ECONOMETRIC ANALYSIS OF CREDIT AND FARM RESOURCE TECHNICAL EFFICIENCIES' DETERMINANTS IN CASSAVA FARMS IN KOGI STATE, NIGERIA: A DIAGNOSTIC AND STOCHASTIC FRONTIER APROACH

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Abstract

*Against the backdrop of reported low efficiency of cassava production in the world's largest cassava producing country, Nigeria, this study was designed to determine the technical efficiencies of farm credit along with other farm resource inputs in farms within the country's second largest producer of cassava, Kogi State. A stratified random sampling was used to select 174 cassava farmers from two agricultural zones of the state. Results of their responses to the structured questionnaire items administered were analyzed first using a Cobb-Douglas production function to fit the determinants after which coefficients were subjected to White's test for heteroscedasticity, Wald Test and Chow's Break-Point test using E-Views. The farm inefficiencies' levels and sources were determined by the use of stochastic frontier model using Frontier 3.1 software. Farm credit, farm size, chemical fertilizer quantity applied, labour and seedlings planted were significant determinants at 0.05% & 0.01 levels. An increasing return to scale (*4.855*) was confirmed among the farms while the overall technical efficiencies were high (81%). A statistically unstable result was obtained across the two zones studied which could not be ascribed to heteroscedasticity. Need for policy interventions in farm credit access, panel data survey to ascertain sources of variation in the various zones, promotion of use of organic fertilizer while adopting improved varieties and enhanced extension contacts were recommended.*

Key Words: *Cassava, Technical Efficiency, Stochastic Frontier, Cobb-Douglas, Chow's Break-Point test, Wald Test, Nigeria, Kogi State.*

Introduction

Cassava belongs to the family Euphorbiaceae. Two varieties of the cassava are of economic value: the bitter, or poisonous (*Manihot esculenta)*; and the sweet, or nonpoisonous (*Manihot dulcis)*. (Microsoft Encarta Premium, 2009). Cassava is the chief source of tapioca and "garri'; its roots are eaten as food, fed to stock, or used in the manufacture of starch and glucose. The leaves are used as vegetable and source of vitamins, mineral and proteins (Alabi & Alabi, 2002). In Sub Saharan Africa the per capita per kg/year consumption of Cassava is 103, which is far higher than maize (40), banana/plantain (28), sorghum (23), milk (27), meat (11), yam (28) and millet (17) in the same region (IITA, 2004a).

Nigerian cassava production is by far the largest in the world; a third more than production in Brazil and almost double the production of Indonesia and Thailand; its cassava transformation is the most advanced in Africa (IFAD, 2004). The Food and Agriculture Organization of the United Nations (FAO) in Rome (FAO, 2004a) estimated 2002 cassava production in Nigeria to be approximately 34 million tonnes. According to National Fadama Development Project (2009), Kogi State is the second largest producer of cassava in Nigeria with a production figure of 2.854 million metric tonnes. Farmers produce cassava as a source of family food and income here. IITA (2004b) corroborated this ranking by noting that Benue and Kogi state in the North Central Zone are the largest producers of cassava in Nigeria. IFAD (2004) showed that on a per capita basis, North Central is the highest producing state at 0.72 tonnes/per person in 2002, followed by South East (0.56), South-South (0.47), South-West (0.34), North-West (0.10) and North-East (0.01). National per capita production of cassava is 0.32 tonne/per person.

Prior to the pronouncement of the Presidential Initiative on Cassava, there had been several organizations that had contributed to the development and improvements or the cassava commodity (Department of Public Communication, State House, 2006). Nigeria's Presidential Initiative on Cassava Production is one of the strategies of the past Federal Government's National Economic

Empowerment and Development Strategy (NEEDS) whose objective was to generate ₦3 billion from agricultural exports (National Planning Commission, 2005). IITA (2004a) noted that poverty reduction can be attained in Sub-Sahara Africa by improving the technical and economic efficiencies of food production in crops such as cassava. IFAD (2004) showed that the growing demand for cassava which will spur rural industrial development and contribute to the economic development of producing, processing and trading communities and well-being of numerous disadvantaged people in the world, has prompted the development of the Global Cassava Development Strategy. The Strategy suggested that industry analysis in cassava producing countries should be undertaken to indicate current status, strengths, weaknesses and issues for attention and action needed to resolve pressing constraints and take advantage of markets and business opportunities as well as to encompass findings of committed national experts. This study rises up to this demand.

One of the strategies recommended for the successful implementation of the Seven Point Agenda of the current Federal Government led by President Yardua is the need to improve farm productivity and efficiency (Olayemi, 2008). As noted by Abdulai & Teitje (2007), findings from the study of technical efficiency have far-reaching policy implications. The study of technical efficiency has therefore drawn considerable attention from researchers over the past three decades (Hallam and Machado, 1995).

Despite the fact that Kogi State ranks as the second largest cassava producing states in a country that produces the largest output of cassava in the world, research works bordering on technical efficiency differentials in the state are scant or none existing. Few works such as Omonoaona (2008) attempted such study but failed to ascertain the differentials of efficiency of cassava in the important agricultural zones of the state. Omonoaona’s study did not use adequate econometric tools to enable derivation of meaningful conclusions from the study. There is a need for a study that will determine the efficiency determinants and compare these coefficients in the various cassava zones of Kogi State to enable uniform policy or specific policy frameworks be designed for boosting the efficiency of cassava in the study area based on research findings. The above scenario underlined the need for this study.

Objectives of the Study

The study was designed to ascertain and compare the major determinants of technical efficiency of cassava in two major agricultural zones of the state with special reference to farm credit and other basic farm inputs. Specifically, the study was designed to:

(1.) determine the effects of farm credit and basic farm inputs utilized by cassava producers in two major agricultural zones of the state on cassava output;

(2.) ascertain the presence (or absence) of a structural break in the results of the estimated coefficients of the production function used to determine the productivity of cassava in the two agricultural zones studied;

(3.) estimate the level of technical efficiency and determinants of inefficiency of cassava production in the study area.

Theoretical Framework

Production costs and efficiency are primarily determined by the prices of inputs including time, labour, capital and technological advances (Samuelson and Nordhaus, 2005). *Technical efficiency* in production is defined as the ability of the farmer to produce at the maximum output (frontier production), given quantities of inputs and production technology (Amaza and Maurice, 2005). In Farrell's (1957) concept, the overall efficiency (OE) is a multiplicative combination of technical (TE) and allocative efficiency (AE), so that OE=TE*AE. *Allocative efficiency* measures the extent to which an analyzed Diminishing Marginal Utility (DMU) produces its outputs in a proportion that minimizes costs of production, assuming that the unit is already fully technically efficient (i.e. when allocation is *pareto efficient*), (Field, 1997). Olayide and Heady (1982) also defined *allocative efficiency* as the choice of optimum levels of inputs consistent with relative factor prices. A farm therefore is considered allocatively efficient in the use of a production if the farm is able to equate the value of the marginal value product (MVP) of the factor to that factor price or is able to maximize profit with respect to that factor.

Many empirical studies that have examined technical efficiency among farmers in Nigeria reported gross inefficiency in farm production (Ogunyika & Ajibefun, 2004). However, Ogunyika and Ajibefun maintained that on an average, the farms have not been behaving badly in terms of *technically efficiency* unlike other efficiency measures like allocative and scale efficiencies especially in the developing countries. They cited that despite the rampant use of traditional or less advanced agricultural technology in some low and middle income countries like Argentina, Bangladesh, Nigeria, Philippines, Zaire and Malaysia, the mean technical efficiency indices between 1964 and 1993 have been 1.00, meaning that they are technically efficient but others like China, Iran, Ireland, South Africa, Zimbabwe etc. experience very low levels of efficiency. Although the technical efficiency indices are of great importance in examining farm performance, a determination of the factors influencing those indices is equally important.

Analytical Framework

Battesse and Coelli (1988), Tijani (2005), Kibaara (2005), Amaza and Maurice (2005) applied stochastic frontier model to estimate technical efficiency using input approach. The empirical model takes the following general form:

$$Y = f(x_i, \beta)e^{v_i - u_i}$$

Where *Y* is the dependent variable, *f(x)* is the functional form, β is the technical coefficient, v_i is the random component which assumed to be identically and independently distributed with mean zero, and u_i is the inefficiency effect of the firm. A Cobb Douglas logarithmic function was adopted resulting in estimation equation (2). The estimated Cobb-Douglas stochastic frontier Production function is assumed to specify the technology of the farmers. It is specified in the form:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 \ln X_{3ij} + \beta_4 \ln X_{4ij} + \beta_5 \ln X_{5ij} + \beta_6 \ln X_{6ij} + V_{ij} - \mu_{ij} \text{........}(1)$$

Where 'ln' represents logarithm to base e; subscripts $_{ij}$ refers to the $_j$th observation of the ith farmer; Y = value of total output of the farmers in tones; X_1 = total land area under cultivation (hectares); X_2 = family labour (in standard days);amount; X_3 = hired labour (in man days); X_4 = quantity of inorganic fertilizer (in kgs); X_5 = farm credit accessed (in Naira); X_6 = quantity of seed (cassava stem cuttings) planted (count); V_{ij} = a symmetric error component that accounts for random effects and exogenous shocks. $\mu_{ij} \leq 0$ = a one sided error component that measures technical inefficiency.

It is assumed that the technical inefficiency effects are independently distributed and μ_{ij} arises by truncation (at zero) of the normal distribution with mean μ_{ij} and variance, δ2 , where μ_{ij} is defined as:

$$\mu_{ij} = \delta 0 + \delta 1 \ln Z1_{ij} + \delta 2 \ln Z2_{ij} + \delta 3 \ln Z3_{ij} + \delta 4 \ln Z4_{ij} \text{......} \quad (2)$$

Where μ_{ij} represents the technical efficiency of the ith farmer; Z_1 = years of farming experience; Z_2 = number of years of formal education; Z_3 = number of meetings with extension agents; and Z_4 = household size; $(V_i\text{-}U_i)$ = A composed error term where. V_i: is the random error term (statistical noise) and Ui: represents the technical inefficiency

The maximum–likelihood estimates of the β and δ coefficients in equations (1) and (2) respectively was estimated simultaneously using the computer program FRONTIER 4.1 (Coelli and Battese, 1995). The above model was used for determining the efficiencies of cassava in this study.

One of the ways of comparing two regressions with a view of checking the slope and intercept differentials in both time series and horizontal data according to Koutsoyianis (2001) and Gujarati

(2006) is through the use of Chow test. E-views econometric package call this Chow-Break point test. The formula for the Chow test, according to Koutsoyiannis (2001) is given by:

$$F^* = \frac{[\sum e_p^2 - (\sum e_1^2 + \sum e_2^2)]/K}{(\sum e_1^2 + \sum e_2^2)]/(n_1 + n_2 - 2K)}$$

Where, n = number of observation (sample size); $(\sum e_1^2 + \sum e_2^2)$ = total unexplained variation, $\sum e_p^2$ = pooled residual variance of the regression based on the two samples (n1 + n2) (i.e.$\tilde{Y} = \square_0 + \square_1 X$) $= \sum Y_p^2 - \sum \tilde{Y}_p^2$, with $(n_1 + n_2 - K)$ degrees of freedom. (p stands for 'pooled' and K = total number of coefficients including bo). The null hypothesis is $\boldsymbol{b_i = \beta_i}$, that is, there is no difference in the coefficients obtained from the two samples.

Gujarati (2006) and Berka (2007) observed that in the presence of heteroscedasticity, Ordinary Least Squares (OLS) estimators, although unbiased, are inefficient. He observed that to remedy this flaw, White developed an estimating procedure that produces standard errors of regression coefficients that take into account heteroscedasticity. As a result, we can continue to use the t and F tests, except that they are now valid asymptomtically, that is, in large samples. EViews has the capacity of computing the White statistics (EViews, 1999).

For test of presence of conditions such as positive or negative returns to scale in a regression coefficients, EViews has a diagnostic test that can perform this operation through imposition of restrictions on the regression. The package uses Wald Test to impose this restriction.

The Wald test computes the test statistic by estimating the unrestricted regression without imposing the coefficient restrictions specified by the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfying the restrictions. The Wald test can be applied to equations estimated by least squares, two-stage least squares, nonlinear least squares, binary, ordered, censored, truncated, and count models, and systems estimators. The Wald test is one of a few tests that can be applied to equations estimated by system methods.

For the special case of a linear regression model, following EViews 3.1 the formula can be analyzed thus : $y = X\beta + \epsilon$

and linear restrictions : $H_0: \quad R\beta - r = 0$,

where *R* is a known *q k* matrix, and *r* is a *q* vector, respectively, the Wald statistic reduces to

$W = (Rb - r)'\left(s^2 R(X'X)^{-1}R'\right)^{-1}(Rb - r)$, which is asymptotically distributed as $\chi^2(q)$ under *Ho.*

If we further assumed that the errors are independent and identically normally distributed, we have an exact, finite sample *F*-statistic: $F = \frac{(\tilde{u}'\tilde{u} - u'u)/q}{u'u/(n-k)} = W/q$,

where $\tilde{u}$ is the vector of residuals from the restricted regression. The *F*-statistic compares the residual sum of squares computed with and without the restrictions imposed. If the restrictions are valid, there should be little difference in the two residual sum of squares and the *F*-value should be small. EViews reports both the chi-square and the *F*-statistics and the associated *p*-values.

Methodology of Study

Study Area: Kogi State lies between longitudes 5^o40‘E and 7^o49‘E; and latitudes 6^o 33‘N and 8^o44‘N. It is bounded to the South by Anambra and Edo States; and to the North by Niger, Nassarawa and Federal Capital Territory; to the East by Benue and Enugu States. On the Western flank it shares a common border with Ondo, Ekiti and Kwara States (Kogi A.D. P, 1993). Going by the 2006 population census, the state pooled a population of 3,278,487 representing 2.34% of the Nigerian population.

Sampling Procedure: A stratified random sampling was used to select 174 cassava farmers from two agricultural zones of the state. A list of cassava farmers in the four agricultural zones of the state was obtained from the State’s Agricultural Project’s Office at Lokoja. Two zones, Zone D, situated in the Eastern senatorial zone and Zone A, in the Western Senatorial Zone of the State, were chosen for the study. From each of these zones, 87 cassava farmers were sampled.

Data Collection Method: Primary data were collected using a structured questionnaire. The secondary sources for the data used in this study were from text books, journals, government papers, research reports, online materials and periodicals.

Data Analysis Technique: The determination of coefficients of the inputs' variables was first done using a Cobb-Douglas function of the form:

$In\ Y_i = \beta_0 + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 \ln X_{3ij} + \beta_4 \ln X_{4ij} + \beta_5 \ln X_{5ij} + \beta_6 \ln X_{6ij}$ (where Y_i and X_{ij} represented the same variables as already given in equation 1.) to fit the determinants after which coefficients were subjected to White's test for heteroscedasticity using E-Views. When heteroscedasticity was observed, the residuals were used to correct the function after which the transformed data was regressed again to give the final coefficients. The corrected function was used to discuss the determinants and was further subjected to Wald Test and Chow's Break-Point test. The farm inefficiencies' levels and sources were determined by the use of stochastic frontier model (as presented in Equation 1 and 2) using Frontier 3.1 software.

Results and Discussion

For results of the Cobb-Douglas function estimation before correction for heteroscedasticity, see Appendix 1. The White's test for heteroscedasticity gave an F-statistic of 4.515 which was significant at a p-value of 0.0000 (<1% alpha level) (Appendix 2). This implies that unless transformed the result would be fraught with the presence of heteroscedasticity. However we used the results in the transformed function (See Table 1 in text) for the use of *White Heteroskedasticity-Consistent Standard Errors & Covariance regression)* for our discussion of the inputs' effects on cassava output in the study area. From this model the following coefficients gave positive signs: family labour (X_2) and farm credit size (X_5). This is in line with *a priori* expectations. It implies that as these variables inputs increase (i.e. X_2 and X_6), output of cassava also increases. Hired labour (X_3), quantity of inorganic fertilizer (in kg)(X_4), and quantity of seed (cassava stem cuttings) planted (count) (X_6) gave negative signs meaning that their elasticities were below zero. They are probably not being efficiently utilized. Land size (X_1) also gave a negative sign which means that increase in land size given commensurate level of the inputs they were using could only lead to fall in cassava yield. Land expansion may not bring marginal returns given the way they were combining their resources.

Table 1.0 White Heteroskedasticity-Consistent Standard Errors & Covariance

	Coefficient	Std. Error	t-Statistic	Prob.
C(1) Intercept	5.594703	1.180385	4.739726	0.0000
C(2) Farm Size (ha)	-0.232530	0.140844	-1.650970	0.1006
C(3) Family Labour in mandays	0.087601	0.045477	1.926276	0.0558
C(4) Hired Labour in mandays	-0.327369	0.054253	-6.034087	0.0000
C(5) Quantity of chemical fertilizer.ha	-0.096610	0.026110	-3.700054	0.0003
C(6) Credit accessed	0.010650	0.005678	1.875512	0.0625
C(7) Stem cuttings used/ha	-0.180605	0.120862	-1.494313	0.1370

R-squared	0.462549	Mean dependent var	2.203621
Adjusted R-squared	0.443239	S.D. dependent var	0.610848
S.E. of regression	0.455793	Akaike info criterion	1.305841
Sum squared resid	34.69374	Schwarz criterion	1.432929
Log likelihood	-106.6082	Durbin-Watson stat	1.620882

Source: Computed from results of field survey, 2008.

The coefficient for land size was -0.232 signifying that further unit increase of land size added to what was obtainable could lead to a slight drop in yield of cassava of up to 23.2%. This factor is significant at 10% alpha level. This means that cassava farmers could gain from increasing land size only if other inputs are better combined than the proportion being used now otherwise they may experience a decreasing return from land expansion. Meanwhile, family labour gave coefficients of 0.087 implying that a unit increase in family labour could lead to an output rise by 8.7% (significant at 5%); while a unit input of hired labour would contribute negatively to cassava yield, dropping yield by 32% (significant at 1%). This could be due to high cost of hired farm labour in the area. Inorganic fertilizer applied gave a coefficient of -0.096, signifying that inorganic fertilizer was not elastic to fertilizer yield in the area. Each marginal increase in unit of inorganic fertilizer on the farms there could lead to yield loss of about 9.6%, a factor that was significant even at 1% alpha level. It thus appeared that these farmers might have been applying too much inorganic fertilizer on their relatively small and limited farms over the years and the soil was possibly losing some nutrients which organic fertilizers could have better replenished. It was observed that cassava farms in this state were credit-elastic. Farm credit gave a coefficient of 0.073 indicating that for each naira increase in farm credit accessed by farmers' cassava yield increased by 7.3%. This figure was significant at 5% alpha level. Cassava stem cuttings did not show any significant effect on yield in the study area with low elasticity of -0.18 and a p value of 0.137 (not statistically significant). It could be that the farmers' planting spacing and stem cutting varieties were very poor.

The null hypothesis of returns to scale being equal to 0, was rejected, since the Wald test statistics with an F-statistic of 225.66 was significant at 1% alpha level given a p value of 0.000 (See Appendix 3). Adding the elasticities of the independent variables and the intercept of this function (corrected Cobb-Douglas equation for heteroscedasticity), a positive or increasing return to scale of 4.855 was observed. This means that cassava farmers in this state were experiencing increasing returns on their farm investments. Their investment was yielding 48.55% above their farm expenses.

The result of the Chow test for structural break in the estimated function for the two zones gave an F statistic of 5.907 which was significant at 1% alpha level (See Appendix 4). This result implies that the slope of the coefficients estimated for the two agricultural zones with regards to the determinants of cassava output elasticities varied significantly. This variation among the zones could be attributed to farm management practices or other physical factors such as soil or climatic factors that may not be uniform across the state. The model's R Square of 0.46 indicated that 46%

of the variation in yield of cassava was influenced directly by the variables entered in the transformed Cobb Douglas model.

The mean efficiency estimate among cassava farmers in the state is 81% (0.815). The range is: Minimum, 0.62 – Maximum, 0.99. Only 0.60% had a low technical efficiency estimate in the study area while 21.8% had a moderately high estimate of >0.50 to 0.60. Farms with very high efficiency estimate of above 0.61 constituted the majority (77.6%) in the study area. This is in agreement with earlier literature (Ogunyika & Ajibefun, 2004) who observed that the mean technical efficiency in Nigeria between 1964 and 1993 have been 1.00. The gamma estimate of 0.253 (Standard Error, 0.555) and t value of 0.456 indicated that the gamma parameter is not statistically significant at the 10% level. This result indicates that inefficiency is not significant among the studied farms. In other words only 25% of the technical inefficiency experienced on the studied farms' was explained by the estimated inefficiency variables included in this model. The inefficiency variables included are: years of farming experience; number of years of formal education; number of meetings with extension agents and household size. They all had low t ratios which confirmed that their effects in the model were not significant.

Conclusion

The study has been able to identify the major determinants of cassava technical efficiency in Nigeria's second largest cassava producing state (using reliable econometric models). It noted that the magnitude of these variables' effects vary depending on agricultural zones (i.e. along geographic axes). Almost all the variables studied including farm credit but excluding stem cuttings exerted statistically significant effect on the output of cassava (at 1%, 5% and 10% alpha levels). The study affirmed that cassava farming is an enterprise that brings increasing returns to its investors. The technical efficiency of the farms was very high, averaging 81%, while the inefficiency variables entered were not statistically significant. For cassava production in this state to brace up to the challenges posed by negative indices in the farms (with regards to some inputs) and fill in its efficiency gap of 19%, the following recommendations need to be considered for implementation.

Recommendations

- Farm credit need to be provided by government and private institutions such as banks especially to genuine cassava farmers at a single digit interest rate so that they can consolidate on the gains they are making from cassava production in the area.
- Improved inputs especially appropriate inorganic fertilizers and hybrid stem cuttings should be made available to cassava farmers in the state based on soil testing so that they can get optimal benefits from the use of these resources. The use of organic fertilizers should also be encouraged.
- Further studies should be carried out using adequate models and panel data (if possible) to verify the magnitude and major sources of the differences in the effects of determinants of technical efficiency of cassava in the various cassava producing zones of the state with a view of designing policies based on each zone's peculiarities.
- Efforts should be made by the state and Federal Government as well as donor institutions to make cassava farming less labour intensive through introduction of cassava farm mechanization to avert inefficiencies resulting from use of hired labour in the state.

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APPENDIX 1: COBB DOUGLAS EQUATION ESTIMATES

Results **Before Correction for Heteroscedasticity (Compare with Table 1.0 in Text which is the corrected version for heteroscedasticity)**

Dependent Variable: Y = Cassava output in tonnes (Logged)
Method: Least Squares
Date: 03/29/09 Time: 21:34
Sample: 1001 1174
Included observations: 174
Y=C(1)+C(2)*X1+C(3)*X2+C(4)*X3+C(5)*X4+C(6)*X5+C(7)*X6

	Coefficient	Std. Error	t-Statistic	Prob.
C(1) Intercept	5.594703	0.911136	6.140358	0.0000
C(2) Farm Size (ha)	-0.232530	0.096248	-2.415941	0.0168
C(3) Family Labour in mandays	0.087601	0.038305	2.286914	0.0235
C(4) Hired Labour in mandays	-0.327369	0.038307	-8.545916	0.0000
C(5) Quantity of chemical fertilizer.ha	-0.096610	0.025939	-3.724566	0.0003
C(6) Credit accessed	0.010650	0.005381	1.979311	0.0494
C(7) Stem cuttings used/ha	-0.180605	0.094035	-1.920611	0.0565

R-squared	0.462549	Mean dependent var	2.203621
Adjusted R-squared	0.443239	S.D. dependent var	0.610848
S.E. of regression	0.455793	Akaike info criterion	1.305841

Sum squared resid	34.69374	Schwarz criterion	1.432929
Log likelihood	-106.6082	Durbin-Watson stat	1.620882

APPENDIX 2 : TESTS FOR HETEROSCEDASTICITY

White Heteroskedasticity Test:

F-statistic	4.514783	Probability	0.000003
Obs*R-squared	43.80974	Probability	0.000016

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/29/09 Time: 21:51
Sample: 1001 1174
Included observations: 174

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-36.67696	12.66529	-2.895865	0.0043
X1	-0.884014	0.247429	-3.572806	0.0005
X1^2	0.573480	0.129190	4.439035	0.0000
X2	0.099099	0.080197	1.235695	0.2184
X2^2	-0.042008	0.022396	-1.875655	0.0625
X3	0.233657	0.120457	1.939761	0.0542
X3^2	-0.077996	0.030571	-2.551312	0.0117
X4	0.087576	0.093196	0.939696	0.3488
X4^2	-0.015637	0.016907	-0.924837	0.3564
X5	0.073427	0.040014	1.835029	0.0683
X5^2	-0.009319	0.004576	-2.036740	0.0433
X6	7.783564	2.664653	2.921042	0.0040
X6^2	-0.400580	0.138663	-2.888870	0.0044

R-squared	0.251780	Mean dependent var	0.199389
Adjusted R-squared	0.196012	S.D. dependent var	0.365658
S.E. of regression	0.327868	Akaike info criterion	0.679365
Sum squared resid	17.30713	Schwarz criterion	0.915387
Log likelihood	-46.10479	F-statistic	4.514783
Durbin-Watson stat		Prob(F-statistic)	0.000003

APPENDIX 3 WALD TEST FOR COEFFICIENTS:

Results of Wald Test for coefficients

Wald Test:
Equation: Untitled

Null Hypothesis:	C(1)+C(2)+C(3)+C(4)+C(5)+C(6)+C(7)=0		
F-statistic	19.49947	Probability	0.000018
Chi-square	19.49947	Probability	0.000010

APPENDIX 4 : CHOW BREAKPOINT TEST

Chow Breakpoint Test: 1087

F-statistic	5.907447	Probability	0.000004
Log likelihood ratio	39.99938	Probability	0.000001