciation of the sector's asset values.

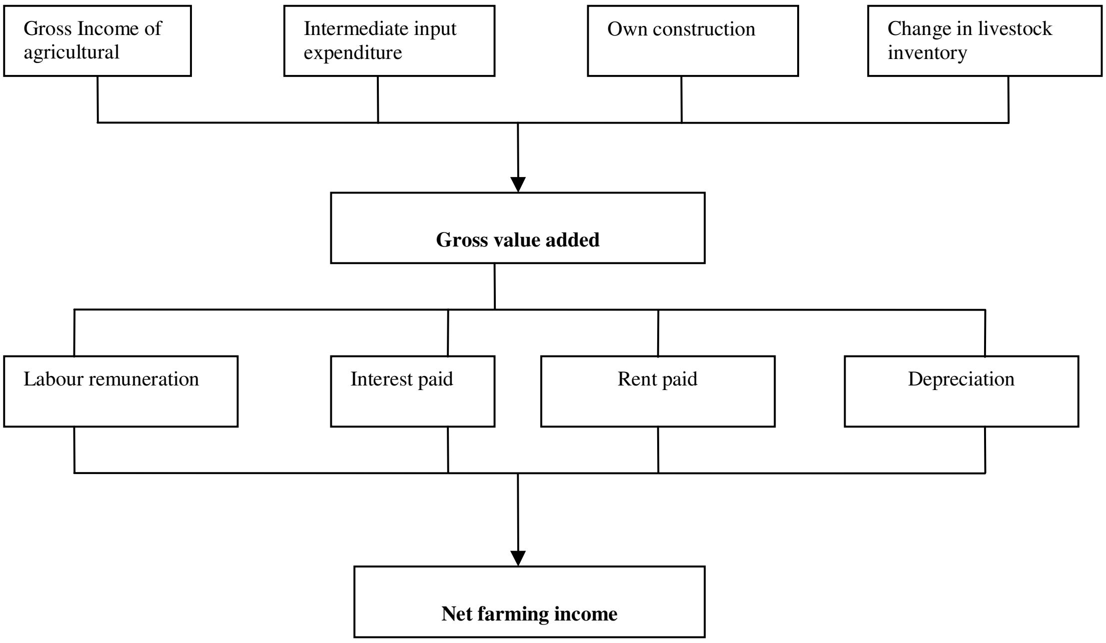

Figure 4.3: A schematic view of the main variables required to estimate the target variables.

4.3 List of Variables

Table 4.1 lists and describes the construction and the source of all the endogenous and exogenous variables used in the model.

Table 4.1: List of endogenous and exogenous variables in the model

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
	ENDOGENOUS VARIABLES	
FUELP	Fuel price index	DAFF
RFUELP	Real fuel price index	(FULP/PPI)*100
FUELEXP	Fuel expenditure	DAFF
RFUELEXP	Real fuel expenditure	(FUELEXP/PPI)
RFUELD	Real fuel demand	(FUELP/FUELP)*100
FERTP	Fertiliser price index	DAFF
RFERTP	Real fertiliser price index	(FERTP/PPI)*100
AFERTP	Aggregate fertiliser price	GRAINSA
RAFERTP	Real aggregate fertiliser price	(AFERTP/PPI)*100
FERTEXP	Fertiliser expenditure	DAFF
RFERTEXP	Real fertiliser expenditure	(FERTEXP/PPI)*100
FEEDP	Feed price index	DAFF
RFEEDP	Real feed price index	(FEEDP/PPI)*100
FEEDC	Feed cost	DAFF
RFEEDC	Real feed cost	(FEEDCST/PPI)*100
FEEDEXP	Feed expenditure	DAFF
RFEEDEXP	Real feed expenditure	(FEEDEXP/PPI)*100
RFEEDD	Real feed demand	(FEEDEXP/FEEDP)*100
MREXP	Maintenance and repairs expenditure	DAFF
RMREXP	Real maintenance and repairs expenditure	(MREXP/PPI)*100
RMRD	Real maintenance and repairs demand	(MREXP/MRP)*100
FSEXP	Farm services expenditure	DAFF
RFSEXP	Real farm services expenditure	(FSEXP/PPI)*100
INTEXP	Intermediate input expenditure	DAFF
RINTEXP	Real intermediate input expenditure	(INTEXP/PPI)*100
PFC	Price of field crops	DAFF
RPFC	Real price of field crops	(PFC/CPI)*100
GINCFC	Gross income: field crops	BFAP
RGINCFC	Real gross income: field crops	(GINCFC/CPI)*100
GINCANI	Gross income of animal products	BFAP
RGINCANI	Real gross income of animal products	(GINCNI/CPI)*100
GINC	Gross income: agricultural sector	DAFF
RGINC	Real gross income: agricultural sector	(GINC/CPI)*100
OCON	Own construction	DAFF
ROCON	Real own construction	(OCONS/PPI)*100
GVA	Gross value added of agricultural sector	DAFF
RGVA	Real gross value added of agricultural sector	RGINC-RINTEXP+ROCON+CLI
LREMU	Labour remuneration	DAFF
RLREMU	Real labour remuneration	(LREMU/CPI)*100
INTPAID	Interest paid	DAFF
RINTPAID	Real interest paid	(INTPAID/CPI)*100
RENPAID	Rent paid	DAFF

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
RRENPAID	Real rent paid	(RENPAID/CPI)*100
AREA	Total field crop area planted[1]	BFAP
NAREA	Nitrogen share weighted area (field crops)[2]	DAFF
PAREA	Phosphorous share weighted area (field crops)[3]	DAFF
KAREA	Potassium share weighted area (field crops)[4]	DAFF
NCONSFC	Nitrogen consumption by field crops	DAFF
PCONSFC	Phosphorous consumption by field crops	DAFF
KCONSFC	Potassium consumption by field crops	DAFF
FERTEXPFC	Fertiliser expenditure by field crops	NCONSFC+PCONSFC+ KCONSFC
RFERTEXPFC	Real fertiliser expenditure by field crops	(FERTEXPFC/PPI)*100
NP	Nitrogen price[5]	GrainSA
RNP	Real nitrogen price	(NPR/PPI)*100
PP	Phosphorous price[6]	GrainSA
RPR	Real phosphorous price	(PPR/PPI)*100
KP	Potassium price[7]	GrainSA
RKP	Real potassium price	(KP/PPI)*100
GCFIX	Gross capital formation: fixed improvement	DAFF
RGCFIXD	Real demand of gross capital formation: fixed improvement	(GCFIX/PFIX)*100
GCFMTI	Gross capital formation: machinery, tractors, implements	DAFF
RGCFMTID	Real demand of gross capital formation: machinery, tractors and implements	(GCFMTI/PMTI)*100
DEBT	Total debt value of agricultural sector	DAFF
RDEBT	Real total debt of agricultural sector	(DEBT/CPI)*100
DEPR	Depreciation: total asset	DAFF
RDEPR	Real depreciation: total asset	(DEPR/CPI)*100
DEPRFIX	Depreciation: fixed improvement	DAFF
RDEPREFIX	Real depreciation: fixed improvement	(DEPRFIX/CPI)*100
DEPRMTI	Depreciation: machinery, tractors and	DAFF

[1] Field crops comprises maize, wheat, sorghum, barely, sunflower, soybeans and sugarcane.
[2] The share of nitrogen consumption by field crops according to the survey by Fertiliser Society of South Africa (FSSA) (2005) is as follows: 54.2 % maize, 7.7 % wheat, 11.8 % sugarcane, 2.5 % sunflower, 0.3 % soybean, 6.5 % lucerne and pastures and 16.4 % horticulture and fruit.
[3] The share of phosphorous consumption by field crops according to the survey by Fertiliser Society of South Africa (FSSA) (2005) is as follows: 38 % maize, 9.4 % wheat, 12.5 % sugarcane, 5.7 % sunflower, 0.5 % soybean, 13.5 % lucerne and pastures and 18.2 % horticulture and fruit.

[4] The share of potassium consumption by field crops according to the survey by Fertiliser Society of South Africa (FSSA) (2005) is as follows: 13.6 % maize, 2.4 % wheat, 43.2 % sugar cane, 0.8 % sunflower, 0.8 % soybean, 5.6 % Lucerne and pastures and 32.8 % horticulture and fruit.
[5] Urea price is used as a proxy for the Nitrogen price.
[6] MAP price is used as a proxy for the Phosphorous price.
[7] Potassium (Kaliumchloried, GROF) price is used as a proxy for the Potassium price.

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
	implements	
RDEPRMTI	Real depreciation: machinery, tractors and implements	(DEPRMTI/CPI)*100
ASSET	Total asset value of agricultural sector	DAFF
RASSET	Real total asset value of agricultural sector	(ASSET/CPI)*100
ASSETFIX	Asset value of fixed improvement	DAFF
RASSETFIX	Real asset value of fixed improvement	(ASSETFIX/CPI)*100
ASSETMTI	Asset value of machinery, tractors and implements	DAFF
RASSETMTI	Real asset value of machinery, tractors and implements	(ASSETMTI/CPI)*100
NFINC	Net farming income	DAFF
RNFINC	Real net farming income	RGVA-RLREMU-RINTPAID-RRENPAID-RDEPR
AVOL	Animal volume index	BFAP
EXOGENOUS VARIABLES		
OIL	U.S. refiners acquisition oil price	Global insight
ROIL	Real US refiners acquisition oil price	(OIL/PPI)*100
GDPDEF	GDP deflator	FAPRI
GROWTH	GDP growth	Reserve Bank
INT	Average annual prime rate	Reserve Bank
EXC	Exchange rate	Reserve Bank
PPI	Producer price index	Reserve Bank
CPI	Consumer price index	Reserve Bank
INT	Prime interest rate	Reserve Bank
INFL	Inflation	$((CPI-CPI_{(-1)})/(CPI)_{(-1)})*100$
RINT	Real interest rate	INT – INFL
WNP	World nitrogen price[8]	GrainSA
WPP	World phosphorous price[9]	GrainSA
WKP	World potassium price[10]	GrainSA
FEMPT	Labour employed in agricultural sector[11]	DAFF
WAGE	Agricultural wage rate	LREMU/FEMPT
RWAGE	Real agricultural wage rate	(WAGE/CPI)*100
FIXP	Fixed improvement price index	DAFF
RFIXP	Real fixed improvement price index	(FIXP/PPI)*100
MTIP	Machinery, tractors and implements price index	DAFF
RMTIP	Real machinery tractors and implements price index	(MTIP/PPI)*100

[8] The price of urea, Eastern Europe, bulk is used as world Nitrogen price.
[9] The price of DAP, USA gulf is used as the Phosphate world price.
[10] The price of MOP, CIS, bulk is used as world Potassium price.
[11] The missing data on the time series was extrapolated using the average annual growth rate.

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
MRP	Maintenance and repairs price index	DAFF
RMRP	Real maintenance and repairs price index	(MRP/PPI)*100
WNAREA	World Nitrogen share weighted area[12]	FAPRI and IFA
WPHAREA	World Phosphorous share weighted area[13]	FAPRI and IFA
WPOAREA	World Potassium share weighted area[14]	FAPRI and IFA

Endogenous variables are determined within the model and these are the variables of interest for assessing the various impacts of policy instruments. Exogenous variables, on the other hand, are determined outside of the model. They often include policy, trade and other macro variables. Once the input expenditure model that will be developed is fully integrated with the sectoral model, the impact of all the policy variables and exogenous factors used in the sectoral model (like trade policies, weather and world commodity prices) on the input expenditure, gross value added and net farming income of the sector could also be analysed.

As the gross value added (GVA) by the agricultural sector to the economy shows the value added by the sector on factor inputs in converting them into final outputs, it indicates the contribution of the sector to the economy. Likewise, net farming income (NFI) represents the money left to producers after paying all operating expenses. Hence, it indicates the financial sustainability of the operators. Thus, both of these variables are used as target variables to assess the effect of policies and exogenous factors on the sector.

4.4 Model Specification

To create a recursive linkage between the input and output models, the models for fuel and fertiliser prices, which are used as a proxy for the input costs in the area response

[12] Area harvested of major fertiliser consumer countries (China, India, EU, USA and Brazil) is used. Each area is weighted using the share of the country's fertiliser consumption to the world consumption. The data is sourced from IFA (2009b). For Nitrogen: China (31.5 %), India (14.4 %), USA (12.5 %), EU (11.2 %) and Brazil (2.4 %).
[13] For Phosphorous: China (30.5 %), India (14.5 %), USA (10.8 %), EU (8.1 %) and Brazil (8.2 %).
[14] For Potassium: China (21.4 %, India (8.6 %), USA (17.1 %), EU (13.2 %) and Brazil (12.7 %).

equation of the sectoral model, are specified in equations 4.1 and 4.2. These equations will enable the sectoral model to capture the impact of exogenous factors and macro variables that affect these prices in the sectoral output. Thus, they would be able to capture the effect of variables that simultaneously affect both input and output sides of the agricultural sector.

The model for the price transmission equation for the real fuel price index, which is used as a proxy in the area response equation of the output model, is specified as follows.

$$RFUELP = \alpha + \beta_1 \, OIL^* \, EXCH + \varepsilon \qquad (4.1)$$

From the price transmission equation given in 4.1, depreciation of exchange rate and rising world oil prices are expected to raise the domestic fuel price.

The price transmission equation for the domestic fertiliser price is specified as follows:

$$RFERTP_i = \alpha + \beta_1 \, RWFP_i * EXCH + \beta_3 \, RGINCFC\,(-1) + \varepsilon \qquad (4.2)$$

The world fertiliser price and the exchange rate play a significant role in the price transmission equation. Moreover, the gross income of field crops, which is a proxy for the cash flow of farmers before the planting season, is expected to play a role in prompting demand and hence increasing the prices charged by input providers. Thus, the recursive effect of the output market on input price is captured by the gross income of field crops in this equation. This is an observed phenomenon in South Africa due to the oligopolistic market structure, where market supply is dominated by few suppliers.

The real aggregate fertiliser price index, which was and exogenous in the output model, is endogenised by the following equation.

$$RFERTPX = \alpha + \beta_1 \, RAFERTP + \varepsilon \qquad (4.3)$$

RAFERTP refers to the real aggregate domestic fertiliser price for all fertilisers. It is constructed using a weight based on the consumption share. Thus, 70% is given to the nitrogen price and 15% each for potassium and phosphorous.

The above equations reveals how the output side (gross income) determines input prices by affecting the domestic demand for inputs. The area planted in the output model also subsequently determines the quantity of input demands, and thus input expenditure. Hence, the integration of input expenditures into the existing output model captures the recursive effect of the input side on the output side and vice versa. This recursive link will also be 'switched off' to compare the result of a shock on both versions of the integrated model to test the hypothesis of the study.

Total intermediate input expenditure is the sum of expenditures on feed, fuel, fertiliser, maintenance and repairs, farm services and others, which encompasses all expenditures on dips and sprays, electricity, land tax, licences, packing material, seeds and plants, insurance, water tax and others not specified. The above five inputs that will be estimated in this model comprise more than 74% of all the intermediate inputs expenditure in 2008. The remaining inputs classified under other expenditure (ROTHEREXP) are projected in the model to increase by the growth outlook of the inflation rate, area planted and animal production.

$$RINTEXP = RFEEDEXP + RFUELEXP + RFERTEXP + RMAREXP + RFASEXP + ROTHEREXP \quad (4.4)$$

Input expenditure is the product of quantity demanded and its price. For the inputs where both quantity and price data are available, they are estimated separately and the expenditure is calculated by multiplying the quantity demanded and the price. If the data is only available as expenditure value, however, then it is deflated by its own price index to obtain a proxy for the quantity demanded (Maligaya and White, 1989) and the input price index is deflated by PPI to obtain the real price index. Thus, the real expenditure on the input is retrieved by multiplying the real quantity demand and the real price index.

The model for fuel demand is specified as follows.

$$RFUELD = \alpha - \beta_1 RFUELP + \beta_2 AREA + \beta_3 AVOL + \varepsilon \qquad (4.5)$$

The real fuel demand equation is specified as a function of its real price index, the agricultural area planted, which is a proxy for capturing the activities of field crops, and the volume of animal products, which is also used as a proxy for the activities of animal production. The fuel demand is expected to be positively influenced by the expansion of area planted and increased animal production. It is also expected to be inversely related to the increase in the real fuel price. The projected values of the real fuel price index will be obtained from the estimated equations specified in 4.1. The projected value of area planted and animal volume production index is obtained from the BFAP output model. The animal production volume index, which is used as a proxy for the activities of animal production is computed and projected using the production volume of milk, chicken, pork, eggs and beef. The data for these variables is sourced from BFAP output model.

The real expenditure on fuel by the agricultural sector is obtained by multiplying the real fuel price index estimated in equation 4.1 and real fuel demand estimated in equation 4.5.

Real feed demand by the agricultural sector is specified using the following equation.

$$RFEEDD = \alpha - \beta_1 RFEEDP + \beta_2 AVOL + \varepsilon \qquad (4.6)$$

Feed demand is expected to increase by the rise in the level of animal production, which is captured by animal volume index and deterred by the rise of feed price.

The price index of feed is estimated using the following equation.

$$RFEEDP = \alpha + \beta_1 RFEEDC + \varepsilon \qquad (4.7)$$

Feed price index is estimated as a function of real feed cost for animal production (RFCOST), which is obtained from sectoral model that calculates the feed cost for each animal product[15]. The representative feed cost for the sector is then computed by assigning various weights to each feed cost. Based on the aggregate feed expenditure, a 60% weight is given to poultry feed and 10% is given for cattle, dairy, eggs and pork. Since the feed cost equation is directly linked to the commodity prices, it captures all the policy variables in the sectoral model that influence its value. Hence, equation 4.7 links these effects to the real feed price index that will ultimately be used to compute the real feed demand and expenditure, which is obtained by multiplying the real feed demand, obtained from equation 4.6, and the real feed price index of equation 4.7.

The equation for real demand of materials and repairs is given in 4.8.

$$RMAREPD = \alpha + \beta_1 \, RGCF - \beta_2 \, RMRP + \varepsilon \qquad (4.8)$$

The real demand of maintenance and repairs is expected to be affected negatively by higher own price and positively by the rise of real gross capital formation in the agricultural sector, which is used as a proxy for the activities of the agricultural sector that mainly deal with implements, tractors, machinery and fixed improvement.

For the fertiliser demand by the field crops, the following model is specified.

$$FERTCONS_i = \alpha - \beta_1 \, RFERTP_i + \beta_2 \, WAREA_i + \beta_3 \, RFCP + \varepsilon \qquad (4.9)$$

Domestic fertiliser consumption is expected to be determined by its own price and the area planted. When producers expand area and fertiliser prices fall, the demand for fertilisers is expected to increase. Moreover, the rise in output price is expected to encourage more fertiliser consumption. The *i* in the equation refers to the three macro fertiliser nutrients, which are Nitrogen, Phosphorous and Potassium. The planted area included in the model is a weighted area of field crops by the share of fertiliser nutrient demanded.

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[15] Feed cost for each animal product is computed as the weighted product of the inclusion rate of feed stocks in the feed and the respective price of the feed stock used by the animal product. Some of these feed stocks include: maize, wheat, fishmeal, cotton seed, soybean full fat, soybean cake, sunflower cake and sorghum.

The world fertiliser price model is specified as follows.

$$WFP_i = \alpha + \beta_1\, WAREA_i + \beta_2\, OIL + \varepsilon \qquad (4.10)$$

World fertiliser price is expected to be influenced by energy and transport costs (oil price) and the demand by major consumers for fertiliser. This is captured using a weighted area of domestic consumption share of total world fertiliser consumption by major fertiliser consumer counties. The world fertiliser price is expected to rise due to high energy cost and world fertiliser demand.

The total field crop fertiliser expenditure is obtained by multiplying the total field crops fertiliser demand and the real fertiliser price of each nutrient obtained from equations 4.2 and 4.9. Then, equation 4.11 is used to get the real total fertiliser expenditure of the agricultural sector.

$$RFERTEXPE = \alpha + \beta_1\, RFERTEXPFC + \varepsilon \qquad (4.11)$$

The real farm services expenditure equation is specified in equation 4.12.

$$RFASEXP = \alpha + \beta_1\, RGINC + \varepsilon \qquad (4.12)$$

Real Farm services expenditure, which recently has increased its share of total expenditure, is expected to be determined by the gross income of the agricultural sector.

Own construction is expected to be positively influenced by the gross capital formation of fixed improvement. Hence, it is specified as follows:

$$ROCONS = \alpha + \beta_1\, RGCFFI + \varepsilon \qquad (4.13)$$

The model for interest paid is specified in equation 4.14.

$$INTP = INT\,(DEBT) \qquad (4.14)$$

The main factors that influence the amount of interest payment by the farming sector are the total debt value and interest rate. The rise in the value of both determinants is expected to increase the amount of interest payment. The projected value of total debt value by the agricultural sector is obtained from equation 4.20. Once the interest payment is obtained from the above equation, it will be deflated by CPI to obtain the real interest paid by the agricultural sector.

For estimating the rent paid equation, the total area devoted for production is expected to be a major determinant variable. The larger the area planted, the higher the amount of rent paid by the producers. Moreover, gross income from agricultural sector is used to capture the profitability of the agricultural sector in determining rent paid by agricultural producers. Hence, the model is specified as follows:

$$RRENT = \alpha + \beta_1 AREA - \beta 2RGINC + \varepsilon \qquad (4.15)$$

Labour remuneration is the product of the real wage rate and the number of farm employees. The labour employed in the sector is specified as follows:

$$FEMPT = \alpha - \beta_1 RWAGE - \beta_2 TIME + \beta_2 GINC + \varepsilon \qquad (4.16)$$

Farm employment is expected to fall due to the rise in real wages. Moreover, as the economy progresses, it is expected that less labour will be engaged in the agricultural sector. The rise in the profitability of the agricultural sector (real gross income), however, is expected to create more employment. The average annual wage rate is obtained by dividing the total labour remuneration by total farm employment (Poonyth *et al.,* 2001) and it is projected to increase by the inflation rate.

Depreciation of the asset value of the agricultural sector is computed by the given annual depreciation rate used by DAFF, using the following formula.

$$RDEPRE = 0.02RAVFIX + 0.1RAVMTI \qquad (4.17)$$

The coefficients 0.02 (2%) and 0.1 (10%) are the annual depreciation rate applied for the asset value of fixed improvement and tractors, machinery and implements respectively.

The asset value is computed using the following formula:

$$RAV_i = RAV_i(-1) + RGCF_i - RDEPRE_i \tag{4.18}$$

The asset value of the agricultural sector is simply the depreciation value of the assets taken from the sum of the lagged asset value and the current gross capital formation. *i* in the equation refers to fixed improvement and machinery, tractors and implements. The asset value of land in the agricultural sector is adjusted by increasing the value by 6% semi-annually (the value currently applied by DAFF).

The model for gross capital formation of the agricultural sector is specified as follows:

$$RGCF_i = \alpha - \beta_1\, RINT - \beta_2\, RPi + \beta_2\, RGINC + \varepsilon \tag{4.19}$$

Gross capital formation is determined by the real income level of the sector, real interest rate and the price of the equipments. While the rise in income is expected to spur the capital formation, the increase in interest rate and price of equipment will deter it. *i* in the equation refers to the fixed improvement (FIX) and machinery, tractors and implements (MTI).

The model for total debt of the sector is specified by the following equation

$$RDEBT = \alpha + \beta_1\, RASSET + \beta_2\, RINT - \beta_2\, GROWTH + \varepsilon \tag{4.20}$$

The agricultural sector's debt is expected to be influenced by real interest rate and real asset value. The rise in interest rate and the asset value is expected to increase the amount of debt in the sector. The downturn of the economy, on the other hand, is expected to put more pressure on producers' ability to meet their obligation; hence, it increases the debt burden.

Once all the above behavioural equations are estimated, the following identity is used to calculate the real gross value added of the agricultural sector.

$$RGVA = RGINC - RINTEXP + ROCONS \quad (4.21)$$

Once the expenditures on land, labour, capital and depreciation values have been estimated using the above equations, net farming income is calculated by subtracting these expenditures from the gross value added of the agricultural sector computed in equation 4.21. The formula for net farming income is given below.

$$RNFI = RGVA - RINTPAID - RLREMU - RRENPAID - RDEPRE \quad (4.22)$$

4.5 Estimation Techniques

The estimation approach used in this study closely follows the FAPRI approach, which puts consultation of experts as its centre during the model building exercise (McQuinn and Binfield, 2002) and follows a general-to-specific methodology to estimate the specified equations (Binfield *et al.,* 2000). Hence, in this study, officials from the Department of Agriculture, Forestry and Fisheries have been consulted in formulating most of the model specifications and a similar methodology is used to estimate the individual equations.

Due to the limited span of data for most of the variables in the model, a parsimonious specification is used in estimating the models. Thus, most of the equations have a small number of explanatory variables, which are deemed important in explaining the dependent variable. In cases where the limited data set does not allow to undertake a general-to-specific methodology, a simple regression is used to estimate the relationship of the variables. Moreover, economic importance is given more weight than the statistical significance in explaining most of the dependent variables due to the short span of the data that precludes from obtaining statistical sound estimations.

Traditional econometric methodology uses the specified equation 4.23 to estimate the parameters. The relationship among the variables is derived mainly from economic theory. To examine the adequacy of the model, basic diagnostic tests like R^2, t statistic and Durbin-Watson are often applied.

$$y_t = \beta_1 + \beta_2 x_t + \mu_t \qquad (4.23)$$

If the models fail to pass the diagnostic tests, additional or alternative variables will be added until the adequacy of the model is accepted and passes all diagnostic tests. This methodology, though started with simpler model, could end up being much more complicated. Thus, it entails data mining, since all the possible estimations will be carried out until the acceptable model is obtained. Furthermore, prior beliefs will largely dictate the result of the estimation and it is impossible to judge the statistical significance of the reported final estimated equation (Roche, 2001). This methodology is known as simple-to-general methodology.

An alternative methodology, which was developed by Hendry, is known as the general-to-specific methodology. In this methodology various competing economic models are nested within the general model. If the actual data generation process (DGP) is equation 4.23, it could be reached by testing down procedures from the general-to-specific methodology as specified in equation 4.24. However, if equation 4.24 describes the actual DGP, estimating 4.23 will result in an inefficient and biased estimation. Moreover, it is often difficult to reach equation 4.24 if one starts with the model specification of equation 4.23. Hence, in the Hendry methodology, omitted variable bias is rarely found (Roche, 2001).

$$y_t = \beta_1 + \beta_2 y_{t-1} + \beta_3 x_t + \beta_4 x_{t-1} + \mu_t \qquad (4.24)$$

Economic theory in general determines which variables are to be included in the model; hence, the long-run equilibrium determinants of the dependent variable. The theory, however, has little to say about the short-run dynamics that are often captured by the lag structure and are largely determined by the data.

Some of the nested models within the general-to-specific, autoregressive distributive lag model specification of two variables given in 4.24 include:

The static regression – restriction on (4.24): $\beta_2 = \beta_4 = 0$

$$y_t = \beta_1 + \beta_3 x_t + \mu_t \qquad (4.25)$$

The AR (1) process- restrictions $\beta_3 = \beta_4 = 0$

$$y_t = \beta_1 + \beta_2 y_{t-1} + \mu_t \qquad (4.26)$$

The leading indicator equation- restriction on (4.24): $\beta_2 = \beta_3 = 0$

$$y_t = \beta_1 + \beta_4 x_{t-1} + \mu_t \qquad (4.27)$$

The first difference equation – restrictions on (4.24): $\beta_2 = -1$ *and* $\beta_3 = \beta_4$

$$\Delta y_t = \beta_1 + \Delta \beta_3 x_t + \mu_t \qquad (4.28)$$

The PDL (1) equation- restriction on (4.24): $\beta_2 = 0$

$$y_t = \beta_1 + \beta_3 x_t + \beta_4 x_{t-1} + \mu_t \qquad (4.29)$$

The partial adjustment equation – restriction on (4.24): $\beta_4 = 0$

$$y_t = \beta_1 + \beta_2 y_{t-1} + \beta_3 x_t + \mu_t \qquad (4.30)$$

The 'Dead-Start' lagged information model – restrictions on (4.24): $\beta_3 = 0$

$$y_t = \beta_1 + \beta_2 y_{t-1} + \beta_4 x_{t-1} + \mu_t \qquad (4.31)$$

The proportional response model – restrictions on (4.24): $\beta_4 = - \beta_2$

$$y_t = \beta_1 + \beta_3 x_t + \beta_4 (x_{t-1} - y_{t-1}) + \mu_t \qquad (4.32)$$

The error correction model (ECM) – restrictions on (4.24): $\beta_2 - 1 = -(\beta_3 + \beta_4)$

$$\Delta y_t = \beta_1 + (\beta_2 - 1)(x_{t-1} - y_{t-1}) + \beta_3 \ \Delta x_t + \mu_t \qquad (4.33)$$

The static model with AR (1) errors – restrictions on (4.24): $\beta_4 = -\beta_2 \beta_3$

$$y_t = \beta_1 + \beta_3 x_t + \mu_t$$

$$\mu_t = \beta_2 \mu_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim NIID(0, \sigma^2_\varepsilon)$$

$$y_t = \beta_1 + \beta_2 \mu_{t-1} + \beta_3 x_t + \beta_2 \beta_3 x_{t-1} + \varepsilon_t \qquad (4.34)$$

The main steps to be followed in estimating each equation are the following (Roche, 2001):

- Plotting and analyzing the trend in the data and perform basic statistics;
- Estimating each equation using an ADL (1) model in the absence of theory suggesting a specific functional form;
- After estimating the equation, diagnostic tests determine the adequacy of the model;
- If some tests suggest a breaking trend, one might add trend and trend break dummy variables to the equation;
- If the final equation appears to be robust and if the parameters appear to be stable then the estimated equation can be reduced using t or F-tests.

After estimating the final equation, many misspecification tests should be performed to determine its adequacy.

4.6 Summary

This chapter applied the economic theory discussed in the previous chapter to specify an econometric model of all equations necessary to build the model for intermediate input expenditure and other aggregate variables. In addition, it presented a schematic view of the recursive link between input and output model, all the behavioural equations developed in the study, and the main aggregate variables needed to compute the target variables of the model. All data needed for building the model, with their source and constructions are also outlined. Most of the endogenous variables are sourced from DAFF and GrainSA and the exogenous variables are obtained mainly from FAPRI projections, Global Insight and the Reserve Bank.

To estimate the econometric equation, the Hendry methodology of general-to-specific was applied. This methodology is based on ADL (1) specification which nested various competing models. Thus, it is able to test these models in estimating each equation. Some of the nested models in ADL (1) specification include partial adjustment, the auto regressive (1) process, the leading indicator equation and the static regression. The econometric estimation results of all specified models are presented in the next chapter.

CHAPTER FIVE

ESTIMATION RESULTS OF INDIVIDUAL EQUATIONS

5.1 Introduction

In this chapter, each model specified in the previous chapter are estimated. In the following section, the statistical properties of the variables are examined. This is followed by the estimation results of all the individual equations, together with the diagnostic tests of the residuals of the equation. These tests examine violations of the underlying assumptions of the estimation techniques. Corrections are made for the violated assumptions to improve the adequacy of the model.

5.2 Statistical Properties of the Variables

The unit root test for variables with long span is conducted to examine the stationarity of the variables. As the Augmented Dickey Fuller (ADF) test suffers from low power, a recently developed Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is used. Unlike most unit root tests, the null hypothesis of the KPSS test is the stationarity of the variables. For variables suspected to show a structural break, a Philips Perron test is used to examine the stationarity of the variable.

Table 5.1: Examining the stationarity of the data

Variable	Description	LM-Stat.
RFUELP	Real fuel price	0.34
RFUELEXP	Real fuel expenditure	0.20
RFERTP	Real fertiliser price	0.43
RFEEDP	Real feed price	0.24
RFEEDEXP	Real feed demand	0.64**
RMRP	Real maintenance and repairs price	0.59**
RINTPAID	Real interest paid	0.15
ROCON	Real own construction	0.62**
RRENPAID	Real rent paid	0.37
RGINC	Real gross income	0.22
RFIXP	Real fixed improvement price	0.63**
RGCFIX	Real gross capital formation: fixed	0.36

Variable	Description	LM-Stat.
	improvement	
RGCFMIT	Real gross capital formation: Machinery, implements and tractors	0.43
RDEBT	Real debt value	0.37
RFSEXP	Real farm services expenditure	0.7***
RMREXP	Real maintenance and repairs expenditure	0.59*
RMITP	Real price of machinery, implements and tractors	0.69**
RCLI	Real change in livestock inventory	0.07
RLREMU	Real labour remuneration	Philips-Perron structural break test (-4.44)
AREA	Total area planted	0.66**
RASSET	Real asset value	0.41
RFERTEXP	Real fertiliser expenditure	0.37

As shown in the above table, most of the variables in the model, including those that have a limited span due to data limitation, are stationary and when a non-stationary variable appears in the model and the residuals of the estimated equation fails to pass the diagnostic tests, it is addressed using the appropriate econometric techniques.

5.3 Intermediate Input Expenditure

Intermediate input expenditure estimated in the model consists of expenditure on fuel, feed, fertiliser, farm services and repairs and maintenance. These inputs represent more than 70% of the intermediate input expenditure. Both prices and quantity for fuel, feed and fertiliser expenditure are estimated. The expenditure value for each input is obtained by multiplying the price and quantity of inputs.

Each price equation specified in the model is used to link with the area response equation of the output model. Thus, the impact of all the factors that affect these prices on output will be captured through these price equations. Furthermore, most of the quantity of intermediate inputs are directly influenced by the factors from the output side, such as area planted, gross income and volume of production. Thus, the recursive impact of output components on input expenditure is reflected by its effect on the quantity demanded for inputs.

5.3.1 Fuel Demand

The demand for fuel in the agricultural sector is estimated using an Autoregressive Distributed Lag (ADL (1)) model specification and the results of various nested models are given in Table 5.2. Out of all estimated models, the partial adjustment model fits the data very well. As shown in the table, all variables are statistically significant and have the expected signs in equation 5.1C. The estimated model explains 83% of the variation in fuel demand, as shown by the adjusted R^2.

$$\underset{}{RFUELD} = \underset{(0.92)}{1371.15} - \underset{(-7.47)}{14.51}RFUELP + 0.27\underset{(4.13)}{AREA} + \underset{(3.15)}{16.84}AVOL + \underset{(3.74)}{424.76}D85 + \underset{(4.68)}{778.10}D06 \quad (5.1C)$$

$Adj.\ R^2 = 0.83 \qquad T = (1980\text{-}2007)$

The expansion of both area planted and animal production drives up the demand for fuel in the sector. Conversely, a rise in the fuel price deters the demand. The computed elasticity of the variables shows that a ten percent increase in area planted and animal production will increase the fuel demand by 4.7 and 4.6% respectively. As expected, the own price elasticity is inelastic and a ten percent increase in price would only reduce the fuel demand by 3.42%. Hence, an increase in fuel price raises fuel expenditure by the sector.

Table 5.2: ADL (1) Models for real fuel demand

VARIABLE	5.1A	5.1B	5.1 C
CONSTANT	-100.15 (-0.06)	1,737.43 (1.38)	1,371.14 (1.61)
RFUELD(-1)	0.21 (0.97)	0.04 (0.24)	
RFUELP	-5.29 (-0.77)	-13.06 (-2.23)	-14.51 (-7.84)
RFUELP(-1)	-2.91 (-0.43)	-2.11 (-0.39)	
AREA	0.09 (0.71)	0.33 (2.84)	0.27 (4.39)
AREA(-1)	0.20 (1.5)	-0.09 (0.73)	
AVOL	12.23 (0.81)	21.77 (1.85)	16.83 (3.23)
AVOL(-1)	5.45 (0.33)	-7.61 (-0.57)	
D85		462.34 (2.08)	424.76 (2.64)
D06		867.43 (3.78)	778.10 (4.61)
R^2	0.63	0.79	0.83

Note: t-statistics are given in parentheses.

The diagnostic test performed on the residual of equation 5.1C shows that none of the classical assumptions of the OLS are violated.

Table 5.3: Misspecification tests for real fuel demand equation 5.1C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.44	0.79
Serial Correlation	Ljung Box Q	Q(12)	10.78	0.54
	Breusch-Godfrey	$N*R^2(2)$	0.92	0.63
	Breusch-Godfrey	$N*R^2(1)$	0.92	0.33
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.15	0.70
	ARCH LM	$N*R^2(2)$	0.26	0.87
	White	$N*R^2(1)$	4.45	0.81
Misspecification	Ramsey RESET	LR(1)	3.47	0.07
	Ramsey RESET	LR(2)	3.67	0.15
Parameter Stability	Recursive Estimates			

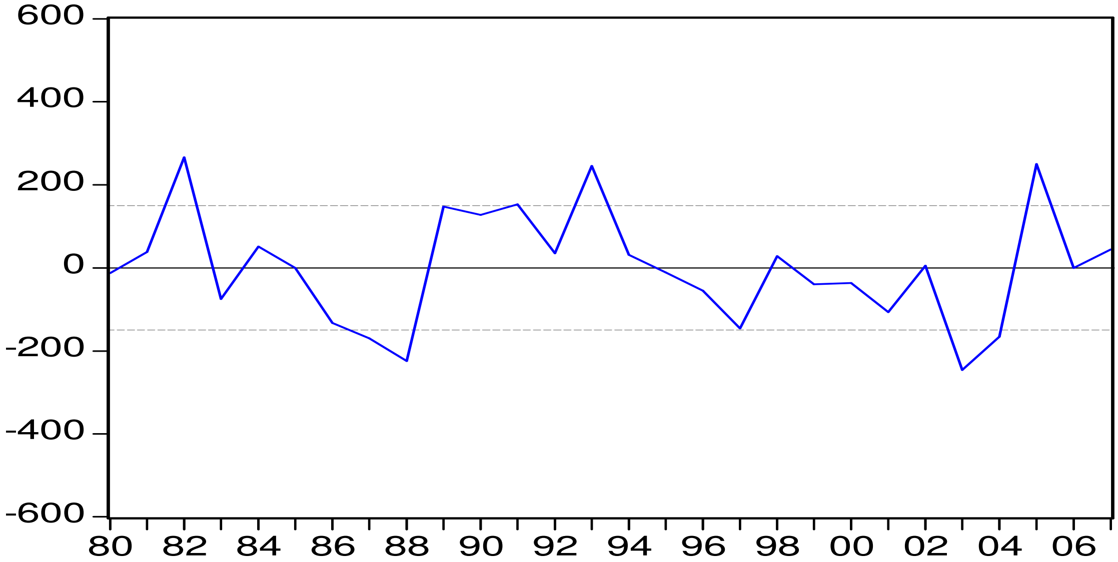


Figure 5.1 Residual graph for the real fuel demand equation 5.1C

5.3.2 Fuel Price

The result of the static model specified for the price transmission equation of the fuel price is given in equation 5.2. All variables are statistically significant with the expected signs. As expected, the domestic fuel price increases with the rise in the world crude oil price (USD) and depreciation of the exchange rate. The real domestic fuel price elasticity of crude oil price and exchange rate is 0.55. Hence, a ten percent increase in international oil price in local currency causes a 5.5% increase in domestic fuel price.

The fuel price equation plays a pivotal role in linking the input and output models. The variable cost used in the area response of the output model will now be linked with equation 5.2. Hence, the implications of all the determinant factors of fuel prices on the output side of the sector are captured and endogenised in the integrated model.

$$RFUELP = 46.75 + 0.27\ OIL^{*}\ EXC - 19.41D06 \qquad (5.2)$$
$$(11.64)\quad (10.25) \qquad\qquad (-3.98)$$

$$Adj.R^2 = 97.2 \qquad\qquad T = (1991\text{-}2008)$$

Table 5.4: Diagnostic tests for real fuel price equation 5.2

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.02	0.29
Serial Correlation	Ljung Box Q	Q(6)	3.11	0.99
	Breusch-Godfrey	$N*R^2(1)$	0.22	0.37
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.52	0.38
	ARCH LM	$N*R^2(2)$	0.67	0.14
	White	$N*R^2(1)$	2.11	0.46
Misspecification	Ramsey RESET	LR(1)	2.88	0.23
	Ramsey RESET	LR(2)	2.39	0.12
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level.

The diagnostic test performed on the residual of equation 5.2 shows that none of the classical assumptions of the OLS are violated.

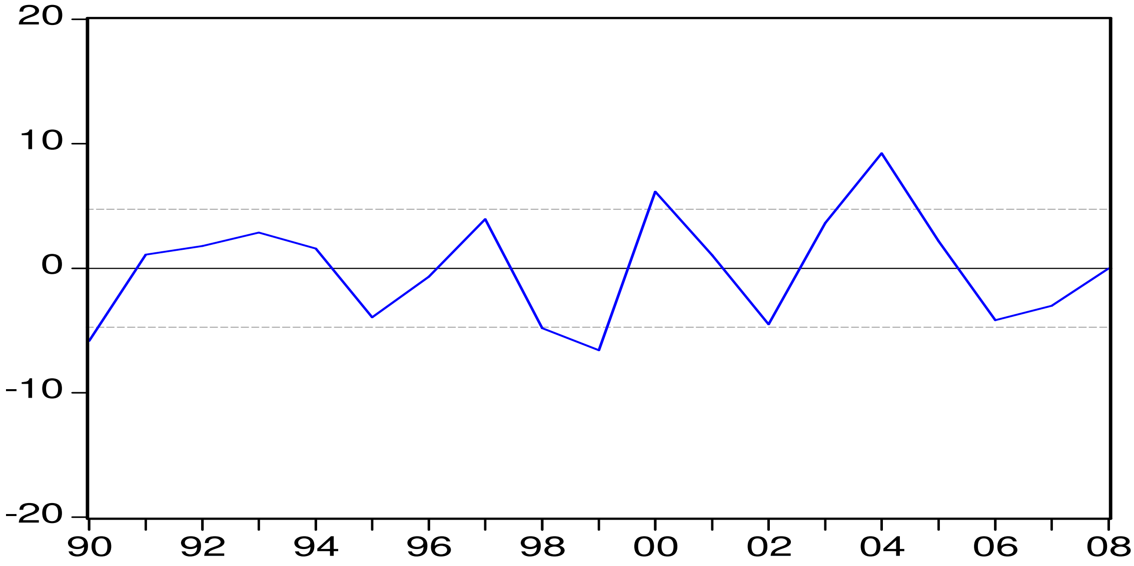


Figure 5.2: Residual graph of the real fuel price equation 5.2

5.3.3 Feed Demand

The results of ADL (1) model and various nested models of feed demand are given in Table 5.5. The results show that the partial adjustment model fits the data very well. All the variables are statistically significant and hold the expected sign. As expected, the rise in feed price affects the feed demand negatively and the expansion of animal production augments feed demand in the sector. The short run elasticities for feed price and animal production are -0.62 and 0.7 respectively. Thus, a ten percent increase in feed price and animal production would reduce the feed demand by 6.2 % and increase it by 7 % respectively.

As expected the long run elasticity of feed price and animal productions are higher than the short run. The long run own price and animal production elasticity are -1.53 and 1.71 respectively. Thus, any percentage increase in animal production and feed price would result in higher percentage increase in the feed demand. It, therefore, can be concluded that both animal production and feed price are important determinants of feed demand in the long run.

Table 5.5: ADL (1) Model for real feed demand

VARIABLE	5.3A	5.3B	5.3 C
CONSTANT	128.00 (0.08)	1219.00 (0.59)	1605.00 (1.09)
RFEEDD(-1)	0.89 (6.17)	0.69 (3.51)	0.59 (4.14)
RFEEDP	-54.30 (-5.01)	-23.24 (-2.01)	-30.82 (-3.69)
RFEEDP(-1)	51.60 (4.72)		
AVOL	73.56 (1.88)	29.09 (1.02)	37.41 (1.81)
AVOL(-1)	-66.34 (-1.52)		
D02			1949.29 (4.57)
R^2	0.87	0.74	0.87

Note: t-statistic is given in parenthesis

Like the other input demand models, the animal volume index variable from the output model is used in determining the feed demand of the agricultural sector. Thus, the integration of the feed demand model implies that all the factor incorporated in the sectoral model that determines the amount of animal production are also indirectly determine the feed demand of the sector. Similarly, the aggregate feed price index utilises the variable from the output model in estimating its value, which is discussed in the following section.

$$FEEDD = 1605 + 0.59RFEEDD(-1) - 30.82FEEDP + 37.41AVOL + 1949.3D02 \quad (5.3C)$$
$$(1.09) \quad (4.1) \qquad (-3.69) \qquad (1.81) \qquad (4.57)$$

$$Adj.R^2 = 0.95 \qquad T = (1985\text{-}2008)$$

The results of the diagnostic tests performed on the residual of equation 5.3C show that the all the classical assumptions are not violated.

Table 5.6: Misspecification tests of real feed demand equation 5.3C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	1.43	0.48
Serial Correlation	Ljung Box Q	Q(12)	5.15	0.95
	Breusch-Godfrey	$N*R^2(2)$	0.14	0.86
	Breusch-Godfrey	$N*R^2(1)$	0.11	0.73
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.13	0.71
	ARCH LM	$N*R^2(2)$	0.27	0.76
	White	$N*R^2(1)$	1.25	0.33
Misspecification	Ramsey RESET	LR(1)	0.66	0.42
	Ramsey RESET	LR(2)	0.41	0.66
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level

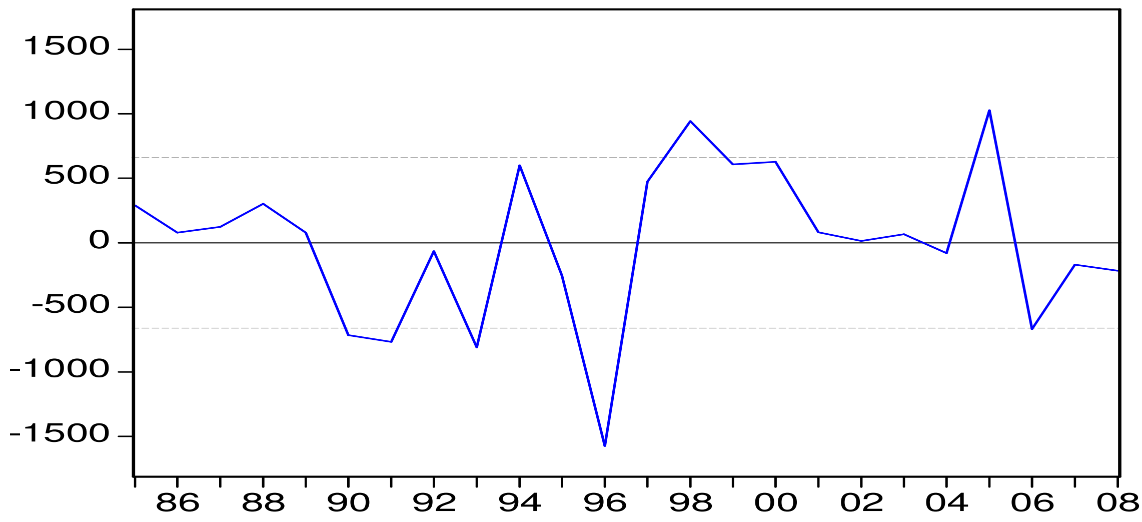


Figure 5.3: Residuals of real feed demand equation 5.3C

5.3.4 Real Feed Price

The result of the estimated model of real feed price is given in equation 5.4. The variable included in the model is statistically significant and display the expected signs. As expected the feed cost for animal production computed in the sectoral model well explains the aggregate feed price index of the agricultural sector. The elasticity of aggregate feed price to the cost of feed for animal production from the sectoral model is 0.65. Hence, a rise of 10% will increase the aggregate price index by 6.5%.

$$RFEEDP = 73.95 + 0.06\ RTFEEDC \qquad (5.4)$$
$$(5.13) \qquad (2.40)$$

$$Adj.R^2 = 0.54 \qquad T = (1990\text{-}2007)$$

This equation links the output model with the aggregate feed cost index, which is used also to determine the demand in equation 5.3C. Hence, the impact of all the variables that determine the feed cost in the output models, such as domestic commodity prices (which are also related to the world prices and exchange rate), are indirectly factored in determining feed expenditure by the agricultural sector.

Table 5.7: Misspecification tests for feed price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.55	0.22
Serial Correlation	Ljung Box Q	Q(12)	3.21	0.99
	Breusch-Godfrey	$N^*R^2(2)$	0.14	0.86
	Breusch-Godfrey	$N^*R^2(1)$	0.00	0.96
Homoscedasticity	ARCH LM	$N^*R^2(1)$	1.38	0.26
	ARCH LM	$N^*R^2(2)$	0.73	0.49
	White	$N^*R^2(1)$	1.14	0.84
Misspecification	Ramsey RESET	LR(1)	0.19	0.66
	Ramsey RESET	LR(2)	2.60	0.12
Parameter Stability	Recursive Estimates			

The diagnostic test performed on the residual of equation 5.4 shows that the classical assumptions of the OLS are not violated.

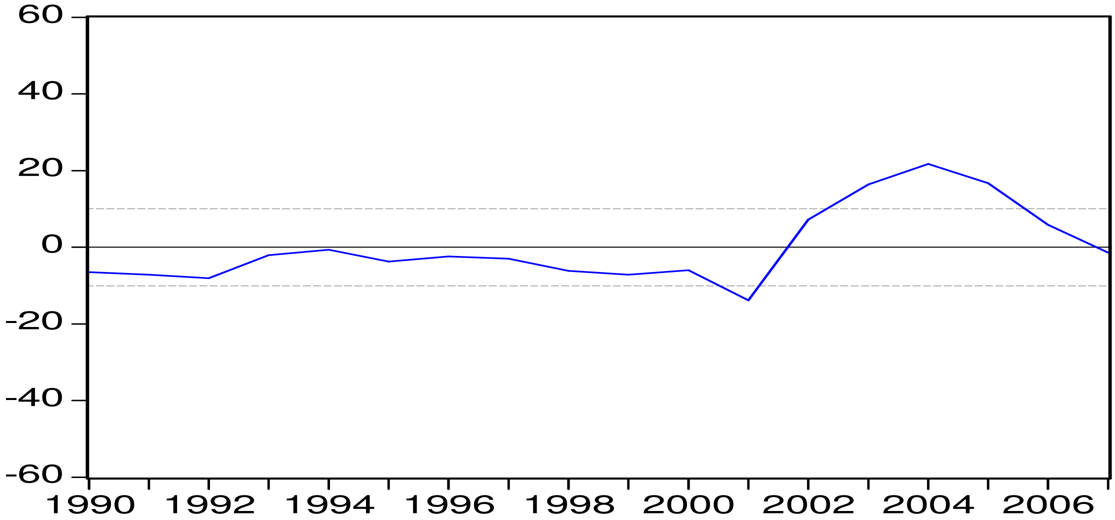


Figure 5.4: Residuals of real feed price equation

5.3.5 Real Maintenance and Repairs Demand

The results of the ADL (1) and the nested models for real maintenance and repairs demand are presented in Table 5.8. The results of various models show that the partial adjustment model fits the data very well. All the variables included in the model are statistically significant and display the expected signs. While the rise in the price of repairs and maintenance reduces the demand, the increase of the gross capital formation, which is used as a proxy for the activities in the sector, augments the demand. The Chow break point test, which shows a break in 1993, is also significant in the equation. The demand for maintenance and repairs is price inelastic. A ten percent increase of own price would reduce the demand by only 2.7%. The demand also increases by 1.1%, for a ten percent increase in gross capital formation.

Table 5.8: ADL (1) Model for real maintenance and repairs demand

VARIABLE	5.5A	5.5B	5.5C	5.5D	5.5E
CONSTANT	433.00 (1.04)	2,899.00 (7.30)	2,791.00 (19.19)	2,809.89 (19.27)	2,800.67 (18.10)
RMAREPD(-1)	0.80 (5.67)	-0.04 (-0.33)			
RGCF	0.07 (1.36)	0.03 (0.97)	0.03 (1.15)		0.07 (2.88)
RGCF(-1)	-0.09 (-1.58)	0.07 (1.74)	0.06 (1.9)	0.08 (3.39)	
RMRP	1.26 (0.18)	-10.34 (-2.7)	-8.53 (-4.8)	-8.33 (-4.67)	-7.42 (-4.15)
RMRP(-1)	0.59 (0.08)	1.53 (0.44)			
SHIFT93		508.37 (7.32)	488.45 (14.04)	504.00 (15.60)	469.95 (2.88)
R^2	0.66		0.92	0.92	0.91

Note: t-statistics are given in parentheses.

$$RMAREPD = 2800.67 + 0.07\ RGCF - 7.42\ RMRP\ (-1) + 469.95\ SHIFT93 \qquad (5.5E)$$
$$(18.10) \quad (4.15) \quad (2.88) \quad (13.22)$$

$$Adj.\ R^2 = 0.91 \qquad T = (1985\text{-}2008)$$

The diagnostic tests performed on the residual of equation 5.3E shows that the classical assumptions of the OLS are not violated.

Table 5.9: Misspecification test for real maintenance and repairs demand equation 5.5E

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.43	0.80
Serial Correlation	Ljung Box Q	Q(12)	6.75	0.87
	Breusch-Godfrey	$N*R^2$ (2)	0.26	0.77
	Breusch-Godfrey	$N*R^2$ (1)	0.22	0.64
Homoscedasticity	ARCH LM	$N*R^2$ (1)	0.00	0.96
	ARCH LM	$N*R^2$ (2)	0.08	0.92
	White	$N*R^2$ (1)	0.62	0.68
Misspecification	Ramsey RESET	LR(1)	1.54	0.22
	Ramsey RESET	LR(2)	0.79	0.46
Parameter Stability	Recursive Estimates			

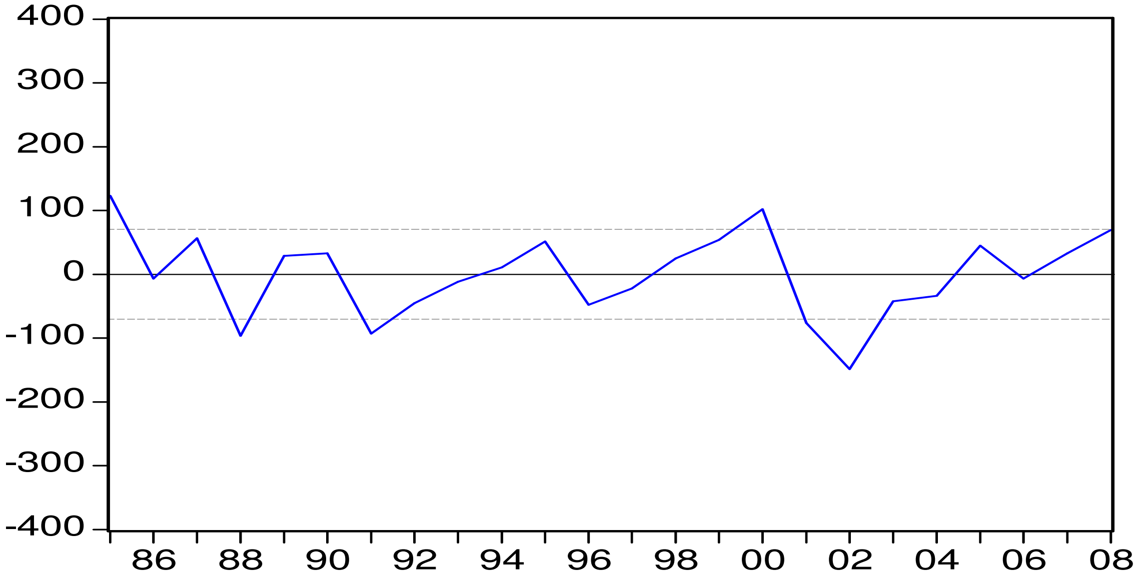


Figure 5.5: Residuals of real maintenance and repairs demand equation 5.5E

5.3.6 Real Farm Services Expenditure

The results of ADL (1) and various nested models for the estimated real farm services expenditure are given in Table 5.10. From the results, the autoregressive model with trend and lagged agricultural income fits the data well. The model explains 98% of the variation in the expenditure during the specified period of time.

Table 5.10: ADL (1) Model for real farm services expenditure

VARIABLE	5.6A	5.6B	5.6C
CONSTANT	272.83 (0.98)	-56, 641 (-2.10)	-60,153 (-2.31)
RFASEXP(-1)	1.08 (27.36)	0.87 (7.99)	0.84 (8.48)
RGINC	-0.007 (-1.01)	-0.004 (-0.62)	
RGINC(-1)	0.002 (0.21)	0.008 (0.99)	0.0053 (0.8)
TREND		28.48 (2.11)	30.22 (2.32)
R^2	0.98	0.98	0.98

Note: t-statistics are given in parentheses.

$$RFASEXP = -60\ 153 + 0.84RFASEXP\,(-1) + 30.22\ TIME + 0.005\ RGINC(-1)$$
$$(-2.31) \quad (8.48) \quad (2.32) \quad (0.8) \qquad (5.6C)$$

$$Adj.\ R^2 = 0.98 \qquad T = (1982\text{-}2008)$$

Table 5.11: Misspecification tests for the real farm services expenditure equation 5.6D

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	24.03	0.00***
Serial Correlation	Ljung Box Q	Q(12)	9.33	0.67
	Breusch-Godfrey	$N*R^2$ (2)	1.96	0.16
	Breusch-Godfrey	$N*R^2$ (1)	1.93	0.18
Homoscedasticity	ARCH LM	$N*R^2$ (1)	0.02	0.89
	ARCH LM	$N*R^2$ (2)	0.02	0.97
	White	$N*R^2$ (1)	1.59	0.21
Misspecification	Ramsey RESET	LR(1)	0.10	0.75
	Ramsey RESET	LR(2)	1.41	0.26
Parameter Stability	Recursive Estimates			

The diagnostic test performed on the residual shows that the classical assumptions, except the normality, of the OLS are not violated. As noted in Gujarati (1995), the OLS estimators are best linear unbiased estimators (BLUE), regardless of the assumption of normality.

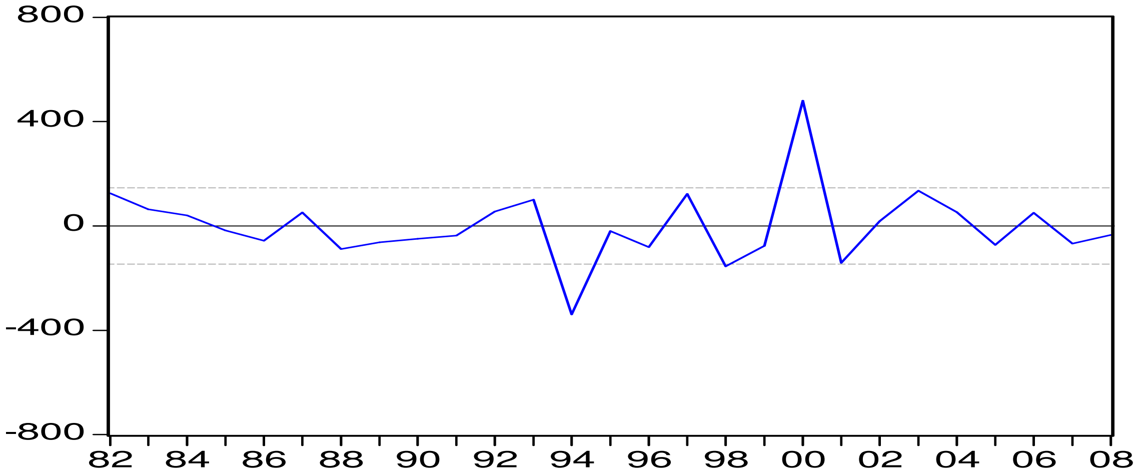


Figure 5.6: Residuals for the real farm services expenditure equation 5.6D

5.3.7 Nitrogen Consumption by Field Crops

The results of the estimated model of nitrogen consumption by field crops is given in equation 5.7. The result shows that nitrogen consumption soars with the increase in the nitrogen consumption share weighted area and a rise in field crop prices. A rise in nitrogen price, however, reduces consumption. The own price and weighted area elasticity show that a ten percent increase in the price will reduce consumption by 1.7% and an increase of the weighted area by ten percent will increase consumption by 5.6%. A 10% increase in field crop prices will also induce a 1.7% rise in nitrogen consumption.

$$NCONS = -15\,236\,305 - \underset{(-5.09)}{} 26.18\, RUREAP \underset{(-2.81)}{} + 103.51\, NWAREA \underset{(5.36)}{} + 7684.08\, TREND \underset{(5.16)}{}$$

$$+ 435.34\, RPFC \underset{(1.82)}{} - 40202.01\, D02 \underset{(-2.75)}{} \quad (5.7)$$

Adj. $R^2 = 0.73$ $\quad\quad$ $T = (1995\text{-}2008)$

The diagnostic tests performed on the residual show that none of the classical assumptions are violated.

Table 5.12: Misspecification tests for nitrogen consumption equation 5.7

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	2.07	0.60
Serial Correlation	Ljung Box Q	Q(6)	3.55	0.59
	Breusch-Godfrey	$N*R^2(2)$	1.63	0.44
	Breusch-Godfrey	$N*R^2(1)$	1.37	0.24
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.01	0.31
	ARCH LM	$N*R^2(2)$	2.44	0.29
	White	$N*R^2(1)$	2.09	0.46
Misspecification	Ramsey RESET	LR(1)	0.08	0.94
	Ramsey RESET	LR(2)	2.35	0.41
Parameter Stability	Recursive Estimates			

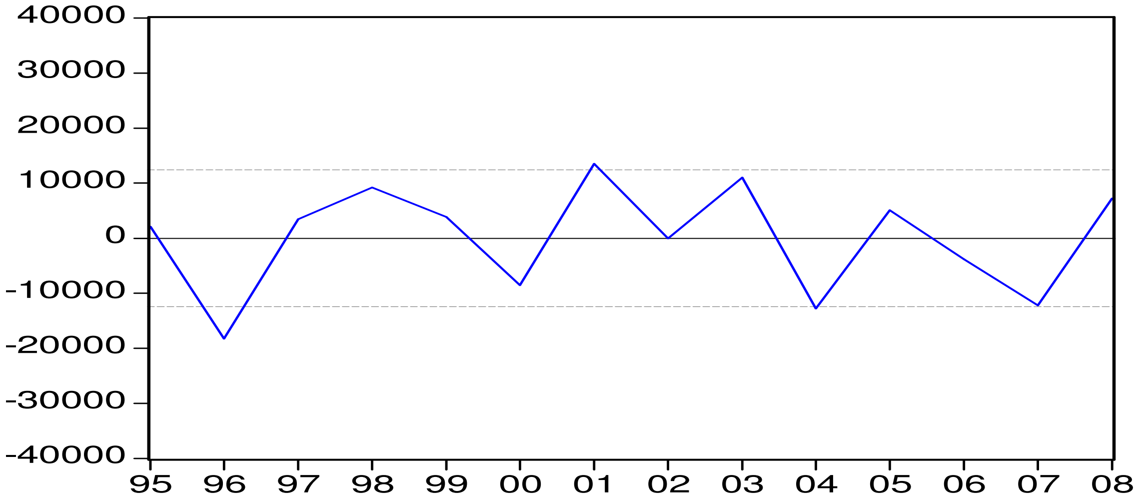


Figure 5.7: Residuals of nitrogen consumption by field crops equation 5.7

5.3.8 Phosphorous Consumption by Field Crops

The results of the estimated model of phosphorus consumption by field crops is given in equation 5.8. As expected, a rise in the phosphorous price reduces consumption and an increase in the phosphorous weighted area increases consumption. A ten percent increase in own price reduces phosphorous consumption by 1% and a ten percent increase in weighted area will increase consumption by 6.7%. Field crop price, however, was not found to have influence on the phosphorous consumption.

$$PCONS = 24\,999.21 - 1.38\,RPHOSP + 33.17PAREA - 7630.47D01 \qquad (5.8)$$
$$\quad (3.23) \qquad (-1.9) \qquad (5.98) \qquad (-2.11)$$
$$Adj.\ R^2 = 0.79 \qquad T = (1995\text{-}2008)$$

The diagnostic test performed on the residual of equation 5.8 shows that none of the classical assumptions of the OLS are violated.

Table 5.13: Misspecification tests for phosphorous consumption equation 5.8

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	1.87	0.38
Serial Correlation	Ljung Box Q	Q(6)	1.56	0.95
	Breusch-Godfrey	$N*R^2$ (2)	0.38	0.34
	Breusch-Godfrey	$N*R^2$ (1)	0.06	0.79
Homoscedasticity	ARCH LM	$N*R^2$ (1)	0.02	0.24
	ARCH LM	$N*R^2$ (2)	0.88	0.64
	White	$N*R^2$ (1)	3.62	0.39
Misspecification	Ramsey RESET	LR(1)	0.39	0.53
	Ramsey RESET	LR(2)	0.54	0.76
Parameter Stability	Recursive Estimates			

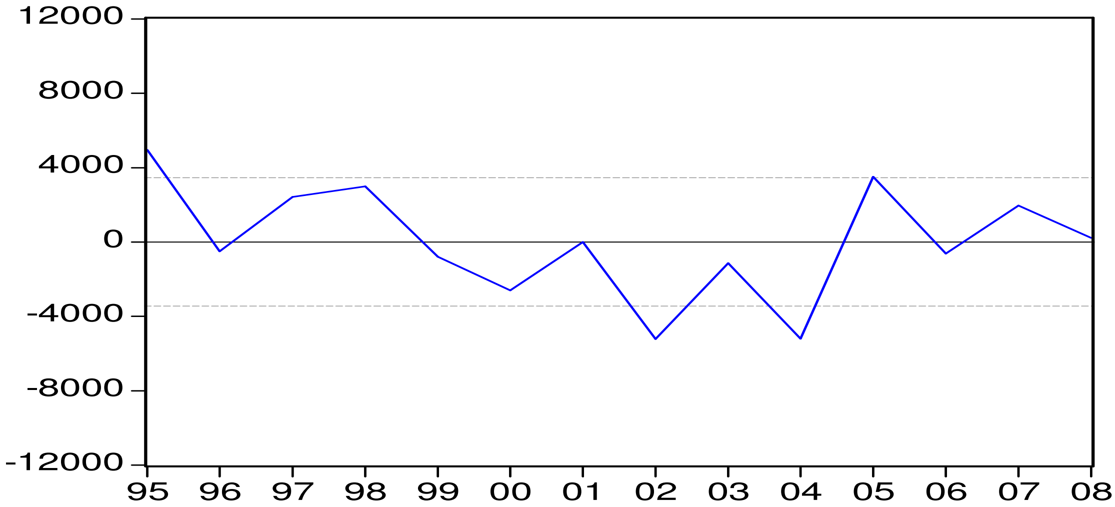


Figure 5.8: Residuals of phosphorous consumption by field crops equation 5.8

5.3.9 Potassium Consumption by Field Crops

The results of the estimated model for potassium consumption is given in equation 5.9. As expected, consumption is positively affected by the expansion of planted area and influenced negatively by the rise in its own price. The own price and field crops price elasticity of potassium consumption are -0.39 and 0.45 respectively. Thus, a ten percent increase in own price and field crop price would decrease the consumption by 3.9% and increase it by 4.5% respectively.

$$KCONS = -77599.59 + 337.96SCAREA - 15.89RKP(-1) + 258.43\,RFCP +$$
$$(-1.37) \qquad (2.41) \qquad (-1.8) \qquad (2.09)$$

$$11604.88D99 + 10368.66D05 \qquad (5.9)$$
$$(2.54) \qquad (2.05)$$

$Adj.\ R^2 = 0.48$ $\qquad$ $T = (1992 - 2007)$

The diagnostic tests on the residual of equation 5.9 show that none of the classical assumptions are violated.

Table 5.14: Misspecification tests for potassium consumption equation 5.9

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	2.66	0.43
Serial Correlation	Ljung Box Q	Q(6)	1.96	0.92
	Breusch-Godfrey	$N*R^2(1)$	0.25	0.61
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.67	0.21
	ARCH LM	$N*R^2(2)$	2.07	0.35
	White	$N*R^2(1)$	6.96	0.12
Misspecification	Ramsey RESET	LR(1)	1.53	0.21
	Ramsey RESET	LR(2)	2.07	0.35
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level.

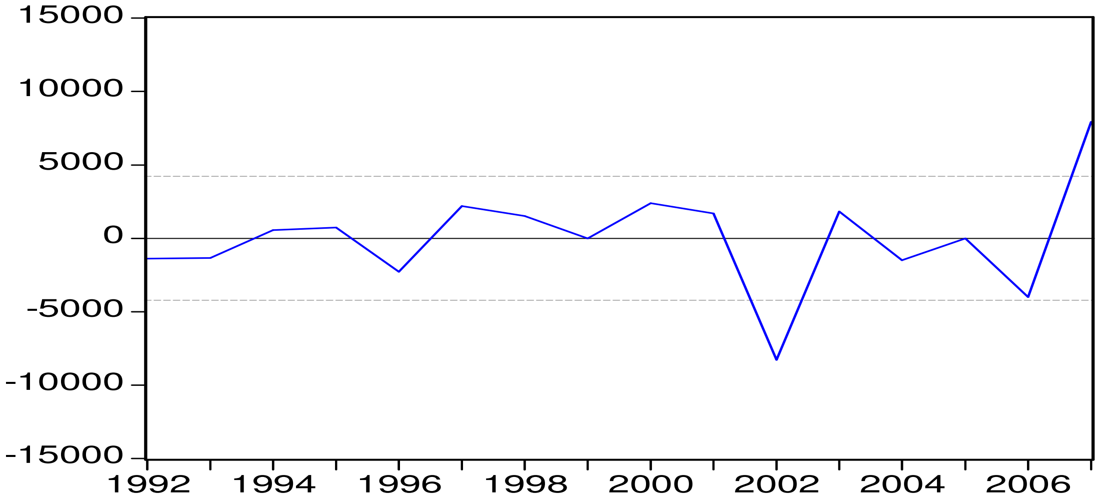


Figure 5.9: Residual of potassium consumption equation 5.9

5.3.10 Potassium Price

The result of the price transmission of domestic potassium price equation is presented in equation 5.10. A rise in the world price and depreciation of the exchange rate will increase the domestic potassium price. Moreover, the effect of the 'cash availability' of producers on domestic price is positive. Hence, it indicates input providers have the market power to charge more for inputs if they realised producers have obtained enough cash during the previous season. This behaviour is among the issues that have been investigated by the Competition Commission recently. The price elasticity for the transmission and cash availability are 0.56 and 0.24 respectively. Thus, a ten percent increase in world potassium price (in terms of Rand) and in gross income by field crops would cause the domestic price to increase by 5.6% and 2.4% respectively.

$$RPOTP = \underset{(3.01)}{415.14} + \underset{(30.34)}{1.34}\ RWPP*EXCH + \underset{(3.58)}{0.034}RGINCFC\,(-1) \qquad (5.10)$$

$Adj.\ R^2 = 0.98$ $\qquad T = (1995 - 2008)$

None of the classical assumptions of OLS are violated, as shown in the diagnostic tests of the residual given in Table 5.15.

Table 5.15: Misspecification tests for real potassium price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.25	0.87
Serial Correlation	Ljung Box Q	Q(6)	1.58	0.95
	Breusch-Godfrey	$N*R^2(1)$	0.33	0.56
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.41	0.23
	ARCH LM	$N*R^2(2)$	1.73	0.42
	White	$N*R^2(1)$	2.90	0.57
Misspecification	Ramsey RESET	LR(1)	1.05	0.30
	Ramsey RESET	LR(2)	1.26	0.53
Parameter Stability	Recursive Estimates			

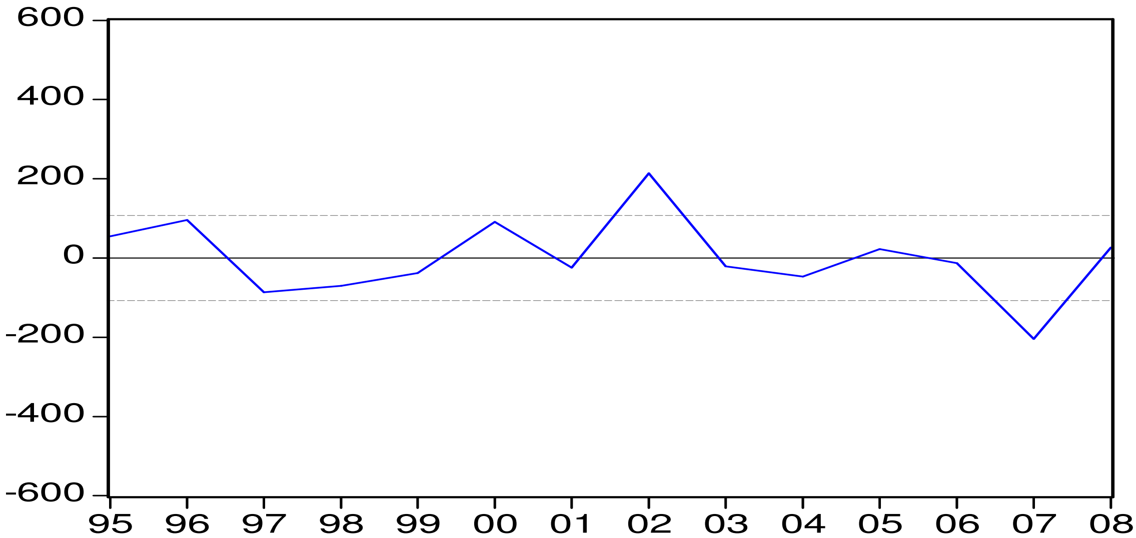


Figure 5.10: Residuals for real potassium price equation

5.3.11 Phosphorous Price

The estimation results of the model specified for the price transmission of domestic phosphorous price equations is given in equation 5.11. The rise of world price, depreciation of the Rand and cash availability of producers increases the domestic price. Thus, similar to the domestic potassium fertiliser prices, the result shows the input suppliers' response to higher income by setting domestic prices higher, which could be attributed to the market structure of fertiliser producers in the country. The price transmission elasticity is higher than the other fertiliser prices. A 10% increase in world price would cause a 7.7% rise in phosphorous price. Moreover, an increase by 10% in 'cash availability' would cause a simultaneous 1.7% increase in the domestic phosphorous price.

$$\underset{}{RPHOSP} = \underset{(0.79)}{146.46} + \underset{(33.3)}{1.48}\ RPHWP*EXC + \underset{(2.77)}{0.03}\ RGINCFC\ (-1) \qquad (5.11)$$

$$Adj.R^2 = 0.99 \qquad\qquad T = (1996\text{ -}2008)$$

The diagnostic test performed in the residual of equation 5.11 shows that most of the classical assumptions of OLS are not violated.

Table 5.16: Misspecification test for phosphorous price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.56	0.75
Serial Correlation	Ljung Box Q	Q(6)	6.13	0.40
	Breusch-Godfrey	$N*R^2(1)$	2.58	0.11
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.00	0.96
	ARCH LM	$N*R^2(2)$	1.75	0.41
	White	$N*R^2(1)$	7.07	0.13
Misspecification	Ramsey RESET	LR(1)	3.84	0.05**
	Ramsey RESET	LR(2)	4.00	0.13
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level

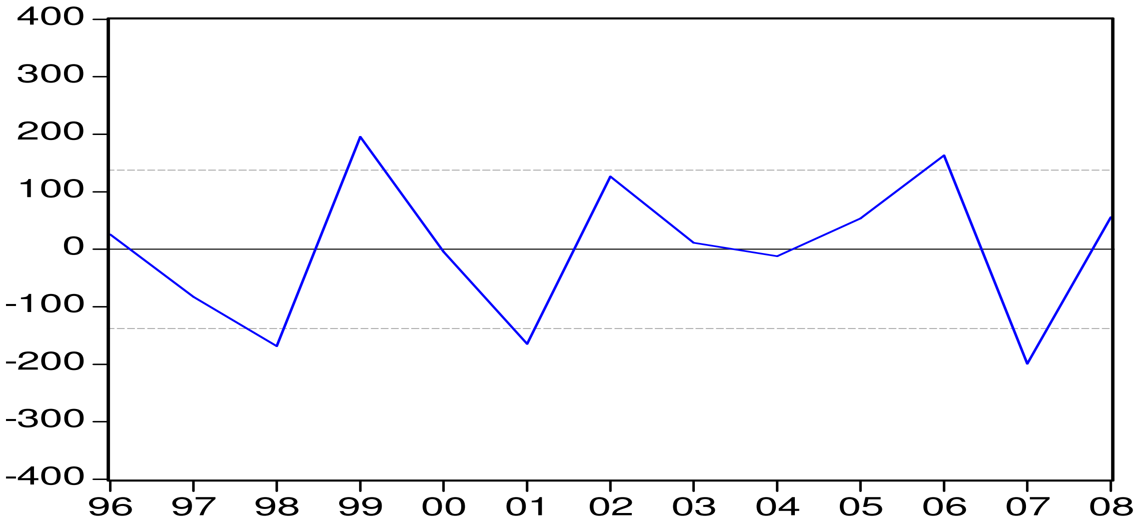


Figure 5.11: Residuals of real phosphorous equation

5.3.12 Nitrogen Price

The estimation result of the specified model for the price transmission of domestic nitrogen price equation is given in equation 5.12. As expected, a rise in world price or depreciation of exchange rate increases the domestic price. Moreover, the cash availability of farmers, though statistically insignificant, shows a positive effect on the domestic price, which suggests that input prices are set higher in response to cash availability. The elasticity of the price transmission from the world price (in terms of Rand) is 0.59 and from 'cash availability' is 0.114. Thus, a 10% increase in world price (in terms of Rand) and cash availability will cause the domestic price to increase by 6 and 1.14% respectively.

$$RNP = 589.60 + 1.31\ RWNP*EXCH + 0.012\ RGINCFC\ (-1) \qquad (5.12)$$
$$(3.06) \qquad (15.52) \qquad\qquad (1.3)$$
$$Adj.\ R^2 = 0.96 \qquad T = (1995 - 2008)$$

The diagnostic test on the residual of equation 5.12 shows that the classical assumptions are not violated.

Table 5.17: Misspecification test for real nitrogen price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	2.18	0.33
Serial Correlation	Ljung Box Q	Q(6)	1.2	0.97
	Breusch-Godfrey	$N^*R^2(2)$	3.41	0.18
	Breusch-Godfrey	$N^*R^2(1)$	1.76	0.18
Homoscedasticity	ARCH LM	$N^*R^2(1)$	0.20	0.65
	ARCH LM	$N^*R^2(2)$	1.03	0.59
	White	$N^*R^2(1)$	2.52	0.64
Misspecification	Ramsey RESET	LR(1)	2.79	0.10
	Ramsey RESET	LR(2)	5.96	0.05**
Parameter Stability	Recursive Estimates			

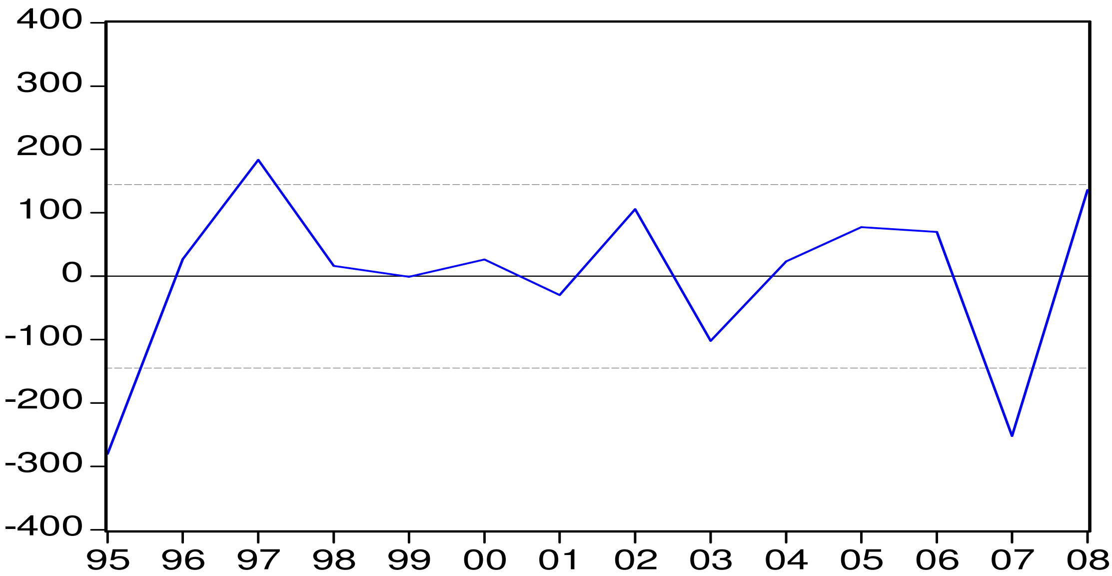


Figure 5.12: Residuals for real nitrogen price equation

5.3.13 Real Fertiliser Price

The result of the estimated model for real aggregate fertiliser price index is given in equation 5.13. As expected, the aggregate price for all fertilisers, which was constructed using a weight based on the consumption share for each fertilisers displays the expected signs and is highly significant. In addition, the elasticity of the aggregate price index to the actual constructed aggregate fertiliser price is close to unity.

$$RFERTINDEX = 22.87 + 0.04AFERTP \quad (5.13)$$
$$(4.87) \quad (19.65)$$
$$Adj.\ R^2 = 0.96 \quad T = 1991\text{-}2008$$

The diagnostic test on the residual of equation 5.16 shows that the classical assumptions are not violated.

Table 5.18: Misspecification tests for real fertiliser price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.56	0.75
Serial Correlation	Ljung Box Q	Q(6)	4.35	0.62
	Breusch-Godfrey	$N*R^2(1)$	1.21	0.27
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.03	0.86
	ARCH LM	$N*R^2(2)$	1.13	0.57
	White	$N*R^2(1)$	5.29	0.07
Misspecification	Ramsey RESET	LR(1)	0.59	0.44
	Ramsey RESET	LR(2)	0.77	0.67
Parameter Stability	Recursive Estimates			

This equation is also among the input prices equation that links the input model with the output model. The area response equation used in the output model uses fertiliser prices (a proxy for variable costs) as its determinant. The model specified in this equation will be linked with the area response equation in the output model. Thus, all the effects of the determinants of each fertiliser price (world price, exchange rate and cash availability) on the output sector are captured and endogenised in the integrated model.

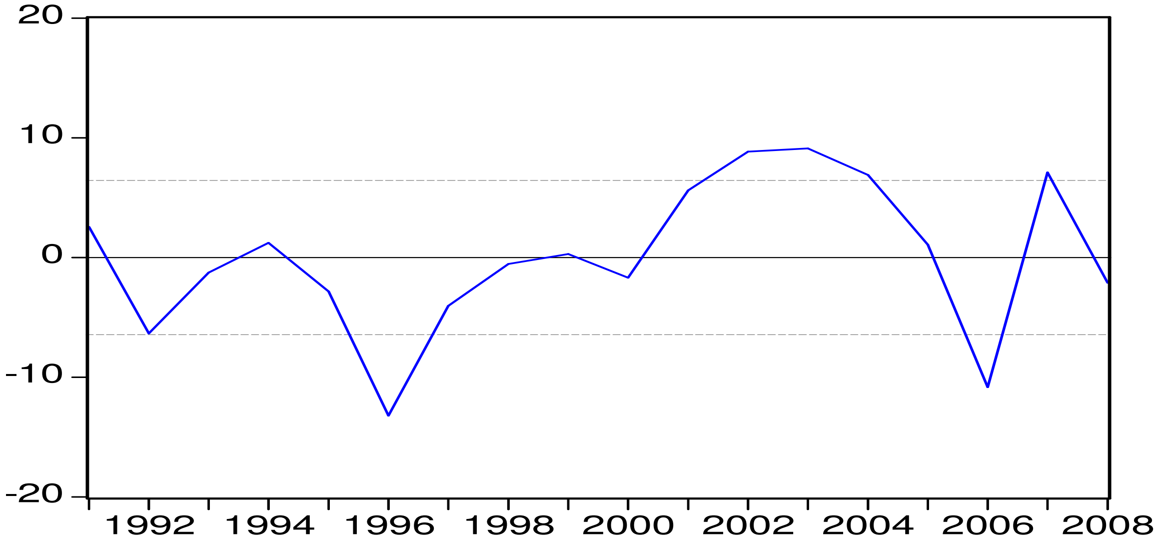


Figure 5.13: Residuals of fertiliser price equation

5.3.14 World Fertiliser Price

Due to the lack of a projected world fertiliser prices, its forecasted value is estimated using world oil prices and area allocated by major world fertiliser consumer countries (China, India, EU, USA and Brazil) as its determinants. Area allocated for each commodity is weighted according to the fertiliser consumption share of each country. The data for the weight is obtained from IFA and the projections of area planted for each commodity in each country are obtained form the projections of FAPRI. A recent study by Chen *et al.,* (2010) also found that crude oil price significantly determines world fertiliser prices.

The result of the world fertiliser price estimations are given in equations 5.14 – 5.16. Due to the limited span of dataset, only economically significant variables are used to evaluate the model. The variables included in the model show the expected signs and all the equations have adjusted R^2 more than 0.79. Hence, it would be adequate to use the model for projecting world fertiliser prices.

Potassium price equation:

$$WKP = -1630.66 + 0.04WKAREA + 6.03\ OIL - 191.20D07 \quad (5.14)$$
$$(-1.55) \quad (1.46) \quad (4.3) \quad (-1.96)$$
$$Adj.\ R^2 = 0.79 \qquad T = (1999\ -2008)$$

Nitrogen price equation:

$$WNP = -65.44 + 5.48\ OIL + 0.00056\ WNAREA \quad (5.15)$$
$$(-0.2) \quad (11.56) \quad (0.08)$$
$$Adj. R^2 = 0.95 \qquad T = (1999\ -2008)$$

Phosphorous price equation:

$$WPHP = -894.15 + 9.08\ OIL + 0.018\ WPHAREA - 216.49\ D06 \quad (5.16)$$
$$(-0.83) \quad (5.38) \quad (0.73) \quad (-3.2)$$
$$Adj.\ R^2 = 0.83 \qquad T = (1999\ -2008)$$

5.3.15 Total Fertiliser Expenditure

Once the individual prices and quantities of each fertiliser group are estimated, the following formula is used to calculate the fertiliser expenditure by major field crops.

$$RFERTEXPFC = (NCONSU*RNP) + (PCONSU*RPHP) + (KCONS*RKP) \quad (5.17)$$

Then, the fertiliser expenditure by the agricultural sector as reported in DAFF is estimated using the estimated field crop fertiliser consumption. Equation 5.18 displays the result of the estimation. The variable in the model is statistically significant and shows the expected signs. As expected, the elasticity of the total fertiliser expenditure by the sector to the field crops fertiliser expenditure is close to one.

$$RFERTEXPE = 306.63 + 2.65\ RFEXPFC - 810.57D05 \quad (5.18)$$
$$(1.05) \quad (7.45) \quad (-3.48)$$
$$Adj.\ R^2 = 0.77 \qquad T = (1991\ -2007)$$

The diagnostic tests on the residual of equation 5.18 show that none of the classical assumptions of OLS are violated.

Table 5.19: Misspecification tests for total fertiliser consumption equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	4.52	0.11
Serial Correlation	Ljung Box Q	Q(6)	0.33	0.99
	Breusch-Godfrey	$N*R^2(2)$	1.63	0.23
	Breusch-Godfrey	$N*R^2(1)$	0.61	0.45
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.09	0.31
	ARCH LM	$N*R^2(2)$	0.58	0.57
	White	$N*R^2(1)$	2.64	0.11
Misspecification	Ramsey RESET	LR(1)	0.33	0.57
	Ramsey RESET	LR(2)	1.21	0.33
Parameter Stability	Recursive Estimates			

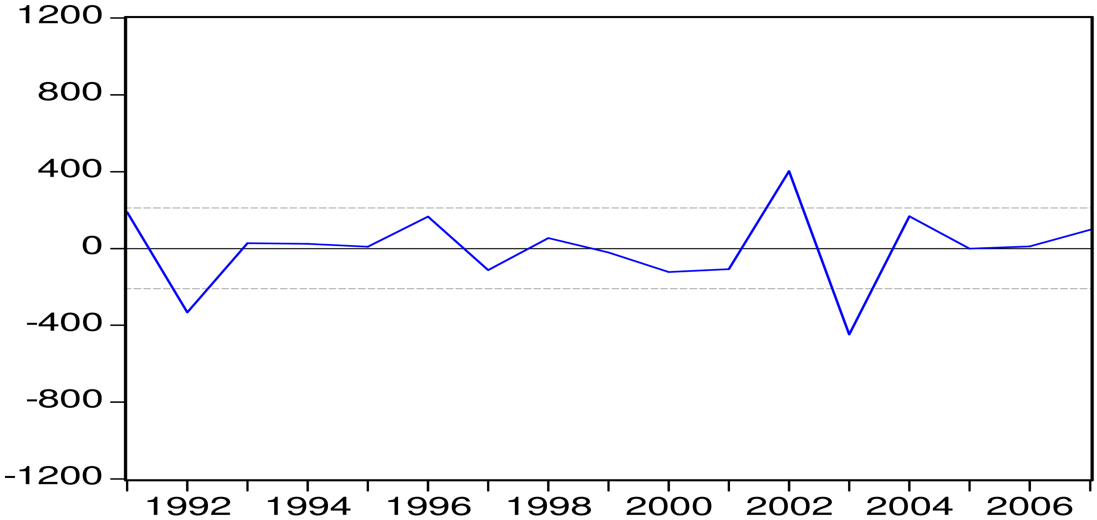


Figure 5.14: Residual of aggregate fertiliser expenditure

5.4 Real Own Construction

The results of ADL (1) and nested models of real own construction are given in Table 5.20. Of all the models estimated, the partial adjustment model with time trend fits the data very well. All the variables included in the model are statistically significant and show the expected signs. As expected, real gross capital formation of fixed improvements

(RGCFFIX) influences the value of own construction positively. The short- and long-run elasticity of RCCFFIX are 0.5 and 0.62 respectively. Thus, a 10% increase in RGCFFIX would increase own construction by 5% in the short run and 6.2% in the long run.

Table 5.20: ADL (1) Model for real own construction

VARIABLE	5.19A	5.19B	5.19C
CONSTANT	27.72 (0.43)	-23,205.7 (-2.90)	-25,815.18 (-4.14)
ROCONS(-1)	1.03 (40.71)	0.72 (6.56)	0.684 (7.77)
RGCFFIX	0.23 (2.42)	0.23 (2.73)	0.20 (3.48)
RGCFFIX(-1)	-0.24 (-2.6)	-0.056 (-0.54)	
TREND			12.90 (3.48)
R^2	0.98	0.98	0.98
	T = (1975-2008)		

Note: t-statistics are given in parentheses.

$$ROCONS = \underset{(-4.14)}{-25815.18} + \underset{(7.77)}{0.684}ROCONS(-1) + \underset{(3.48)}{0.2}\ RGCFFIX + \underset{(3.48)}{12.9}\ TREND \quad (5.19C)$$

$$Adj.R^2 = 0.98 \qquad T = (1975\text{-}2008)$$

The classical assumptions of OLS are not violated, as shown in the diagnostic tests of equation 5.19C. As noted in Gujarati (1995), the OLS estimators are BLUE, regardless of the assumption of normality.

Table 5.21: Misspecification tests for real own construction equation 5.19C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	11.87	0.002***
Serial Correlation	Ljung Box Q	Q(12)	4.66	0.97
	Breusch-Godfrey	$N*R^2(2)$	0.07	0.93
	Breusch-Godfrey	$N*R^2(1)$	0.00	0.97
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.06	0.81
	ARCH LM	$N*R^2(2)$	0.16	0.85
	White	$N*R^2(1)$	1.85	0.13
Misspecification	Ramsey RESET	LR(1)	0.00	0.97
Parameter Stability	Recursive Estimates			

Notes: ***: 1% significant level; **: 5% significant level

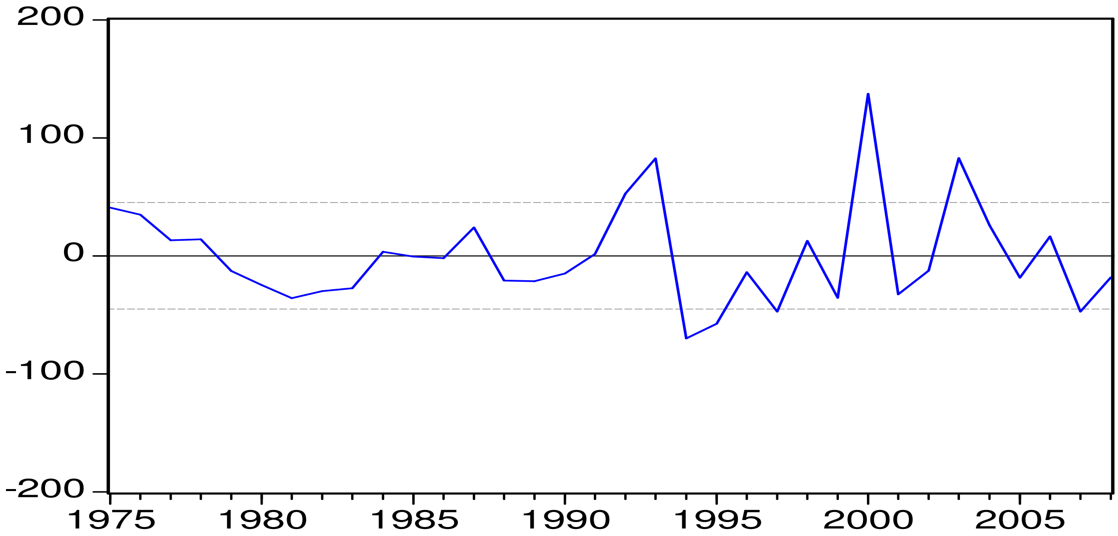


Figure 5:15: Residuals of real own construction equation 5.19C

5.5 Real Gross Capital Formation in Fixed Improvement

The results of ADL (1) and various nested models for the gross capital formation of fixed improvement are given in Table 5.22. The result shows that a partial adjustment model with lagged interest rate fits the data very well. All the variables included in the model are statistically significant and they explain 90% of variation in the capital formation during the estimated period. As expected, the rise in real interest rate and the price of fixed improvement deter the gross capital formation of fixed improvement. The real gross income, however, is found insignificant but holds the expected sign. The Chow break point test, which shows a structural break in 1993, is also significant in the equation. The short and long run elasticities of the real interest rate are -0.04 and -0.31 respectively. Thus, a rise of real interest rate by 10% would decrease the capital formation in the short run by 0.4 and in the long run by 3.1%. The own price elasticity in the short and long run is -0.31 and -1.46 respectively. Thus, gross capital formation of fixed improvement is highly responsive to its own price in the long run.

Table 5.22: ADL (1) Model for the real gross capital formation: fixed improvement

VARIABLE	5.20A	5.20B	5.20C
CONSTANT	186.98 (0.51)	623.32 (2.00)	946.44 (3.49)
RGCFFIX(-1)	0.911 (9.00)	0.85 (11.10)	0.77 (11.28)
RINT	8.77 (1.33)	0.58 (0.10)	
RINT(-1)	-7.48 (-1.10)	-11.15 (-2.03)	-11.24 (-2.30)
RPFIX	-10.49 (-1.55)	-14.31 (-3.07)	-6.74 (-2.40)
RPFIX(-1)	12.38 (1.77)	10.9 (1.99)	
RGINC	0.0035 (0.69)	-0.0012 (-0.34)	0.0016 (0.5)
RGINC(-1)	-0.008 (-1.22)		
SHIFT93		209.75 (3.76)	227.95 (4.32)
R^2	0.86	0.91	0.90

Note: t-statistics are given in parentheses.

$$RGCFFIX = \underset{(3.5)}{946.44} + \underset{(11.28)}{0.77}\, RGCFIX\,(-1) - \underset{(-2.3)}{11.24}\, RINT\,(-1) - \underset{(-2.4)}{6.74}\, PFIX +$$

$$\underset{(0.5)}{0.0016\, RGINC} + \underset{(4.32)}{227.95\, SH93} \qquad (5.20C)$$

$R^2 = 0.91$ $\qquad$ $T = (1980 - 2008)$

The diagnostic test on the residual of equation 5.20C shows a non-violation of all the classical OLS assumptions, except normality. As noted in Gujarati (1993), the OLS estimators are BLUE, regardless of the assumption of normality.

Table 5.23: Misspecification tests for real gross capital formation: fixed improvement equation 5.20C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	23.48	0.00***
Serial Correlation	Ljung Box Q	Q(12)	12.17	0.43
	Breusch-Godfrey	$N*R^2(2)$	5.32	0.07
	Breusch-Godfrey	$N*R^2(1)$	0.19	0.66
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.015	0.90
	ARCH LM	$N*R^2(2)$	0.13	0.93
	White	$N*R^2(1)$	13.11	0.07
Misspecification	Ramsey RESET	LR(1)	3.82	0.05**
	Ramsey RESET	LR(2)	10.57	0.00***
Parameter Stability	Recursive Estimates			

Notes: ***: 1% significant level, **: 5% significant level.

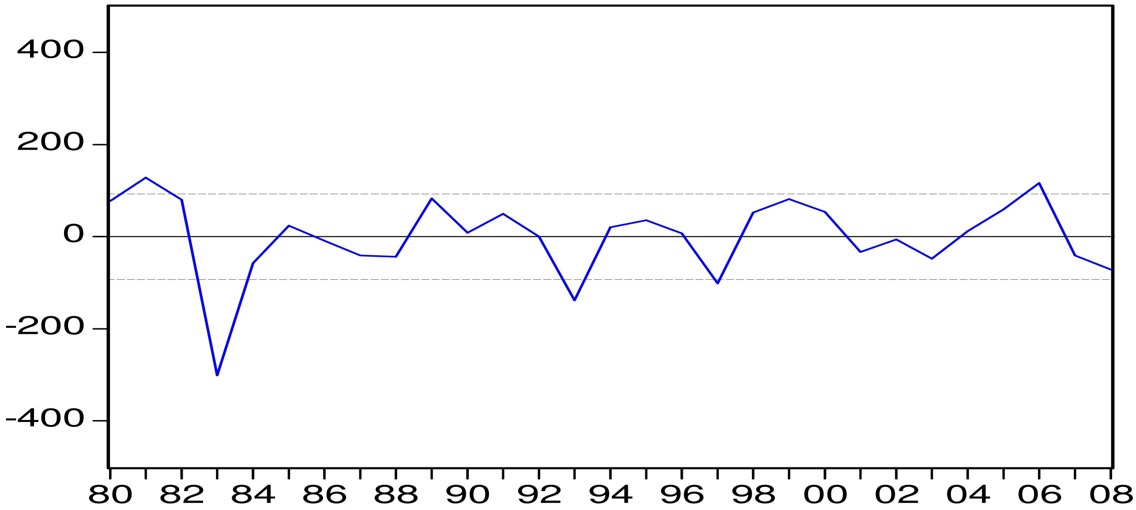


Figure 5.16: Residuals of real gross capital information: fixed improvement

5.6 Real Gross Capital Formation in Machinery Tractors and Implements

The results of the ADL (1) and nested models of real gross capital formation for machinery, tractors and implements (RGCFMTI) estimation are given in Table 5.24. Of all estimated models, the partial adjustment model fits the data very well. The gross income of the sector, however, is found significant in the equation, unlike in the capital formation of fixed improvement equation. As expected, the increase in real price of machinery, tractors and implements (RPMTI) reduces the RGCFMTI and the rise in gross income augments RGCFMTI. The rise in interest rate also deters the gross capital formation, though it is statistically insignificant in the equation. The short and long run own price elasticities are -0.55 and -1.10 respectively. Similarly, the short and long run income elasticities of RGCFMTI are 0.62 and 1.24 respectively. Thus, RGCFMTI is elastic in the long run for both own price and income elasticities. For interest rate elasticity of the gross capital formation in the short and long run is -0.03 and -0.06 respectively. Thus, the result of the model shows that the profitability of the agricultural sector and the price of the equipments play a key role in determining investment in machineries, tractors and implements than the cost of financing the purchase.

Table 5.24: ADL (1) Model for the real gross capital formation: MTI

VARIABLE	5.21A	5.21B	5.21C	5.21D
CONSTANT	1,643.62 (1.08)	1,408.00 (1.61)	1,466.00(1.58)	1,466.62 (1.61)
RGCFMTI(-1)	0.72 (4.12)	0.63 (6.24)	0.49 (6.23)	0.49 (6.42)
RINT	-14.1 (-0.31)	7.04 (0.26)		
RINT(-1)	-55.25 (-1.24)	-31.77 (-1.22)	-19.86 (-0.92)	-19.87 (-0.94)
RPMTI	-35.26 (-1.15)	-19.49 (1.09)	-21.46 (-1.12)	-21.51 (-2.37)
RPMTI(-1)	27.56 (0.89)	-31.77 (-1.22)	-0.05 (-0.003)	
RGINC	0.10 (3.56)	0.07 (4.37)	0.04 (3.41)	0.04 (3.56)
RGINC(-1)	-0.09 (-2.01)	-0.06 (-2.36)		
D8081		2,666.00 (7.00)	2,779.00 (6.84)	2,779.00 (6.99)
R^2	0.81	0.92	0.93	0.93

Note: t-statistics are given in parentheses.

$$RGCFT = 1466.62 + \underset{(6.42)}{0.497\, RGCFT(-1)} - \underset{(-0.94)}{19.87\, RINT(-1)} - \underset{(-2.37)}{21.51\, RPMTI} +$$

$$\underset{(3.56)}{0.044RGINC} + \underset{(6.99)}{2779D8081} \qquad (5.21D)$$

$$Adj.\ R^2 = 0.93 \qquad T = (1976\ \text{-}2008)$$

The diagnostic test on the classical assumptions of OLS on the residual of equation 5.21D shows that they are not violated.

Table 5.25 Misspecification tests for real gross capital formation: machinery, tractors and implements equation 5.21D

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.63	0.72
Serial Correlation	Ljung Box Q	Q(12)	8.47	0.75
	Breusch-Godfrey	$N*R^2(2)$	0.99	0.38
	Breusch-Godfrey	$N*R^2(1)$	0.12	0.73
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.38	0.54
	ARCH LM	$N*R^2(2)$	0.16	0.85
	White	$N*R^2(1)$	1.07	0.42
Misspecification	Ramsey RESET	LR(1)	0.03	0.85
	Ramsey RESET	LR(2)	0.31	0.74
Parameter Stability	Recursive Estimates			

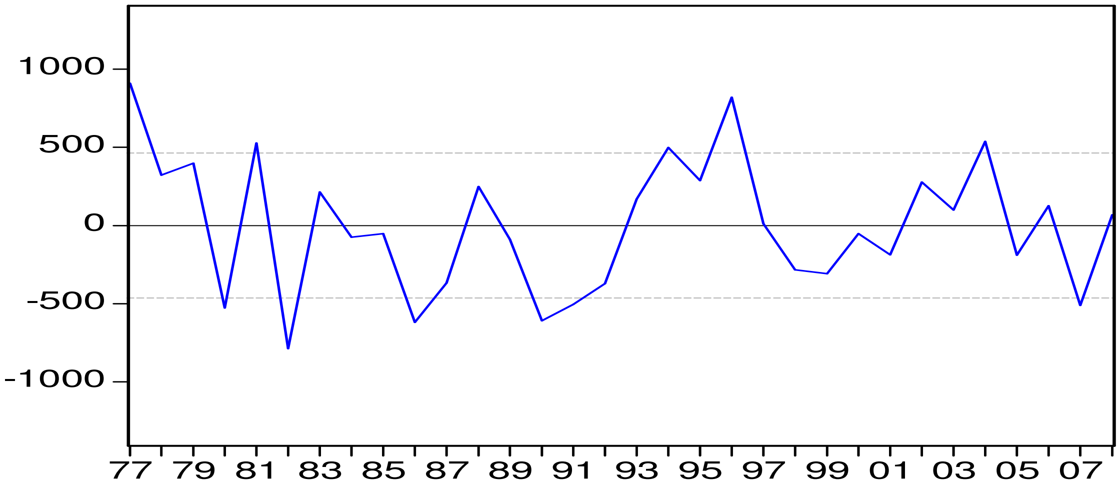


Figure 5.17: Residuals of real gross capital formation: machinery, tractors and implements equation 5.21D

5.7 Real Rent Paid

The results of the ADL (1) and nested models equation for real rent paid are given in Table 5.26. For the estimated models, the partial adjustment model fits the data very well. The short run area elasticity of rent paid is 0.3. Thus, a 10% increase in planted area would result in a 3% increase in real rent paid. In the long run, however, the elasticity remains unitary. Similarly, the elasticity of rent paid to field crop prices is 0.4. Hence, a 10 % increase in field crop prices will trigger a 4% rise in rent paid.

Table 5.26: ADL (1) Model for the real rent paid

VARIABLE	5.22A	5.22B	5.22C
CONSTANT	-204.03 (-2.35)	-.208.77 (-0.64)	- 10.54 (-0.25)
RRENTP(-1)	0.83 (5.31)	0.76 (4.56)	0.68 (6.24)
AREA	0.04 (1.30)	0.02 (0.64)	0.02 (1.83)
AREA(-1)	0.01 (0.56)	0.02 (0.72)	
PFC/CPI	1.78 (2.53)	0.72 (1.25)	0.89 (2.37)
PFC(-1)/CPI(-1)	-2.11 (-2.28)		
R^2	0.93	0.92	0.93

Note: t-statistics are given in parentheses.

$$RRENTP = -10.54 + 0.68\ RRENTP\ (-1) + 0.02\ AREA - 0.89RPFC \quad (5.22C)$$
$$(-0.25) \quad (6.24) \quad (1.83) \quad (2.37)$$

$R^2 = 0.93$ $T = (1979 - 2007)$

The classical assumptions of OLS, except homoscedasticity, are not violated. Hence, White heteroscedasticity-consistent variances and standard errors are used to address the problem. The re-estimated model shows that all the variables still remain significant in the equation.

Table 5.27: Misspecification tests for real rent paid equation 5.22C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	1.02	0.53
Serial Correlation	Ljung Box Q	Q(12)	9.92	0.62
	Breusch-Godfrey	$N*R^2(2)$	0.14	0.93
	Breusch-Godfrey	$N*R^2(1)$	0.03	0.85
Homoscedasticity	ARCH LM	$N*R^2(1)$	3.26	0.07
	ARCH LM	$N*R^2(2)$	6.95	0.03**
	White	$N*R^2(1)$	10.45	0.06
Misspecification	Ramsey RESET	LR(1)	0.77	0.38
	Ramsey RESET	LR(2)	1.75	0.49
Parameter Stability	Recursive Estimates			

Notes: ***: 1% significant level, **: 5% significant level.

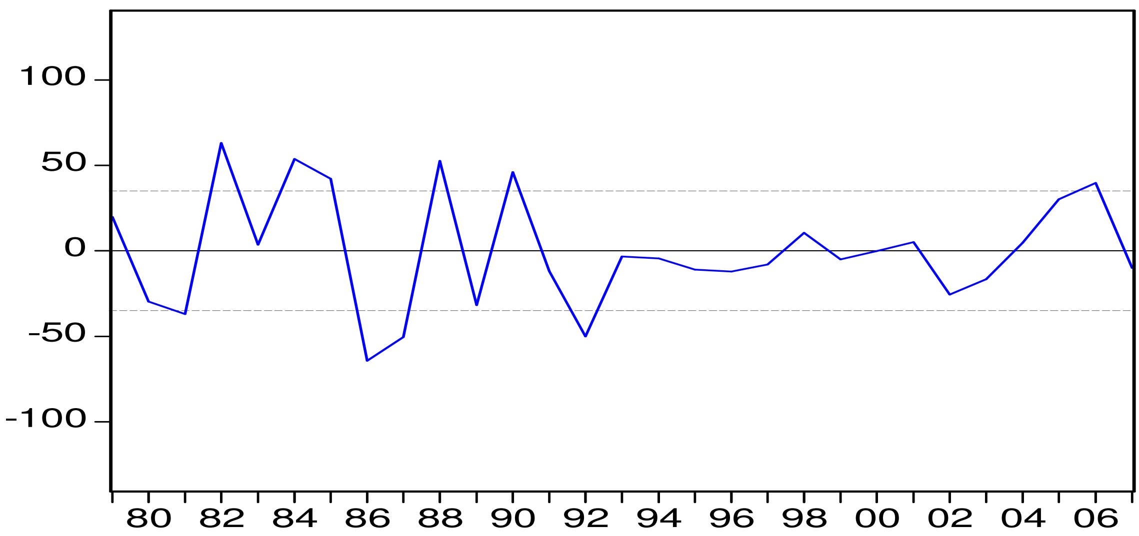


Figure 5.18: Residuals for real rent paid equation 5.22C

5.8 Real Interest Paid

The main lender institutions for the agricultural producers are commercial banks, agricultural cooperatives, Land Bank, Department of Agriculture, Forestry and Fisheries and other financial institutions. In 2009, the loan from commercial banks to the agricultural sector accounts for 69% of the debt followed by cooperatives (14%) and private persons (6%). By giving a weight to each of the interest rate charged by these lender institutions, the DAFF estimates the average cost of borrowing by the agricultural sector.

Interest paid by the agricultural sector is estimated by multiplying the nominal average cost of borrowing and total debt level. The projection of the prime rate by Reserve Bank is used to project the average cost of borrowing by the agricultural sector. The nominal value is then deflated by the projected CPI to produce the real interest paid by the agricultural sector.

5.9 Real Total Debt

The results of the estimated ADL (1) and nested models of real total debt are given in Table 5.28. The data is fitted very well by the partial adjustment model. Most of the variables included in the model are statistically significant and display the expected signs. The rise in the asset value and real interest rate increases the debt value. The short-run elasticity for interest rate and asset is respectively 0.06 and 0.15. Thus, a 10% increase in asset value and interest rate would respectively increase the debt value by 1.5 and 0.6% respectively. In the long run, the asset elasticity is almost unitary and the interest rate elasticity is 0.40. Thus, accumulation of new assets by agricultural producers through gross capital formation plays a greater role in increasing the debt level than the interest rate. The estimated result also shows that a downturn in economic growth puts pressure on the debt level of the sector, even though it is statistically insignificant.

Table 5.28: ADL (1) Model for the real total debt

VARIABLE	5.23A	5.23B	5.23C
CONSTANT	-3,089.69 (-0.45)	-3,807.17 (-0.59)	-1, 776.67 (-0.50)
RDEBT(-1)	0.82 (5.2)	0.84 (5.97)	0.84 (13.02)
RASSET	0.11 (0.29)	0.17 (2.05)	0.13 (3.27)
RASSET(-1)	0.05 (0.13)		
RINT	196.60.55 (0.93)	292.12 (2.00)	214.35 (2.59)
RINT(-1)	130.38 (0.78)		
GROWTH	-9776.87 (-0.29)	-6639.13 (-0.24)	-998.32 (-0.06)
GROWTH(-1)	-11217.60(-0.40)	-13388.17 (-0.51)	
D02			-4,221.81 (-5.42)
R^2	0.81	0.83	0.93
	T = (1990-2008)		

Note: t-statistics are given in parentheses.

$$RTDEBT = -1\,776.67 + \underset{(13.07)}{0.83}\, RTDEBT(-1) + \underset{(3.86)}{0.16}\, RASSET + \underset{(2.17)}{237.75}\, RINT -$$
$$\quad (-0.58)$$

$$\underset{(-0.06)}{998.32 GROWTH} - \underset{(-5.42)}{4241.10 D02} \qquad (5.23C)$$

$$Adj.R^2 = 0.94 \qquad T = (1990 - 2008)$$

The diagnostic tests on the residual of the equation shows that the classical assumptions of OLS are not violated.

Table 5.29: Misspecification tests for real total debt for equation 5.23C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.53	0.74
Serial Correlation	Ljung Box Q	Q(6)	7.87	0.25
	Breusch-Godfrey	$N*R^2(2)$	3.49	0.15
	Breusch-Godfrey	$N*R^2(1)$	3.44	0.06
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.68	0.44
	ARCH LM	$N*R^2(2)$	1.71	0.42
	White	$N*R^2(1)$	9.40	0.28
Misspecification	Ramsey RESET	LR(1)	0.12	0.72
	Ramsey RESET	LR(2)	1.04	0.59
Parameter Stability	Recursive Estimates			

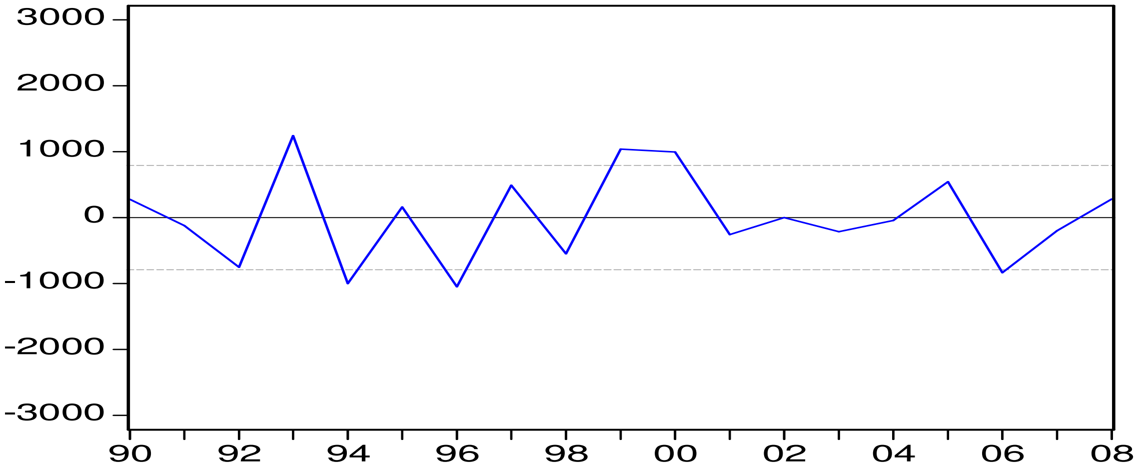


Figure 5.19: Residuals of real total debt equation 2.23C

5.10 Farm Employment

The results of ADL (1) and the nested models of the farm employment equation are given in Table 5.30. The static model with time trend fitted the data very well. The wage and trend variables included are statistically significant and show the expected signs. As expected, the rise in real wage deters farm employment. Similarly, as the economy of the country progresses, fewer people are engaged in farming activities. An increase in the profitability of the agricultural sector, however, generates employment, though it is statistically insignificant. The estimated wage elasticity of employment is 0.58. Thus, a 10% increase in real wage induces a 5.8% decline in farm jobs.

Table 5.30: ADL (1) Model for farm employment

VARIABLE	5.24A	5.24B	5.24C
CONSTANT	9136.41 (1.42)	15 102.00 (2.10)	17,073.00 (2.44)
LABOUR(-1)	0.31 (1.03)	0.04 (0.44)	
RWAGE	-0.06 (-5.85)	-0.06 (-6.52)	-0.06 (-7.85)
RWAGE(-1)	0.02 (0.88)		
RGINC	0.001 (1.01)	0.002 (1.44)	0.002 (1.47)
RGINC(-1)	-0.001 (-0.72)		
TIME	-4.07 (-1.30)	-6.89 (-1.89)	-7.86 (-2.20)
Adj. R^2	0.96	0.96	0.97

Note: t-statistics are given in parentheses.

$$FEMPT = 17\,073.00 - 0.06\ RWAGE - 7.86\ TIME + 0.002\ RGINC \qquad (5.24C)$$
$$(2.44) \quad (-7.85) \qquad (-2.2) \qquad (1.47)$$

$$Adj.\ R^2 = 0.96 \qquad T = (1988 - 2007)$$

The diagnostic test on the residual of equation 5.24C shows that the classical assumptions of OLS are not violated.

Table 5.31: Misspecification tests for farm employment equation 5.24C employment model

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.77	0.69
Serial Correlation	Ljung Box Q	Q(6)	3.76	0.77
	Breusch-Godfrey	N^*R^2 (2)	1.15	0.56
	Breusch-Godfrey	N^*R^2 (1)	0.72	0.39
Homoscedasticity	ARCH LM	N^*R^2 (1)	3.15	0.07
	ARCH LM	N^*R^2 (2)	3.83	0.70
	White	N^*R^2 (1)	8.43	0.07
Misspecification	Ramsey RESET	LR(1)	0.76	0.38
	Ramsey RESET	LR(2)	0.79	0.67
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level.

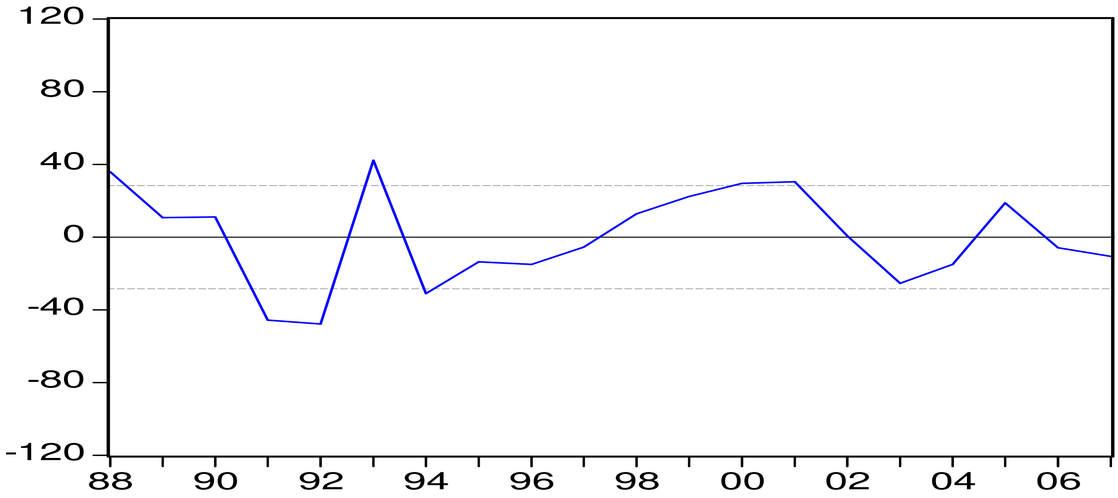


Figure 5.20: Residuals for farm employment equation

5.11 Summary

This chapter presented the estimation results of individual models specified in the previous chapter. Diagnostic tests were conducted on all the residuals of the estimated model to examine a violation of the underlying assumptions. These include correlograms of residuals, a normality test, a serial correlation Lagrange Multiplier (LM) test, an autoregressive conditional heteroskedasticity (ARCH) LM test, and White's heteroskedasticity test. Most of the violations are corrected using the appropriate techniques.

White's heteroskedasticity consistent coefficient covariance is used to address the violation of homoscedasticity assumption. Moreover, the presence of serial correlation in the model is addressed using the Chochrane-Orcutt iterative procedure. In general, most of the diagnostic tests on the estimated models display no violation of the basic assumption, and the goodness of fit measured using adjusted R^2 for most models lies above 85%, indicating a satisfactory result. In addition, the diagnostic tests for most of the equations reveal the absence of econometric problems associated with the presence of few non-stationarity variables in the models. The next chapter will be devoted to a comprehensive assessment and validation of the model.

CHAPTER SIX

MODEL EVALUATION

6.1 Introduction

Economic models should undergo various tests to evaluate to what extent they replicate real-world phenomena before employing them for forecasting and policy analysis purposes. Various techniques, which comprise graphical as well as statistical methods, are often used to evaluate the adequacy of the model in replicating the actual values.

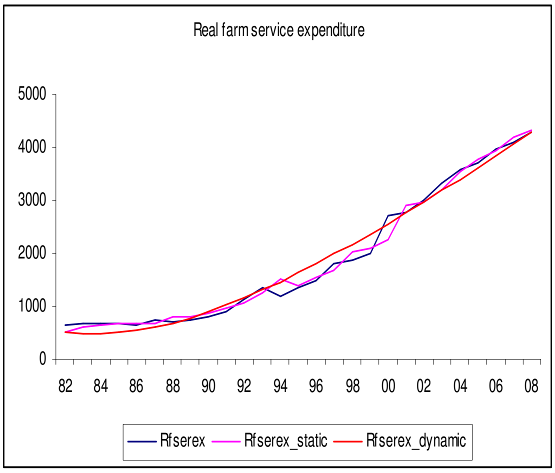
Once the model is validated and found adequate in tracking the actual values, it can be used to analyse several '*what if?*' policy questions or simulations for the agricultural sector. As mentioned in previous chapters, the incorporation of the input model into the multi-market output model enables the integrated model to evaluate the net effect of policies on gross value added and net farming income by assessing their impact on both agricultural gross income and input expenditures. Furthermore, the incorporation of other aggregate variables, like gross capital formation, asset values and total debt of the sector, would enable the model to generate several financial and economic indicators that would not have been possible with the mere integration of input expenditures into the output model.

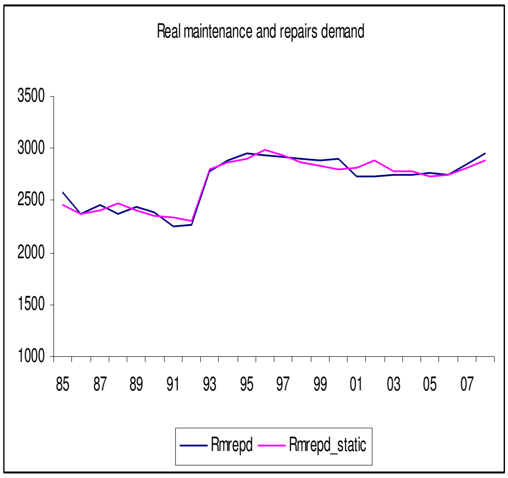
The next two sections of this chapter present an assessment of the model's performance in tracking past trends using a graphical view and various statistical techniques.

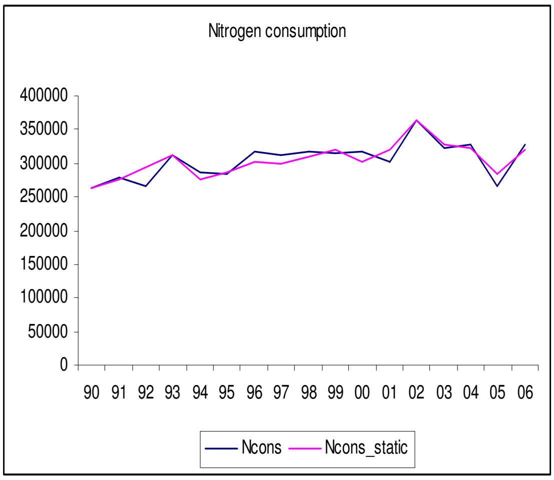
6.2 Graphical Evaluation of the Model

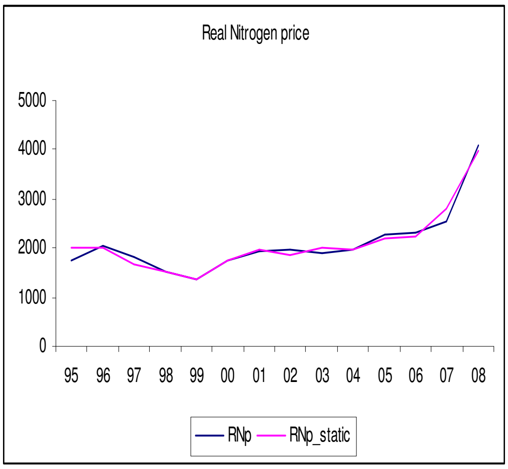
One of the straightforward assessments of the forecast ability of the model is made by looking at graphs of the actual and estimated values of the model. There are two approaches to evaluating the model graphically. These are static and dynamic forecasting. Static forecasting is a one-step ahead forecast, which uses the actual values of both endogenous and exogenous variables. Dynamic forecasting, however, is a multi-step forecast, since it takes the estimated values of the lagged dependent variables to forecast the current value. Thus, any error term occurring in one period will be carried throughout the whole period. Dynamic forecasting can only be formed if the model incorporates lagged dependent variables. The actual, static and dynamic versions of the models for the estimated endogenous variables are presented in Figure 6.1.

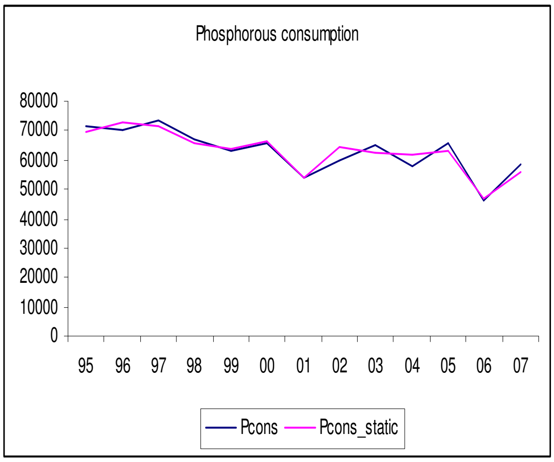
Figure 6.1: The actual and fitted (static and dynamic) graphs of all endogenous variables in the model.

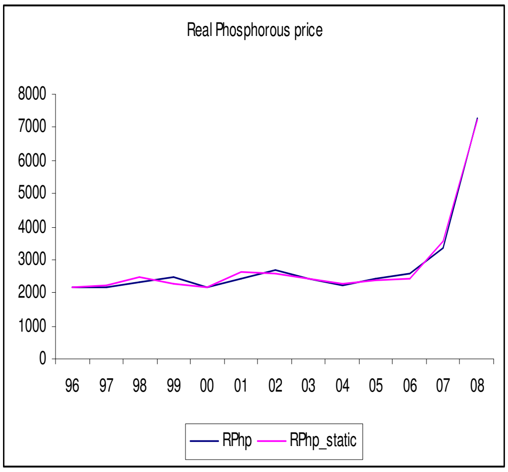

Real farm service expenditure
5000
4000
3000
2000
1000
0
82 84 86 88 90 92 94 96 98 00 02 04 06 08
Rfserex
Rfserex_static
Rfserex_dynamic

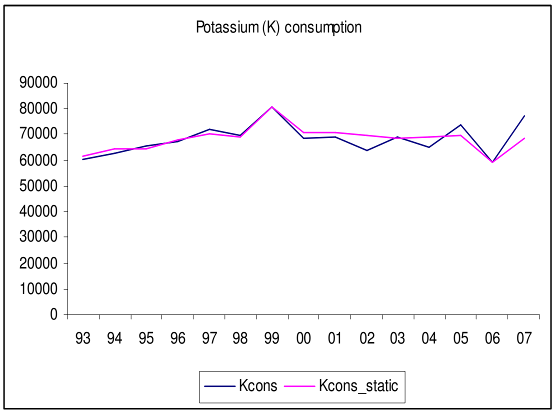

Real maintenance and repairs demand
3500
3000
2500
2000
1500
1000
85 87 89 91 93 95 97 99 01 03 05 07
Rmrepd
Rmrepd_static

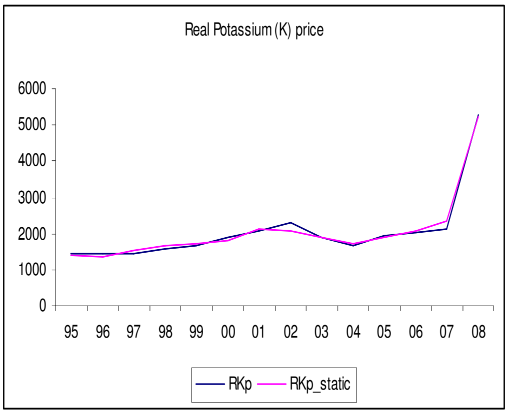

Nitrogen consumption
400000
350000
300000
250000
200000
150000
100000
50000
0
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06
Ncons
Ncons_static

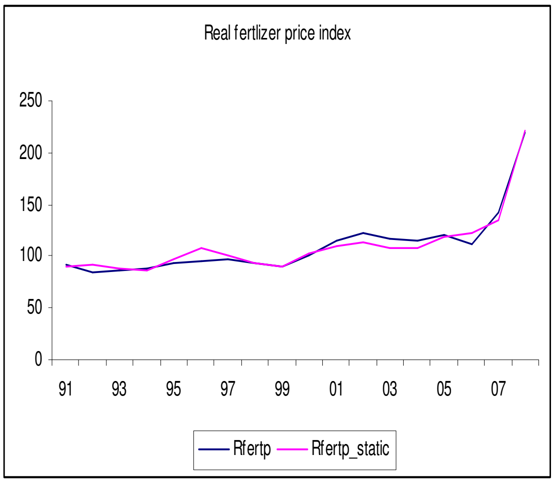

Real Nitrogen price
5000
4000
3000
2000
1000
0
95 96 97 98 99 00 01 02 03 04 05 06 07 08
RNp
RNp_static

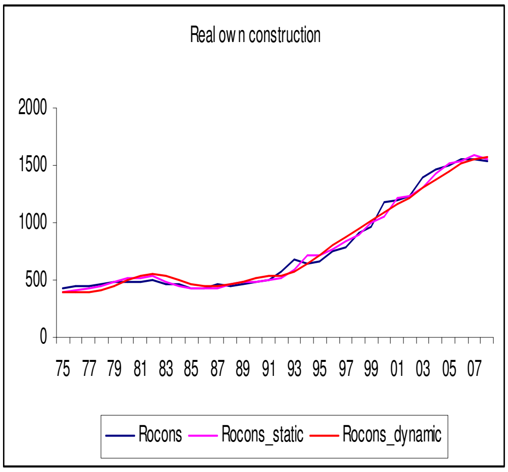

Phosphorous consumption
80000
70000
60000
50000
40000
30000
20000
10000
0
95 96 97 98 99 00 01 02 03 04 05 06 07
Pcons
Pcons_static

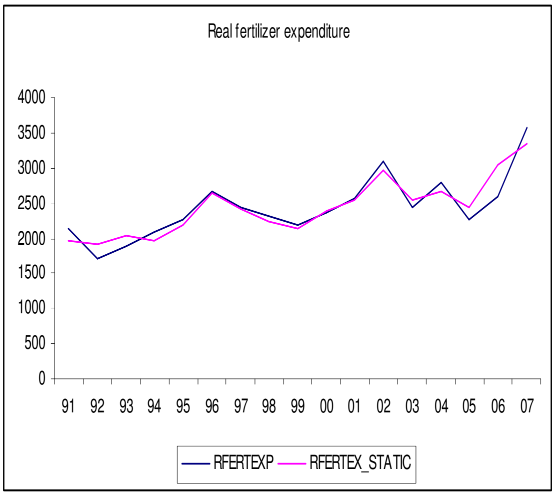

Real Phosphorous price
8000
7000
6000
5000
4000
3000
2000
1000
0
96 97 98 99 00 01 02 03 04 05 06 07 08
RPhp
RPhp_static

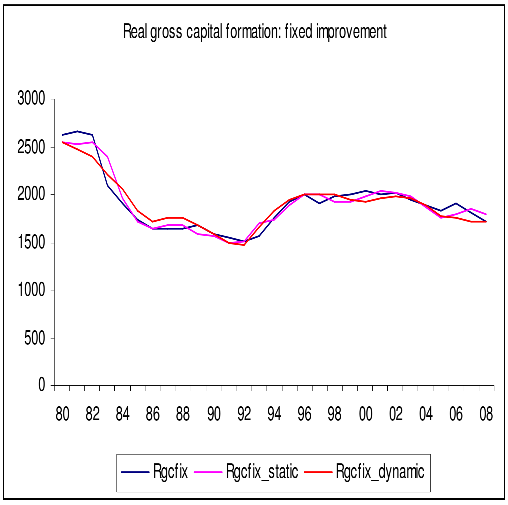

Potassium (K) consumption
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
Kcons
Kcons_static

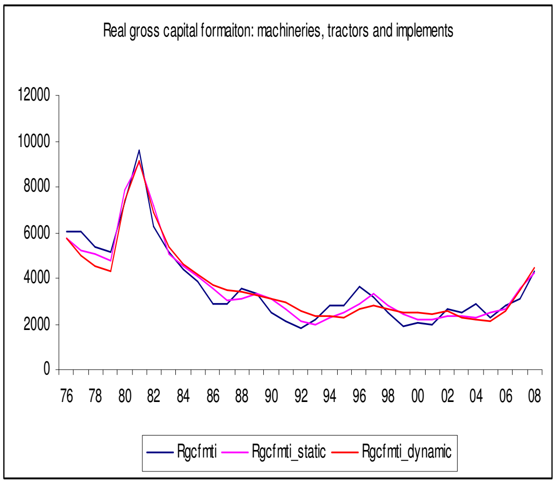

Real Potassium (K) price
6000
5000
4000
3000
2000
1000
0
95 96 97 98 99 00 01 02 03 04 05 06 07 08
RKp
RKp_static


Real fertlizer price index
250
200
150
100
50
0
91 93 95 97 99 01 03 05 07
Rfertp
Rfertp_static

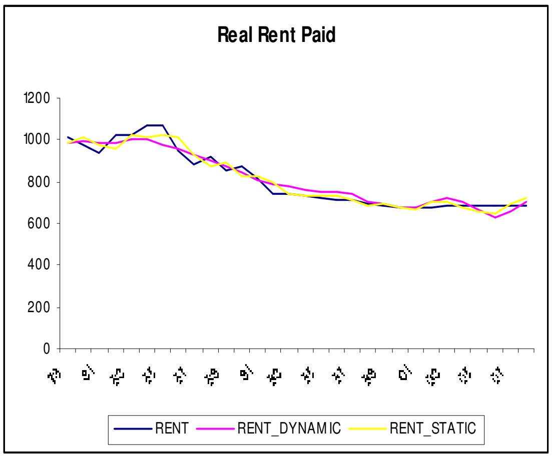

Real own construction
2000
1500
1000
500
0
75 77 79 81 83 85 87 89 91 93 95 97 99 01 03 05 07
Rocons
Rocons_static
Rocons_dynamic

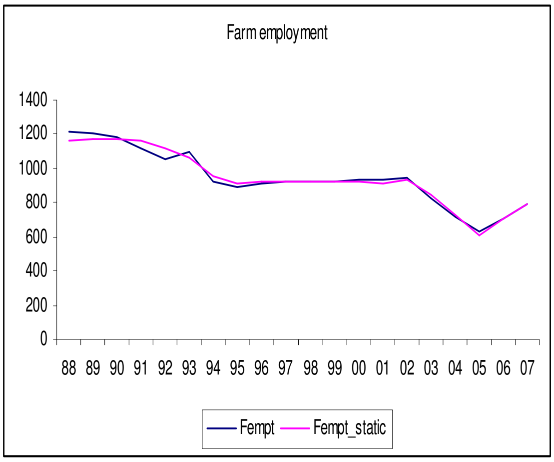

Real fertilizer expenditure
4000
3500
3000
2500
2000
1500
1000
500
0
91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
RFERTEXP
RFERTEX_STATIC


Real gross capital formation: fixed improvement
3000
2500
2000
1500
1000
500
0
80 82 84 86 88 90 92 94 96 98 00 02 04 06 08
Rgcfix
Rgcfix_static
Rgcfix_dynamic


Real gross capital formaiton: machineries, tractors and implements
12000
10000
8000
6000
4000
2000
0
76 78 80 82 84 86 88 90 92 94 96 98 00 02 04 06 08
Rgcfmti
Rgcfmti_static
Rgcfmti_dynamic


Real debt
40000
35000
30000
25000
20000
15000
10000
5000
0
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
Rdebt
Rdebt_static
Rdebt_dynamic


Real Rent Paid
1200
1000
800
600
400
200
0
RENT
RENT_DYNAMIC
RENT_STATIC


Farm employment
1400
1200
1000
800
600
400
200
0
88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
Fempt
Fempt_static

The view of all actual and fitted graphs shows a generally good performance of the model in tracking past trends and turning points for most endogenous variables.

6.3 Statistical Evaluation of the Model

Statistical methods that examine the forecasting ability of the model largely assess the forecast error value, computed as the deviation of the forecast value from the actual value. Thus, if the model produces a low error value, its forecasting ability is regarded as relatively good and hence it can be used for forecasting and policy analyses.

Based on the forecast error term, the following four statistical techniques are often applied to evaluate the forecasting ability of the model (Pindyck and Rubinfeld, 1998).

$$MAE = \frac{1}{T}\sum_{t=1}^{T}\left|\hat{Y}_t - Y_t\right| \qquad (6.1)$$

Mean Average Error (MAE) given in equation 6.1 is simply computed as the average value of the absolute value of the error terms occurring in each period. The Mean Average Percentage Error (MAPE), on the other hand, measures the error in terms of the percentage of the actual value. The formula to compute MAPE is given in equation 6.2.

$$MAPE = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{\hat{Y}_t - Y_t}{Y_t}\right| \qquad (6.2)$$

The other statistical technique measures the square root of the square of the error terms to evaluate the forecasting ability of the model. In this method, unlike the mean average error (MAE), large errors weigh more, thus it penalises large deviations. The square root of the mean square error (RMSE) is computed using the following formula.

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{Y}_t - Y_t\right)^2} \qquad (6.3)$$

Like the MAPE, Theil has also developed a scale invariant forecast error measurement called the Theil Inequality Coefficient (U). The formula used to compute U is given in equation 6.4. The numerator of the formula is simply the root mean square of errors. The denominator, however, causes the value of U to fall between 0 and 1. A coefficient close to zero shows that the forecasting ability of the model is relatively good and a value close to one implies the model is inadequate to be used for forecasting purpose.

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{Y}_t - Y_t\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{Y}t\right)^2}\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t)^2}} \qquad (6.4)$$

The value of the RAMSE, MAE, MAPE and U for the 25 endogenous equations is given in Table 6.1.

Table 6.1: Dynamic and static simulation accuracy of stochastic variables

Variable name	Acronym	Root Mean Square Error (RMSE)	Mean Absolute Error (MAE)	Mean Absolute Percentage Error (MAPE)	Theil Inequality Coefficient (U)
Real fuel demand	RFUELD	132.70	101.60	2.9332	0.0189
Real fuel price index	RFUELP	7.52	5.86	6.71	0.0421
Real feed demand	RFEEDD	263.62	223.95	4.95	0.0240
Real feed price index	RFEEDP	3.77	3.23	2.97	0.0174
Real maintenance and repairs demand	RMREPD	64.14	52.6	1.98	0.0119
Real farm services expenditure	RFSEREX	172.23	141.44	11.31	0.0381
Nitrogen consumption by field crops	NCONS	1,1806	8,965.93	3.04	0.019
Phosphorous consumption by field crops	PCONS	2,395.19	2,072.99	3.303	0.018
Potassium consumption by field crops	KCONS	3,348.92	2,330.57	3.369	0.0244
Real Nitrogen price	RNP	128.14	94.99	4.52	0.0294
Real Phosphorous price	RPHP	120.78	97.10	3.697	0.0193
Real Potassium price	RPP	94.96	72.04	3.88	0.021
Real fertiliser price index	RFP	6.08	4.75	4.41	0.02
Real total fertiliser expenditure	RFERTEX	164.58	127.42	5.37	0.033
Real own construction	ROCONS	51.30	44.28	6.66	0.029
Real gross capital formation: fixed improvement	RGCFIX	94.83	75.46	3.88	0.0247
Real gross capital formation: machinery,	RGCFMTI	522.55	441.97	14.19	0.064

Variable name	Acronym	Root Mean Square Error (RMSE)	Mean Absolute Error (MAE)	Mean Absolute Percentage Error (MAPE)	Theil Inequality Coefficient (U)
tractors and implements					
Real rent paid	RRENT	46.19	37.81	5.17	0.029
Real total debt	RDEBT	612.20	511.49	1.819	0.0105
Farm employment	FEMPT	27.56	21.30	2.15	0.014

As shown in Table 6.1, most of the forecast error measurements using Theil's Inequality Coefficient produce a U value approaching zero. Moreover, the Mean Absolute Percentage Error is below ten percent for most of the variables. Thus, from the statistical tests it can be concluded that the model performs reasonably well and therefore can be used for policy analysis and forecasting.

6.4 Summary

This chapter presented model validations conducted using graphical and statistical techniques. The graphic approach uses a static and dynamic forecasting to evaluate the forecast ability of the model. Generally, the view shows that it tracked past trends and turning points for most of endogenous variables well. The statistical method also applied Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Theil Inequality Coefficient (U) to assess the model's performance. The results of these forecast error measurements indicate that the model has generally replicated the actual values well. Hence, it can be used for policy analysis and forecasting purposes.