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# The impact of real exchange rate volatility on economic growth: Kenyan evidence

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This paper examines the impact of real exchange rate volatility on economic growth in Kenya. The study employed the Generalized Autoregressive Condition of Heteroscedasticity (GARCH) and computation of the unconditional standard deviation of the changes to measure volatility and Generalized Method Moments (GMM) to assess the impact of the real exchange rate volatility on economic growth for the period January 1993 to December 2009. Data for the study was collected from Kenya National Bureau of Statistics, Central Bank of Kenya and International Monetary Fund Data Base by taking monthly frequency. The study found that RER was very volatility for the entire study period. Kenya's RER generally exhibited a appreciating and volatility trend, implying that in general, the country's international competitiveness deteriorated over the study period. The RER Volatility reflected a negative impact on economic growth of Kenya.

**JEL Classifications:** C2, C3, C8, E1, E4, F1, F4

**Keywords:** Real exchange rate, nominal exchange rate, real effective exchange rate, nominal effective exchange rate, volatility, GARCH

## Introduction

The real exchange rate (RER), is the rate at which goods, and services produced in one country can be exchanged for those produced in another country or group of countries abroad, has been recognized as an important aspects in international macroeconomics, and finance. Volatility in the RER has important implications on Kenya's economic growth. Increased RER volatility would, for instance, increase the uncertainty of profits on contracts denominated in a foreign currency, and would therefore reduce economic growth to levels lower than would otherwise exist if uncertainty were removed (Cote, 1994). There is, however, no available evidence that success has since been achieved in realizing the objective for which the foreign exchange market was liberalized. Large volatilities in nominal exchange rates have since characterized Kenya financial market (Kiptoo, 2007).

The problem of RER volatility has given rise to a broad debate in the economics, and finance professions in many parts of the world (Frenkel and Goldstein, 1987; Cote, 1994). In Kenya, the subject has been at the center of current economic policy debate, involving policymakers, the business community, academic researchers, and the business press. All point out the potential deleterious effects of "excessive" volatility observed in the country's currency market since the adoption of a floating exchange rate in 1993 on the country's economic growth (CBK, 2002). There is, however, no consensus yet on whether such volatilities in the RER have influenced the Kenyan economic growth, or whether any such influences have been negative or positive. It is not known, also, whether such RER volatilities have translated into misalignment, and if so, the nature, extent, and impact of such misalignment on the Kenyan economic growth (Kiptoo, 2007).

Various studies, particularly, in the developed and middle-income countries, have also explored the impact of exchange rate volatility and associated uncertainty on trade, investment, and economic growth. Majority of these studies have found that exchange rate volatility can affect trade directly, through uncertainty and adjustment costs, and indirectly through its effect on the structure of output and investment (Cote, 1994; Serven, 2002; Pickard, 2003; Cheong, 2004; Kikuchi 2004; Arize et. al., 2004).

In spite of the abundant literature on the effects of exchange rate volatility on macroeconomic variables such as economic growth, studies that specifically focus on Kenyan economy are scanty. The few studies that have been undertaken in Kenya on the subject of exchange rate behavior have mainly focused on explaining the determinants of exchange rate behavior, with emphasis on the role of macroeconomic variables such as monetary policy shocks. For instance, Were et. al., (2001), analyzed factors that have influenced the exchange rate movements since the foreign exchange market was liberalized in 1993. A related study by Ndung'u (1999) assessed whether the exchange rates in Kenya were affected by monetary policy, and whether these effects were permanent or transitory. The study by Kiptoo (2007) focused on the real exchange rate, volatility, and misalignment, and its impact on the Kenya's international trade, and investment. Sifunjo, (2011) focused on chaos and non-linear dynamical approaches to predicting exchange rates in Kenya. Even then, these studies including Ndung'u (1995), Ndung'u (2001), Kiptoo (2007), and Sifunjo, 2011 did not deal with the impact of exchange rate volatility on the Kenya's economic growth.

### ***The Real Exchange Rate concept***

An exchange rate as stated earlier is the rate at which one currency may be converted into another. Among other things, the exchange rate determines how much the residents of a country pay for imported goods, and services, and how much they receive as payment for exported goods, and services. RER can be expressed in nominal or real terms. It is referred to as the nominal exchange rate (NER) when inflation effects are embodied in the rate, and as the real exchange rate (RER) when inflation influences have been excluded (Copeland, 1989; Lothian and Taylor, 1997).

The NER can be expressed in bilateral or multilateral term. A bilateral exchange rate refers to the exchange rate of one currency, say the Kenya shilling, in terms of another, say, the US dollar (Copeland, 1989). On the other hand, a multilateral exchange rate, also referred to as the Nominal Effective Exchange Rate (NEER). It is the rate of one currency against a weighted composite basket of that country trading partner currencies. The movements in the multilateral exchanges rates represented by NEERs rather than those of the bilateral exchange rates are the focus of this study. This is because Kenya trades with more than one country, and hence, the need to focus on the composite basket of trading partner currencies. Subsequent use of Norminal Exchange Rate (NER) in this study therefore refers to NEER except where specific reference is made to NER.

The RER, on the other hand is expressed as the NER adjusted for inflation. This adjustment can be obtained through the multiplication of the NER with the ratio of the foreign price level to the domestic price level (Adler and Lehman, 1983). Alternatively, the inflation adjustment can be achieved by multiplying the NER with the domestic relative price of tradable to non-tradable goods (Edwards, 1989).

### ***Real exchange rate volatility***

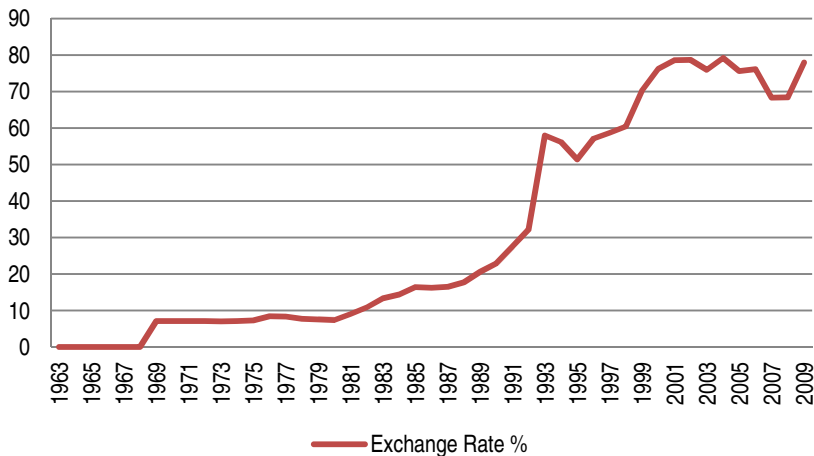
RER volatility refers to short-term fluctuations of the RER about their longer-term trends (Frenkel and Goldstein, 1987). It also entails short-term (monthly, weekly, or even hourly) fluctuations in the exchange rates as measured by, their absolute percentage changes

during a particular period (Williamson, 1985). Excess RER volatility has been known to reduce the level of economic growth by creating uncertainty about the profits, unemployment, and poverty. It is also known to restrict the international flow of capital by reducing both direct investment in foreign operating facilities, and financial portfolio investment. Finally, increased RER volatility may lead to higher prices of internationally traded goods by causing traders to add a risk premium to cover unanticipated exchange rate fluctuations (McKinnon and Ohno, 1997).

There are two situations in which flexible exchange rates may be described as too volatile. First, exchange rates can be fully consistent with fundamental economic variables, such as relative prices, and macroeconomic policies, while still responding excessively to shocks to those variables before adjusting gradually to new long-term equilibrium levels. Such exchange rate 'overshooting' may occur because international capital markets adjust almost instantaneously to shocks, while goods and services markets adjust slowly (Dornbush, 1976). While predictable, this type of exchange rate volatility is costly since it amplifies the domestic impact of disturbances arising in foreign markets, exacerbating fluctuations in domestic growth, and unemployment. Second, flexible exchange rates may be too volatile if they are primarily influenced by factors unrelated to fundamental economic variables. In this case, exchange rate movements would be largely unpredictable, especially, in the short term. Furthermore, the short-term independence of exchange rates from fundamental variables can lead to long-term exchange rate misalignment volatility could also have an impact on growth. Theoretical and empirical work shows that a volatile economic environment (for example volatility of the terms of trade, exchange rates, money supply, productivity) has a harmful effect on economic performance (Frenkel and Goldsten, 1987).

The exchange rate of Kenya shilling to the US Dollar from 1967 to 2009 has been described by the fixed exchange rate error, the crawling peg error and the floating error.

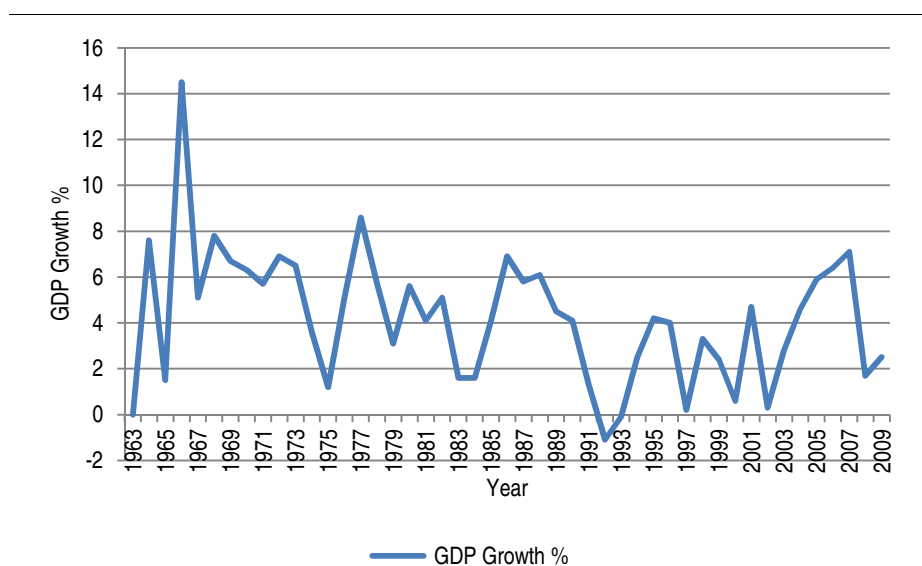
FIGURE 1. PROFILE OF KENYA'S EXCHANGE RATE REGIMES, 1967-2009  
(Kenya Shilling per US dollar)



Source: Derivations from data from Kenya National Bureau of Statistics (KNBS)-2010.

The economic growth profile of Kenya can be divided into five decades as highlighted by Figure 2 below

FIGURE 1. KENYA'S GDP GROWTH RATES (1963-2009)  
Real GDP growth rate (1964/1982 prices)



Source: Derivations from data from Kenya National Bureau of Statistics (KNBS)-2010.

## Exchange rate determination

Economists and financial experts are yet to agree on a single theory that defines the exchange rate. Hitherto, there are at least five competing theories of the exchange rate concept, which may either be classified as traditional or modern. The traditional theories are based on trade and financial flows, and purchasing power parity, and are important in explaining exchange rate movements in the long run.

These theories are: the elasticity approach to exchange rate determination, the monetary approach to exchange rate determination, the portfolio balance approach to exchange rate determination, and the purchasing power theory of exchange rate determination. The modern theory, however, focuses on the importance of capital and international capital flows, and hence, explains the short run volatility of the exchange rates and their tendency to overshoot in the long run.

## The model estimation methods

The real exchange rate (*rer*) is obtained by adjusting the nominal exchange rate (*ner*) with inflation differential between the domestic economy, and foreign trading partner economies. The derivation of the *rer* therefore, requires that the data of the *ner*, domestic inflation and foreign inflation be obtained. Since the Kenya shilling appreciated against some currencies and depreciated against others during the study period, the Nominal Effective Exchange Rate (*NEER*) is constructed. The *NEER* is derived by weighting the

bilateral shilling exchange rate against its trading partner currencies using the value of Kenya's trade (imports plus exports) with its respective trading partners. The data required to derive the *NEER* is for Kenya's bilateral exchange rates with respective trading partners. Since some of the data on bilateral exchange rates are originally expressed in terms of (United States) US dollars, cross rates had to be obtained, so as to have all bilateral exchange rates expressed in terms of Kenya Shilling per foreign currency. The calculation of the *NEER* is achieved through the arithmetic mean approach that involves summing up the trade weighted bilateral exchange rates as shown in equation 1 below:

$$NEER_t = \sum_{it}^n ER_{it} * w_{it} \quad (1)$$

where,  $ER_{it}$  is Kenya's bilateral exchange rate index with country  $i$  at time  $t$  while  $w_{it}$  is the bilateral trade weight for Kenya's  $i^{th}$  trading partner at time  $t$ . Each bilateral exchange rate index ( $ER_{it}$ ) in (equation 1) is computed as follows:

$$ER_{it} = \left[ \frac{NER_c}{NER_{t=0}} \right] * 100 \quad (2),$$

where, the  $NER_c$  is the index of Kenya shilling exchange rate per unit of trading partner currency in the base period (2007) while  $NER_{t=0}$  is the index or Kenya shilling exchange rate per unit of trading partner currency in the current period year.

The choice of 2007 as the base year is rationalized in terms of relative stability of the economy, and low volatility in the domestic foreign exchange market during the year. Kenya's Gross Domestic Product (GDP) growth rate during this period was 7.1%, the highest rate ever achieved during the 1993-2009-study period. The year 2007 also enjoyed macroeconomic stability, with inflation rates that were not only low but also stable, while the current account balance as well as fiscal deficits was considered to have been at sustainable levels.

Each monthly bilateral trade weight in (equation 1) was computed as a ratio of total trade (exports plus imports) for each trading partner to the ratio of total trade (export plus imports) for all Kenya's trading partners. The formula used in deriving the trade weights is:

$$w_{it} = \left[ \frac{\sum(x_{it} + m_{it})}{\sum(X_t + M_t)} \right] \quad (3),$$

where,  $x_{it}$  is total value of Kenya's exports to  $i^{th}$  trading partner at time  $t$ ,  $m_{it}$  is the total value of imports from Kenya's  $i^{th}$  trading partner also at time  $t$ ,  $X_t$  are Kenya's total exports to all trading partners at time  $t$ , and  $M_t$  are total imports to all trading partners at time  $t$ . In this study  $i=1, 2, \dots, n$  where,  $n$  is the total number of Kenya's trading partners which in this study was 140. The *NEER* is obtained by combining equations 2, and 3 using the following formula:

$$NEER_t = \sum_{it}^n ER_t * w_t \quad (4),$$

where,  $ER_t$  is the bilateral exchange rate (equation 2), and  $w_t$  is the bilateral trade weight,  $n$  is the total number of countries, which is 140. Based on (equation 4), a decline in  $NEER$  represents an appreciation, while an increase represent a depreciation of the  $NEER$ . This is because in the calculation of the  $NEER$  index, the base year (2007) exchange rate is taken as the denominator while the current exchange rate is taken as the numerator.

In order to obtain the Real Effective Exchange Rate ( $REER$ ), the  $NEER$  is adjusted by the relative price indices of Kenya, and the weighted average price indices of Kenya's trading partners. In an equation form, this is expressed as:

$$REER_t = NEER_t \left[ \frac{P_{wt}}{P_{dt}} \right] \quad (5),$$

where,  $P_{dt}$  is the price level in Kenya proxied by Consumer Price Index (CPI) at time  $t$ , and  $P_{wt}$  is the weighted average price level of Kenya's trading partner countries proxied by weighting CPI at time  $t$ . The price level of Kenya's trading partner countries is obtained by adding all the trade weighted price levels proxied by CPI of Kenya trading partners. This is shown in an equation form as follows:

$$P_{wt} = \sum_{it}^n P_{it} * w_t \quad (6),$$

where,  $P_{it}$  is the price level of Kenya's  $i^{th}$  trading partner countries proxied by CPT at time  $t$ ,  $w_{it}$  is the trade weight of Kenya's  $i^{th}$  trading partner country at time  $t$ . These weights are the same as those used in the derivation of  $REER$ .

*Real Exchange Rate volatility (V)*. This study attempted to measure  $RER$  volatility in two ways. The first was through the computation of the (unconditional) standard deviations of  $RER$  changes within pre-determined periods while the second was through the Generalized Auto-Regressive Conditional Heteroscedasticity (GARCH) developed by Bollerslev in 1986. The standard deviation method is the most traditional way of measuring volatility (Kenen and Rodrik, 1986; Caballero and Corbo, 1989). Under this approach, the  $RER$  volatility is measured by computing the annual standard deviation of the  $RER$ . The monthly  $RER$  volatility also referred to as the growth rate of  $RER$  ( $V$ ) is defined as the natural logarithm of the standard deviation of monthly  $RER_s$  within a year, and is measured as follows:

$$V_i = \ln \left[ \sqrt{\frac{1}{n-1} \sum (RER_i - \overline{RER}_i)} \right] \quad (7),$$

where,  $V_i$  denotes the *RER* volatility,  $RER_i$  represents the monthly *RER*, and  $\overline{RER}_i$  denotes the 12-month average of *RER*s. The use of the standard deviation approach, however, has two weaknesses. The first weakness is that it assumes that the empirical distribution of *RER* is normal. The second limitation is that it ignores the distinction between predictable and unpredictable elements in the exchange rate process.

Due to the tendency for *RER* data to be skewed in terms of distributions or volatility clusters, the use of simple descriptive statistics such as the standard deviation method has been discouraged as a measure of *RER* volatility. Consequently other alternative models have been developed to measure *RER* volatility. One such model is, the Auto-Regressive Conditional Heteroscedasticity (ARCH), developed by Engle (1982). The model considers the variance of the current error term to be a function of the variances of the previous time period's error terms. In the context of this study, the model assumed that the *rer* uncertainty (volatility) was generated by first order autoregressive process that is specified as:

$$rer_t = \beta_0 + \beta_1 rer_{t-1} + \varepsilon_t \tag{8}$$

where  $rer_t$  is the natural logarithm of *rer*,  $\beta_0$  and  $\beta_1$  are the parameters to be estimated and  $\varepsilon_t$  is an error that is normally distributed with zero ( $0$ ) mean, and constant variance ( $\delta^2$ ). The variance of the error term depends upon time ( $t$ ). The ARCH model characterizes the way this dependence can be captured by an autoregressive process of the form:

$$\delta_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \dots + \alpha_m \varepsilon_{t-m}^2 \tag{9}$$

where  $\delta_t^2$  is the conditional variance of the *rer*,  $\varepsilon_{t-1}^2$  for  $I = 1, 2, 3 \dots m$  denotes the squared residuals derived from equation 10, and  $\alpha_1$  for  $I = 0, 1, \dots m$  are the parameters to be estimated.

The restriction  $\alpha_1 \geq 0$  is meant to ensure that the predicted variance is always not a negative value. The term  $\varepsilon_{t-1}^2$  represents the ARCH, and is therefore a measure of information about the *rer* volatility in the previous period. This study, however, employed the Generalized Auto-Regressive Conditional Heteroscedasticity (GARCH). The GARCH model is an extension of the ARCH model in which the variance is given by:

$$\delta_t^2 = \alpha_0 + \beta_1 \delta_{t-1}^2 + \beta_2 \delta_{t-2}^2 + \dots + \beta_k \varepsilon_{t-k}^2 + \alpha_1 \delta_{t-1}^2 + \alpha_2 \delta_{t-2}^2 + \dots + \alpha_m \delta_{t-m}^2 \tag{10}$$

where  $\delta_{t-1}^2$  for  $j=1, 2 \dots k$  is the GARCH term representing the last period's forecast variance. GARCH ( $1, 1$ ) is the simplest specification in this class, and is the most widely used specification. Thus, the GARCH ( $1, 1$ ) model is given by:

$$\delta_t^2 = \alpha_0 + \beta_1 \delta_{t-1}^2 + \alpha_1 \varepsilon_{t-1}^2 \tag{11}$$



This study employed equation 11 as the GARCH process to capture the *rer* volatility. This involves explaining the *rer* volatility by positing a structural relationship between volatility and its determinants.

### Data source

The method of data collection was secondary research, which essentially involved reviewing data sources that have been collected for some other purpose than the study at hand. The main sources of the data was from local institutions were as follows: The Statistical Bulletins and the Monthly Economic Reviews of the Central Bank of Kenya (CBK); the Economic Surveys of the Kenya National Bureau of Statistics (KNBS), the Budget Outturns of the Ministry of Finance. For the study period of January 1993 to December 2009 with monthly frequency total of 204 in construction of RER while, yearly frequency total of 17 data values were used. In other instances, however, the data was extracted from the relevant publications or documents of the above institutions, and saved in Excel spreadsheet. The main sources of international data were the International Financial Statistics (IFS), and the Directorate of Trade Statistics (DTS). The Library Network that serves the World Bank Group, and the IMF, was the sole source of data from international sources. United Nations data base on social indicators was extensively reliable source of information.

### Empirical results

This section measures and reports on the results of the *RER* volatility. In order to measure the *RER* volatility, the study generated GARCH specification as follows:

$$\ln REER_t = \pi_t + \beta_t \ln REER_{t-1} + \varepsilon_1 \quad (12),$$

where,  $\varepsilon_t(O, h_t)$

$$\varepsilon_t = \alpha_t + \beta \varepsilon_{t-1}^2 + \gamma h_{t-1} + u_1 \quad (13).$$

The above conditional variance of *RER* is a function of three terms (i) the mean,  $\alpha$ , (ii) news about volatility from the previous period, measured as the lag of the squared residual from the mean equation,  $\varepsilon_{t-1}^2$  (the ARCH term), and (iii) the last period's forecast error variance,  $\gamma h_{t-1}$  (the GARCH term) as shown in equation 13. This study estimated a number of versions of ARCH models. The GARCH (1, 1) model generated the best result shown in Table 1 (Appendix).

### Growth model

This section employed the GMM methodology: first, to empirically examine the impact of volatility on economic growth. The findings and results were presented, interpreted, and evaluated against theory, and results of other studies. Table 2 (Appendix) shows the descriptive statistics of economic growth model.

### Time series properties

It is important to test whether there are any structural breaks, trends, or stationary in the data. The integration order of all the variables in the economic growth demand equation was determined by employing the ADF, and PP tests. The results are presented in Table 3 (Appendix). The movements of the variables suggest that they are all stationary (some variables suggest that they are all stationary, and others are first difference stationary). This was ascertained by carrying out formal unit root test.

Table 4 (Appendix) provides all the variables including the *rer* volatility, and the results are rather interesting. The *rer* volatility positively influence growth. A one percent increase in *rer* volatility decreases growth by 0.348. Government expenditure impact on growth as earlier observed in the two tables previously. Per capita, health, and secondary education positively influence growth as expected even though insignificant. Primary enrolment had a negative impact on growth. Terms of trade indicated a negative influence on growth. R-squared of 42 percent, and a Durbin Watson statistics of 2.1 higher than the desired of 2.

Table 5 (Appendix) provides all the variables but eliminating the *rer* volatility, from the model. This does not affect the negative impact of the government expenditure on economic growth. However, the influence is significant. This means that neither *rer* volatility nor misalignment affect how government expenditure influence growth. The same argument applies to primary enrolment, secondary enrolment, and terms of trade. However and notably is education (primary and secondary enrolment), have significant negative, and positive influence on economic growth respectively. Per capita insignificantly negatively influences economic growth. The R-squared value is 42 percent indicating the highest fit model, A Durbin-Watson statistics of 2.3 indicating a positive autocorrelation of the model.

### Discussion

The results show that the economic growth is influenced largely by changes in all explanatory variables *rer* volatility showed a negative elasticity of 0.348 insignificant. This evidence confirms what is available in literature. Government expenditure, primary enrolment, and term of trade indicate negative elasticity's to economic growth. All the three variables are insignificant. Secondary enrolment had a positive significant elasticity to economic growth. Life expectancy showed a positive but insignificant elasticity to economic growth in the absence of *rer* misalignment in the model.

The above findings of the current study concur with the finds of Bini-Smaghi (1991) used Ordinary Least Square (OLS) technique to estimate the effect of *RER* volatility on trade in manufactured goods within the European Monetary System (EMS). The study found that *RER* volatility, measured by the standard deviation of weekly rates of changes of the intra-EMS effective rate for the quarter, had a negative, and significant effect on export volumes in all the three countries of (Germany, France, and Italy). Hondroyannis *et al.*, (2005) undertook a study that examined the relationship between exchange-rate volatility, and aggregate export volumes for 12 industrial economies using a model that included real export earnings of oil-producing economies as a determinant of industrial-country export volumes. Five estimation techniques, including a generalized method of moments (GMM), and random coefficient (RC) estimation, were employed on panel data covering the estimation period 1977:1-2003:4 using three measures of volatility, namely, the absolute values of the quarterly percentage change in the exporting nation's effective exchange rate, log of the eight-quarter moving standard deviation of the *REER*, and a constructed GARCH measure of volatility. In contrast to current study, the study by Hondroyannis *et al.*, (2005) did not find a single instance in which volatility had a negative, and significant impact on trade. In all cases, the coefficient on volatility was near zero.

Studies reviewed in this paper that used Johansen cointegration technique and found a negative and significant relationship between the *RER* volatility, and investment in developed countries are Caves (1989), Eun (1997), Dominquez and Tesar (2001), Bergin and Tchakarov (2003), Doukas et al., (2003), Kiyota and Urata (2004) and Siregar and Rajan (2004). These studies findings agree with the findings of the current study. About the impacts of *RER* Volatility on economic growth and investment.

The study by Kiptoo (2007), focused on *RER* volatility and misalignment on international trade and investment. The study used Generalized Autoregressive Condition Heteroscedasticity (GARCH) and unconditional standard deviation. The study found out that *RER* volatility has a negative and significance impact on trade and investment during the study period 1993 to 2003. Finally, the study by Sifunjo (2011) examined chaos and non-linear dynamical approaches to predicting exchange rates in Kenya. The study used GARCH to measure foreign rate volatility. The results suggest presence of non-linearity in the returns, high volatility in the exchange market with a maximum duration of 6 months. Foreign exchange market was found not to be efficient in the weak form. The two study findings are similar o the current study findings indicate a large volatility of the real exchange rate in Kenya.

## Conclusion

The study adduced evidence that the conditional volatility of the *RER* depended on both domestic and external shocks to *RER* fundamental and macroeconomic changes. Overall, however, Kenya's *RER* generally exhibited a appreciating and volatility trend, implying that in general, the country's international competitiveness deteriorated over the study period, hence, impacting negatively on the economic growth of Kenya.

## References

- Adler, M. and Lehman, B., 1983. "Deviations from purchasing power parity in the long run," *Journal of Finance*, Vol.38(5), pp.1471-487
- Arize, A., Osang, T. and Slottje, D., 2004. Exchange-rate volatility in Latin America and its impact on foreign trade, Department of Economics, Southern Methodist university, Dallas, Texas 75275, USA: <http://faculty.smu.edu/tosang/pdf/latin.pdf>
- Bergin, P. and Tchakarov, I., 2003. Does exchange rate risk matter for ~welfare? A Quantitative Investigation, National Bureau of Economic Research (NBER) Working Paper Series, No.9900. <http://papers.nber.org/papers/w9900.pdf>
- Bini-Smaghi, L., 1991. "Exchange rate variability and trade: Why is it so difficult to find any empirical relationship?" *Applied Economics* 23, May, pp.927-35
- Bollerslev, T., 1986. "Generalized autoregressive conditional heteroscedasticity," *Journal of Econometrics*, Vol.31, pp.307-27
- Caballero, R. and Corbo, V., 1989. "The effect of real exchange uncertainty on exports: Empirical evidence," *World Bank Economic Review*, Vol.3, pp.263-78
- Caves, R., 1989. "Exchange rate movements and foreign direct investment in the United States," in Audstretsch, D. and Claudon, M. (eds) *The Internationalization of us Markets*, pp.199-225
- Central Bank of Kenya (CBK), 2002. *Monthly Economic Review*, December, 2002, research Department, Central Bank of Kenya, Nairobi
- Cheong, C., 2004. "Does the risk of exchange rate fluctuations really flows between countries?," *Economics Bulletin*, Vol.6, pp.1-8
- Copeland, L., 1989. *Exchange rates and international finance*, University of Manchester Institute of Science and Technology, Wokingham, England: Addison-Wesley publishing company Inc.
- Cote, A., 1994. Exchange rate volatility and trade: A survey, Working Paper 94-5, Bank of Canada

- Dominquez, K. and Tesar, L., 2001. "A reexamination of exchange rate exposure," NBER Working Paper Series, No.8128, NBER, 1050 Massachusetts Avenue Cambridge, MA 02138: <http://www.nber.org/Papers/w8453>
- Dornbush, R., 1976. "Expectations and exchange rate dynamics," *Journal of Political Economy*, Vol.84, pp.1161-176
- Doukas, J., Hall, P. and Lang, L., 2003. *Exchange Rate Exposure at the Firm and Industry, Financial Markets, Institutions and Instruments*, New York University, Salomon Center, Published by Blackwell Publishing Inc., 350 Main St., Malden, MA 02148, USA
- Edwards, S., 1989. "Exchange rate misalignment in developing countries," National Bureau of Economic Research (NBER) Working Paper Series, No.2950, April, Oxford University Press
- Engle, F., 1982. "Autoregressive conditional heteroscedasticity with Estimates of the Variance of United Kingdom Inflation," *Econometrica*, Vol.50, pp.987-1006
- Eun, C., 1997. "International equity investments with selective hedging strategies," *Journal of International Financial Markets, Institutions and Money*, Vol.7, pp.21-42
- Frenkel, J. and Goldstein, M., 1989. "A guide to target zones," NBER Working Papers 2113, National Bureau of Economic Research, Inc.
- Hondroyiannis, G., Swamy, P. and Ulan, M., 2005. "Some further evidence on exchange-rate volatility and exports," Working Paper No.28, Bank of Greece
- Kenen, P. and Rodrik, D., 1986. "Measuring and analyzing the effects of short-term volatility in real exchange rates," *The Review of Economics and Statistics*, Vol.68, pp.311-15
- Kikuchi, T., 2004. *The impact of exchange rate volatility on bilateral exports in East Asian countries*, Graduate School of Systems and Information Engineering, University of Tsukuba, Thailand
- Kiptoo, C., 2007. *Real exchange rate volatility, and misalignment in Kenya, 1993-2003, Assessment of its impact on International Trade, and investments*, unpublished Ph.D thesis, University of Nairobi
- Kiyota, K. and Urata, S., 2004. "Exchange rate, exchange rate volatility and foreign direct investment," *The World Economy*, Wiley Blackwell, Vol.27(10), pp.1501-536
- Lothian, J. and Taylor, M., 1997. "Real exchange rate behavior," *Journal of International Money and Finance*, Vol.116, No.6, pp.945-54
- McKinnon, R. and Ohno, K., 1997. *Dollar and Yen, resolving economic conflict between the United States and Japan*, Cambridge, MA, USA: MIT Press
- Ndung'u, N., 2001. "Liberalization of the foreign exchange market in Kenya and short term capital flows problem," AERC, Research Paper No.109, Nairobi, Kenya
- Ndung'u, N., 1995. "Price and exchange rate dynamics in Kenya: An empirical investigation (1970-1993)," African Economic Research Consortium (AERC) Discussion Paper, No.58, Nairobi Kenya
- Ndung'u, N., 1999. "Monetary and exchange rate policy in Kenya," AERC Research Paper, No.94, Nairobi, Kenya
- Pickard, J., 2003. *Exchange rate volatility and bilateral trade flows, ana analysis of U.S. Demand for certain steel products from Canada and Mexico*, Thesis submitted to faculty of the Polytechnic Institute and State University impartial Fulfillment of the requirements for the Degree of Master of Arts in Economics
- Serven, L., 2002. *Real exchange rate uncertainty and private investment, in developing countries*, Forthcoming, *Review of Economics and Statistics*, The World Bank, Washington D.C., USA
- Sifunjo, E. Kisaka, 2011. *Chaos and non-linear dynamical approaches to predicting exchange rates in Kenya*, Unpublished Ph.D Thesis, University of Nairobi
- Siregar, R. and Rajan, R., 2004. "Impact of exchange rate volatility on Indonesia's trade performance in the 1990s," *Journal of the Japanese and International Economies*, Vol.18, pp.218-40
- Were, M., Geda, A., Karingi, S. and Njuguna, S., 2001. "Kenya's exchange rate movement in a liberalised environment: An empirical analysis," The Kenya Institute for Public Policy Research and Analysis (KIPPRA), Discussion paper Series No.10, Nairobi, Kenya
- Williamson, J., 1985. *The exchange rate system*, revised edition, Washington, D.C.: Institute for International Economics

## Appendix

TABLE 1. GARCH ESTIMATION OF RER VOLATILITY (DEPENDENT VARIABLE: LNRER)

| Dependent Variable: RER                             |             |                         |             |          |
|---|-------------|-------------------------|-------------|----------|
| Method: ML - ARCH (Marquardt) - Normal distribution |             |                         |             |          |
| Date: 09/21/11 Time: 11:53                          |             |                         |             |          |
| Sample: 1993M01 2009M12                             |             |                         |             |          |
| Included observations: 204                          |             |                         |             |          |
| Convergence achieved after 33 iterations            |             |                         |             |          |
| Presample variance: backcast (parameter = 0.7)      |             |                         |             |          |
| GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)    |             |                         |             |          |
| Variable  | Coefficient | Std. Error              | z-Statistic | Prob.    |
| C   | 39172.50    | 90547.53                | 0.432618    | 0.6653   |
| Variance Equation                                   |             |                         |             |          |
| C   | 3.35E+11    | 1.98E+10                | 16.89336    | 0.0000   |
| RESID(-1)^2   | 0.818655    | 0.363499                | 2.252151    | 0.0243   |
| GARCH(-1)   | -0.046961   | 0.039906                | -1.176791   | 0.2393   |
| R-squared   | 0.057691    | Mean dependent variance |             | 211632.3 |
| Adjusted R-squared                                  | 0.057691    | S.D. dependent variance |             | 719782.2 |
| S.E. of regression                                  | 740253.6    | Akaike info criterion   |             | 29.21426 |
| Sum squared residual                                | 1.11E+14    | Schwarz criterion       |             | 29.27933 |
| Log likelihood                                      | -2975.855   | Hannan-Quinn criteria.  |             | 29.24058 |
| Durbin-Watson stat                                  | 0.562470    |                         |             |          |

FIGURE 3. GARCH BASED RER VOLATILITY

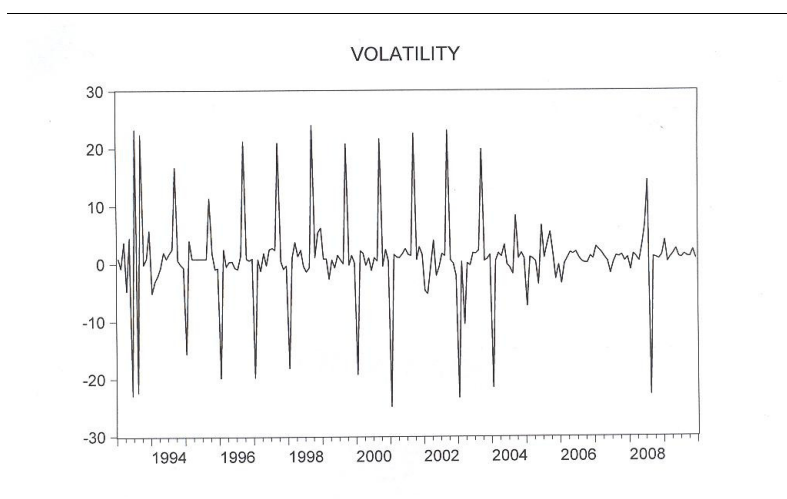


TABLE 2. DESCRIPTIVE STATISTICS OF ECONOMIC GROWTH MODEL

|              | GROWTH   | GOVT     | CAPITA   | HEALTH   | PRI       | SEC       | VOL       |
|--------------|----------|----------|----------|----------|-----------|-----------|-----------|
| Mean         | 0.011765 | 20.44560 | 486.2941 | 50.70588 | 43.15262  | 27.95924  | 3.176710  |
| Median       | 0.000000 | 18.05942 | 438.0000 | 51.00000 | 62.42384  | 39.25363  | 0.810246  |
| Maximum      | 0.200000 | 79.57454 | 773.0000 | 82.00000 | 85.69088  | 59.46480  | 41.07310  |
| Minimum      | 0.000000 | 1.484199 | 276.0000 | 28.00000 | 0.000000  | 0.000000  | -0.482978 |
| Std. Dev.    | 0.048507 | 15.80351 | 142.0426 | 17.50987 | 37.75703  | 24.74450  | 9.789075  |
| Skewness     | 3.750000 | 3.253762 | 0.880362 | 0.315993 | -0.273533 | -0.202710 | 3.719558  |
| Kurtosis     | 15.06250 | 13.15382 | 2.725836 | 1.938375 | 1.181744  | 1.245856  | 14.92090  |
| Jarque-Bera  | 142.9090 | 103.0256 | 2.249180 | 1.081238 | 2.553780  | 2.295983  | 139.8592  |
| Probability  | 0.000000 | 0.000000 | 0.324786 | 0.582388 | 0.278903  | 0.317273  | 0.000000  |
| Sum          | 0.200000 | 347.5752 | 8267.000 | 862.0000 | 733.5946  | 475.3071  | 54.00406  |
| Sum Sq. Dev. | 0.037647 | 3996.017 | 322817.5 | 4905.529 | 22809.50  | 9796.642  | 1533.216  |
| Observations | 17       | 17       | 17       | 17       | 17        | 17        | 17        |

TABLE 3. UNIT ROOT TEST FOR STATIONARITY - GMM

| Results of Unit Root Tests of variables employed in growth model |  |             |                  |                     |                       |                   |
|--|--|-------------|------------------|---------------------|-----------------------|-------------------|
| Variable   | Type of Test/Level of Test                         | Lag Length* | Calculated Value | Test Critical Value | Level Significance ** | Order Integration |
| CAPITA   | ADF Test Statistic at Levels, without trend        | 1           | -1.149831        | -3.081002           | 5% critical value     | 1(0)              |
|  | ADF Test statistic at 1st difference without trend | 3           | -2.883398        | -2.713751           | 10% Critical Value    | 1(1)              |
|  | ADF Test Statistic at levels with trend.           | 3           | -3.960369        | -4.886426           | 1% Critical Value     | 1(0)              |
|  | ADF Test Statistic at 1st difference with trend    | 3           | -1.982425        | -4.992279           | 1% Critical Value     | 1(1)              |
|  | PP Test statistic at levels without trend          | 2           | -0.540206        | -3.065585           | 5% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 0           | -1.986004        | -3.959148           | 1% Critical Value     | 1(1)              |
|  | PP Test Statistics at levels with trend            | 2           | 1.370587         | -3.733200           | 5% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    | 1           | -1.913664        | -4.728363           | 1% Critical Value     | 1(1)              |
| GOVT   | ADF Test Statistic at Levels, without trend        | 0           | -3.812873        | -3.920350           | 1% Critical Value     | 1(0)              |
|  | ADF Test statistic at 1st difference without trend | 0           | -6.232786        | -3.081002           | 5% Critical Value     | 1(1)              |
|  | ADF Test Statistic at levels with trend.           | 0           | -3.699668        | -4.667883           | 1% Critical Value     | 1(0)              |
|  | ADF Test Statistic at 1st difference with trend    | 0           | -6.021141        | -3.324976           | 10% Critical Value    | 1(1)              |
|  | PP Test statistic at levels without trend          | 0           | -3.812123        | -3.920350           | 1% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 14          | -13.46300        | -3.959148           | 10% Critical Value    | 1(1)              |
|  | PP Test Statistics at levels with trend            | 1           | -3.699034        | -3.733200           | 5% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    | 14          | -15.12411        | -4.728363           | 1% Critical Value     | 1(1)              |

TABLE 3. UNIT ROOT TEST FOR STATIONARITY - GMM

| Results of Unit Root Tests of variables employed in growth model |  |             |                  |                     |                       |                   |
|--|--|-------------|------------------|---------------------|-----------------------|-------------------|
| Variable   | Type of Test/Level of Test                         | Lag Length* | Calculated Value | Test Critical Value | Level Significance ** | Order Integration |
| HEALTH   | ADF Test Statistic at Levels, without trend        | 2           | -0.976350        | -4.004425           | 1% Critical Value     | 1(0)              |
|  | ADF Test statistic at 1st difference without trend | 2           | -3.225762        | -3.119910           | 5% Critical Value     | 1(1)              |
|  | ADF Test Statistic at levels with trend.           | 1           | -3.643737        | -4.728363           | 1% Critical Value     | 1(0)              |
|  | ADF Test Statistic at 1st difference with trend    | 2           | -3.259164        | -3.362984           | 10% Critical Value    | 1(1)              |
|  | PP Test statistic at levels without trend          | 5           | -1.895714        | -3.920350           | 1% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 5           | -2.358690        | -2.681330           | 10% Critical Value    | 1(1)              |
|  | PP Test Statistics at levels with trend            | 4           | -1.343061        | -3.733200           | 5% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    | 7           | -2.682282        | -3.324976           | 10% Critical Value    | 1(1)              |
| PRI  | ADF Test Statistic at Levels, without trend        | 2           | 0.727087         | -2.690439           | 10% Critical Value    | 1(0)              |
|  | ADF Test statistic at 1st difference without trend | 1           | 5.513368         | -4.004425           | 1% Critical Value     | 1(1)              |
|  | ADF Test Statistic at levels with trend.           | 1           | -4.263334        | -4.728363           | 1% Critical Value     | 1(0)              |
|  | ADF Test Statistic at 1st difference with trend    | 1           | -5.266088        | -3.791172           | 5% Critical Value     | 1(1)              |
|  | PP Test statistic at levels without trend          | 15          | -1.74208         | -3.920350           | 1% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 8           | -8.535038        | -3.959148           | 1% Critical Value     | 1(1)              |
|  | PP Test Statistics at levels with trend            | 15          | -5.910484        | -4.667883           | 1% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    |             |                  |                     |                       |                   |
| SEC  | ADF Test Statistic at Levels, without trend        | 2           | -0.505939        | -2.690439           | 10% Critical Value    | 1(0)              |
|  | ADF Test statistic at 1st difference without trend | 1           | -5.351138        | -4.004425           | 1% Critical Value     | 1(1)              |
|  | ADF Test Statistic at levels with trend.           | 1           | -4.443426        | -4.728363           | 1% Critical Value     | 1(0)              |
|  | ADF Test Statistic at 1st difference with trend    | 1           | -5.096970        | -3.342253           | 10% Critical Value    | 1(1)              |
|  | PP Test statistic at levels without trend          | 15          | -0.911743        | -3.065585           | 5% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 8           | -10.44534        | -3.081002           | 5% Critical Value     | 1(1)              |
|  | PP Test Statistics at levels with trend            | 14          | -7.875888        | -4.667883           | 1% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    | 8           | -9.769806        | -4.728363           | 1% Critical Value     | 1(1)              |
| TOT  | ADF Test Statistic at Levels, without trend        | 0           | -2.38862         | -2.673459           | 10% Critical Value    | 1(0)              |
|  | ADF Test statistic at 1st difference without trend | 1           | -4.784952        | -3.081002           | 5% Critical Value     | 1(1)              |
|  | ADF Test Statistic at levels with trend.           | 1           | -1.981264        | -4.667883           | 1% Critical Value     | 1(0)              |
|  | ADF Test Statistic at 1st difference with trend    | 3           | -3.168480        | -3.388330           | 10% Critical Value    | 1(1)              |
|  | PP Test statistic at levels without trend          | 0           | 0.238862         | -3.920350           | 1% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 1           | -4.734753        | -2.681330           | 10% Critical Value    | 1(1)              |
|  |  |             |                  |                     |                       |                   |

TABLE 3. UNIT ROOT TEST FOR STATIONARITY - GMM

| Results of Unit Root Tests of variables employed in growth model |  |             |                  |                     |                       |                   |
|--|--|-------------|------------------|---------------------|-----------------------|-------------------|
| Variable   | Type of Test/Level of Test                         | Lag Length* | Calculated Value | Test Critical Value | Level Significance ** | Order Integration |
|  | PP Test Statistics at levels with trend            | 0           | -1.981264        | -3.733200           | 5% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    | 2           | -4.797961        | -4.728363           | 1% Critical Value     | 1(1)              |
| VOL  | ADF Test Statistic at Levels, without trend        | 3           | -3.2245152       | -4.057910           | 1% Critical Value     | 1(0)              |
|  | ADF Test statistic at 1st difference without trend | 3           | -2.222445        | -2.713751           | 10% Critical Value    | 1(1)              |
|  | ADF Test Statistic at levels with trend.           | 3           | -3.113537        | -3.362984           | 10% Critical Value    | 1(0)              |
|  | ADF Test Statistic at 1st difference with trend    |             |                  |                     |                       |                   |
|  | PP Test statistic at levels without trend          | 1           | -4.040725        | -3.920350           | 1% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 14          | -14.72717        | -3.959148           | 1% Critical Value     | 1(1)              |
|  | PP Test Statistics at levels with trend            | 6           | -5.064456        | -4.667883           | 1% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    | 14          | -13.90660        | -3.759743           | 5% Critical Value     | 1(1)              |
| MISA   | ADF Test Statistic at Levels, without trend        | 3           | -1406928         | -2.701103           | 10% Critical Value    | 1(0)              |
|  | ADF Test statistic at 1st difference without trend |             |                  |                     |                       |                   |
|  | ADF Test Statistic at levels with trend.           |             |                  |                     |                       |                   |
|  | ADF Test Statistic at 1st difference with trend    |             |                  |                     |                       |                   |
|  | PP Test statistic at levels without trend          | 5           | -2.311852        | -3.065585           | 5% Critical Value     | 1(0)              |
|  | PP Test statistic at 1st difference without trend  | 14          | -7.452703        | -2.681350           | 10% Critical Value    | 1(1)              |
|  | PP Test Statistics at levels with trend            | 14          | -5.239709        | -4.667883           | 1% Critical Value     | 1(0)              |
|  | PP Test Statistic at 1st difference, with trend    |             |                  |                     |                       |                   |

\*General automatically through use of Schwarz Info Criterion (SIC) based on a maximum lag length of 14

\*\* based on MacKinnon (1996) one-sided p-values.



TABLE 4. ESTIMATION OF ECONOMIC GROWTH MODEL

| Dependent Variable: GROWTH   |             |                    |             |          |
|--|-------------|--------------------|-------------|----------|
| Method: Generalized Method of Moments  |             |                    |             |          |
| Date: 10/04/11 Time: 12:51   |             |                    |             |          |
| Sample: 1993 2009  |             |                    |             |          |
| Included observations: 17  |             |                    |             |          |
| Linear estimation with 3 weight updates  |             |                    |             |          |
| Estimation weighting matrix: HAC (Bartlett kernel, Newey-West fixed<br>bandwidth = 3.0000) |             |                    |             |          |
| Standard errors & covariance computed using estimation weighting matrix                    |             |                    |             |          |
| Instrument specification: GOVT CAPITA HEALTH PRI SEC TOT VOL                               |             |                    |             |          |
| Constant added to instrument list  |             |                    |             |          |
| Variable   | Coefficient | Std. Error         | t-Statistic | Prob.    |
| GOVT   | -0.483      | 0.000314           | -1.536240   | 0.1555   |
| CAPITA   | 8.41E-03    | 8.69E-05           | 0.096813    | 0.9248   |
| HEALTH   | 0.618       | 0.000815           | 0.758922    | 0.4654   |
| PRI  | -0.5710     | 0.003621           | -1.576635   | 0.1460   |
| SEC  | 9.039       | 0.005732           | 1.577033    | 0.1459   |
| TOT  | -11.437     | 0.022997           | -0.497324   | 0.6297   |
| VOL  | -0.348      | 0.000412           | 0.845140    | 0.4178   |
| R-squared  | 0.420154    | Mean dependent var |             | 0.011765 |
| Adjusted R-squared   | 0.072247    | S.D. dependent var |             | 0.048507 |
| S.E. of regression   | 0.046722    | Sum squared resid  |             | 0.021829 |
| Durbin-Watson stat   | 2.144265    | J-statistic        |             | 0.766837 |
| Instrument rank  | 8           | Prob(J-statistic)  |             | 0.381197 |

TABLE 5. ESTIMATION OF ECONOMIC GROWTH MODEL

Dependent Variable: GROWTH  
 Method: Generalized Method of Moments  
 Date: 10/16/11 Time: 22:48  
 Sample: 1993 2009  
 Included observations: 17  
 Linear estimation with 3 weight updates  
 Estimation weighting matrix: HAC (Bartlett kernel, Newey-West fixed  
 bandwidth = 3.0000)  
 Standard errors & covariance computed using estimation weighting matrix  
 Instrument specification: GOVT CAPITA HEALTH PRI SEC TOT  
 Constant added to instrument list

| Variable           | Coefficient | Std. Error         | t-Statistic | Prob.    |
|--------------------|-------------|--------------------|-------------|----------|
| GOVT               | 0.539       | 0.000298           | -1.806386   | 0.0983   |
| CAPITA             | -4.20E-04   | 0.000123           | -0.340737   | 0.7397   |
| HEALTH             | 0.867       | 0.000901           | 0.962582    | 0.3564   |
| PRI                | -6.116      | 0.003321           | -1.841724   | 0.0926   |
| SEC                | 9.681       | 0.005307           | 1.824333    | 0.0954   |
| TOT                | -3.723      | 0.020686           | -0.179965   | 0.8605   |
| R-squared          | 0.421403    | Mean dependent var |             | 0.011765 |
| Adjusted R-squared | 0.158405    | S.D. dependent var |             | 0.048507 |
| S.E. of regression | 0.044500    | Sum squared resid  |             | 0.021782 |
| Durbin-Watson stat | 2.340381    | J-statistic        |             | 0.163588 |
| Instrument rank    | 7           | Prob(J-statistic)  |             | 0.685874 |