The Impact of Exchange Rate Changes on Disaggregated Agricultural Output in Nigeria: A Two-Stage-Least-Squares Approach

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Abstract

Agriculture was the mainstay of the Nigerian economy prior to independence and immediately after. Agriculture however, has suffered persistent decline since the 1970s with the exchange rate policy being implicated in the misfortune of this sector. Earlier studies on the effect of exchange rate on agricultural output focussed on aggregate output and ignored the possibility of differences in the response of components of agricultural output. Besides, the fact that there may be a possibility of reverse causality between the exchange rate and agricultural output has been ignored in earlier studies. This study attempts to fill these gaps, by investigating the effect of the exchange rate changes on the components of agricultural output using the two-stage-least-squares techniques for the period between 1970 and 2008. The obtained result indicates that there are differences in the way the output of different sub-sectors responds to the exchange rate changes. While the exchange rate changes have negative effects on crop and fishery output, they have positive effects on livestock and forestry. The fact that the real exchange rate has differential effect on the output of the agricultural sub-sectors indicates the need for policy to be put in place to mitigate the adverse consequences of the exchange rate depreciation on crop and fishery output.

Keywords: Exchange rate, Disaggregated, agricultural output and Two-stage-least-squares

JEL Classification: Q17, O13, F31

1. Introduction

Agriculture was the mainstay of the Nigerian economy before and immediately after independence. It employed more than 70% of the labour force and provided more than 80% of foreign exchange earnings during this time. The agricultural output however suffered from serious setback in the early 1970s, especially with the discovery and production of oil in commercial quantity. The exchange rate policy was implicated in the dismal performance

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of agriculture during this period, as it was argued that the Nigerian currency was overvalued and this discouraged the export and production of agricultural products, while it encouraged the import of food items. Based on this perception, the exchange devalued on a number of occasions in order to attain a realistic exchange rate until the foreign exchange market was eventually liberalised and the exchange rate was made to reflect market forces (with the adoption of the structural adjustment programme in 1986 and the eventual deregulation of the foreign exchange market).

Despite the deregulation of the foreign exchange market and the subsequent depreciation / devaluation of the Nigerian currency, the agricultural sector performance did not improve substantially. The contribution of agriculture to the gross domestic product (GDP) continued to dwindle. Its contribution, which was about 40 % in 1986, went down to about 20% in 1990 (CBN, 2007). Although it increased afterwards, its share never exceeded 40% thereafter, with different sub-sector's contribution changing regularly and food importation rising. It therefore becomes imperative to ask the following questions: to what extent has the adoption of liberal exchange rate policy affected agricultural output? And: does this liberal exchange rate policy have similar or dissimilar impacts on the components of agricultural output? An understanding of this issue would help policymakers identify the role of exchange rate policy in the poor performance of agriculture and facilitate the formulation of appropriate sectoral policy. Based on the above, the main objective of this study is to investigate the impacts of the exchange rate changes on agricultural output, while the specific objectives is to investigate the impacts of the exchange rate changes on the output of different agricultural sub-sectors of the Nigerian economy.

Although several studies have been conducted on the effect of the exchange rate on agricultural output, the majority of these studies focussed on aggregate output and ignored the possibility of differences in the response of the components of agricultural output, which may necessitate differential policy response. Those that examined the effect on sectoral output (for example Yaqub, 2010) did not examine the components of each sector. Moreover, many of these studies did not consider the fact that both the exchange rate and the agricultural output may actually be jointly determined or that there may actually be reverse causality from the exchange rate to agricultural output. For example, the exchange rate depreciation may discourage importation and prompt exportation and production, while in the same vein, improvement in agricultural output and export may strengthen the exchange rate of the domestic currency. This is the gap that this paper tries to fill by investigating the impacts of the real exchange rate changes on the components of the agricultural sector output, given the significance of agriculture for food security and poverty alleviation. The output of the agricultural sector is thus disaggregated into crop output, fishery, livestock and forestry output; the impact of the exchange rate changes on each are then investigated. Moreover, the study adopts the two-stage-least-squares estimation techniques to cater for possible reverse causality and joint determination of the exchange rate and agricultural output. The rest of the paper is structured in six parts. Following this introduction is the discussion of the exchange rate policy and trend in Nigeria. The third section of the paper presents the literature review, while the fourth section discusses the scope of study and

sources of data. The fifth section contains the econometric framework, while the sixth section presents the empirical analysis. The seventh section, which is the last one, is devoted to summary and conclusion.

2. Exchange Rate Policy and Trend in Nigeria

Oyejide and Ogun (1995) and Ogun (2000) have classified Nigeria's exchange rate regimes since independence into four types (the brief period of confusion between 1972 and 1974 is excluded). These are the fixed rate regime of 1960 to 1970, the adjustable peg regime of 1974 to 1978, the managed float regime of 1978 to 1985, and the flexible exchange rate regime of 1986 to date. The different regimes have implications for the behaviour of the exchange rate. While the period between 1960 and 1986 was characterised by misaligned exchange rate, the market based exchange rate period is characterised by unprecedented volatile exchange rate (Oyejide and Ogun, 1995).

Table 1: Averages of Nominal and Real Effective Exchange Rate in Nigeria (1970-2007)

Variable	1970-2007	1970-1980	1981-1990	1991-2000	2001-2007	1987-1993
NER	20.09	5.79	32.07	31.87	4.33	39.02
RER	6.19	1.58	16.19	8.49	-6.65	12.13

Note: NER stands for Nominal Exchange Rate, RER stands for Real Exchange Rate.
Source: Computed by the author.

Over the period 1970 to 2007, the nominal exchange rate depreciated on the average at the rate of 20.09%, while the real exchange rate only depreciated at the rate of 6.19% (on the average). The divergence between nominal[1] and real exchange rate[2] depreciation during the period brings out the fact that inflation is higher in Nigeria relative to the foreign trading partners. The average figures hid some important phases in the exchange rate trends. Although both nominal and real exchange rates actually depreciated on the average between 1970 and 1980, the nominal exchange rates depreciated at a higher rate compared with the real exchange rate. Similarly, both nominal and real exchange rates depreciated on the average by 32.07% and 16.19% respectively between 1981 and 1990 (see Table 1). A similar scenario was repeated between 1991 and 2000. However, between 2001 and 2007, the nominal exchange rate depreciated at a lower rate (4.33%), while the real exchange rate actually depreciated by 6.65% on the average, reflecting the relative stability of the nominal exchange rate.

[1] Nominal exchange rate is defined as the unit of Naira that is exchanged for a unit of the dollar

[2] The real exchange rate is obtained by weighing the nominal exchange rate US Consumer Price Index (CPI) relative to CPI in Nigeria.

3. Literature Review

The position of the theoretical literature on the effect of the exchange rate on output is divergent. While the traditional view opines that the exchange rate depreciation would expand output by making export cheaper and increasing the price of import, provided the Marshal-Lerner conditions hold[3], the Monetarists conclude that the exchange rate changes leave all real variables unchanged in the long run (Domac, 1977). The Structuralists posit that the exchange rate depreciation has a contractionary effect on output through the combination of demand and supply side effects. This position is based on the fact that many countries that depreciate their currencies are usually import-dependent economies, whose cost of production would escalate with depreciation thereby reducing the availability of inputs and thus curtailing production (Kandil and Mirzaie, 2003).

The empirical evidence of the effect of the exchange rate on output is extensive and mixed. The conclusions differ not only quantitatively but also qualitatively. Differences in conclusions may be due to differences in approach, samples, time frame of study or methodology of study. Four main approaches are used to evaluate the effects of the exchange rate on output (macroeconomic performance in general) according to Agenor (1991) and Taye (1999), among others. The first one, the "before and after" approach, compares relative economic performance before and after the currency is devalued/depreciated, to capture the effects of the change on economic aggregates. The second approach known as "with-without" or "control group" approach, compares the economic performance of devaluing countries with that of non-devaluing countries. The third approach, named "actual-versus-target" approach, focuses on evaluating the actual performance of some macroeconomic aggregates compared to their pre-specified targets using econometric models. The fourth approach uses the simulation technique to examine the impact of changes in the exchange rate on economic activity. While some studies examined the effect of nominal exchange rate changes, others focussed on real exchange rate changes.

Cooper (1971) and Diaz-Alejandro (1963) focussed on nominal devaluation and found that it has contractionary effect on output. Agenor (1991) focussed on real exchange rate, using OLS technique and data from twenty-four developing economies; he found contractionary effects of real exchange rate depreciation. A similar conclusion was arrived at by Bahmani-Oskooee (1998) as well as Taye (1999), with respect to Ethiopia. Studies such as Odusola and Akinlo (2001) and Adewuyi (2005) found expansionary effect of nominal exchange rate depreciation with respect to Nigeria. Ubok-Udom (1999) found contractionary effect using data from 1971 to 1995, contrary to what Odusola and Akinlo as well as Adewuyi found. His analysis may however suffer from the problem of spurious regression since he did not account for the possibility of unit root in the series used or endogeneity problem which Adewuyi and Odusola and Akinlo controlled for. Other studies which found contractionary effects of exchange rate depreciation are those of Kamin and

[3] Marshal-Lerner condition states that the elasticities of import and export must be higher than unity.

Rogers (2000) and Berument and Pasaogullari (2003). In this study, the real exchange rate is used while the two-stage-least-squares technique is used to cater for the possibility of joint determination of the exchange rate and output and possible reverse causality.

4. Scope and Sources of Data

The study covers the period between 1970 and 2008; it makes use of annual data on Nigeria for this same period. The Data description, definition and sources are given in Table 2 below:

Table 2: Description and Sources of Data

Variables	Description	Sources
Nominal Exchange rate	This is the Bilateral exchange rate between Nigeria and the USA. It is the monthly average official exchange rate of the Naira vis-à-vis the US dollar	The Central Bank of Nigeria Statistical Bulletin, 2008
Real Exchange Rate	This is the nominal exchange rate weighted by the relative Consumer Price Index (CPI) of Nigeria to USA	Computed by the author
CPI	The CPI is used as a measure of price. It is used to weigh the nominal exchange rate in order to obtain the real exchange rate	WDI CD ROM, 2008
Crop output	This is the GDP of crop sub-sector of agriculture. It is expressed at 1990 Constant Basic Prices	The Central Bank of Nigeria Statistical Bulletin, 2008
Fishery output	This is the GDP of fishery sub-sector of agriculture. It is expressed at 1990 Constant Basic Prices	The Central Bank of Nigeria Statistical Bulletin, 2007
Livestock output	This is the GDP of livestock sub-sector of agriculture. It is expressed at 1990 Constant Basic Prices	The Central Bank of Nigeria Statistical Bulletin, 2007
Forestry output	This is the GDP of forestry sub -sector of agriculture. It is expressed at 1990 Constant Basic Prices	The Central Bank of Nigeria Statistical Bulletin, 2007
Money supply	This is money supply narrowly defined. It consists of currency outside bank and demand deposits	The Central Bank of Nigeria Statistical Bulletin, 2007

5. Econometric Framework

5.1 Theoretical Framework

The theoretical framework for this study is the modified IS-LM framework, which was also adopted by Kandil (2004) and Kandil and Mirzai (2007). In this framework, the output is assumed to be demand determined. The demand side of the economy consists of three markets, namely, the goods, money and the foreign exchange market, all of which must simultaneously be in equilibrium, for the economy to be in equilibrium. Under this condition, the economy attains both internal and external equilibrium, which is the objective of exchange rate management. Each market is explained in turn below.

The goods market

Equilibrium in the goods market is obtained when the demand and supply of goods and services are equal implying that the aggregate planned expenditure is equal to income. The equilibrium condition is given as:

$$y = c + g + i + x - m \tag{1}$$

where y = real income, c = real consumption, g = real government expenditure, i = real investment, x = real export and im = real import.

The components of the goods market is modelled as equations 2 to 6 below:

$$c = \beta_0 + \beta_1 y_t \tag{2}$$

$$g = g \tag{3}$$

$$i = i_o + i_1 r_t + i_2 y_t \tag{4}$$

$$x_t = x_0 + x_1 e_t + x2y^f + x_4 y_t \tag{5}$$

$$im_t = im_0 + im_1 y_t + im_2 e_t \tag{6}$$

where r is real interest rate, yf is income of trading partners and e is real interest rate.

Equation 2 expresses real consumption as a function of real income, while equation 3 shows real government expenditure as being autonomous. Equation 4 depicts investment as being determined by real interest rate and real income. Export is shown, in equation 5, to depend on real exchange rate, income of trading partners and domestic income/output, while equation 6 depicts import as being dependent on real income and real exchange rate.

Substituting equations 2, 3, 4, 5 and 6 into equation 1 produces the IS equation, which shows equilibrium condition in the goods market. This is expressed as equation 7 below.

$$y_t = \frac{(\beta_0 + i_0 + x_0 + im_0) + \overline{g} + i_1 r_t + (x_1 + im_2) e_t}{1 - \beta_1 - i_2 - x_4 - im_1} \tag{7}$$

The money market

The money market is modelled along the standard money demand theories. Real money demand is expressed as a function of real income and interest rate; this is shown as equation 8 below.

$$m^d = \theta_0 + \theta_1 y_t + \theta_2 r_t \tag{8}$$

Money demand may also be influenced by exchange rate because economic agents may hold foreign money for speculative purposes (Kandil, 2003). Therefore, the demand for money is expressed as equation 9 to reflect this fact.

$$m^d = \theta_0 + \theta_1 y_t + \theta_2 r_t + \theta_3 e_t \tag{9}$$

Real money supply is equal to the nominal money balances, M, which is assumed to be exogenously determined, deflated by price, P. The money supply is expressed as

$$m^s = \frac{m_t}{p_t} = \overline{m} \tag{10}$$

At equilibrium, money supply equals money demand, thus the money market equilibrium is modelled as equation 11.

$$\overline{m} = \theta_0 + \theta_1 y_t + \theta_2 r_t + \theta_3 e_t \tag{11}$$

Equation 11 can be expressed as 12, which is the LM equation.

$$y_t = \frac{\overline{m}_t - \theta_0 - \theta_2 r_t - \theta_3 e_t}{\theta_1} \tag{12}$$

External Sector

This sector is captured by the balance of payment (BP) equation, which shows different combinations of interest rate and income that ensure equilibrium in the balance of payment (Appleyard and Field, 2001).

The fundamental identity in the BP equation is expressed as

$$B = CA + K \tag{13}$$

where B = balance in the official reserve transactions account.
CA = current account balance
K = capital account balance

$$CA = x - im \tag{14}$$

From equations 5 and 6,

$$CA = x_0 + x_1 e_t + x_2 y^f + x_3 y_t - \left(im_0 + im_1 y_t + im_2 e_t\right) \tag{15}$$

The capital account is expressed as equation 16 below

$$K = \alpha_0 + \alpha_1 r_t \tag{16}$$

Equilibrium in the balance of payment account requires that B is equal to zero. Substituting equations 15 and 16 into equation 13, and by assuming B = 0, makes equation 13 to become:

$$0 = x_0 + x_1 e_t + x_2 y^f + x_3 y_t - im_0 - im_1 y_t - im_2 e_t + \alpha_0 + \alpha_1 r_t \tag{17}$$

Collecting the like terms and simplifying 17, equation 18, which is the BP equation, is obtained:

$$y_t = \frac{-\pi_0 - \pi_1 e_t - \pi_2 y^f - \alpha_1 r_t}{\pi_2} \tag{18}$$

where: $\pi_0 = x_0 + im_0 + \alpha_0$, $\pi_1 = x_1 - im_2$ and $\pi_2 = x_3 - im_1$

Combining equations 7, 12 and 18, which are equilibrium conditions in the goods, money and external sectors respectively, and with series of manipulations, we obtain the equation for output, y, which is

$$y_t = \varphi_0 - \varphi_1 e_t - \varphi_2 y^f - \varphi_3 m_t - \varphi_4 g_t \tag{19}$$

From the derivation above, a change in exchange rate, e, affects output directly through the import and export channels and indirectly though the response of import and export to changes in income brought about by changes in exchange rate. But whether the effect of exchange rate depreciation on output would be negative or positive depends on the strength of the income elasticities of import and export. Where elasticity of export with respect to income is greater than the elasticity of import with respect to income, we may have positive response; otherwise, we have a negative response.

From the discussion above, it is clear that the output effect of exchange rate depreciation is ambiguous *a priori*. The magnitude and direction of effect depend on the size of change (in exchange rate), the relative strength of the import and export elasticities of income. Output is expected to respond positively to government expenditure, provided there is no crowding-out effect of government spending. Income of trading partners is expected to impact positively on output since this would promote demand for export

(all else being equal). Money supply is also expected to promote output growth through reduction in interest rate and stimulation of investment.

5.2 The Empirical Model

Equation 19 is modified by including the stochastic disturbance term. Moreover, because we are interested in disaggregated agricultural output analysis, the output of agriculture is sub-divided into crop, fishery, forestry and livestock. Four equations are thus estimated with output of crop, fishery, forestry and livestock as dependent variables respectively. The empirical model is as presented in equation (20) below:

$$\ln GDP = \beta_0 + \beta_1 lnREER + \beta_2 lny^f + \beta_3 lnM^s + \beta_4 lnGOVTEXP + u_1 \quad (20)$$

where *GDP* stands for the output of agricultural output (crop, fishery, forestry and livestock), REER stand for real effective exchange rate, y^f stands for foreign income, M^S is money supply and *GOVTEXP* stands for government expenditure. *ln* before each variable stands for logarithm while *u* stands for the stochastic error term.

6. Empirical Analysis

The models were estimated using the two-stage-least-squares technique in order to capture the possibility of reverse causality. The residuals were thereafter tested for serial correlation using the Breusch-Godfrey LM test. Besides, the model was evaluated to see how well it fits actual data. These results are discussed below. The summary statistics is presented in Table 3.

Table 3: Summary Statistics of Variables

Variables	Observations	Mean	Maximum	Minimum	Std. Dev.
FISHERY (N, Million)	27	4402.97	8135.79	1726.50	1754.20
FORESTRY (N, Million)	27	3288.69	24885.40	1992.00	4324.37
CROPS (N, Million)	27	125531.10	221622.30	67551.80	43682.00
LIVESTOCK (N, Million)	27	10230.15	15654.70	6934.50	2191.58
Real Exch Rate Index	27	226.62	772.50	71.44	201.12
Govt. Expenditure (N, Million)	27	118809.50	947690.00	701.10	214516.10
GDP of Trading Partner ($, Million)	27	7140.43	13246.60	2795.60	3056.86

The average values of output of crop, fishery, forestry and livestock during the period of study are N125,531.10 million, N4402.57 million, N3288.69 and N10,230.15 million respectively. During the period under review, the minimum output for crop is N67,551.89 million while the minimum for fishery is N1726.50. For forestry and livestock, the minimum is N1992.00 million and N6934.50 million respectively. The Maximum for crop, fishery, forestry and livestock are N221622.30 million, N8135.79 million, N24,885.40 million and N15,654.70 million respectively.

Two-Stage-Least- Squares Regression Result

Table 4 below presents the result from the two-stage estimation technique. The results indicate that the real exchange rate has a negative impact on crop output, implying that real exchange rate depreciation has a contractionary effect on crop output. Money supply has a positive effect on crop output but this is not significant. The income of trading partners (represented by the USA GDP) has a positive and significant effect on crop output, while government expenditure has a negative but insignificant effect on crop output. The coefficient of real exchange rate is significant at the 10 percent level. For the fishery output equation, real exchange has a negative but insignificant effect. However, money supply has a positive and significant effect on the fishery output. The income of trading partners and government expenditure has negative and significant effects on fishery's output. As depicted on Table 4, the real exchange rate has a positive and significant effect on forestry and livestock outputs, while money supply has negative effects in both cases. However, the effect of money supply is insignificant in the forestry equation. The income of trading partners has positive effects on forestry and livestock outputs but the effect is insignificant in the forestry equation. Government expenditure has positive and significant effect in the forestry equation, while it has negative and significant effect in the livestock equation. In all the equations, the variables included in the models are able to explain over 60 percent of variation in the dependent variable except in the forestry model where only 24 percent of variation could be explained. The standard error of regression is plausibly low in all cases.

Table 4: Estimated Results of Two-Stage-Least-Squares

	Crop	**Fishery**	**Forestry**	**Livestock**
Constant	6.45(5.51)	19.01(3.06)	-9.18(-0.89)	3.11(3.27)
Real Exch. Rate	-0.05(-1.79)	-0.16(-1.13)	0.47(2.02)	0.04(1.97)
Money Supply	0.03(0.94)	0.51(2.77)	-0.23(-0.74)	-0.08(-2.73)
Inc of Trading Parts	0.59(3.55)	-1.72(-1.96)	1.88(1.28)	0.779(5.92)
Government Exp	-0.01(-1.25)	-0.07(-2.07)	0.08(1.76)	-0.02(-3.98)
Adjusted R^2	0.97	0.60	0.24	0.95
SEE	0.05	0.27	0.44	0.04

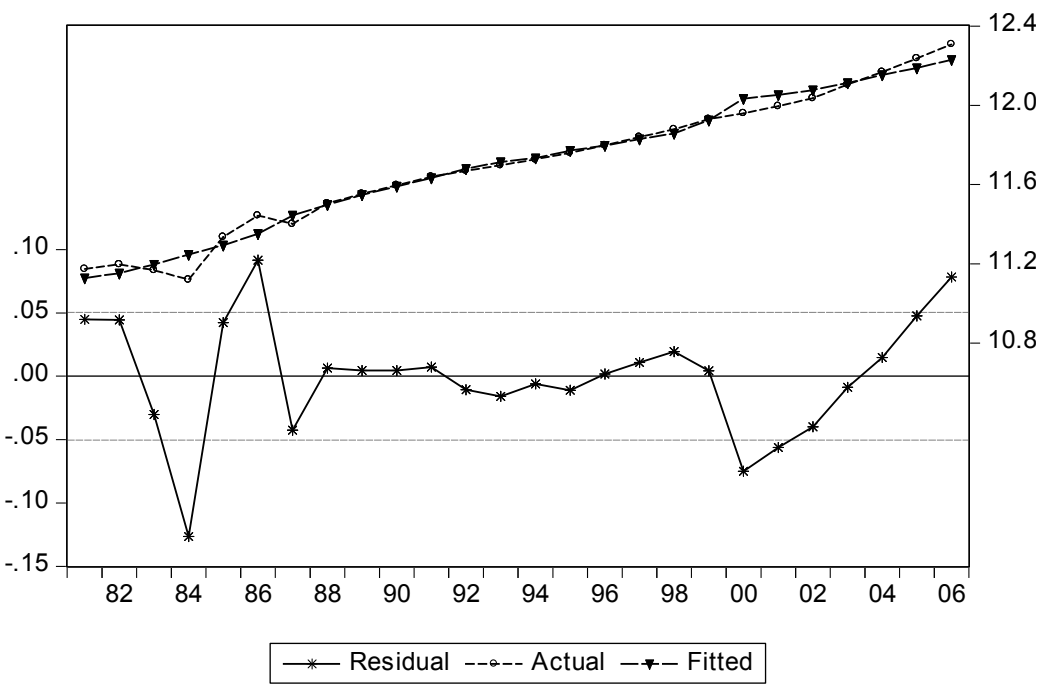
To test the robustness of the model, the Breusch-Godfrey Correlation LM test was conducted in order to find out whether the error terms are serially correlated. The results presented in Table 5 below suggest that the null hypothesis of no serial correlation could not be rejected in the cases of fishery, forestry and livestock models, while in the crop model the null hypothesis of no serial correlation could not be accepted. This suggests that there is no problem of serial correlation of error terms in the fishery, forestry and livestock models.

Table 5: Breusch-Godfrey LM test Tesult

	Crop	Fishery	Forestry	Livestock
Breusch-Godfrey Statistics	6.01	4.24	3.02	4.17
Probability Chi-Square(2)	0.05	0.13	0.22	0.12

Furthermore, the graphs of the models were examined to see how well the estimated model is able to track the actual data. The graphs of the actual fitted and residuals for crop, fishery, forestry and livestock are shown in Figures 1, 2, 3 and 4 respectively.

Figure 1: Actual, Fitted and Residual for the Crop Model



From Figure 1, it can be observed that the fitted line actual tracts the actual very well, indicating a well fitted model. For the fishery model, the fitted line did not tract the actual data very well as shown in Figure 2. However, for the forestry and livestock models, the fitted model track actual data very well, except between 1997 and 1999 in the forestry model, where the tracking is poor (see Figures 3 and 4 for forestry and livestock respectively).

Figure 2: Actual, Fitted and Residual for the Fishery Model

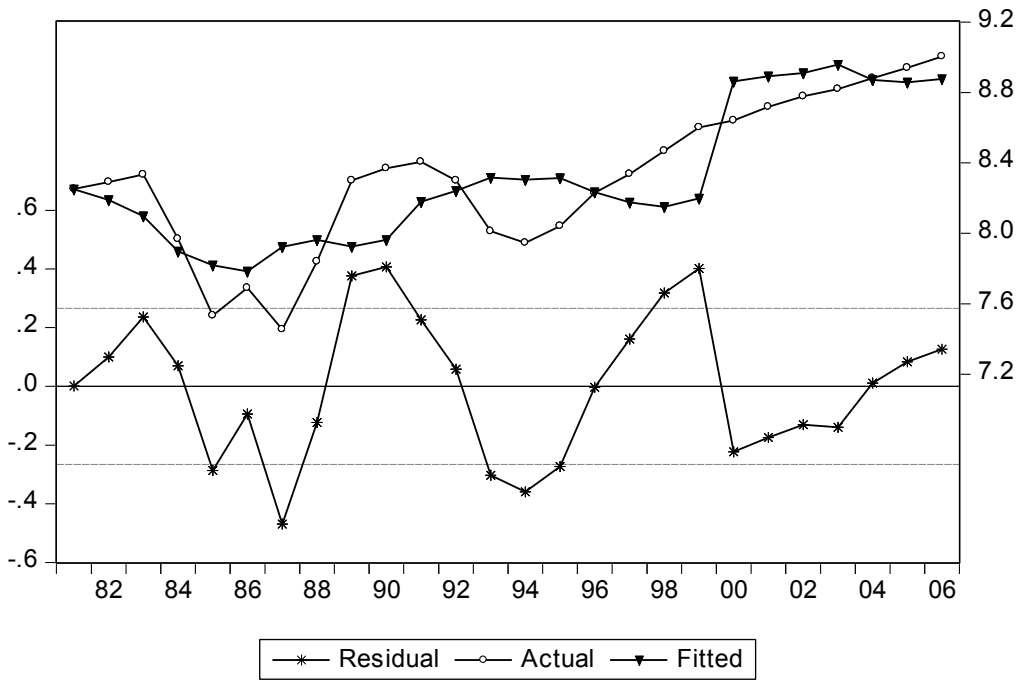


Figure 3: Actual, Fitted and Residual for the Forestry Model

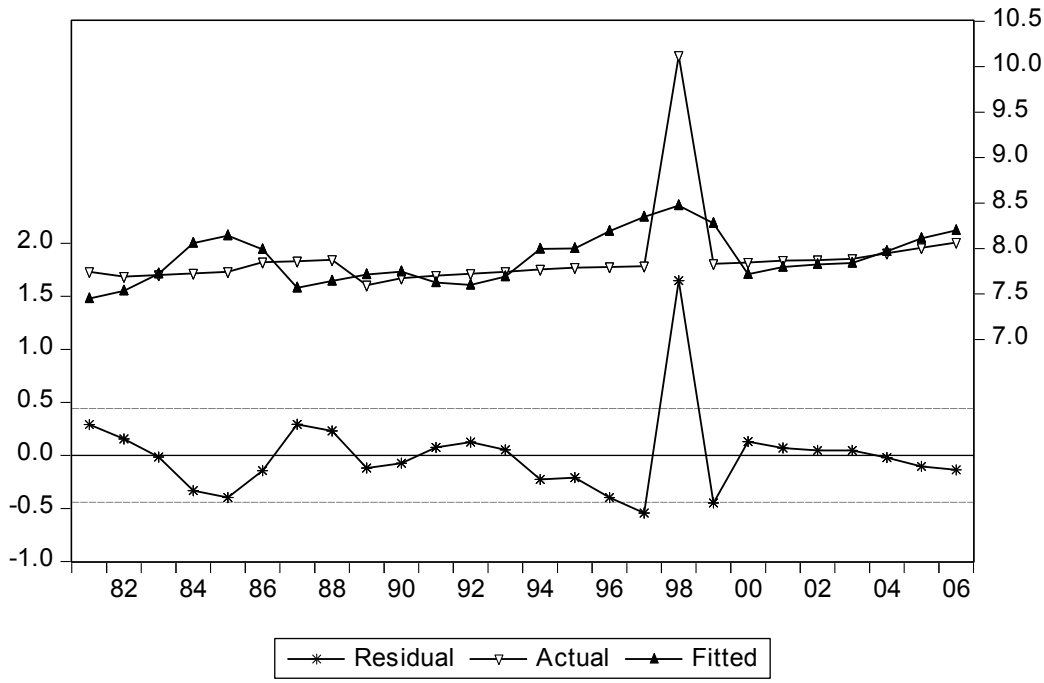
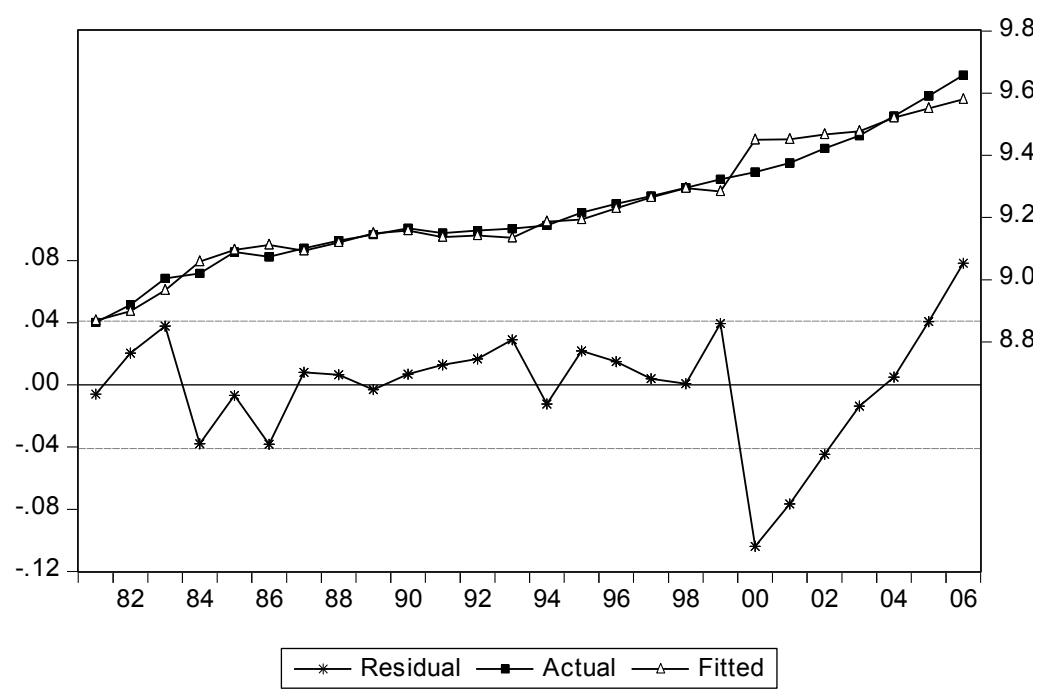


Figure 4: Actual, Fitted and Residual for the Livestock Model



7. Summary and Conclusion

From the analysis presented above we observe that there are differences in the way output of different sub-sectors responds to exchange rate changes. While crop and fishery output have negative relationship with real exchange rate, forestry and livestock output have a positive one. The effect of exchange rate was found to be significant in all cases except in the fishery model. Money supply has significant impact on fishery and livestock output but the effect goes in different direction in both cases. Government expenditure has negative and significant effect on fishery and livestock output. This probably indicates the crowding out effect of government expenditure on private investment. The fact that real exchange rate has differential effect on output of the agricultural sub-sector indicates the need for caution in exchange rate policy and also the need for policy to be put in place to mitigate the adverse consequences of exchange rate depreciation on crop and fishery output.

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