A Multivariate Time Series Analysis of Household Debts during 2007-2009 Financial Crisis in South Africa: A Vector Error Correction Approach

Ntebogang Dinah Moroke*

North West University
Email: Ntebo.Moroke@nwu.ac.za

Janine Mukuddem-Petersen

North West University

Mark Petersen

North West University

Abstract

In this study, we adopted multivariate time series approach to investigate the effect selected macroeconomic variables on household debts using South African data collected from 1990 Q1-2013 Q1. SAS 9.3 was used for the analysis. Johansen multivariate cointegration and the Toda-Yamamoto causality testing approaches were adopted. The ADF and KPSS unit root test results confirmed that all the variables under study were stationary. Cointegration results allowed the acceptance of four cointegrating vectors. The ECM revealed a negative sign implying the existence of a long-run equilibrium relationship among the variables. The coefficient of the error term implied that 13.8% of disequilibrium due to negative and positive shocks was previously corrected in one period per quarter. This adjustment provided the model with all the signs concurring with economic theory and literature on household debts. Toda-Yamamoto causality results revealed a unidirectional relationship running from GDP, UR and ER to HHD. A feedback relationship was discovered between the remaining variables confirming they are not weakly exogenous in South African household debts systems. This study recommends the formulation and implementation of policies that will effectively help in dealing with household indebtedness in SA and also to complement the NCR. More emphasis should be placed on threatening determinants such as household consumption expenditure, gross domestic product and house prices.

Keywords: Cointegration, Household Debts, Multivariate Analysis, Vector Error Correction Model, South Africa

1. Introduction

The 2007-2009 financial crisis emerged in the United States (U.S). It has gripped much of the entire world including some of the developed countries. It has given rise to the largest wave of banking crises since the great depression. As reported by Laeven and Valencia (2012), the recent wave of crises has affected most of the advanced economies as compared to previous crises. It is evident that the effects of this crisis are still lingering and in many cases the crisis is still on-going. Most of the developing countries such as South Africa (SA) also suffered the effects of this crisis. Naudé (2009) warned that the overall effects of the financial crisis on developing countries such as Africa, especially those dependent on trade with the U.S like SA would surely be negative. Though it was reported that SA was not severely affected by the financial crisis, the spill-over effects of this crisis began to hit the industries in the country. These effects resulted in assets being devalued, tightening of financial conditions, closing down of companies, escalation in the rates of unemployment and economic growth decrease.

Furthermore, due to these effects, SA registered several losses in almost all the companies in the financial industry, causing serious problems in their business. Taking out loans was brought to a minimum and the severity of the whole situation seriously shook people's confidence in banks and other financial institutions. This also forced investors to withdraw funds from the financial markets, thus exacerbating the situation even more. The crisis thwarted credit extension to households and businesses and as a result created credit crunches and, ultimately recessions. The increase in unemployment and poverty in the whole world contributed to the decline in aggregate demand. The 2007-2009 crisis has

had an enormous impact on economies, with stock markets falling, financial institutions collapsing and governments forced to intervene with bailouts, while refocusing on regulatory reform. Furthermore, this resulted in a drop of the GDP in almost all the countries. The South African Reserve Bank 2010 quarterly report reveals that SA's GDP decline was 15.3% in 2009. The director of the Federal Reserve's Alan Greenspan advocated significant reductions in Central Bank interest rates. Economic reporters are of the view that this might have served as an invitation to companies and the population to increase their investments and consumption.

Kojucharov, Martin and Martin (2008) observed several factors as contributors to the rapid growth in subprime lending namely low interest rates, rapid house price appreciation, easier credit, and new mortgage instruments. The authors' study revealed that between 2001 and 2005, interest rates on both fixed and adjustable rate subprime mortgages declined by over 2% points. This considerably reduced the borrowing costs for prospective homebuyers. In addition, the results revealed that hybrid products such as adjustable rate mortgages (ARMs) attracted a larger pool of borrowers by offering lower initial costs. Moreover, high house price appreciation also allowed many borrowers to refinance out of the subprime pool. Demyanyk and Van Hemert (2008) are of the view that it is due to this reason why mortgage originators in the U.S. were tempted to loosen their underwriting standards. Consequently, irrespective of bad credit records of borrowers and income documentation, credit providers started giving out credits.

Allen and Giovannetti (2010) are in support of the reports by Kojucharov *et al.* (2008) who postulated that the seeds of the crisis can be traced to the low interest rate policies adopted by the Federal Reserve Bank and other central banks after the collapse of the technology stock bubble. The interest rates cut affected the investors as well as households who were compelled to lower their savings rates escalating to household indebtedness. As indicated by Aron and Muellbauer (2000), low savings rates made a contribution to persistent structural weakness in SA. This in turn caused households to borrow rather than save. This situation was worsened during the crisis and the result was a high percentage of household debt in the country.

As reported by Central Bank, the South African household debts vis-à-vis disposable income was about 82% in 2009 and dropped to 75.6% during the first quarter of 2013. Reports further indicated that experts were worried as this could get worse as banks push into unsecured loans. The high debt level incurred by the household sector has created economic and political concern in developed and developing countries. It is of interest to model household debts in SA based on the facts discussed above. This study intends using macroeconomic variables to build a forecasting model of household debts in SA. This Vector Error Correction Model (VECM) approach is adopted in building the model. The findings of this study may be of help to economic policy makers in the country as they would know what to emphasise on in respect of household indebtedness. The problem of household indebtedness in SA may also be reduced and a gap in literature on the subject may also be bridged.

2. Household Debts in South Africa

Several authors looked into the problem of household debts in SA by applying mostly descriptive measures. Daniels (2001) provided a descriptive overview of urban household indebtedness in SA. The study was only focused on the basic relationships of consumer theory such as the composition of income and consumption. The results indicated that (a) at the national level, indebtedness trends upwards as income increases while cashflow trends towards a decrease as income increases; (b) the composition and sources of debt vary widely between the poor and the rich; (c) between 1995 and 1999, household indebtedness generally increased while household cashflow generally decreased; also, important substitution shifts took place in the consumption schedule, with a greater proportion of income being spent on housing and food.

Prinsloo (2002) used descriptive measures in studying household debts in SA and their study findings showed that there was a decline in personal savings expressed as a percentage of disposable income over the past 20 years. His study also reported a rise in the household sector's indebtedness at a rate that almost corresponded with the rate of increase in the disposable income. The current study concurs with this claim in reference to the (South African Reserve Bank 2009) report which shows that 13.65 million households in SA had at their disposal a combined income of R1.631 billion. Reports showed that this figure characterises a nominal growth of 6.5% compared with 2008 when the household income was R1.1531 billion. The study by Prinsloo was solely based on estimating the composition of household balance sheet, the determinants of savings and the impact of financial liberalisation in SA. The LCH and PIH postulate that if households dissave, they will be forced to go into debt in order to satisfy their consumption needs. Kotzé and Smit (2008) are in support of Prinsloo's findings that high levels of household debt are due to a lack of a comprehensive savings culture among people. Lorgat (2003) believes that this problem was caused by financial illiteracy on the part of the consumers who spend almost all of their income leaving little if nothing for their savings and investments.

Mashigo (2006) Mashigo's study adopted a qualitative approach and looked into factors contributing to the debt spiral in the poor communities in South Africa. The study evaluated the levels of indebtedness at the household level and the effectiveness of the regulation of micro lending. Key findings of this study showed that the poor income households witnessed the greatest increase in the number of loans and percentages of indebtedness.

Meniago, Mukuddem-Petersen, Petersen and Mongale (2013) adopted the LCH and applied econometric methods to their study. The looked into financial crisis and household debts in SA. A long-run cointegration and short run error correction model (ECM) were used in the analysis. CPI, interest rates, GDP, prime rates and consumption expenditure were used as independent variables. The findings revealed that these variables moved together in the long-run with about 3.8% of the disequilibrium is corrected each quarter in the short run.

3. Theoretical Framework

Several theories seeking to explain household indebtedness have been formulated. These theories are used as a motivation for choosing the determinants of household debts. Keynes (1936) developed one and he thought of the subject in the form of the absolute income hypothesis. This theory is more focused on the savings and assumes that consumption is determined by the current level of income. Keynes was worried that as a country and its people became richer, they would not spend as much and would save more. Consequently, this might threaten future growth. He views savings in the context of theory of demands and the consumption function. Income, he regards it as the systematic determinant of individual and national saving. He emphasised that the average propensity of the households to save would increase as these households reached a higher income level. Keynes also postulated that as consumption of households increased, their income would also increase. This increase in consumption, however; would not be as great as the increase in income. Modigliani and Friedman accepted the Keynesian theory, but not enough evidence could be gathered to accentuate it. Hence the two theories, the life cycle and permanent income hypotheses were developed in order to explain the saving and borrowing behaviour of households.

From the economic perspective, the life-cycle and permanent income hypotheses are useful points of departure for examining trends in household borrowing. The former is an initiative of Ando and Modigliani (1963) and Friedman (1957) devised the latter hypothesis. Both these hypotheses were derived from the Keynesian theory. The proposition for the life cycle hypothesis (LCH) is that household savings and consumption are a reflection of the life cycle stage of the household. Modigliani (1986) further proposed that consumption is a linear function of available cash and the discounted value of future income. This means that a household can choose a path of consumption to maximise utility over its life time subject to an intertemporal budget constraint (Rinaldi and Sanchis-Arellano 2006). This limits a household to consume no more than the sum of the present discounted value of its labour income and its current net worth (*i.e.* its asset holdings less its liabilities). During times when their income is low relative to average income over the life-time, households may borrow to fund current consumption. They may alternatively run down their asset holdings. Debelle (2004) advises that by then the loan would be repaid (assets would be accumulated) in periods where income is high relative to average life-time income.

Ando and Modigliani (1963) based their proposal on the assumption that as income is expected to increase during working years and decline at retirement, households will be inclined to borrow when they are still young, save during middle age, and start spending during retirement. As the permanent income hypothesis (PIH) suggests, the debt position of an individual household can therefore be determined by the path of future income and the interest rate (relative to the discount rate) (Debelle 2004). As suggested by Yilmazer and DeVaney (2005), household borrowing can be explained by focusing on demand-side determinants. According to the life-cycle model, aggregate household debt depends on other factors such as the households' demographics, the expected path of future income and real interest rates. This study does not consider the demographic variable as one of the determinants of household debt, but income and interest rates are included in the list of determinants. The life-cycle and permanent income hypotheses consider consumer spending as a function of expected lifetime earnings, consisting of wage earnings and income from assets (Rinaldi and Sanchis-Arellano 2006). These two theories identify a number of variables that influence household choice of consumption and level of borrowing (Ando and Modigliani 1963, Friedman 1957 and Debelle 2004).

4. Data and Methods

4.1 Data

The study employed several sources to obtain the data for the analysis. Macroeconomic factors of household debts were identified through the guidance of the LCH, PIH together with the reviewed literature. The following model is identified;

$$\ln HHD_t = \beta_0 + \underset{+}{\beta_1 \ln HP_t} + \underset{-}{\beta_2 \ln CP_t} + \underset{-}{\beta_3 \ln INC_t} + \underset{-}{\beta_4 \ln IR_t} + \underset{+}{\beta_5 \ln GDP_t} + \underset{+}{\beta_6 \ln HC_t} + \underset{-}{\beta_7 \ln HS_t} + \underset{-}{\beta_8 \ln ER_t} + \underset{-}{\beta_9 \ln UR_t} + \mu_t$$

(1)

Where β_0 = intercept, ε = error term and the $\beta's$ = coefficients of the independent variables as described in Table 3.1 below:

Table 1. Variable names and descriptions

Name	Description
*ln*HP	Natural log of house prices
*ln*CP	Natural log of consumer prices
*ln*INC	Natural log of household income
*ln*IR	Natural log of interest rate
*ln*GDP	Natural log of gross domestic product
*ln*HC	Natural log of household consumption
*ln*HS	Natural log of household savings
*ln*ER	Natural log of exchange rates
*ln*UR	Natural log of unemployment

The sample used consists of 88 quarterly observations collected from 1990 Q1 to 2013 Q1. The data sources are SARB, STATSSA, OECD and ABSA Bank amongst others. The analysis of data is done using the Statistical Software Analysis (SAS) version 9.3.

4.2 Method

Multivariate econometric methods such as the Johansen cointegration and the Toda-Yamamoto causality testing approaches were adopted to perform data analysis in this study. The study intends to determine macroeconomic factors that may pose threat to household debts in SA both in the long run and the short run. Several variables are included in the analysis hence the choice of these methods. Moreover, these methods are recommended by several authors because they have been found to be effective in avoiding spurious regression results and can accurately be used to estimate direct short run and long run relationships. This procedure for using these methods is discussed below.

4.2.1 Stationarity analysis

This study follows a three-stage procedure to build a model. Firstly, the variables are checked for stationarity using the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test is used to confirm the unit root test results.

4.2.1.1 ADF test

Dickey and Fuller (1976; 1981) suggested estimation of the following regression equation for unit root testing;

$$\Delta Y_t = \alpha_0 + \beta_0 Y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + \varepsilon_t$$

(2)

Where Δ is the first difference operator; *t* is the time drift; *k* represents the number of lags used and ε is the error term; α's and β's are the model bounds. The ADF test includes a constant and time trend. For the decision rule, assuming that the series $\{Y_t t^{T}{}_{=1}\}$ follows the AR *(p)* process, Hamilton (1990) shows that the rejection or acceptance of

the null hypothesis of a unit root is based on running the regression;

$$Z_t = \mu + (\phi_1 - 1)Y_{t-1} + \sum_{j=1}^{p-1} C_j Z_{t-j} + \varepsilon_t$$

(3)

Where $Z_{t-j} = Y_{t-j} - Y_{t-j-1}$ for j = 0, 1, 2,..., *p-1* and ε_t is a white noise process. The ADF test statistic is given as;

$$\hat{\tau}_{ADF} = \frac{\hat{\phi}_1 - 1}{se(\hat{\phi}_1)}$$

(4)

$se(\phi - 1)$ is the standard error of $\phi - 1$. The null hypothesis of a unit root $H_o: \phi_1 = 1$ is rejected if $\hat{\tau}_{ADF}$ is less than the appropriate critical value at some level of significance.

4.2.1.2 Kwiatkowski, Phillips, Schmidt and Shin (KPSS) Test

Kwiatkowski, Phillips, Schmidt and Shin (1992) suggested this test to enable the researcher to test whether the series have a deterministic trend versus the stochastic trend. It is used in this study to confirm the decision made by the ADF and PP tests. The KPSS test statistic is given as;

$$KPSS = n^{-2} \sum_{t=1}^{n} \frac{S_t}{\hat{\sigma}^2}$$

(5)

Where $S_t = \sum_{i=1}^{t} e_i$ and $\hat{\sigma}^2$ is the estimate of the long-run variance of the residuals. The null hypothesis is rejected when the KPSS is larger than the critical value, because that is the evidence that the series wander from its mean. First order of differencing was applied to stationarise the variables. A lag of up to four was included to correct for autocorrelation since the data are collected on a quarterly basis. Table 2 summarises the results of the unit root tests for variables included in the model.

Table 2. ADF unit root tests

	ADF	Decision
HHD	-4.83 (0.0009)	Reject the null hypothesis
HP	-6.99 (0.0001)	Reject the null hypothesis
CP	-4.55 (0.0022)	Reject the null hypothesis
INC	-6.76 (0.0001)	Reject the null hypothesis
IR	-7.75 (0.0001)	Reject the null hypothesis
GDP	-6.72 (0.0001)	Reject the null hypothesis
HC	-3.64 (0.0001)	Reject the null hypothesis
HS	-8.72 (0.0001)	Reject the null hypothesis
ER	-6.28 (0.0001)	Reject the null hypothesis
UR	-8.01 (0.0001)	Reject the null hypothesis

Source: Authors' own calculation from Household debts data, South Africa

It is evident from Table 2 that the ADF rejects the null hypothesis of no unit roots for all the time series at their first differences. The observed probabilities (on parenthesis) are greater than the 5% level of significance. The KPSS test results in Table 3 confirm this conclusion. As a result, the variables are stationary and integrated of same order, i.e., I (1). This allows us to proceed to the next step of determining the cointegration relationship between the variables.

Table 3. KPSS Stationarity Test

Type	Lags	Eta	Prob 10 %	Prob 5 %	Prob 1 %
Single Mean	3	0.0874	0.3470	0.4630	0.7390
Trend	3	0.0862	0.1190	0.1460	0.2160

Source: Authors' own calculation from Household debts data, South Africa

4.2.2 *The Johansen Multivariate Cointegration Test*

This study adopts Johansen and Juselius (1990) multivariate cointegration framework to determine the number of cointegrating vectors. Two tests, the Maximum Eigenvalue and the Trace test are used to achieve this objective. The Maximum Eigenvalue statistic tests the null hypothesis of *r* cointegrating relations against the alternative of *r+1* cointegrating relations for r = 0, 1, 2…n-1. The associated null hypothesis that there are at most *r* cointegrating vectors is given as; $H_0 : \lambda_i = 0$ *for i=r+1,...,k* and the opposing hypothesis is $H_0 : \lambda_i \neq 0$. Johansen (1988) suggested two test statistics to test the associated hypothesis above. In addition, Fountis and Dickey (1989) suggested an examination of eigenvalues following the multivariate setting. Steps for this methodology are as follows;

Step 1: Fit linear multivariate time series as;

$$X_{1,t} = \phi_{1,1}X_{1,t-1} + \phi_{1,2}X_{1,t-2} + ... + \phi_{1,p}X_{1,t-p} + \varepsilon_{1,t},$$
$$X_{2,t} = \phi_{2,1}X_{2,t-1} + \phi_{2,2}X_{1,t-2} + ... + \phi_{2,p}X_{2,t-p} + \varepsilon_{2,t},$$

$$X_{n,t} = \phi_{n,1}X_{n,t-1} + \phi_{n,2}X_{n,t-2} + ... + \phi_{n,p}X_{n,t-p} + \varepsilon_{n,t},$$
$$\Rightarrow \quad X_t = \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + ... + \Phi_p X_{t-p}.$$

(6)

Step 2: Compute the largest eigenvalue, λ_{max} , based on the characteristic equation

$$\left| \lambda^p I - \Phi_1 \lambda^{p-1} - \Phi_p \lambda^{p-2} - ... - \Phi_p \right| = 0,$$

(7)

Where I is the $p \times p$ matrix.

Step 3: Test of the null hypothesis of unit root is based on the following test statistic

$$\hat{\tau}_{mfd} = N(\lambda_{max} - 1),$$

(8)

Where λ_{max} is the largest eigenvalue based on step 2.

Step 4: At the 0.05 significance level, obtain the critical value from the table. Reject H_0 if $\hat{\tau}_{mfd} >$ critical value or alternatively if the observed probability is less than the level of significance. The following are the Johansen trace and maximum eigenvalues formulae also calculated through these four steps;

$$J_{Trace} = -N \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_{max})$$

(9)

$$J_{Max} = -N \ln(1 - \hat{\lambda}_{max})$$

(10)

The asymptotic critical values are found in the Johansen and Juselius (1990) tables. The null hypotheses for these statistics are rejected if the observed values are greater than the critical values at 5% level of significance. This implies the presence of cointegration among the variables and thus confirms a long run relationship (Sjö, 2008). Osterwald-Lenum (1992) provided detailed tables of the critical values of these statistics. Alexander (2001) warned that the two tests can yield different results. Table 4 gives summary results indicating the order for the Johansen cointegration rank tests and also confirms possibility of long-run relationships between the variables.

Table 4. Cointegration results

H$_0$: Rank=r	H$_1$: Rank>r	Trace	5 % Critical Value	Max eigenvalue	5 % Critical Value
0	0	452.3907	232.60	109.7215	62.81
1	1	293.7431	192.30	95.4438	57.12
2	2	194.7045	155.75	68.2503	51.42
3	3	131.1307	123.04	56.6987	45.28
4	4	86.6066	93.92	31.0888	39.37
5	5	52.7427	68.68	25.3193	33.46
6	6	29.0491	47.21	15.0285	27.07
7	7	15.1736	29.38	10.2022	20.97
8	8	4.0680	15.34	6.0080	14.07
9	9	0.0702	3.84	1.5898	3.76

Source: Authors' own calculation from Household debts data, South Africa

The two tests are less than the associated critical values from rank 4 implying the rejection of the hypothesis no cointegrating relationships. It is therefore concluded that there are at least four cointegrating vectors providing evidence of long run relations between households and related determinants. Based on these results, the analysis continues by fitting a VECM model that may be used for improvement of longer term forecasting of household indebtedness in SA. Reviewed below is a VECM model of household debts in SA.

4.2.3 Vector Error Correction Model (VECM)

Once cointegration has been detected between series, it becomes apparent that there exists a long-term equilibrium relationship between them. The study applies VECM to evaluate the short run properties of the cointegrated series. In case of the absence of cointegration, VECM is no longer required the analysis can directly proceed to causality analysis. The presence of

cointegration between variables suggests a long term relationship among the variables under consideration. An ECM is developed in this study to estimate the speed at which household debt return to equilibrium after change in the related determinants (Banerjee *et al.* (2011). This also reduces or increases the parameters of the long run relations where necessary ((Nwachukwu and Egwaikhide 2007). Suppose a vector of $n \times 1$ time series variables is given as

$y_t = (y_{1t}, y_{2t}, ..., y_{nt})'$. The basic p-lag VAR (p) has the form;

$$y_t = c + \Pi_1 y_{t-1} + \Pi_2 y_{t-2} + ... + \Pi_p y_{t-p} + \varepsilon_t , \quad t = 1, ..., T \tag{11}$$

Where *p* denotes the number of variables, Π_i is $n \times n$ coefficient matrices and ε_t are an $n \times 1$ unobservable zero mean white noise vector process (serially uncorrelated).

For this study given 10 variables including the dependent, the Johansen's approach takes its starting point in equation (11) as;

$$y_t = \alpha + \beta_1 HHD_{t-i} + \beta_2 HP_{t-i} + \beta_3 CPI_{t-i} + ... + \beta_{10} UR_{t-i} + \varepsilon_t \tag{12}$$

Equation (12) is expressed in the following VECM *(p)* form assuming there exist at least one cointegrating vector;

$$\Delta y_t = \alpha + \beta_1 \Delta \ln HHD_{t-i} + \beta_2 \Delta \ln HP_{t-i} + \beta_3 \Delta \ln CPI_{t-i} + ... + \beta_{10} \Delta \ln UR_{t-i} + \delta ECT_{t-i} + \varepsilon_t \tag{13}$$

with ECT_t representing the error correction term.

An ECM is calculated by normalising (13) as;

$$\ln HHD_t = \alpha + \beta_1 \ln \Delta HP_{t-i} + \beta_2 \Delta \ln CPI_{t-i} + ... + \beta_9 \Delta \ln UR_{t-i} + \delta ECT_{t-i} + \varepsilon_t \tag{14}$$

with the error correction term obtained from equation [10] as:

$$ECT_{t-i} = \Delta \ln HHD_t + \beta_1 \Delta \ln HP_{t-i} + \beta_2 \Delta \ln CPI_{t-i} + ... + \beta_9 \Delta \ln UR_{t-i} \tag{15}$$

Finally, the equation of HHD in its detailed form for constrained VEC model is written as:

$$\Delta \ln HHD_t = \alpha + \beta_1 \Delta \ln HP_{t-i} + \beta_2 \Delta \ln CPI_{t-i} + ... + \beta_9 UR_{t-i} + \delta ECT_{t-i} + \varepsilon_t \tag{16}$$

ECT_{t-1} represents the deviation from equilibrium in period *t* and the coefficient δ characterises the response of the dependent variable (HHD) in each period to departures from equilibrium. Where Δ the differencing operator and all the variables are I (0), $\ln HP$ is the natural log of house prices, etc. The existence of the long-run relations between the variables is determined through testing the significance of the lagged levels of the variables. The long run relationship between household debts and associated determinants for four cointegrating vector SA in the period 1990 Q1 to 2013 Q1 is summarised in Table 5.

Table 5. Household debt VEC Model

Long-Run Parameter Beta Estimates When RANK=4				
Variable	1	2	3	4
HHD	1.000	1.000	1.000	1.000
HP	0.048	0.169	-1.756	-3.428
CP	3.441	-0.732	-8.799	-27.937
INC	-0.765	-2.284	16.013	-1.971
IR	-0.229	0.724	0.831	2.591
GDP	-1.282	2.680	-6.415	31.303

HC	-0.021	-1.134	-5.911	-28.992
HS	0.259	-0.419	2.714	-5.099
ER	-0.189	0.216	0.084	0.395
UR	0.638	0.787	0.441	-0.202

Source: Authors' own calculation from Household debts data, South Africa

The parameters of rank 3 have signs (reversed) consistent with economic theory and a specified model in equation (1). The estimated long run equation expressed as a loglinear function of household debt in SA becomes;

$$\Delta \ln HHD = 1.756\, HP + 8.799\, CPI - 16.013\, INC + ... - 0.084 - 0.441\, \Delta \ln UR \quad (17)$$

CP is the only determinant showing a different sign and the findings contradict views by Debelle (2004) and Prinsloo (2002) in terms of this determinant. The LCH and Kotzé and Smit (2008) concluded that CP depreciates HHD. Although this equation shows the parameters that are over estimating the contribution to household debt, the results do concur with those by Hurst and Stafford's (2004) and Debelle's (2004). These authors suggested that when interest rates are halved, households could double their take-out loan and accumulate more debts. Moreover, HP have positive impact of HHD confirming Debelle (2004), Subhanji (2007) and Ando and Modigliani (1963) who highlighted that rise in HP could encourage households to consume more and save less, thus building up debts by betting higher expectations for the future. The ECM is calculated to correct for short run dynamics and the results are summarised in Table 6.

Table 6. Error correction representation: dependent variable: HHD

Model Parameter Estimates						
Equation	Parameter	Estimate	Standard Error	t Value	Pr > |t|	Variable
D_HHD	CONST1	-0.123	0.882	-0.14	0.889	1
	XL0_1_1	0.075	0.026	2.83	0.005	HP(t)
	XL0_1_2	0.255	0.127	2.00	0.049	CP(t)
	XL0_1_3	-0.581	0.129	-4.50	0.0001	INC(t)
	XL0_1_4	-0.053	0.023	-2.23	0.028	IR(t)
	XL0_1_5	0.244	0.144	1.70	0.093	GDP(t)
	XL0_1_6	0.276	0.141	1.96	0.053	HC(t)
	XL0_1_7	-0.123	0.028	-4.32	0.0001	HS(t)
	XL0_1_8	-0.001	0.011	-0.07	0.946	ER(t)
	XL0_1_9	-0.095	0.018	-5.15	0.0001	UR(t)
	AR1_1_1	-0.138	0.032			HHD(t-1)

Source: Authors' own calculation from Household debts data, South Africa

The ECM result shows that the overall fit is fit with only ER, GDP and HC confirmed as not having effects on household debts in the long run. This conclusion is based on the insignificant associated probabilities of these variables. The coefficient of the ECM is negative as expected indicating a satisfactory speed of adjustment in the long and short run. This implies that the system corrected its previous disequilibrium period due to its shocks in one period at an adjustments speed of 13.8% per quarter.

4.3 Causality analysis

According to the concept of Granger causality, if say HHD represents the dependent and ER the independent variables, 'ER will cause HHD' if and only if the past values of ER help to predict the changes of HHD. Alternatively, HHD causes ER if and only if the past values of HHD help to predict the changes of ER. These explanations can be found in Tang (2011). If a set of variables are cointegrated, then there must be short- and long-run causality which cannot be captured by the standard first difference VAR model (Granger 1988). This study implements the modified Toda-Yamamoto Granger causality test. The VECM framework as adopted from Tang (2011) provides equations explaining causal relationship between the variables as follows;

$$\Delta \ln HHD_t = \alpha_1 + \sum_{i=1}^{p} \eta_i \Delta \ln HHD_{t-i} + \sum_{i=1}^{p} \beta_i \Delta \ln HP_{t-i} + ... + \sum_{i=1}^{p} \varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{1t}$$

$$(18)$$

$$\Delta \ln HP_t = \alpha_2 + \sum_{i=1}^{p}\beta_i \Delta \ln HP_{t-i} + \sum_{i=1}^{p}\eta_i \Delta \ln HHD_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{2t}$$
(19)

$$\Delta \ln CP_t = \alpha_3 + \sum_{i=1}^{p}\phi_i \Delta \ln CP_{t-i} + \sum_{i=1}^{p}\beta_i \Delta \ln HP_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{3t}$$
(20)

$$\Delta \ln INC_t = \alpha_4 + \sum_{i=1}^{p}\theta_i \Delta \ln INC_{t-i} + \sum_{i=1}^{p}\phi_i \Delta \ln CP_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{4t}$$
(21)

$$\Delta \ln IR_t = \alpha_5 + \sum_{i=1}^{p}\kappa_i \Delta \ln IR_{t-i} + \sum_{i=1}^{p}\theta_i \Delta \ln INC_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{5t}$$
(22)

$$\Delta \ln GDP_t = \alpha_6 + \sum_{i=1}^{p}\rho_i \Delta \ln GDP_{t-i} + \sum_{i=1}^{p}\kappa_i \Delta \ln IR_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{6t}$$
(23)

$$\Delta \ln HC_t = \alpha_7 + \sum_{i=1}^{p}\vartheta_i \Delta \ln HC_{t-i} + \sum_{i=1}^{p}\rho_i \Delta \ln GDP_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{7t}$$
(24)

$$\Delta \ln HS_t = \alpha_8 + \sum_{i=1}^{p}\gamma_i \Delta \ln HS_{t-i} + \sum_{i=1}^{p}\vartheta_i \Delta \ln HC_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_{8t}$$
(25)

$$\Delta \ln ER_t = \alpha_9 + \sum_{i=1}^{p}\tau_i \Delta \ln ER_{t-i} + \sum_{i=1}^{p}\gamma_i \Delta \ln HS_{t-i} + ... + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \psi_1 ECT_{t-1} + \upsilon_9$$
(26)

$$\Delta \ln UR_t = \alpha_9 + \sum_{i=1}^{p}\varpi_i \Delta \ln UR_{t-i} + \sum_{i=1}^{p}\gamma_i \Delta \ln HS_{t-i} + ... + \sum_{i=1}^{p}\tau_i \Delta \ln ER_{t-i} + \psi_1 ECT_{t-1} + \upsilon_9$$
(27)

Where Δ represent the first difference operator, $\ln$ is the natural logarithm, $i = 1, 2, 3, ..., 9$, $\beta, \phi, \theta, \kappa, \rho, \vartheta, \gamma, \psi, \varpi$ are the parameters in the model. The residuals υ_{it} are assumed to be normally distributed and to follow a white noise process. ECT_{t-1} is the one period lagged error-correction term derived from the cointegration equation. The ECT_{t-1} variable is excluded from that model if the variables are not cointegrated.

In the next step, the Likelihood Ratio (LR) statistic is used to determine the direction of causality between the variable. The expected results from the analysis are that household debt determinants are well behaved. The null hypothesis for this test is that the series is weakly exogenous (Harris 1995). If the observed probability value is greater than a conventional level of significance, this hypothesis is not rejected, implying that, that variable is not a true cointegrating vector. Assuming HHD and ER are subjected to causality testing, either one or two of the following possible conclusions is expected;

- ER causes HHD, but HHD does not cause ER
- HHD causes ER, but ER does not cause HHD
- ER causes HHD and HHD causes ER, i.e., there is a feedback system or bidirectional causality.
- ER does not cause HHD and HHD does not cause ER

On the basis of these outcomes, this section of the study tests the following hypotheses;

$H_{01} : \eta_1 = \eta_2 = ... = \eta_p = 0$; *HHD does not cause ER*

$H_{02} : \tau_1 = \tau_2 = ... = \tau_p = 0$; *ER does not cause HHD*

The same process is applied to the rest of the variables. Granger causality uses the *F* statistic to check the statistical significance of the short-run causal effects. The null hypothesis that one variable does not cause another is rejected if the observed *F* test exceeds the expected statistic at 5% level of significance. Alternatively, the associated observed probability of this statistic is compared with 5% significance level and the hypothesis is rejected if the former is less than the latter. The *t*-statistic is used to assess the statistical significance of the long-run causal effect on the coefficient of the ECT_{t-1}. The significance of this statistic is tested the same way as the F statistic. Though Granger causality test is widely used, it has its limitations.

- A two-variable Granger-Causality test without considering the effect of other variables is subject to possible specification bias (Alimi and Ofonyelu 2013). As pointed out by Gujarati (2003), a causality test is sensitive to model specification and the number of lags. It would reveal different results if the variable was relevant and was not included in the model. Therefore, the empirical evidence of a two-variable Granger-Causality is fragile because of this problem.
- According to Maddala (2001) time series data are often non-stationary and this could create a situation of spurious regression. Consequently, when the variables are integrated, the F-test procedure becomes invalid as the test statistics do not have a standard distribution (Gujarati and Porter 2009). The test can still be used

for significance testing of individual coefficients with t-statistic, but one may not be able to use F-statistic to jointly test the Granger-Causality. Enders (2005) proved that in some specific cases, using F-statistic to jointly test first differential VAR is permissible, only when the two-variable VAR has lagged length of two periods and only one variable is nonstationary. Other deficiencies of these tests are discussed in Toda and Phillips (1994).

Based on the problems discussed above, this study uses a modified Granger causality testing statistic proposed by Toda and Yamamoto (1995). This statistics requires the estimation of an augmented VAR which guarantees the asymptotic distribution of the Wald statistic. The statistic follows a x^2 distribution with *m* degrees of freedom. Table 7 provides a summary of Toda-Yamamoto Granger causality test.

Table 7. Toda-Yamamoto Causality Test Results

Test	Group 1Variables	Group 2 Variables	DF	Chi-Square	Pr > ChiSq
1	HHD	HP CP INC IR GDP HC HS ER UR	9	19.76	0.019
2	HP	HHD CP INC IR GDP HC HS ER UR	9	16.92	0.050
3	CP	HHD HP INC IR GDP HC HS ER UR	9	65.56	<.0001
4	INC	HHD HP CP IR GDP HC HS ER UR	9	30.63	0.0003
5	IR	HHD HP CP INC GDP HC HS ER UR	9	20.95	0.013
6	GDP	HHD HP CP INC IR HC HS ER UR	9	7.65	0.569
7	HC	HHD HP CP INC IR GDP HS ER UR	9	50.88	<.0001
8	HS	HHD HP CP INC IR HC GDP ER UR	9	34.26	<.0001
9	ER	HHD HP CP INC IR HC GDP HS UR	9	12.80	0.172
10	UR	HHD HP CP INC IR HC GDP HS ER	9	10.86	0.285

Source: Authors' own calculation from Household debts data, South Africa

Toda-Yamamoto Granger causality results presented in Table 6 indicate a unidirectional causal relationship running from GDP, ER and UR to other variables. A bi-causal relationship is shown running between the entire variables. This conclusion is due to the probabilities associated the LR test using a 5% significance level. Based on these findings, all the independent variables are confirmed not to be weakly exogenous in the system of household debts except GDP, ER and UR.

5. Concluding Remarks

This study adopted multivariate time series approach to model household debt in SA. Quarterly data ranging from 1990 Q1-2013 Q1 was analysed with SAS 9.3. The Johansen (1988) multivariate cointegration and the Toda and Yamamoto (1995) causality approaches were adopted. The ADF and KPSS unit root tests formulated from Fountis and Dickey (1989) results revealed no unit root in the series confirming the variables are stationary at first difference. The results of cointegration analysis revealed at least four vectors which were incorporated in the analysis to construct a long run model. This model had the signs of the coefficients in accordance with theory and most of the authors. The sign of CP was found to be in conflict with Debelle (2004), the PIH and the LCH. Though most of the variables were found to be moving together in the long-run, the magnitudes of their coefficients were also found to be over estimating. The ECM corrected this problem and even more stable coefficients were obtained. An adjustment speed of about 13.8 % was calculated and it has been concluded that this model is a true cointegrating vector according to Aziakpono (2006).

The ECM results confirmed that in the short-run, an increase in HHD is attributed to all variables except HC, GDP and ER. With reference to these findings, we assume that the current HHD status in SA cannot be associated with these determinants. The remaining six determinants are proven to be leading causes of debts to household in the country. HC and HS are identified as having the most significant negative effect in both the long and the short-run. These results are in accordance with theories and findings by Debelle (2004), Subhanij (2007), Prinsloo (2002) and Kotzé and Smit (2008). Furthermore, Toda-Yamamoto causality results revealed GDP, UR and ER A unidirectional relationship running to household debt with the remaining variables revealing a feedback type of relationship.

This study recommends even harsher policy measures to be legislated that would benefit not only the consumers but also credit suppliers. Financial suppliers should be closely monitored and perhaps harsh penalties be decreed to those that do not adhere to the law. Reserve banks should in future think of other ways of assisting consumers other than reducing interest rates as this decision was reported to be one of the root causes of financial crises. This study accurately

modelled household debts for SA following the VECM approach. Further analysis on the issue may be done using the CVAR. The results of these analyses may be compared to those of the current study. This may help policy-makers to advocate policies that may be adopted when dealing with household indebtedness. Furthermore, it is suggested that other variables affecting household debts not used in this study be included in the VECM and the recommended CVAR models. This may help in accurately and fairly marking the most important similarities and differences between these models. The findings may fill a gap to existing literature on this subject and may also help data analysts to better make a distinction between the different multivariate methods used for modelling economic data. They will also understand that the analysis of household indebtedness is not only limited to univariate or bivariate measures.

References

Alexander, C. (2001). *Market models: A guide to financial data analysis*. John Wiley and Sons Ltd.

Alimi, S. R. and Ofonyelu, C. C. (2013). Toda-Yamamoto Causality test between money market interest rate and expected inflation: The Fisher hypothesis revisited. *European Scientific Journal*, 9(7).

Allen, F. and Giovannetti, G. (2010). Fragile countries and the 2008-2009 crisis. (EUI- RSCAS Working Papers 2010/13). Retrieved from http://cadmus.eui.eu/dspace/bitstream/1814/13536/3/RSCAS_2010_13.pdf.

Ando, A. and Modigliani, F. (1963). The life cycle hypothesis of savings. *Journal of American Economic Review*, 53(1).

Aron, J., Muellbauer, J. and Prinsloo J. (1999). Estimates of personal sector wealth for South Africa. The centre for the study of African economies. Working paper series101. Retrieved from http://www.bepress.com/csae/paper101.

Aron. J. and Muellbauer, J. (2000). Personal and corporate saving in South Africa. *World Bank Economic Review*, 14(3) : 509–544.

Aziakpono, M. J. (2006). Financial integration amongst the SACU countries: evidence from interest rate pass-through analysis. *Studies in Economics and Econometrics*, 30(2) : 33- 46.

Banerjee, A., J.J. Dolado, J.W. Galbraith and Hendry, D. (2011). Co-integration, error correction, and the econometric analysis of non-stationary data. OUP Catalogue.

Daniels, R. (2001). Consumer indebtedness among urban South African households: a descriptive overview. *Cape Town Development Policy Research Unit*. (DPRU), working Paper 01/55).

Duasa, J. (2007). Malaysian foreign direct investment and growth: Does stability matter. *Journal of Economic Cooperation*, 28(2): 83-98.

Debelle, G. (2004). Household debt and macroeconomy. *BIS Quarterly Review*, March, 51-64, http://www.bis.org/publ/qtrpdf /r_qt0403e.pdf.

Demyanyk, Y. and Van Hemert, O. (2008). Understanding the Subprime Mortgage Crisis. Working Paper, Federal Reserve Bank of St. Louis.

Dickey, D. A., and Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, (49) : 1057-1072.

Dickey, D. A. and Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, (74) : 427-431.

Enders, W. (2005). *Applied Econometric Time Series*. USA: John Wiley and Sons Ltd..

Fountis, N. G. and Dickey, D. A. (1989). Testing for a unit root nonstationarity in Multivariate Autoregressive time series. *Annals of Statistics*, (17) : 419-428.

Friedman, M. (1957). *A Theory of the Consumption Function*. New Jersey: Princeton University Press.

Granger, C. W. J. (1988). Some Recent developments in a Concepts of Causality. *Journal of Econometrics*, 39(1-2) : 199-211.

Gujarati, D. N. (2003). *Basic Econometrics*. New York: McGraw-Hill Inc.

Gujarati, D. N., and Porter, D.C. (2009). *Basic Econometrics*. Australia: McGraw-Hill.

Gul, E. and A. Ekinc, (2006). The causal relationship between nominal interest rates and inflation: The case of Turkey. *Scientific Journal of Administrative Development*, (4): 54-69.

Hamilton, J. D. (1990). Analysis of time series subject to changes in regime. *Journal of Econometrics*, (45) : 39-70.

Harris, R. J. D. (1995). *Using Cointegration Analysis in Econometric Modelling*. Harvester Wheatsheaf, Prentice Hall.

Hurst, E. and Stafford, F. (2004). Home Is Where the Equity Is: Mortgage Refinancing and Household Consumption. *Journal of Money, Credit and Banking*, Blackwell Publishing 36(6) : 985-1014.

Johansen, S. and Juselius, K. (1990). Maximum Likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, (52) : 169-210.

Kojucharov, N., Martin, C. F., Martin, R. F. and Xu, L. (2008). The Subprime Mortgage Crisis: Irrational Exuberance or Rational Error? Working Paper, Federal Reserve Board of Governors, 3.

Kotzé, L. and Smit, A. V. A. (2008). Personal finances: What is the possible impact on entrepreneurial activity in South Africa? Department of Business Management, Faculty of Economic and Management Sciences, University of the Free State. Available at Southern African Business Review, www.myunisa.ac.za.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. and Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that time series have a unit root? *Journal of Econometrics*, 54 : 159-178.

Keynes, J.M. (1936). *The General Theory of Employment, Interest and Money*. London: Macmillan.

Laeven, L. and Valencia, F. (2012). Systemic banking crises database: An update. IMF Working Paper 12/163.

Lorgat, M. (2003) Enabling worker finances: The effects of rising costs of living and debt on worker finances. Unpublished paper, South African Sociological Association, Durban.

Maddala, G. S. (2001). *Introduction to Econometrics*. New York: Wiley and Sons, Inc.

Mashigo, M. P. (2006). The debt spiral in the poor households in South Africa. *International Indigenous Journal of Entrepreneurship, Advancement, Strategy and Education*, 2(1).

Meniago, C., Mukuddem-Petersen, J., Petersen, M. A. and Mongale, I. P. (2013). What causes household debt to increase in South Africa? *British Journal of Economic Modelling*, 1(33) : 482-492.

Modigliani, F. (1986). Life cycle hypothesis, individual thrift and the wealth of nations. *The American Economic Review*, 76(3) : 297-313.

Naudé, W. (2009) The financial crisis of 2008 and the developing countries. UNU-Wider Discussion paper, No 2009/01, Retrieved from http://wider.unu.edu/dp2009-01.pdf.

Nwachukwu, T. E. and Egwaikhide, F. O. (2007). An Error-Correction Model of the determinants of private saving in Nigeria. A Paper presented at the African Economic Society (AES) Conference, Cape Town, South Africa.

Osterwald-Lenum, M. (1992) A Note with Quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistic. *Oxford Bulletin of Economics and Statistics*, (54) : 461-472.

Prinsloo, J. W. (2002). Household debt, wealth and saving. *South African Reserve Bank Quarterly Bulletin*, (226) : 63-78.

Rinaldi, L. and Sanchis, A. (2006). Household debt sustainability: What explains household non-performing loans? An empirical analysis, ECB Working Paper (570) : January.

Sjö, B. (2008). Testing for unit roots and cointegration.

South African Reserve Bank (SARB), 2010. Annual economic report, Pretoria.

South African Reserve Bank (SARB), 2009. Annual economic report, Pretoria.

Subhanij, T. (2007). Some lessons from Securitisation Crisis. Bangkok Post, Business New, (13 July, 2007).

Tang, C. F. (2011). Multivariate Granger causality and the dynamic relationship between health care spending, income, and relative price of health care in Malaysia. Hitotsubashi *Journal of Economics*, 52(2) :199-214.

Toda, H. Y. and Yamamoto, T. (1995). Statistical inference in Vector Autoregressions with possibly integrated processes. *Journal of Econometrics*, (66) : 225-250.

Toda, H. Y. and Phillips, P. C. B. (1994). Vector Autoregressions and Causality: a theoretical overview and simulation study. *Econometric Reviews*, (13): 259-285.

Yilmazer, T and Devaney, S.A. (2005). Consumer debt over the life-cycle. Financial Services Review, 14(4) : 285-304.