INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, ECONOMICS & MANAGEMENT

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   REVIEW OF LITERATURE

   NEED/IMPORTANCE OF THE STUDY

   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

   ACKNOWLEDGMENTS

   REFERENCES

   APPENDIX/ANNEXURE

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CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

CONFERENCE PAPERS

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

UNPUBLISHED DISSERTATIONS AND THESES

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

CAUSES AND CONSEQUENCES OF HETEROSKEDASTICITY IN TIME SERIES

DR. FREDRICK ONYEBUCHI ASOGWA
DEPARTMENT OF ECONOMICS
UNIVERSITY OF NIGERIA
NSUKKA

AMBROSE NNAEMEKA OMEJE
RESEARCH SCHOLAR
DEPARTMENT OF ECONOMICS
UNIVERSITY OF NIGERIA
NSUKKA

ABSTRACT

A univariate stochastic process X is said to be heteroskedastic if the standard deviations of X_t are not constant for all times, t. When heteroskedasticity takes place, ordinary least squares (OLS) estimators ($\beta_i^{'s}$) remain unbiased, but have no minimum variance among all linear unbiased estimators. In correcting this, the omitted variable(s) should be checked and if the model is well specified then solutions such as the Weighted Least Squares (WLS) or the White's Heteroskedasticity-Consistent Standard Errors (HCSE) should be considered. This paper examined the causes and the consequences of heteroskedasticity and determined the nature of some selected macroeconomic variables in Nigeria. White's heteroskedasticity test was employed and the results show that the error term of some of the Nigerian macroeconomic variables are homoskedastic.

KEYWORDS
Econometrics, Estimators, Heteroskedasticity, macroeconomic.

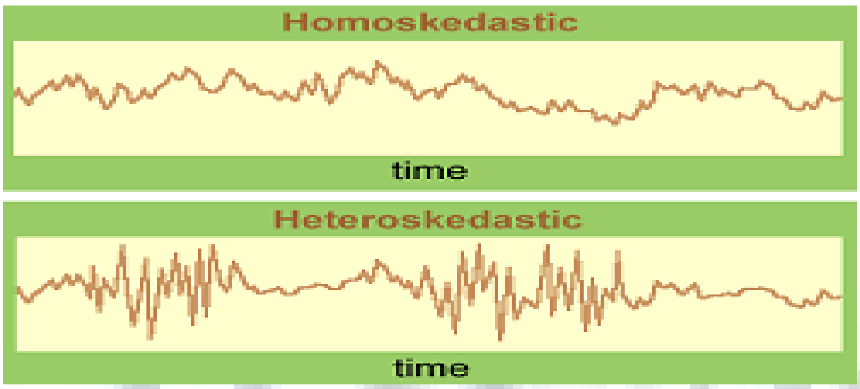
INTRODUCTION

Heteroskedasticity refers to unequal variance in the regression errors. Regression disturbances whose variances are not constant across observations are heteroskedastic (Greene, 2002). This makes ordinary least-squares estimates inefficient. Heteroskedasticity arises more in cross-country than in country specific data. Generally, empirical research in macroeconomics as well as in financial economics is largely based on time series and as a result, heteroskedasticity in these areas are more common. It occurs in country specific studies if the quality of data collection changes dramatically within the sample, or where there is a model specification error. It arises in a variety of ways and a number of tests have been proposed.

The classical statistical assumptions underlying econometric analysis refer to a set of requirements that need to hold in order for ordinary least squares (OLS) to yield the "best" estimator available for regression models. Heteroskedasticity violates the classical assumption that observations of the error term are drawn from a distribution that has a constant variance (Homoskedasticity) (Gujarati, 2004). Homoskedasticity is not always realistic, because the larger the independent variable, the larger the variance of the associated disturbance.

Therefore, a univariate stochastic process X is said to be homoskedastic if the standard deviations of terms X_t are constant for all times, *t*. Otherwise, it is said to be heteroskedastic. This is illustrated with realizations of two stochastic processes in figure 1 given below.

FIGURE 1: HOMOSKEDASTIC VS HETEROSKEDASTIC EXHIBIT



Indicated above are the realizations of two processes in which the first exhibits homoskedasticity and the second exhibits heteroskedasticity.

CONSEQUENCES OF HETEROSKEDASTICITY

When the violation of homoskedasticity takes place, ordinary least squares (OLS) estimation of regression coefficients ($\beta_i^{'s}$) remain unbiased, but they are no longer efficient or have minimum variance among all linear unbiased estimators. There are cases where OLS can be BLUE despite the presence of heteroskedasticity, but such cases are not often seen in practice (Gujarati, 2004).

Heteroskedasticity causes OLS to tend to underestimate the variances (and standard errors) of the coefficients. As a result, tests of statistical significance, such as the t-statistic and the F-statistic, cannot be relied upon in face of uncorrected heteroskedasticity, hence, leading to erroneous conclusions. In practice OLS usually turns up with higher t-scores than would be obtained if the error terms were homoskedastic, leading researchers to reject null hypotheses that should have been accepted.

METHOD OF DETECTING HETEROSKEDASTICITY

Greene (2002) posits that heteroskedasticity, poses potentially severe problems for inferences based on least squares. As a result, one can rarely be certain that the disturbances are heteroskedastic and unfortunately, what form does the heteroskedasticity take if they are. Gujarati (2004) argued that the consequences of heteroskedasticity are easier documented than detecting it. There are several available diagnostic tests, but one cannot exactly tell which one of them works best in a given situation. These tests are done through Visual inspection of residuals plotted against the suspected independent variable, the White's General

Heteroskedasticity test, the Goldfeld-Quandt test, the Breusch-Pagan-Godfrey (BPG) test, the Glejser test, the Park test, the Koenker-Bassett (KB) test, and the Spearman's Rank Correlation test of heteroskadasticity.

Majority of these tests use the residuals of an equation to test for the possibility of heteroskedasticity in the error terms. The above mentioned techniques of detecting heteroscedasticity are faced with the problem of computational cost (Maximum Likelihood technique) or the identification of a proper value for the best possible form of heteroskedasticity (Park test).

CORRECTION OF HETEROSKEDASTICITY

In an attempt to correct heteroskedasticity, the first thing to do is to check for omitted variable(s) that might have caused impure heteroskedasticity. If the specification is as good as possible, then solutions such as the Weighted Least Squares (WLS) or the White's Heteroskedasticity-Consistent Standard Errors (HCSE) should be considered as the next option. The WLS involves dividing the main equation by whatever will make the error term homoskedastic and then re-running the regression on the transformed variables. A disadvantage of this method is on how to identify the proportionality factor. The HCSE is the most popular remedy for heteroskedasticity, and it takes a completely different approach to the problem. HCSE focuses on improving the standard errors of the coefficients without altering the parameter estimates. The disadvantages of this technique are that it works best on large samples, and not all computer regression software packages calculate HCSE. However, the White's General Heteroskedasticity test is prominent these days.

LITERATURE REVIEW

This is divided into two parts; the theoretical and empirical literature.

THEORETICAL LITERATURE

(I) THE CLASSICAL VIEW

The classical statistical assumptions underlying econometric analysis refer to a set of requirements that need to hold in order for ordinary least squares (OLS) to yield the "best" estimators available for regression models (Studenmund 2008). However, the classical views are of the opinion that observations of the error term are homoskedastic. The fact remains that heteroskedasticity violates the classical assumption that observations of the error term are drawn from a distribution that has a constant variance. In fact, homoskedasticity is not always realistic, because the larger an independent variable, the larger the variance of the associated disturbance.

(II) A NEW ASYMPTOTIC THEORY FOR HETEROSKEDASTICITY-AUTOCORRELATION ROBUST TESTS

Kiefer and Vogelsang (2000) in their Asymptotic theory of heteroskedasticity autocorrelation consistent (HAC) covariance matrix estimators involve a fictitious promise that the researcher will, eventually, ignore potentially relevant information in the data.

Kiefer and Vogelsang (2005) provided a new and improved approach to the asymptotic of hypothesis testing in time series models with arbitrary serial correlation and heteroskedasticity. Heteroskedasticity and autocorrelation consistent (HAC) estimation and testing in models involves calculating an estimate of the spectral density at zero frequency of the estimating equations. Important contributions to the development of these techniques include White (1984), Newey and West (1987), Gallant (1987), Gallant and White (1988), Andrews (1991), Andrews and Monahan (1992), Hansen (1992), Robinson (1998) and De Jong and Davidson (2000). Conventional asymptotic theory for HAC estimators is well established and has proved useful in providing practical formulas for estimating asymptotic variances. The ingenious trick is the assumption that the variance estimator depends on a fraction of sample autocovariances, with the number of sample autocovariances going to infinity, but the fraction going to zero as the sample size grows. Under this condition it has been shown that well-known HAC estimators of the asymptotic variance are consistent. Then, the asymptotic distribution of estimated coefficients can essentially be derived assuming the variance is known. That is, sampling variance of the variance estimator does not appear in the first order asymptotic distribution theory of test statistics regarding parameters of interest. While this is an extremely productive simplifying assumption that leads to standard asymptotic distribution theory for tests, the accuracy of the resulting asymptotic theory if often less than satisfactory.

EMPIRICAL LITERATURE

Some studies verified heteroskedasticity by using the ARCH and/or GARCH models. Julio and Ruiz (2005) confirmed that traditional tests for conditional heteroscedasticity are based on testing for significant autocorrelations of squared or absolute observations. In the context of high frequency time series of financial returns, these autocorrelations are often positive and very persistent, although their magnitude is usually very small. Moreover, the sample autocorrelations are severely biased towards zero, especially if the volatility is highly persistent. Consequently, the power of the traditional tests is often very low. In their paper, they proposed a new test that takes into account not only the magnitude of the sample autocorrelations but also possible patterns among them. This additional information makes the test more powerful in situations of empirical interest. The asymptotic distribution of the new statistic is derived and its finite sample properties are analyzed by means of Monte Carlo experiments. The performance of the new test is compared with various alternative tests. Finally, they illustrated the results by analyzing several time series of financial returns.

The interest toward the classification of time series has recently received a lot of contributions. Most of these studies were devoted to capture the structure of the mean of the process hypothesized as generator of the data, whereas little attention had been devoted to the variance (Otranto 2009). When dealing with heteroskedastic time series, in especially a GARCH process, the comparison of the dynamics of the variances is fundamental. In their paper clustering procedure based on simple statistical tools was proposed. They also considered the squared disturbances of the returns of a financial time series as a measure of the volatility of the series. The GARCH representation of the conditional variance was used to derive the model underlying the squared disturbances. They classified the series with similar unconditional volatility, similar time-varying volatility and similar volatility structure, using classical Wald statistics.

Kumar and Dhankar (2010) analyzed the relationship between stock returns and conditional volatility, and standard residuals. The study applied GARCH (1, 1) and T-GARCH (1, 1) to examine the heteroskedasticity and the asymmetric nature of stock returns respectively. They found saw heteroskedasticity as that which has effect on the nature of stock returns asymmetrically. In their further analysis, their study reported a negative significant relationship between stock returns and conditional volatility but, the relationship between stock returns and standardized residuals is found to be significant. Their findings reveal that investors adjust their investment decisions with regard to expected volatility and hence, expect extra risk premium for unexpected volatility.

The distribution of speculative price changes and rates of return data tend to be uncorrelated over time but are characterized by volatile and tranquil periods (Bollerslev 1987). The study used a simple time series model. The model is an extension of the Autoregressive Conditional Heteroskedastic (ARCH) and Generalized ARCH (GARCH) models obtained by allowing for conditionally t-distributed errors. The study reveals that the model can be derived as a simple subordinate stochastic process by including an additive unobservable error term in the conditional variance equation.

Bera and Higgins (1990) while testing for conditional heteroskedasticity and nonlinearity, found that the power of the test in general depends on the functional forms of conditional heteroskedasticity and nonlinearity that are allowed under the alternative hypothesis. In their paper, they suggested a test for conditional heteroskedasticity and nonlinearity with the nonlinear autoregressive conditional heteroskedasticity (NARCH) model of Higgins and Bera (1989) as the nonlinear ARCH parameter is not identified under the null hypothesis. To resolve this problem, they applied the procedure proposed by Davies (1987). Power and size of the suggested test were investigated through simulation and an empirical application of testing for ARCH in exchange rates.

Hsiao and QiLi (2001) showed that the standard consistent test for testing the null of conditional homoskedasticity (against conditional heteroskedasticity) can be generalized to a time-series regression model with weakly dependent data and with generated regressors. The test statistic of the study showed an asymptotic normal distribution under the null hypothesis of conditional homoskedasticity error. Extending their test, they discussed the case of testing the null of a parametrically specified conditional variance and a bootstrap method was advocated by the study to overcome the issue of slow convergence of this test to its limiting distribution.

Pooter and Dijk (2004) considered tests for sudden changes in the unconditional volatility of conditionally heteroskedastic time series based on cumulative sums of squares.

They showed that when it is applied to the original series, these tests suffered from severe size distortions and the correct null hypothesis of no volatility change is rejected too frequently. More so, applying the tests to standardized residuals from an estimated GARCH model resulted in good size and reasonable power properties when a single break in the variance is tested for. The tests also appear to be robust to different types of misspecification. Further, the study designed an iterative algorithm to test sequentially for the presence of multiple changes in volatility and applying this to emerging markets stock returns illustrates vividly the properties of the different test statistics.
Some studies also verified heteroskedasticity by using the Two-Stage Least Squares estimation method.
Olea and Pflueger (2011) developd a pre-test for weak instruments in linear instrumental variable regression that is robust to heteroskedasticity and autocorrelation. The test statistic of their results showed a scaled version of the regular first-stage F statistic. Moreover, the critical values depend on the long-run variance-covariance matrix of the first stage and can be examined numerically. Here, the test controls the bias of the Two-Stage Least Squares estimator relative to a worst-case bias. They applied their pre-test to the instrumental variable estimation of the Elasticity of Intertemporal Substitution and found that instruments previously considered are not weak and do not exceed their threshold.
Some studies also applied their results to regression setting with dependent heteroskedastic errors.
Politis, Romano and Wolf (1996) in their article, Subsampling for heteroskedastic time series, presented a general theory for the construction of confidence intervals or regions in the context of heteroskedastic-dependent data. Their basic idea is to approximate the sampling distribution of a statistic based on the values of the statistic computed over smaller subsets of the data. Their results were extended to heteroskedastic observations. A general asymptotic validity result under minimal conditions was proved. In contrast, the usual bootstrap and moving blocks bootstrap are typically valid only for asymptotically linear statistics and their justification requires a case-by-case analysis. Their general asymptotic results are applied to a regression setting with dependent heteroskedastic errors.

IMPORTANCE OF THE STUDY
This will help researchers interested in time series to actually know whether in time series regression, heteroskedasticity can arise either because of structural change, cross country data (due to different data generating processes) or as a result of false omission of relevant variables in the regression.

STATEMENT OF THE PROBLEM
The problem of heteroskedasticity has posed a great problem to researchers especially; those that use time series data. The frequently asked questions are; Do the presence of heteroskedasticity in time series alter its results in research? Does the presence of heteroskedasticity affect the conclusion of the research?
Trimbur (2006) in his work tutled "Seasonal heteroskedasticity in time series data:modelling, estimation, and testing", affirmed that seasonal heteroskedasticity exists in a number of monthly time series from major statistical agencies and accounting for such systematic variation in calendar month effects movements in underlying trend.
Many econometric models underline the assumptions of constant variance of residuals over a period of time. But a number of empirical studies question this assumption and hold the presence of auto-correlation in time series data (Kumar and Dhankar (2010), Faff and Mckenzie 2007; Karmakar 2005; Kumar and Dhankar 2009; Morgan 1976; Sentana and Wadhwani 1992; Watanable 2002). The presence of autocorrelation in time series data signifies the non-normality of the error term, called heteroskedasticity.
Julio and Esther (2005) maintained that Traditional tests for conditional heteroscedasticity are based on testing for significant autocorrelations of squared or absolute observations. In the context of high frequency time series of financial returns, these autocorrelations are often positive and very persistent, although their magnitude is usually very small. Moreover, the sample autocorrelations are severely biased towards zero, especially if the volatility is highly persistent.
Engle (1982) confirmed that it is often argued that many economic time series, particularly financial time series, are conditionally heteroskedastic: these series seem to display persistent periods of unusually high (or low) volatility (even though the level of series might be serially uncorrelated).
Edoardo (2009) quoting (Piccolo, 2007) opined that the interest toward the classification of time series has recently received a lot of contributions and that most of these studies are devoted to capturing the structure of the mean of the process hypothesized as generator of the data, whereas little attention has been devoted to the variance. As a result of this, he suggests that while dealing with heteroskedastic time series, in which the (conditional) variance follows a stochastic process (typically a GARCH process), the comparison of the dynamics of the variances is fundamental.

OBJECTIVES OF THE STUDY
The principal objective of this study is to analyse heteroskedastic in selected time series data in Nigeria.
Specific objectives are:
- To explain the causes of heteroskedasticity.
- To explain the consequences of heteroskedasticity.
- To determine if Nigerian data are homoscedastic

STATEMENT OF HYPOTHESIS
- Heteroskedasticity has no specific cause.
- The consequences of heteroskedasticity cannot be determined
- Nigerian data are not homoscedastic

METHODOLOGY
Heteroskedasticity poses potentially severe problems for inferences based on least squares. One can rarely be certain that the disturbances are heteroskedastic hence, unfortunately, what form the heteroskedasticity takes if they are. As a result, it is useful to be able to test for homoskedasticity and if necessary, modify the estimation procedures accordingly. However, tests designed to detect heteroskedasticity will, in most cases, be applied to the Ordinary Least Squares (OLS) residuals.
The application of more appropriate technique requires a detailed formulation of scale factor, Ω. However, it may well be that the form of the heteroskedasticity is unknown. White (1980) showed that it is possible to obtain an appropriate estimator for the variance of least squares estimator even if the heteroskedasticity is related to the variables in X by giving the equation bellow:

Est. Asy. Var[b] = $$\frac{1}{n}\left(\frac{X'X}{n}\right)^{-1}\left(\frac{1}{n}\sum_{i=1}^{n} e_i^2 X_i X_i'\right)\left(\frac{X'X}{n}\right)^{-1} \quad \text{.. (1)}$$

Therefore, following white (1980b), the White's General Heteroskedasticity test was employed in this study. To formulate some of the available test, it is vital we specify the nature of the heteroskedasticity. Hence, the general hypothesis is of the form:

$H_0: \sigma^2 = \sigma^2 \; \forall_i$

$H_1: \sigma^2 \neq H_0$

In view of this, White's covariance matrix for least squares estimator is given as:

$Var[b/X]^{-1} = \sigma^2 [X'X]^{-1} [X'\Omega X][X'X]^{-1}$ ....(2)

The conventional estimator is given as:

$V = S^2[X'X]^{-1}$ ....(3)

If there is no heteroskedasticity, then equation (3) will give a consistent estimator of Var[b/X]. But if there exists heteroskedasticity, it will not give consistent estimator of Var[b/X]. A statistical test was devised by White based on this observation. A simple operational version of his test was carried out by obtaining **nR^2** in the regression of e^2_i on a constant and all unique variables contained in X and all the squares and cross products of the variables in X. The statistic is asymptotically distributed as chi-squared with n-1 degrees of freedom. Where n is the number of regressors in the equation, including the constant term.

Greene (2002) opined that White test is extremely general. .Hence, to carry it out, certain assumptions about the nature of the heteroskedasticity have to be made. Though this feature is a virtue, it is at the same time, a potential serious shortcoming.

EMPIRICAL FINDINGS USING NIGERIAN DATA

To illustrate the White's approach to heteroscedasticity, Nigeria's annual data on Gross Domestic Product (GDP), Consumer Price Index (CPI), Exchange Rate (EXCHR), Interest (INT) and Savings were used.

White's heteroskedasticity test was conducted using OLS equation as:

$GDP = \beta_0+\beta_1CPI+\beta_2EXCHR+\beta_3INT+\beta_4SAVINGS+\mu_t$.. (4)

The results of these tests are shown in the appendix. White's heteroskedasticity test was employed to find out if the error term is heteroskedastic. It follows χ^2 (chi-square) distribution with p-1 degrees of freedom. Where p is the number of regressors in the equation, including the constant term. Hence, we have it as follows:

$H_0 : \beta_0 = \beta_1 = \beta_2 = - - - = \beta_8 = 0$ (Homoskedasticity)

$H_1: \beta_0 \neq \beta_1 \neq \beta_2 \neq - - - \neq \beta_8 \neq 0$ (Heteroskedaticity)

Decision Rule: Reject H_0 if $\chi^2_{cal} > \chi^2_{tab}$ and accept it otherwise. Or if $\chi^2_{cal} < \chi^2_{tab}$, accept the null hypothesis (H_0) and reject it otherwise.

$\mu_i = \beta_0+\beta_1CPI+\beta_2CPI\text{^}2 +\beta_3EXCHR+\beta_4EXCHR\text{^}2+\beta_5INT+\beta_6INT\text{^}2+\beta_7SAVINGS+\beta_8SAVINGS\text{^}2+V_t$............ (5)

$\chi^2_{cal} = n.R^2 = 40(0.304271) = 12.17083$,

where

$n = 40$

$R^2 =0.304271$

p-1 degrees of freedom = 9-1 = 8

$\chi^2_{tab}(8) = \chi^2_{0.05} = 15.5073$

Thus, since $\chi^2_{cal}(12.17083) < \chi^2_{0.05}(8)$ (15.5073), we accept the null hypothesis (H_0) and conclude that the error term of some of the Nigerian macroeconomic variables are homoskedastic.

RECOMMENDATION

Based on our findings, researchers interested in time series should know henceforth that heteroskedasticity arises more in cross-country than in country specific data. This has been tested using Nigerian data and the Nigerian data shows no evidence of heteroskedasticity.

CONCLUSION

Applying White's heteroskedaticity test with no cross terms, it was found that there is no evidence of heteroskedasticity. This implies that some of the Nigerian macroeconomic variables (GDP, CPI, EXCHR, INT, and SAVINGS) are homoskedastic. In sum, the regression of equation (4) does not suffer from heteroskedasticity. In conclusion, heteroskedasticity is not correlated with the variables in the model.

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APENDIX

THE WHITE'S HETEROSKEDASTICITY TEST RESULTS

WHITE HETEROSKEDASTICITY TEST

F-statistic	1.694696	Probability	0.139331
Obs*R-squared	12.17083	Probability	0.143743

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 02/26/12 Time: 17:02
Sample: 1970 2009
Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-69166603	3.26E+09	-0.021219	0.9832
CPI	6992297.	62987157	0.111011	0.9123
CPI^2	19663.27	246543.0	0.079756	0.9369
EXCHR	-55918246	86627737	-0.645500	0.5234
EXCHR^2	330810.3	558092.5	0.592752	0.5576
INT	-2.94E+08	6.81E+08	-0.430690	0.6697
INT^2	6739795.	16393620	0.411123	0.6838
SAVINGS	1.30E+09	6.10E+08	2.133773	0.0409
SAVINGS^2	-64529915	27534705	-2.343585	0.0257

R-squared	0.304271	Mean dependent var	1.69E+09
Adjusted R-squared	0.124728	S.D. dependent var	2.55E+09
S.E. of regression	2.38E+09	Akaike info criterion	46.21461
Sum squared resid	1.76E+20	Schwarz criterion	46.59461
Log likelihood	-915.2923	F-statistic	1.694696
Durbin-Watson stat	1.325206	Prob(F-statistic)	0.139331

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