“Auto-regressive Distributed Lag Model for long-run US household debt determinants”

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AUTO-REGRESSIVE DISTRIBUTED LAG MODEL FOR LONG-RUN US HOUSEHOLD DEBT DETERMINANTS

Abstract

US household debt increased on a yearly basis from 1987 to 2007. In addition, household debt in the USA nearly doubled between 2000 and 2007, from $5.6 trillion to $9 trillion. This came to an abrupt end in 2009 with the crash of the financial market. This paper employs the bound test and Auto-regressive Distributed Lag Model to determine the long-run relationship between US household debt and consumer prices, housing prices, the unemployment rate, and the lending rate. Unit root tests were conducted first to ascertain the stationarity of the variables. E-views 11 was used in the analysis of the data, which was obtained from Q1: 1990 to Q1: 2007 from the International Monetary Fund and the US FED. It was found that in the long run, there is a negative effect of consumer prices and unemployment on US household debt, while house prices and the lending rate would have a positive effect on household debt.

Keywords household debt, Auto-regressive Distributed Lag Model, bound test, unit root tests, housing prices, unemployment

JEL Classification E00, C01, C12, C32, C58

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INTRODUCTION

The period of 2000 to 2009 is marked by drastic increases and decreases in US household debt. These upswings and eventual downswing in the US credit market have been the most significant since the Great depression of 1929. To add to this matter, from 1987 to 2007 US household debt has increased on a yearly basis. In addition, household debt in the USA nearly doubled between 2000 and 2007, from $5.6 trillion to $9 trillion (Federal Reserve Board, 2008). The boom had ended severely in 2009 as a result of the Global Financial Crisis (Fennel & Keys, 2017). This paper will investigate the impact that certain variables have on US household debt, as a macroeconomic concern, as scholars have still not reached a universal agreement on the main variables that fuel household debt. Although no universal agreement exists, there is an agreement amongst scholars that debt is an important factor in the macroeconomic environment (Wildauer, 2016).

However, Debelle (2004) and Krugman (2018) argue that from a macroeconomic perspective unexpected movements in interest rates will have a significant effect on household debt and changes in income which stem from unemployment.

Nonetheless, even if it is argued that loss of income as a result of unemployment will have dire effects on household debt, it also stems to reason that only a relatively small part of the US population is unemployed with the US unemployment rate being 3.6% in April 2019

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(Bureau of Labor Statistics, 2019). In addition, historically unemployed individuals usually do not have such high debt (Debelle, 2004). Nevertheless, since debt usually is given over a long time span, a scenario might exist where an employed person obtained a loan, now unemployed and still needs to pay back some of the debt (Debelle, 2004; Krugman, 2018; Bernardini & Peersman, 2018). What makes this paper so important is the mere size of the US economy, with a Gross Domestic Product (GDP) of $19.39 trillion (World Bank, 2019). Their size makes macroeconomic implications of household debt significant, not only from a US perspective but also the rest of the world (Barba & Pivetti, 2008).

As a result, it became critically important to investigate the variables that have a long-term effect on US household debt. This paper continues with a literature review to discuss US household debt, followed by methodology used to complete the paper. Then, the results are discussed and conclusions are presented.

1. LITERATURE REVIEW

1.1. Household debt as a macroeconomic concern

Although prevalent in all financial transaction of households, credit especially comes to play when a household acquires property. As extensive literature (e.g., Turinetti & Zhuang, 2011; Justiniano et al., 2015; Zinman, 2015; Kim, 2016; Hiilamo, 2018) has already been done on the matter, this paper will further discuss, but not exclude the acquisition of property, other macroeconomic concerns of US household debt, in particular its effect on financial crises.

Hiilamo (2018) asserts that not only credit has established financial and commercial interactions between individuals. In developed societies, individuals are actually encouraged to acquire debt as it in turn promotes economic growth and is not seen as sign of financial distress. Furthermore, the author argues that in these societies, debt might even be an indication of a high level of solvency, and it only becomes perilous when the debtor is unable to repay.

However, Lombardi et al. (2017) argue that household debt's effect is limited in standard macroeconomic models and is by itself not a major determinant of household consumption. Nonetheless, numerous authors (e.g., Main & Sufi, 2010; Dynan, 2012; Schularick & Taylor, 2012; Jorda et al., 2013, 2015, 2016) argue the strong correlation between financial crises and recessions. In addition, these authors together with Hiilamo (2018) emphasize the correlation between household debt and economic growth (Lombardi et al., 2017).

Lombardi et al. (2018) further investigated the papers by Schularick and Taylor (2012) and Jorda et al. (2013, 2015, and 2016), in which they concluded that significant levels of debt and financial crises have a strong positive correlation. In addition, they determined that the level and significance of debt can be used in econometric models to predict the intensity of the said crises.

Moreover, numerous authors (e.g., Zeldes, 1989; Blundell et al., 2008; Main & Sufi, 2010; Dynan, 2012) have estimated the impact of changes in income on changes in consumption, while Dynan (2012) further found that the distribution of wealth in the USA is extremely skewed. She further evidenced that the distribution of debt and assets play a significant role for levels of consumption. These studies further explain that financial crises are intensified by the higher marginal propensity to consume (MPC) of severely indebted households whose spending declines rapidly amidst negative house price shocks (Lombardi et al., 2018).

In addition, Cecchetti and Kharroubi (2015), Borio et al. (2016) focused their efforts and research on the effect debt has on the supply-side of macroeconomics. They found that a severe misallocation of resources and a slowdown in production growth in the construction sector follows credit booms. This, they assert, has adverse effects on the real economy that could be long-lasting (Borio et al., 2016). As such, it is imperative to move past the aggregate demand effects (Lombardi et al., 2017). The subsequent section will emphasize US household debt and its relation to numerous macroeconomic factors to include consumer prices (CPI), housing prices,

Source: IMF (2019).

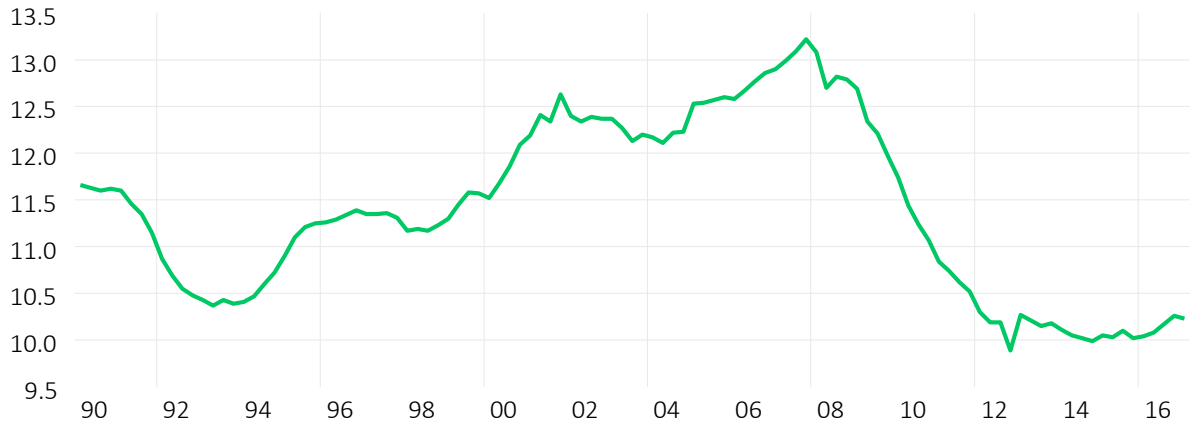

Figure 1. US household debt

unemployment, and the lending rate. The importance and significance of the US economy have already been established.

1.2. US household debt

Despite being perceived as negative, there are benefits to household debt for the economy and the individual. Numerous authors already mentioned have established that credit used to increase consumption will in turn stimulate the economy (e.g., Main & Sufi, 2010; Dynan, 2012; Hiilamo, 2018). As such, money supply is a tool used by the US Federal Reserve (FED) to entice households to either spend more or less. When an economic downturn is experienced, expansionary monetary policies are implemented to increase the supply of money and in turn economic activity. In times of economic prosperity, the FED would decrease the money supply with the aid of contractionary monetary policies to combat inflation (Bunn & Rostom, 2014; Wildauer, 2016).

Nonetheless, since the crash of the financial markets in 2009, there has been a drastic decrease in US household debt (see Figure 1). One of the main determinants to the levels of this household debt is the current level of income as mentioned in Debelle (2004), Dynan (2012), Bernardini and Peersman (2018), and Krugman (2018) (to name but a few). Chmelar (2013) and Cardaci (2014) argue that low-income households use debt mostly to finance basic needs in contrast to high-income households who use debt to increase their social status.

In addition, numerous authors (e.g., Turinetti & Zhuang, 2011; Justiniano et al., 2015; Zinman, 2015; Kim, 2016; Hiilamo, 2018) have studied the effects of homeownership and the price of property on US household debt (see Figure 2). In an effort to stimulate the economy and promote homeownership, the US government created financial services with the intention to boost credit flow towards targeted sectors in the lower-income households (Paiella, 2009).

This policy made it possible for low-income households to become homeowners. Further to this, the financial deregulations and eased access to credit cards increased subsequently and led to an increase in US house prices of 115% between the 1990s and 2000s. This in turn caused homeowners to realize substantial gains on their investment (Paiella, 2009; Barba & Pivetti, 2008).

Figure 2 shows that house prices started to increase drastically from 1998 and reached a peak during the period of 2006 to 2008. Even though the market crashed in 2009, house prices still remain relatively high. This might explain the drastic drop in household debt during the market crash of 2009, since the majority of debt owned by households were mortgage bonds, which they subsequently defaulted on. As such, Figure 2 indicates that since the market crash, US household debt has remained relatively low (IMF, 2019).

In addition, another factor that could explain the drastic increase and subsequent drop in household debt is that as soon as a household obtains a

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Source: IMF (2019).

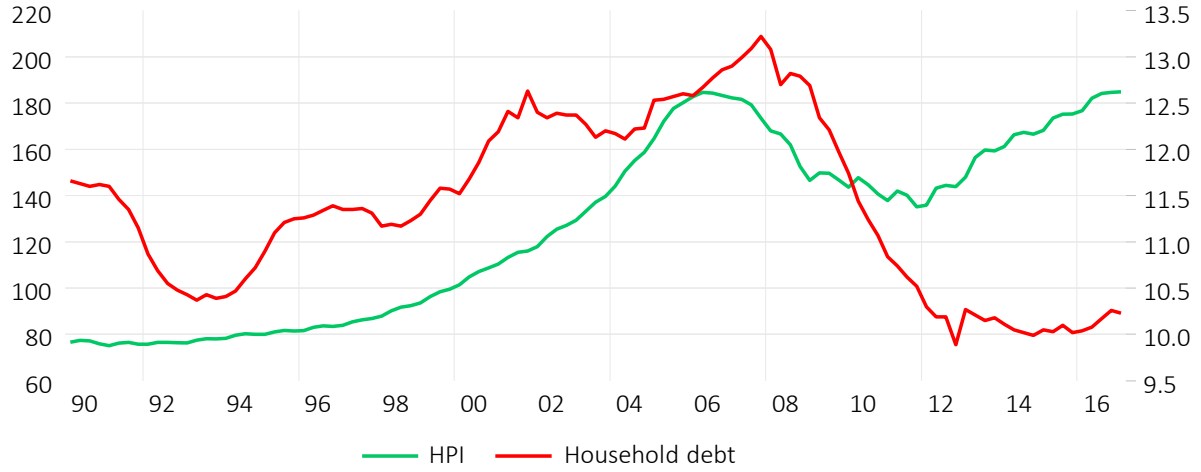

Figure 2. US housing price index vs US household debt

mortgage credit, this will entice them to take on an additional consumer loan. Chen et al. (2015) argue that as a household obtains a mortgage loan, the need for extra funds will become apparent, to amongst others, renovate their houses or buy extra equipment or accessories for maintenance (Chan et al., 2015). In addition, households with mortgages would experience increased awareness of certain financial products and in turn create a sense of comfort amongst these households toward financial liability (Barba & Pivetti, 2008; Chmelar, 2013; Chan et al., 2015; Harari, 2018).

Furthermore, another factor that could have played a significant role are the features of financial institutions that relate to mortgage credit. As financial institutions limit households to the size of their mortgage loan they qualify for based on their disposable income, when interest rates change it could put these households in a situation where they cannot afford the loan they qualified for (Debelle, 2004; Harari, 2018).

In addition to household debt and interest rates, yet another important factor to consider is the US unemployment rate, since several individuals had lost their primary source of income during the market crash of 2009, reaching a peak in 2010 (IMF, 2019). However, unemployment by itself does not have such a large impact, it is when there is a change in interest rates (see Figure 3 and Figure 4). Nonetheless, the effect interest rates will

Source: IMF (2019).

Figure 3. US unemployment rate vs US household debt

Source: IMF (2019).

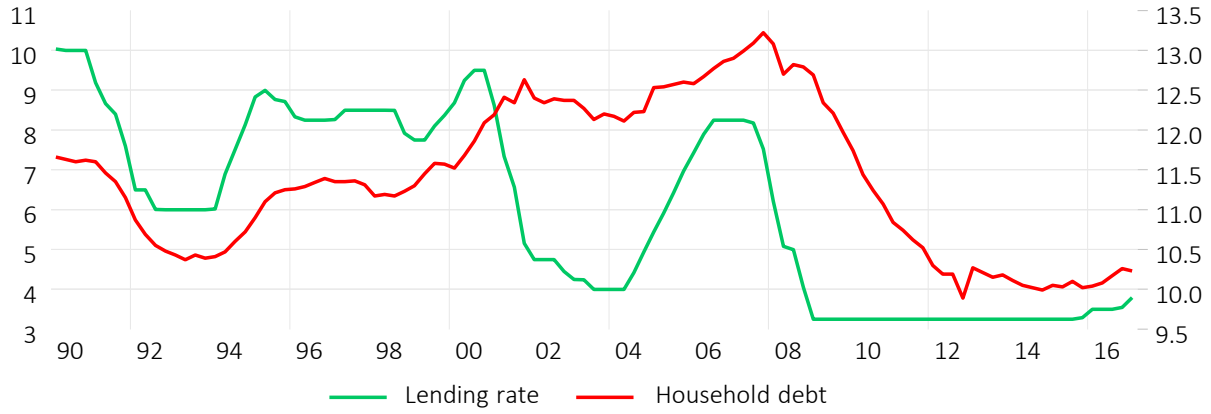

Figure 4. US lending rate vs US household debt

have on these households will be limited to their exposure to either a fixed- or variable mortgage rate (Debelle, 2004; Bernardini & Peersman, 2018).

Household debt will be distorted by changes in interest rates. If interest rates decrease, it will incentivize households to refinance their homes at lower rates. This in turn will increase household income available for consumption (Debelle, 2004; Krugman, 2018).

However, Barba and Pivetti (2008) assert that low- to middle-income households would make irrational decisions between saving or consuming over their life cycle to maintain certain standards of consumption as US income is heavily skewed in favor of higher income households (Dynan, 2012; Harari, 2018; Krugman, 2018). As a result, it is important to ascertain which factors might have a significant long-term effect on US household debt. This will be detailed in the subsequent sections.

2. RESEARCH METHODOLOGY

2.1. Data selection and description

This paper adopts a descriptive research design. The design was necessitated by the usage of quarterly time series data from Q1: 1990 to Q1: 2017. The dependent variable is US household debt with Consumer Price Index (CPI), Housing Price Index (HPI), unemployment, and the lending rate being the independent variables. The data was available from the US Federal Reserve Bank (FED) and the International Monetary Fund (IMF). All of the variables, except for the lending rate, have been transformed into natural logarithm to reduce the problem of heteroscedasticity and obtain linearity. The following model specifications has been developed for this study.

$$LHD = \beta_0 + \beta_1 LCPI + \beta_2 + LHPI + \\ + \beta_3 LUE + \beta_4 LR + \varepsilon, \quad (1)$$

where β_0 denotes a constant, LHD denotes US household debt, $\beta_1 LCPI$ denotes the Consumer Price Index, $\beta_2 + LHPI$ denotes the housing price index, $\beta_3 LUE$ denotes the unemployment rate, $\beta_4 LR$ denotes the lending rate, and ε denotes the error term.

2.2. Analytical model

The Augmented Dicky-Fuller (ADF) unit root tests were conducted first to ascertain the stationarity of the variables. The ADF test can be employed in situations where the assumption that ε_t in equation (2) is an independent and stationary process may not be realized due to the presence of serial correlation (Cromwell et al., 1994). The null hypothesis states that a unit root is present in the sample. The equation can be presented by (Asteriou & Hall, 2011):

$$\Delta y_t = \alpha y_{t-1} + x_t \delta + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \varepsilon_t. \quad (2)$$

Secondly, the study employed the Autoregressive Distributed Lag Model (ARDL) bound test as it is suitable for small samples with no variables inte-

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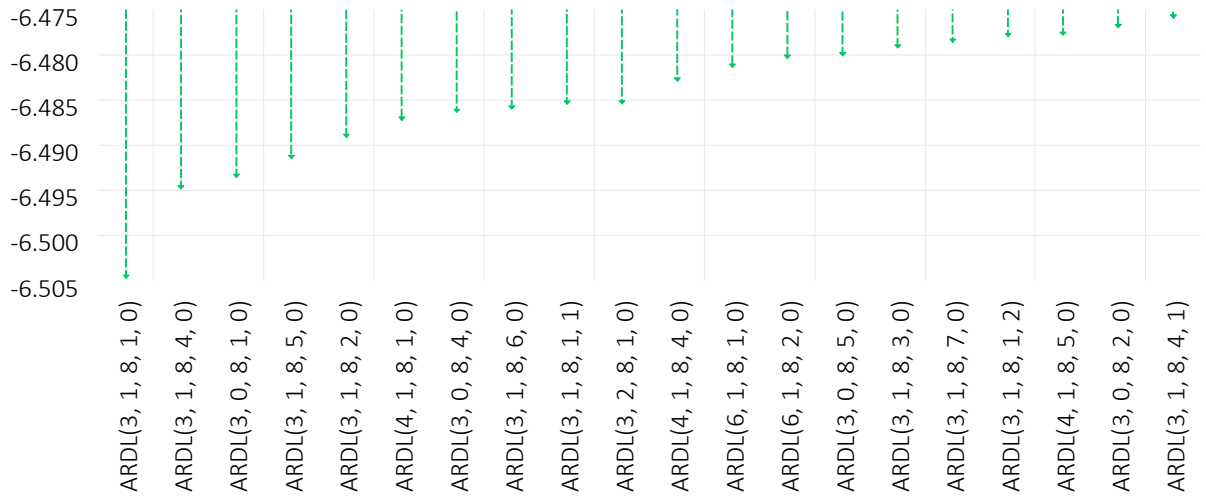

Figure 5. Akaike information criteria (top 20 models)

grated at order two I (2). ARDL models constitute linear time series models, in which dependent and independent variables are related across historical or lagged values. This approach will determine the long-run relationship amongst the variables (Khan et al., 2016). The estimation equation for this paper is specified as follows:

$$\begin{aligned}\Delta LHD_t &= \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta LHD_{t-i} + \\ &+ \sum_{i=0}^{p} \beta_2 \Delta LCPI_{t-i} + \sum_{i=0}^{p} \beta_3 \Delta LHPI_{t-i} + \\ &+ \sum_{i=0}^{p} \beta_4 \Delta LUE_{t-i} + \sum_{i=0}^{p} \beta_5 \Delta LR_{t-i} + \\ &+ \sigma_1 LHD_{t-1} + \sigma_2 LCPI_{t-1} + \sigma_3 LHPI_{t-1} + \\ &+ \sigma_4 LUE_{t-1} + \sigma_5 LR_{t-1} + \varepsilon_t.\end{aligned} \quad (3)$$

Bound testing should confirm the existence of a long-run relationship, then the following model is estimated where λ represents the speed of adjustment:

$$\begin{aligned}\Delta LHD_t &= \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta LHD_{t-i} + \\ &+ \sum_{i=0}^{p} \beta_2 \Delta LCPI_{t-i} + \sum_{i=0}^{p} \beta_3 \Delta LHPI_{t-i} + \\ &+ \sum_{i=0}^{p} \beta_4 \Delta LUE_{t-i} + \sum_{i=0}^{p} \beta_5 \Delta LR_{t-i} + \\ &+ \lambda ECT_{t-1} + \varepsilon_t.\end{aligned} \quad (4)$$

If it is found that λ is negative and statistically significant, it would represent the speed of adjustment and provide an alternative way to support cointegration between variables. In addition, the ECT accommodates the one period lagged error correction term (Dell'Anno & Halicioglu, 2010; Khan et al., 2016).

3. RESULTS AND DISCUSSION

As a primary test, ADF unit root tests were performed. It was found that none of the variables are integrated at order two, I (2). As such, the ARDL model was deemed acceptable to test for the existence of a long-run relationship amongst the variables. The Akaike information criterion (AIC) was used as the model selection method with a maximum of eight dependent lags. The selected ARDL model is based on (3, 1, 8, 1, 0). Figure 5 represents the criteria graph, which indicates that this model is the top model of the 20 models from AIC.

From this, an ARDL bounds test was performed which is presented in Table 1. The results from Table 1, the *F*-statistic, should confirm the existence of cointegration amongst the variables, then the long-run coefficient and the speed of adjustment of the variables can be determined.

The results presented in Table 1 confirm the existence of cointegration amongst the variables at the 5% significance level, while the results from Table 2 represents the long-run relationship amongst the variables, and Table 3 – the speed of adjustment.

Table 1. *F*-bounds test

Test statistic	Value	Significance	I(0)	I(1)
			Asymptotic: *n* = 1000	
F-statistic	3.544850	10%	2.2	3.09
K	4	5%	2.56	3.49
	–	2.5%	2.88	3.87
	–	1%	3.29	4.37

Table 2. A long-run model

Variable	Coefficient
LCPI	–0.474945***
LHPI	0.365425***
LUE	–0.176934***
LR	0.017877**
C	4.300187***

Note: ***, ** indicate the significance level at 1% and 5%, respectively.

The results from Table 2 indicate that the prices on goods and unemployment have a negative effect on household debt, while the housing price index and the lending rate have a positive impact on household debt. Findings from Table 2 suggest that a 10% increase in consumer prices will lead to a decrease in household debt by 4.74%. In addition, an increase in HPI by 10% will lead to an increase in household debt by 3.65%. in addition, an increase of 10% in unemployment and the lending rate will lead to a decrease of 1.76% and an increase of 0.1% in household debt, respectively.

Table 3 presents the Error Correction Model (ECM) that tested for a long-run relationship between the variables. Since the ECM is statistically significant at the 1% level and presents a negative sign, it confirms the existence of a long-run relationship amongst the variables. From this, any short-term deviation in household debt will be adjusted by 11.92% towards long-run equilibrium.

Table 3. ARDL error correction regression

Variable	Coefficient	Prob.
Coint Eq (–1)*	–0.119271***	0.0000

Note: *** indicate that the variable is significant at the 1% level.

The Breusch-Godfrey Serial Correlation LM Test was performed with a Null Hypothesis of no serial correlation. From Table 4 the Null Hypothesis cannot be rejected, as the P value for both the *F*-statistic and the Obs* *R*-squared are 0.86 and 0.74, respectively, which is greater than the 0.05 significance level, hence no serial correlation exists. Table 5 tabulates the results from the Autoregressive Conditional Heteroskedasticity (ARCH) test. The results indicate that the Null Hypothesis cannot be rejected, since the *P* value for the *F*-statistic and the Obs* *R*-squared are both 0.99, which is greater than the 0.05 significance level, hence there is no evidence of heteroskedasticity.

Table 4. Breusch-Godfrey serial correlation LM test

F-statistic	0.476033	Prob. *F* (8,72)	0.8692
Obs**R*-squared	5.073788	Prob. Chi-Square (8)	0.7497

Table 5. Autoregressive conditional heteroskedasticity (ARCH) test

F-statistic	0.137989	Prob. *F* (8,84)	0.9972
Obs**R*-squared	1.206334	Prob. Chi-Square(8)	0.9966

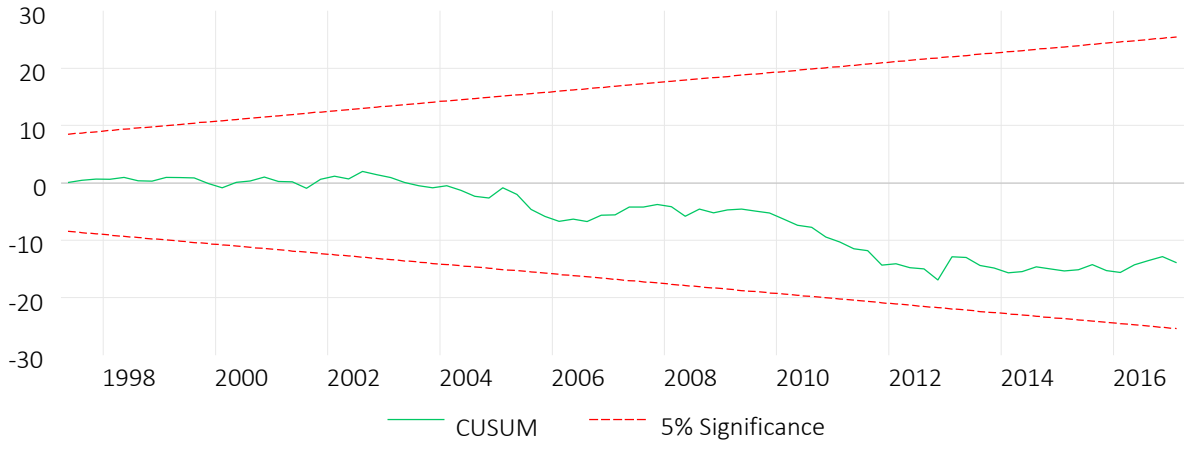

Figure 6. CUSUM chart

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To test for stability, the Cumulative Sum Control Chart (CUSUM) was used to detect process mean shifts based on the standardized observations. In particular, the cumulative sum of the recursive residuals' values is plotted against the upper and lower bounds of the 95% confidence interval at each point. Hence, the model will be deemed stable if the cumulative sum of the recursive residuals falls within the 5% significance interval (Hawkins & Olwell, 2012). The results of the CUSUM chart for this paper is depicted in Figure 6, which reflects that the model is stable as it lies within the 5% significance boundary.

CONCLUSION

The main objective of this study was to measure the long-run relationship between US household debt and consumer prices, housing prices, unemployment, and the lending rate. In order to achieve this objective, an ARDL model was developed and tested. As a preliminary test to assure stationarity of the variables, unit root tests were conducted by means of ADF tests. All the variables were found to be integrated at order one I (1). As such, the ARDL model was developed with household debt as the dependent variable. The Akaike Information Criterion (AIC) was used as the model selection method with a maximum of eight dependent lags. The selected ARDL model is based on (3, 1, 8, 1, 0). From the bounds test performed it was concluded that cointegration amongst the variables at the 5% significance level existed. From the long-run model it was confirmed that consumer prices and unemployment have a negative effect on US household debt, while housing prices and the lending rate have a positive effect on household debt. In addition, the speed of adjustment was also tested with the ARDL Error Correction Regression. The test confirmed the existence of a long-run relationship amongst the variables with a negative coefficient of –0.12.

Further to this, the Breusch-Godfrey Serial Correlation LM Test and the Autoregressive Conditional Heteroskedasticity (ARCH) test were conducted to conclude no presence of serial correlation or heteroskedasticity. As a final test for stability of the model, the CUSUM chart was presented, which reflects that the model is stable as it lies within the 5% significance boundary.

For future research, it might be viable to include student debt as an independent variable to measure the long-term effect on US household debt. This model was limited to the availability of data.

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