3. HOUSEHOLD INDEBTEDNESS IN LUXEMBOURG

Lucas Hafemann[124]

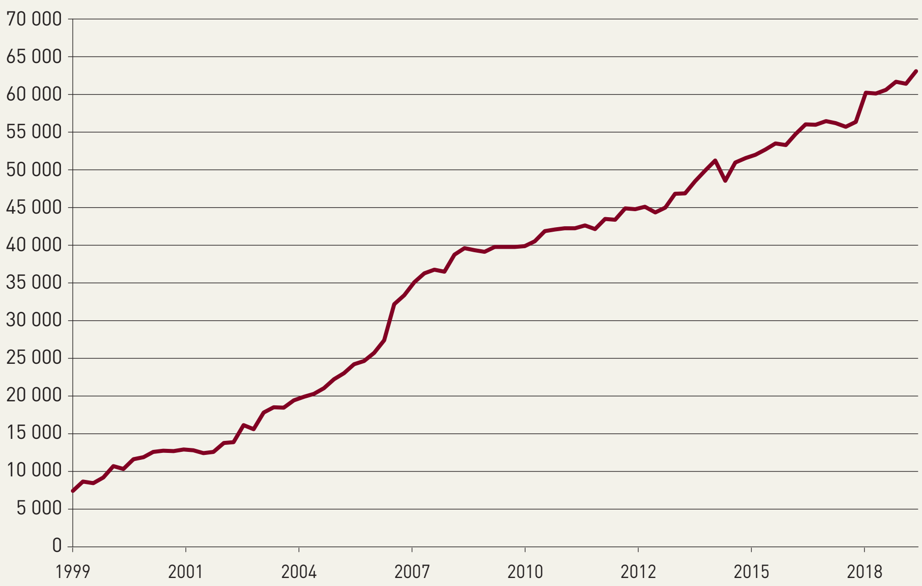
ABSTRACT

Household debt in Luxembourg has increased to historically unprecedented levels raising questions about (i) the driving forces behind this process, (ii) its sustainability and (iii) the possible role of (macroprudential) policymakers. We identify potential variables that drove household indebtedness in Luxembourg via an OLS and a VECM estimation and find that increases in house prices, the Loan-to-Value ratio and the share of mortgage credit with a variable rate lead to higher household indebtedness levels. Based on the VECM and ad-hoc fixed thresholds, we identify the maximum amount of household debt that is in line with economic fundamentals. We then compare this amount with Luxembourg's current household debt levels and conclude that they might be unsustainable. Based on our estimates, average Loan-to-Value ratios should decrease by at least 3.3 percentage points to reach "sustainable" debt levels.

1. INTRODUCTION

The Great Recession highlighted that an unsustainable level of household indebtedness can severely and adversely affect the real economy and the stability of the financial system. Cross-country analyses suggest that the recession was more substantial in countries with high household debt-to-income levels (Glick and Lansing, (2010)). In a similar vein, Jordà, Schularick and Taylor (2013) and Cuerpo *et al.* (2013) present evidence that the likelihood of a financial crisis increases when household debt is high. Finally, higher debt-to-income ratios amplify shocks as households' sensitivity to changes in interest rates and expected income increases, (Chmelar (2013)).

Figure 1
Household debt per capita



Source: BCL calculations. The chart displays household debt per capita at constant prices (Euros in 2015).

Against this backdrop, we analyze the current household debt situation in Luxembourg. By the end of the first quarter of 2020, Luxembourg's economy featured an historically high level of real household debt per capita (Figure 1). This is also mirrored by the sharp increases in debt-to-disposable income ratios since 1999 (Figure 2). Indeed, among the euro area member states, Luxembourg had the second-highest household debt-to-income ratio in 2018, at 174 %, while the average euro area ratio was 94 %.[125]

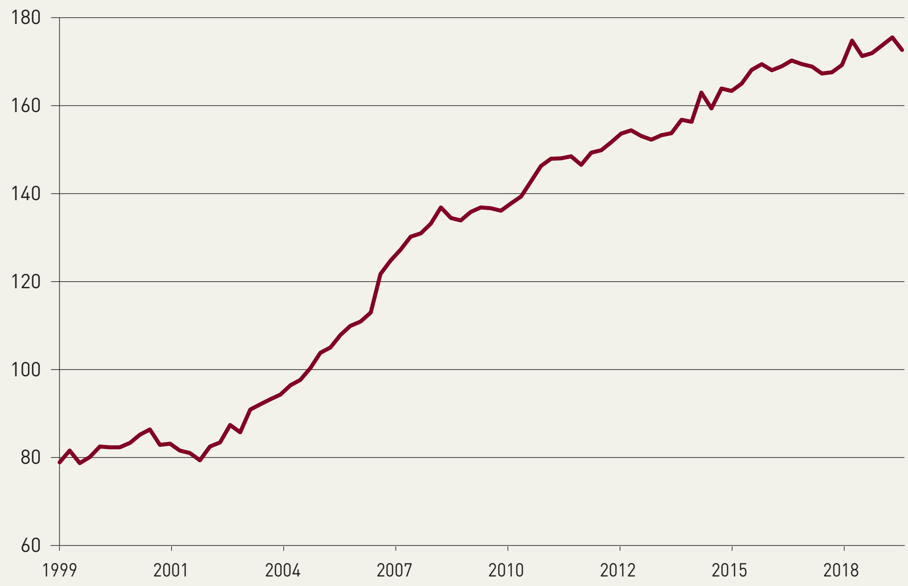
The evolution of household debt does not directly yield information

124 Financial Stability Department, Banque centrale du Luxembourg

125 The corresponding data set comes from Eurostat.

on its sustainability. The debt level may be considered as unsustainable if it permanently exceeds a value justified by economic fundamentals. Although we address the question of household debt sustainability in this analysis, the results should be interpreted with caution, as the calibration of the sustainable debt level is highly uncertain.

Figure 2
Household debt-to-disposable income



Source: BCL calculations. The chart shows the development of debt-to-disposable income in %.

Our contribution in this work is threefold. First, we find the maximum amount of household debt that is "sustainable" for Luxembourg. We derive this maximum amount via empirical models and *ad-hoc* fixed thresholds. Second, we determine which factors influence household debt by relying on two distinct empirical models. We validate our OLS findings with a Vector Error Correction Model (VECM) that yields time-varying sustainable debt levels directly and is better suited to differentiate between long-run and short-run effects. We find that household debt levels in Luxembourg are primarily driven by house prices and the average Loan-to-Value (LTV) ratio, while disposable income is not able to explain the increase in household indebtedness. The results suggest that current debt deviates from its long-run level. These results can help to provide some guidance on potential macroprudential policy responses. Thus, we estimate how much average LTV ratios have to decline so that household debt converges towards its "sustainable" level. Given the time series used, the effects of the differentiated LTV measure that was implemented in January 2021 are not present in the data.

Our findings relate to at least three strands of the literature. First, they contribute to the literature identifying variables that determine the level of household debt. Second, they add to the discussion on household debt sustainability. Finally, our paper is related to the literature on policies to address household indebtedness.

For individual households, the life-cycle hypothesis (LCH) by Modigliani and Brumberg (1954) links an agent's age and income to their personal debt stock. Typically, agents borrow before working-life and, as their age and income increase, they repay this debt and save part of their income for retirement. Barnes and Young (2003) apply a LCH model to US data. They find that changes in interest rates, future income and demographics can explain increases in the debt-to-income ratios during the 1990's. In dynamic stochastic general equilibrium (DSGE) models that account for housing and household debt, agents use debt to smooth consumption so that real debt increases when price levels, or the interest rate, decrease or house prices or the LTV ratio increase (Iacoviello (2005), Gerali *et al.* (2010) and Iacoviello (2015)). Iacoviello and Pavan (2013) combine the life-cycle hypothesis with the business-cycle one and find that household debt is procyclical.

Turinetti and Zhuang (2011) empirically analyze the factors underlying US household debt using an OLS approach. They find that housing prices and consumer confidence are positively associated with the debt service ratio, while the unemployment rate, disposable income per capita, and the interest rate display a negative relationship. Additionally, they provide evidence that age structure and socioeconomic factors such as education level also play a role in household indebtedness.

Relying on household survey data for the US, Dynan and Kohn (2007) arrive at a similar conclusion. The authors find that house prices, financial innovations and demographic factors were responsible for increases in household indebtedness from 1983 until 2004. Meng, Hoang and Siriwardana (2013) examine the determinants of household debt in Australia with a Cointegrated Vector Autoregression (CVAR) model. Their results suggest that housing prices, GDP and the number of new dwellings (interest rates, the unemployment rate and inflation) increase (decrease) household debt. Similarly, Meniago *et al.* (2013) employ a VECM for South Africa. They find that GDP, deflation, increases in consumption and the prime rate are primarily responsible for higher debt levels. Uusküla (2016) studies private debt in the euro area. Panel regressions suggest that household debt is driven by real GDP, economic sentiment, house prices and a crisis dummy variable. Rinaldi and Sanchis-Arellano (2006) focus on the share of non-performing loans. For a panel of six euro area countries, they assess relationships through an error correction model and find that although higher debt to income ratios are positively correlated with arrears, the underlying mechanism is more complex. More specifically, they find that when the increase in the debt-to-income ratio accompanies an increase in disposable income, the negative effect on debt sustainability is compensated.

Barnes and Young (2003) determine a "sustainable" level of household debt using an overlapping generations model. According to their model, current and expected income and interest rates, as well as demographic factors, give rise to sustainable debt levels. Furthermore, they show that US' debt-to-income ratios were above fundamental values at the beginning of the 2000's. Tudela and Young (2005) apply the same methodology to UK data but find no evidence that household indebtedness deviates from its long-term level. Lindquist (2012) identifies "sustainable" household debt levels based on an accounting identity. Assuming that households want to consume a fixed amount, debt is considered as "sustainable" when debt service payments (i.e., interest and principal payments) are low enough that households do not have to cut their consumption. Emanuelsson, Melander and Molin (2015) calculate "risky" levels of debt-to-income ratios. This "risky" debt-to-income ratio provides guidance on how much debt the economy can support if the underlying economic conditions deteriorate to historically extreme levels.

For a panel of the fifty US states, Albuquerque, Baumann and Krustev (2014) utilize an error correction model to estimate time-varying debt-to-income levels. They identify one cointegration relationship and outline that household debt has been above its equilibrium value since 2001. However, since 2009 the gap between actual and sustainable debt-to-income ratios has been slowly decreasing. Juselius and Drehmann (2015) quantify sustainable private debt-to-GDP ratios via a CVAR model. They show that two cointegration relationships can provide indications of debt sustainability.[126] While one relationship suggests that debt evolves with assets in the long-run, the other suggests that debt service costs must be constant in the long-run. They find that their model is able to predict the Great Recession based on real-time data, as private debt deviated from its long-term level prior to the crisis in the US.

126 Juselius *et al.* (2017) add a third cointegration relationship. They impose that the spread between the mortgage and the policy rate is constant in the long-run as they focus on the role of monetary policy in the financial cycle. However, estimating sustainable debt levels is not directly related to this third cointegration relationship.

This paper differs from previous work along three dimensions. First, we exclusively focus on household debt in Luxembourg.[127] Second, we take into account the LTV ratio and the share of adjustable rate mortgages since theory suggests potential linkages between household debt and these variables. Third, we account for the fact that the underlying variables might themselves not be at "sustainable" levels. If debt levels are positively correlated with house prices, then high household debt levels may be observed during house price booms that also deviate from economic fundamentals.

Structural models demonstrate that macroprudential policies can influence household indebtedness when collateral constraints are present (Iacoviello (2005)). Macroprudential policies, such as caps on the LTV ratio, directly influence the collateral constraint, which determines the amount of debt. Alpanda and Zubairy (2017) rely on a DSGE model to analyze those policies best suited to reduce household debt and they compare monetary with fiscal and macroprudential policy. According to their estimates, tightening of LTV caps and reducing mortgage interest rate deductions are the most effective tools to reduce household debt. Turdaliev and Zhang (2017) study the Canadian case in a small open economy DSGE model. They also find that macroprudential policies exhibit less negative side effects than monetary policies when policymakers aim for lower household debt levels. Drawing on panel data sets, Cerutti, Classens and Laeven (2017) and Akinci and Olmstead-Rumsey (2018) provide empirical evidence that macroprudential policy measures can influence household credit.

According to the literature, low interest rates, financial liberalization, and house price appreciation are the main factors that increase household debt. Our estimation results suggest that house prices are among the main determinants of household debt, while the role of interest rates is of minor importance in Luxembourg. Disposable income is a possible factor that increases household debt, but our results suggest that in Luxembourg disposable income and household indebtedness are only weakly related. The estimation results also provide evidence that declining LTV ratios have a negative influence on debt. Hence, the use of macroprudential policy measures, such as borrower-based measures, that decrease LTV ratios can reduce household debt.

In this study, we address the question of how much LTV ratios must be reduced to reach a level of debt that we identify as being "sustainable" for Luxembourg.

The remainder of the paper is organized as follows. Section 2 provides an overview of the variables that explain household debt and defines *ad-hoc* fixed thresholds to distinguish between "unsustainable" and "sustainable" levels of household debt. Section 3 introduces the data set. Section 4 analyses the research questions using an OLS model, and Section 5 provides the results from a VECM model. Section 6 addresses the nexus between household indebtedness and the loan-to-value ratio. Section 7 concludes.

2. HOUSEHOLD DEBT IN THEORY

As outlined above, household debt has increased considerably in Luxembourg since 1999. Before identifying which variables drive this trend, we first assess possible contributing factors.

127 Büyükkarabacak and Valev (2010) claim that indebtedness of households is a better risk indicator than indebtedness of the corporate sector.

One contribution of our analysis is that we assess whether the current level of household indebtedness in Luxembourg deviates from its long-run "unsustainable" level. To do so we compare the current household debt level with the maximum amount of debt that is "sustainable". When the current debt level is below (above) this threshold, it is considered as "sustainable" ("unsustainable"). Various methods are used to identify this threshold.

2.1 DETERMINANTS OF HOUSEHOLD DEBT

The life cycle hypothesis (LCH), the permanent income hypothesis (PIH) as well as real business cycle (RBC) and DSGE models are approaches that explain household debt development from a theoretical viewpoint. The LCH by Modigliniani and Brumberg (1954) and the PIH by Friedman (1957) state that households seek to smooth consumption over their life cycle. Income can be thought of as an "inverted U-shaped" function of age, because it is low before working-life and during retirement. Hence, agents borrow before working-life, when current income is below their desired consumption (e.g., through student loans). During working-life, they first pay back these loans and then begin to save for retirement. However, the linkage between household debt and age is primarily relevant at the individual household level. Since we take a macroeconomic perspective, where overlapping generations are present, the age effects of individual agents are assumed to be negated, on average, at any point in time.

Nevertheless, the LCH and the PIH help to explain how aggregate household debt develops when the underlying macroeconomic variables change. In fact, all four theories state that agents aim to maximize intertemporal utility by smoothing their consumption path. They use debt to decouple consumption from current income levels. If current income falls while expected future income remains stable, agents borrow to partly offset the drag on consumption resulting from a negative income shock (Barba and Pivetti (2009)). However, in the real world, where frictions are present, the relationship between debt and income is more complex. For a lender, an agent's disposable income also serves as an indicator of whether the borrower can repay their debt. Hence, borrowers are able to take on higher debt levels when disposable income is high. The two opposing effects of income on household debt can be disentangled by considering different time horizons. In RBC models, reductions in disposable income only lead to more debt if they are temporary. In contrast, the lender focuses on debt sustainability, which is a long-run concept. In the analysis below, we use an HP-filter to disentangle short-run deviations from the long-run trends in disposable income.

Interest rates may also play a key role. Since debt financing is cheaper when interest rates are low, the level of new loans is inversely related to the interest rate. Besides this effect on new loans, the interest rate also affects existing loans with adjustable-rate mortgages (ARM). Increases in the interest rate lead to a higher debt burden for those households that hold mortgage debt with a variable rate, (Meng, Hoang and Siriwardana (2013)). This means that the sign of the overall interest rate semi-elasticity is theoretically unclear. In Section 4.2, we will disentangle the two channels by the implementation of an interaction term that considers the product of the interest rate and the ARM share.

As the majority of household debt in Luxembourg is mortgage debt[128], house prices also play an important role in Luxembourg household debt dynamics. When house prices rise, the amount of debt needed to purchase a house increases, if households do not have the necessary funds to purchase a dwelling outright. Furthermore, homeowners can increase their debt level if the value of their collateral

128 In Luxembourg, the share of mortgage debt to total household debt has increased from 61 % in 2000 to 80.3 % % in 2020Q4. Household mortgage debt-to-disposable income was 132.1 % in 2020Q4.

increases, (Wadhwani (2002)). Analogously, an increase in households' assets, and therefore available collateral, can also lead to higher debt levels.

Finally, in some cases, financial deregulation has also boosted household debt levels (Rinaldi and Sanchis-Arellano (2006)). On an individual household level, fewer households reach their borrowing constraint. On an aggregate basis, households were able to increase their debt levels, although their income and asset levels remained unchanged. This translates into higher LTV ratios.

2.2 "SUSTAINABLE" DEBT LEVELS

For the purpose of this work, the maximum amount of "sustainable" debt can be derived from either empirical or theoretical models (e.g. accounting identities) or via *ad-hoc* thresholds. In this section, we adopt a number of ad-hoc thresholds taken from the literature on household debt that can help to identify "sustainable" debt-to-income ratios. In Section 5.1, we further apply an empirical model that also yields a time-varying sustainable debt level.

The Macroeconomic Imbalance Procedure Scoreboard (MIPS) suggests a threshold for private sector debt-to-GDP of 133 % as a "sustainable" level. The threshold is set at 133 % based on the upper quartile of the distribution of the ratio of private sector debt-to-GDP of all EU Member States during the period from 1995 to 2007, i.e., before the beginning of the financial crisis (European Commission (2012) and European Commission (2018)). This translates into a value of household-debt-to-disposable income of 77.49 % for Luxembourg when averages of the disposable income-to-GDP ratio and the household-to-total private debt ratio over that period are considered.[129]

The 1995-2007 data period omits the recent low interest rate environment. Following the argumentation above, low interest rates may potentially increase the level of sustainable debt. We therefore calculate a threshold that is based on the 1995Q1-2020Q1 sample. In this period, the upper quartile of the distribution of the ratio of private sector debt-to-GDP of all EU Member States is 158 %, so that the threshold increases to 83.35 %.[130]

Bouis, Christensen and Cournède (2013) and Cuerpo *et al.* (2013) suggest relying on pre-housing boom values. Building on the MIPS' threshold, Cuerpo *et al.* (2013) define country-specific thresholds by computing the upper quartile of the distribution of the ratio of private sector debt-to-GDP on a national basis during the period 1994-2007. Following their approach, the "sustainable" debt threshold resulting from an upper quartile of the debt-to-disposable income in Luxembourg during the years from 1999 to 2007 is 104.59 %.

Bouis, Christensen and Cournède (2013) consider debt-to-GDP values in 2000 "sustainable". According to their approach, household debt-to-disposable income in Luxembourg must be below 82.43 % to be "sustainable". Alternatively, one can take a cross-country perspective. In 2018, the average debt-to-disposable income ratio in the euro area was 93.52 %. The upper quartile for euro area Member States is 114.06 %.[131] Cuerpo *et al.* (2013) further consider a leverage perspective. They suggest that debt is only "sustainable" if it moves in tandem with assets since the latter can serve as a buffer. In this respect, financial assets can be sold and mortgages can serve as collateral. They assume that the debt-to-assets

129 The data comes from the BCL website and Statec.

130 The MIPS calculation is based on a sample that excludes Croatia, as it entered the EU in 2013. To be consistent, we also exclude Croatia in the construction of the value for the 1995-2020 sample.

131 Due to data availability, Greece and Malta are not included in the sample.

level was "sustainable" in 2000, i.e., before the housing boom. Under their definition of "sustainable", debt-to-asset ratios should not exceed 32.01 % in Luxembourg. From 2001Q1 to 2020Q1, this ratio would have been reached, if the debt-to-disposable income ratio was 119.29 % on average.

Table 1:

"Sustainable" Debt-to-disposable income ratios in Luxembourg

MEASURE	DEBT-TO-DISPOSABLE INCOME IN %
Upper quartile of the distribution of the ratio of private sector debt-to-GDP of all EU Member States from 1995 to 2007 (2020).	77.49 (83.35)
Upper quartile of the debt-to-disposable income ratio in Luxembourg from 1999 to 2007 (2020).	104.59 (160.25)
Debt-to-disposable income in Luxembourg in 2000.	82.43
Average debt-to-income ratio in the euro area in 2018.	93.52
Upper quartile of debt-to-income ratios of euro area member states in 2018.	114.06
Sustainable debt-to-asset ratio in Luxembourg.	119.29

Below, we compare actual debt-to-income values with the "sustainable" levels from Table 1. While the upper quartile of debt-to-income ratios of euro area member states in 2018 provides a cross-country view, the upper quartile of the debt-to-disposable income ratio in Luxembourg from 1999 to 2007 provides a national perspective. Finally, the leverage perspective is considered based on debt-to-asset ratios.

3. DATA

The data used in this study stems from several sources. All variables are measured in real terms and are seasonally adjusted, if applicable. The sample considered varies according to the underlying variables. The LTV ratio is the limiting factor for the data period. Whenever it is included, the sample starts in 2005Q1 and ends in 2020Q1. For models omitting the LTV ratio, the sample begins in 1999Q1.

Household debt and assets, as well as total private debt, are taken from the BCL database. Data for household disposable income, the share of adjustable rate mortgages and the house price index are BCL estimates. The mortgage rate is from the ECB Statistical Data Warehouse. For LTV ratios, we merge BCL estimates with data from the Commission de Surveillance du Secteur Financier (CSSF). Data on population size was obtained from Statec Luxembourg. Some variables deserve further attention. Household debt is a stock variable, while disposable income is a flow variable. When considering debt-to-income levels, the vast majority of the literature uses annual income levels. For comparability reasons, disposable income is annualized when we refer to debt-to-disposable income.

As outlined in Section 2.1, the impact of disposable income on household debt depends on whether income changes are permanent or transitory. For the OLS estimations, we disentangle permanent from transitory changes with the HP-filter. We set λ to 400,000 as this describes the credit cycle (ESRB (2014)). To account for the fact that changes in the population size can influence the amount of disposable income, we focus on per capita values. Furthermore, the log of per capita income is considered. In this manner, the coefficient associated with the trend in Section 4.2 provides the sensitivity of the dependent variable to per capita income increases.

As described above, ARMs mean that debt obligations from previous periods vary according to the current interest rate. However, the available time series provides the share of new loans. We therefore have to construct a series that represents the share of ARM out of the stock of debt.[132]

Two assumptions are needed to construct this time series. Figure 3 shows how the ARM share of new loans evolves over time. From 2003 until 2012Q2 the ARM share was relatively stable at around 85 %. After this period, the time series displays a negative trend as well as more volatility. The first assumption is that at the beginning of the sample, i.e., in 2003Q1, the share of ARMs in the stock of mortgage debt was 85 %. The total amount of new loans is the aggregate of the flow of mortgage debt and the amount of credit that has been repaid. The former is derived by taking differences of the stock variable, while the latter calls for a second assumption. More precisely, we assume that the average maturity of the stock of mortgage debt is 15.3 years throughout the sample. The value corresponds to the average maturity in the Household Finance Consumption Survey's third wave. With these variables, we construct a weighted average for the ARM share according to Equation (1). Hereafter, ARM_t^{stock} (ARM_t^{nl}) is the ARM share for the stock of debt (new loans) at time *t*. NL_t and $Amort_t$ are the amount of new loans and the absolute size of the amortization, respectively.

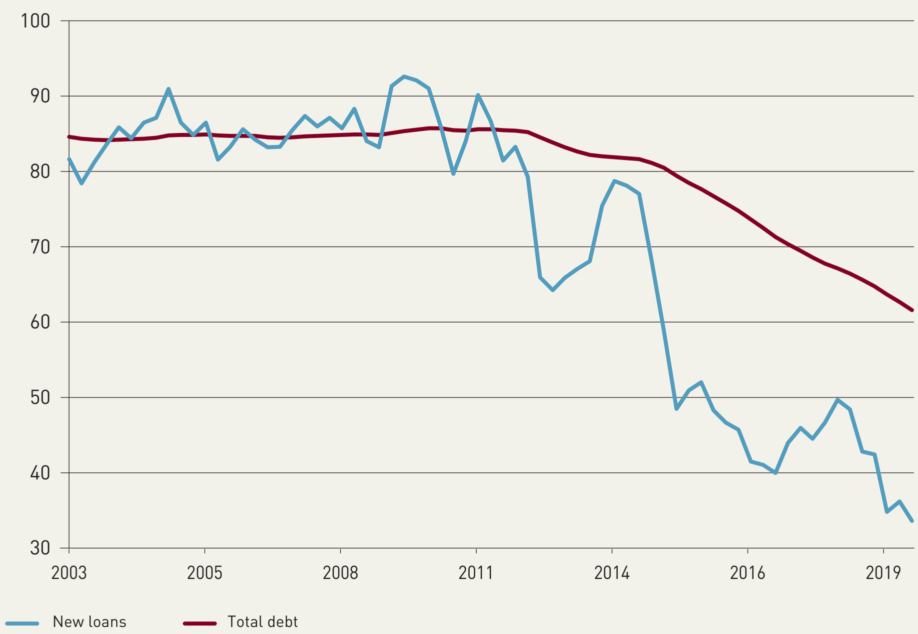
$$ARM_t^{stock} = \frac{ARM_{t-1}^{stock}\,(Debt_{t-1}^{stock} - Amort_t) + ARM_t^{nl} * NL_t}{Debt_{t-1}^{stock} - Amort_t + NL_t} \qquad (1)$$

Juselius and Drehman (2015) show that the mortgage rate of the stock of mortgage debt is better suited to estimate long-run relationships in a VECM. They obtain a stock mortgage rate by smoothing the flow series using an auto-regressive component of 0.7. They argue that this rate closely matches the U.S. effective lending rate from the Bureau of Economic Analysis data. When we use the VECM in Section 5.2, we follow their approach.

Regarding LTV, data from the banks are the preferred option. However, data reported to the CSSF is limited. In fact, only three data points are available on a bi-annual frequency, those are the second semester of 2018 and 2019 and the first semester of 2019. This data set is merged with the LTV ratio from internal BCL estimates to obtain a longer time series, at a quarterly frequency from 2005Q1 to 2020Q1. Both variables show similar movements among the data points available. Starting from 2018S2, we first observe a drop in the LTV ratio before it increases in 2019S1. We combined the two sources as follows. First, we always assign the LTV ratios from the CSSF to the second quarter within a semester. Second, we fill the two gaps between the three assigned values by a

132 Due to the autoregressive structure of the ARM share for new loans, the results shown below are similar for both ARM shares.

Figure 3
Share of adjustable rate mortgages



linear interpolated value. Third, we rebase the values of the BCL estimates with the ratio provided by the CSSF in 2018S2.

4. EMPIRICAL EVIDENCE FROM AN OLS APPROACH

Our main objectives are (i) to analyze if household debt is "sustainable", (ii) to identify which variables influence household debt and (iii) to relate levels of household debt to LTV ratios. We start with unit root and cointegration tests that check whether household debt is in line with economic fundamentals. In Section 4.2, we rely on an OLS model to analyze whether we find empirical support for the aforementioned debt-related hypotheses.

4.1 INCOME AND LEVERAGE PERSPECTIVE

Household indebtedness can be considered as "unsustainable" if it deviates from its long-run value that is justified by economic fundamentals. From an income perspective, debt can be considered as "unsustainable" if the discounted future disposable income is insufficient to pay all debt. Alternatively, debt and disposable income should be cointegrated. We perform Johansen tests[133] with log per capita debt and log disposable income per capita as the only variables.[134] Table 2 displays the eigenvalues for different estimates. None of the null hypotheses can be rejected at the 5 % significance level. This suggests that per capita debt and disposable income per capita are not cointegrated in Luxembourg.

Table 2:
Johansen Cointegration tests

NO. OF CE(S)	INTERCEPT, NO TREND		INTERCEPT, LINEAR TREND	
	1 LAG	4 LAGS	1 LAG	4 LAGS
None	0.049	0.048	0.081	0.269
At most 1	0.020	0.010	0.043	0.042

*Source: BCL. The numbers represent eigenvalues. ***, ** and * display eigenvalues that are different from zero on a 1 %, 5 % and 10 % significance level. We consider MacKinnon-Haug-Michelis (1999) p-values and always display the lower p-value from the trace test or the maximum eigenvalue test.*

From a leverage perspective, debt is "unsustainable", if it increases more than households' assets for a prolonged period of time. Figure 4 shows the development of the debt-to-assets ratio in Luxembourg. This ratio shows an increasing trend over time. An Augmented Dickey-Fuller (ADF) test[135] confirms that it is not stationary around a constant.

4.2 DRIVERS OF HOUSEHOLD DEBT IN LUXEMBOURG

In this section, we identify the determinants of household debt. In Model I (Model II), household debt to disposable income (per capita debt) serves as the regressand. For the assessment, we use the OLS estimation shown in Equation (2). The endogenous variable, Y_t, is explained by its lagged value and a set of lagged exogenous variables, X_{t-1}. The list of explanatory variables includes (log) house prices, the mortgage rate, an interaction term of the mortgage rate with the ARM share, the ARM share separately, the LTV ratio and the squared LTV ratio. For Model II, the trend and the cyclical component of disposable

133 The test is outlined in Johansen (1991) and Johansen (1995).
134 Note that cointegration is a long-run concept. It is therefore unnecessary to differentiate between the cyclical and the trend component of income.
135 The ADF test roots on Dickey and Fuller (1979).

income complete the set of explanatory variables. We apply Newey-West standard errors to address issues related to endogeneity and serial correlation.

$$Y_t = \alpha + \Lambda X_{t-1} + \beta Y_{t-1} + \varepsilon_t \quad (2)$$

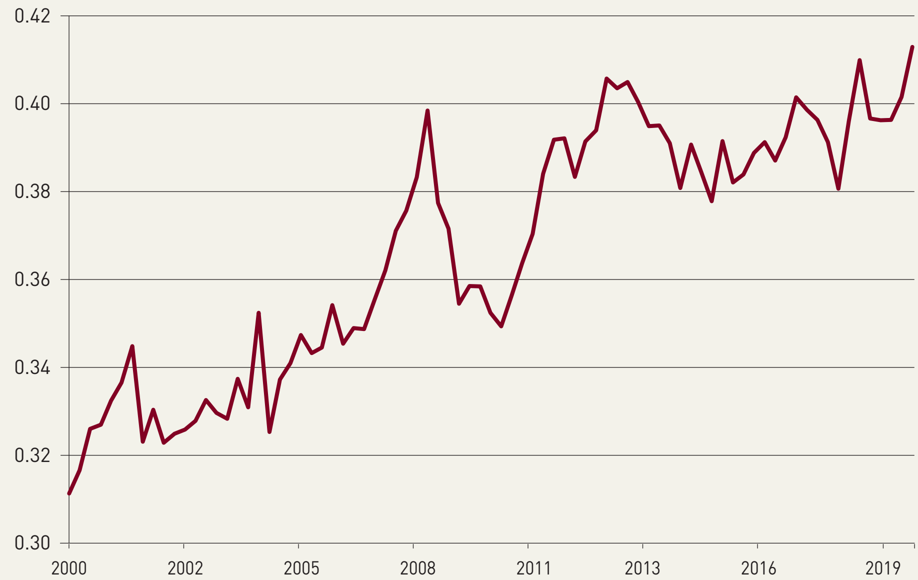
Table 3 outlines the regression results for both models. In line with theory, real house prices and the lag of the dependent variable explains the evolution of household debt in both regressions. This result is significant at the 5 % level. While the coefficient for LTV is positive, the negative coefficient of LTV^2 suggests a non-linear influence of LTV ratios. The two coefficients are only significant in Model II, which generally shows more plausible results. In Section 6, we further discuss the role of the LTV ratio. The regression results also suggest that a higher share of ARMs increases debt. This finding is significant at the 10 % level in both Models.

The mortgage rate and the interaction term display the expected signs and are significant for Model II. Lower interest rates have two effects. They reduce debt service payments for those households holding mortgage debt with a variable rate contract. However, lower interest rates increase the incentive for households to take on more debt. In Table 3, the interest rate effect for households with an ARM contract is captured via the interaction term, while the mortgage rate provides incentives for households to take on new debt. The semi-interest elasticity shows that the former effect dominates the latter effect. Moreover, if the interaction term is omitted, the coefficient for the mortgage rate is positive for both models.

At a first glance, the coefficients in Modell I seem counterintuitive. However, the dependent variable is a ratio and interest rates are likely to affect both the numerator and the denominator. The positive coefficient on the mortgage rate likely stems from a negative reaction of disposable income to the mortgage rate. Changes in the monetary policy stance can potentially explain this negative relationship. In this respect, declines in the interest rates boost output and thereby disposable income. Furthermore, the inflation component in the real interest rate might play a role. In theory, debt as well as income are both negatively affected by an increase in inflation (Debelle (2004)). When the effect on disposable income is disproportionally strong, e.g., due to the bracket creep effect[136], higher inflation rates increase the debt-to-disposable income ratio. On average, the interest rate

136 The bracket creep describes a situation when inflation pushes households into higher income tax brackets although their real earnings before tax have not increased at a similar pace.

Figure 4
Debt-to-assets ratio



Source: BCL Calculations

semi-elasticity is 0.59 in Model I and 0.40 in Model II. However, as outlined above the ARM share has decreased considerably over the last decade. In fact, it was 0.61 in 2020Q1, yielding semi-elasticities of 2.77 and -1.17 in Models I and II.

We find that the two aforementioned interest rate channels exist in Model II. The overall effect of interest rate changes strongly depends on the ARM share. However, it is unlikely that declining interest rates are the primary source for the increases in debt. As expected, households are able to accumulate more debt when they rely on contracts with an adjustable rate, although the coefficient is not significant. The fact that neither the trend nor the cyclical component of disposable income is significant in Model II. This is in line with our findings from Section 4.1 and adds to the discussion that household indebtedness deviates from its long-run value. The lag of the dependent variable is incorporated in the regression's RHS and alone explains 97.9 % of the variations of the dependent variable in Model I.

Table 3 :

Regression Results: ***The left (right) panel describes the results of Model I (Model II)***

DEP. VARIABLE: HH DEBT/DISP. INC.		
VARIABLE	COEFFICENT	P-VALUE
Const	-292.90	0.020
LTV	4.121	0.170
LTV^2	-0.026	0.196
Mortgage Rate	10.119	0.049
Mo. Rate*Share of ARM	-0.120	0.054
Share of ARM	0.276	0.049
House Pr. (log)	0.308	0.002
Hh Debt/Disp. Inc.	0.787	0.000
Inter. Rate Semi-Elasticity	0.590	0.041
(Assumption: Share of ARM equals its average (79.69))		
R^2	0.991	

DEP. VARIABLE: HH DEBT PER CAPITA (LOG)		
VARIABLE	COEFFICENT	P-VALUE
Const	-3113.64	0.106
LTV	7.481	0.002
LTV^2	-0.048	0.004
Mortgage Rate	-6.455	0.081
Mo. Rate*Share of ARM	0.086	0.062
Share of ARM	0.366	0.053
House Pr. (log)	0.365	0.000
Hh Debt per Capita (log)	0.465	0.001
Disp. Income Cycle (per Capita)	0.013	0.944
Disp. Income Trend (per Capita)	3.063	0.111
Inter. Rate Semi-Elasticity	0.398	0.161
(Assumption: Share of ARM equals its average (79.69))		
R^2	0.995	

Source: BCL.

5. LONG-RUN EFFECTS

After establishing some preliminary empirical findings in Section 4, we now turn to a VECM model. The advantage of the VECM is that it directly identifies short-term and long-term relationships between the underlying variables. In this manner, we are able to assess how the considered variables have contributed to increasing household debt levels. Furthermore, the VECM approach allows us to identify time-varying "sustainable" debt levels.

5.1 METHODOLOGY

The VECM is a restricted Vector Autoregression (VAR) model that is capable of dealing with non-stationary variables when they are cointegrated. Consequently, under the requirement that at least one cointegration relationship exists, all time series can enter as endogenous variables. Hence, we first check for stationarity in all variables that enter the VECM. Afterwards we rely on the Johansen test to detect how many cointegration relationships, *r*, are present.

As described above, the VECM combines short-run with long-run relationships of the endogenous variables. After establishing a long-run equilibrium, it outlines how deviations from this equilibrium feed back on the dependent variables. This feedback-loop ensures that the variables will adjust to the equilibrium again. Equation (3) describes the VECM.

$$\Delta Y_t = \nu + \mathbf{\Pi} Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t, \tag{3}$$

where Y_t is a K x 1 vector of endogenous variables and Δ is the difference operator. The vector *v* is for constant effects. The vector Γ_i captures the effects of lagged changes in the endogenous variables. The parameter *p* fixes the number of lags in the underlying VAR.[137] The error term ε_t has zero mean and is iid. The special feature of the VECM is the matrix **Π**, which determines long-run relationships. The number of cointegration relationships yields the rank *r* of the matrix. A valid VECM requires $0 < r < K$. The matrix **Π** can be decomposed into two K x r matrices α and β, i.e., $\mathbf{\Pi}=\boldsymbol{\alpha\beta}'$. The cointegration relationship is given by $\boldsymbol{\beta}'Y_t$ and α describes how the model adjusts to deviations from the long-run equilibrium.

However, the VECM needs to be uniquely identified. In fact, it requires at least r^2 restrictions. Those restrictions can either be imposed on **α** or on **β**. We will discuss the restrictions we impose in the next section.

5.2 "SUSTAINABLE" DEBT LEVELS FROM A VECM

As mentioned in Section 2, we now compare the thresholds for "sustainable" debt stemming from *ad-hoc* values from the literature with those from a VECM. The underlying theory closely follows Juselius and Drehmann (2015). They claim that two long-run relationships help to identify "sustainable" debt levels, i.e., leverage and the debt service burden. Under the leverage hypothesis from above, debt and house prices (or assets) have to move in tandem over the long-run.

The debt service burden is closely related to the income perspective. Expected future income has to be high enough to service future interest payments and amortizations. When the interest rate applicable to the debt stock increases, agents find it more difficult to pay back their debt.[138] Therefore, debt levels have to decrease in the long-run. This shows that there exists a cointegration relationship between debt and interest rates, according to which the two variables negatively influence one another. Put differently, the debt service burden has to be constant in the long-run. It follows that debt is only "sustainable" when both long-run relationships hold.

137 The lag length of this VECM notation is one period shorter than that of conventional VARs as we use the difference operator.
138 Juselius and Drehmann (2012) find that the debt service ratio is a good indicator for an upcoming financial crisis.

Table 4 :

Cointegration tests

	4 VARIABLES VECM			3 VARIABLES VECM		
OLS	OLS	FE	OLS	FE	FE	FE
r=0	0.1947	0.0439	0.3774	0.1451	0.1426	0.2640
r≤1	0.1779	0.0622	0.1441	0.0982	0.2667	0.2033
r≤2	0.1076	0.1924	0.1963	0.0005	0.8204	0.8204
r≤3	0.0119	0.2993	0.2993			

Source: BCL.

As outlined above, we need two cointegration relationship conditions to differentiate between the leverage and the debt service burden view. In this section, we use both a three and a four variable VECM. In the three variable model, the household debt-to-disposable income ratio, the mortgage rate on the debt stock and the (log) house price index are the endogenous variables. In the four variable model, we substitute the debt-to-income ratio with the two underlying time series. Hence, we add (log) per capita household debt and disposable income to the list of variables. We focus solely on real variables.

We look at the number of cointegration relationships within the VECM as displayed in Table 4. The four variable VECM points to two cointegration relationships when a 10 % significance level is applied and the lag length of the underlying VAR, *p*, is set to three as suggested by the Akaike information criteria.[139] The hypotheses of no, and at most one, cointegration relationship is rejected when applying the trace test. Hence, we conclude that two cointegration relationships describe the model reasonably well. In contrast, the three variable model does not suggest any cointegration. Therefore, we retain the four variable model.

The two cointegration relationships in the four variable VECM describe the leverage and the debt service burden perspective. This means we have to impose at least four restrictions on **α** and **β** from Equation (3). In line with Juselius and Drehmann (2015), we only restrict **β**. Let β_{lev} and β_{dsb} be the first and second column in β and let β_{lev} (β_{dsb}) describe the leverage perspective (the debt service burden perspective). Equation (4) lists our set of restrictions stemming from the following theoretical considerations. Juselius and Drehmann (2015) look at debt-to-GDP levels and restrict them to one. Since we focus on "sustainable" household debt levels, we restrict the coefficients on debt, i.e. β_{lev} and β_{dsb}, to one. However, when we consider the two hypotheses, we have to ensure that debt is not increasing due to increases in income. Hence, we restrict the coefficients in β_{lev} and β_{dsb} that correspond to income to zero as well. Two further restrictions are necessary to disentangle the two perspectives. They directly follow from Juselius and Drehmann (2015). Therefore, the parameter describing the mortgage rate (the house price index) has to be zero in β_{lev} (β_{dsb}). This leaves us with the following specification of **β**, where β_{lev}^{hpi} and β_{dsb}^{rate} are parameters that the model estimates.[140]

$$\boldsymbol{\beta}' Y_t = \begin{pmatrix} \beta_{lev} \\ \beta_{dsb} \end{pmatrix} Y_t = \begin{pmatrix} 1 & 0 & 0 & \beta_{lev}^{hpi} \\ 1 & 0 & \beta_{dsb}^{rate} & 0 \end{pmatrix} \begin{pmatrix} debt_{t-1} \\ income_{t-1} \\ rate_{t-1} \\ hpi_{t-1} \end{pmatrix} \quad (4)$$

The upper panel of Table 5 displays the coefficient estimates for the cointegration vectors β_{lev} and β_{dsb}. The coefficients β_{lev}^{hpi} and β_{dsb}^{rate} have signs that are in line with the leverage and the debt service burden

139 The results are not sensitive to changes in the lag length.

140 The variables in Y_t are household debt, disposable income, the mortgage rate of the debt stock and the house price index.

perspective. Both coefficients are statistically different from zero. We obtain a high interest rate semi-elasticity, because we consider real interest rates where the inflation rate does not crowd out the effects. The coefficient β_{lev}^{hpi} shows plausible results. When real house prices increase by 1 %, household debt per capita rises by 1 % in the long-run.

The lower panel in Table 5 outlines the short-run dynamics of the model. As we are primarily interested in long-run effects, we present evidence of the two co-integration relationships. We label deviations from the two cointegration relationships $\widetilde{lev}$ and $\widetilde{dsb}$. The model is only valid when debt reacts to deviations from the equilibrium relationships in a way that it approaches equilibrium long-run. Hence, deviations from the leverage and the debt service burden vector should negatively impact changes in debt for given mortgage rates and house prices. Put differently, a positive leverage or debt service gap depresses credit growth. Indeed, we find a negative coefficient for the leverage vector (first column). For the debt service burden vector, we observe a statistically insignificant coefficient.

The impact of the error correction terms on the other variables matches Juselius and Drehmann's (2015) estimates. In particular, they find that $\widetilde{lev}$ does not significantly affect any of the other variables and that debt service burden deviations significantly affect interest rates negatively. They argue that this reflects monetary policy responses to elevated debt levels.

Table 5:
VECM Results of the four variable Model

PANEL A: COINTEGRATION EQUATIONS					
COINTEGRATING EQ:	$debt_{t-1}$	$income_{t-1}$	$rate_{t-1}$	hpi_{t-1}	Const.
β_{lev}	1	0	0	-0.987	-622.29
T-statistic				[-17.302]	
β_{dsb}	1	0	29.895	0	-1112.13
T-statistic			[3.636]		

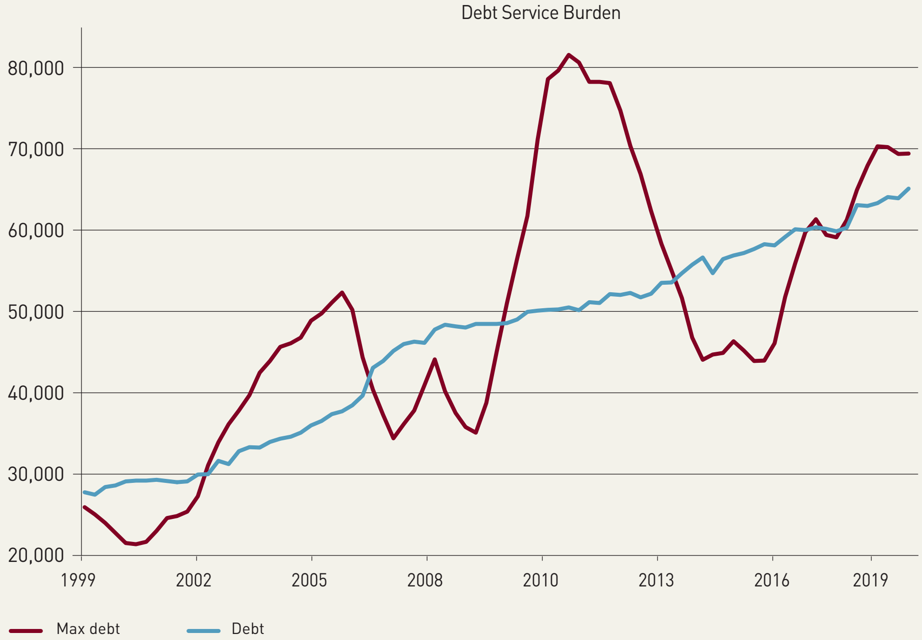
PANEL B: SHORT-TERM DYNAMICS					
ERROR CORRECTION:	$\Delta(debt_t)$	$\Delta(income_t)$	$\Delta(rate_t)$	$\Delta(hpi_t)$	
$\widetilde{lev}$	-0.1142	-0.0149	0.0005	-0.0153	
T-statistic	[-4.012]	[-0.913]	[0.238]	[-0.831]	
$\widetilde{dsb}$	0.0022	0.0047	-0.0025	-0.0038	
T-statistic	[0.242]	[0.891]	[-3.426]	[-0.632]	

With the estimates from Equation (4), we can now evaluate whether current household debt levels are "sustainable". We therefore compare the actual (log) per capita household debt levels with those resulting from the two cointegration relationships as in Equations (5) and (6). Note that we multiply β_{lev}^{hpi} by sustainable real house prices provided by Ferreira Filipe (2018) in order to correct for the overvaluation of house prices. The reason is that "sustainable" debt levels could be artificially high when house prices are overvalued, i.e. they are higher than justified by economic fundamentals, see Cuerpo (2013).

$$\widehat{debt}_{lev,t}^{max} = -const_{lev} - \beta_{lev}^{hpi} hpi_t \quad (5)$$

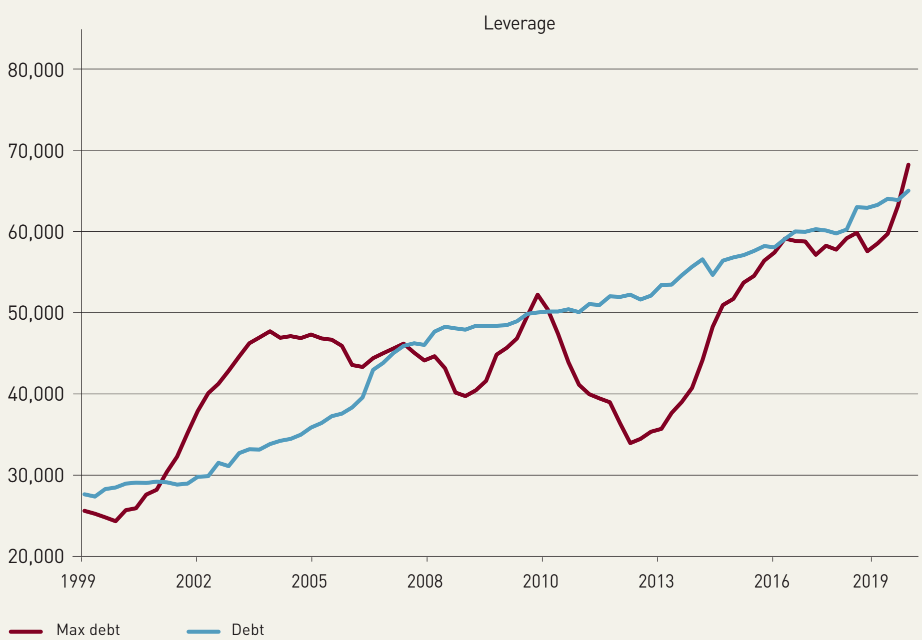
$$\widehat{debt}_{dsb,t}^{max} = -const_{dsb} - \beta_{dsb}^{rate} rate_t \quad (6)$$

Figure 5
"Sustainable" Debt Levels from a VECM



Source: BCL calculations.

Figure 6
"Sustainable" Debt levels from the leverage approach



Source: BCL calculations.

Figures 5 and 6 show the development of the two cointegration relationship equations and the (log) per capita debt over time. Figure 5 shows the maximum "sustainable" level of debt according to the debt service burden while figure 6 shows the maximum amount of leverage relationship. Recall that household debt may be "unsustainable" when one of the two cointegration equations deviates from the long-term value. We observe that under the leverage perspective, debt levels until 2019Q4 were indeed "unsustainable". However, in 2020Q1, household debt converged towards its fundamental value for the first time since 2011Q1. The debt service burden suggests that debt is still close to, but below, its maximum "sustainable" amount. Moreover, Figure 5 shows that there had also been periods where the debt service burden was "unsustainable". Most notably, both variables were at "unsustainable" levels before and during the Great Recession as well as during the subsequent European Sovereign Debt Crisis.

5.3 IDENTIFYING OTHER VARIABLES CONTRIBUTING TO RISING DEBT LEVELS

In Section 4.2, we found that household debt was driven by reductions in the LTV ratio. We now reevaluate our findings with a VECM framework. We again rely on a model where (log) per capita debt and (log) disposable income are separately integrated in the model.

Table 6 :

ADF tests for additional variables

	CONSTANT		CONSTANT & TREND	
	LEVEL	1ST DIF	LEVEL	1ST DIF
Loan-to-Value Ratio				
Lags	0	0	0	0
Test stat.	-1.7283	-9.3668	-2.6463	-9.3804
Prob.	0.4121	0.0000	0.2622	0.0000
Mortgage Rate (New Loans)				
Lags	0	0	1	0
Test stat.	-2.4411	-11.827	-3.5374	-11.855
Prob.	0.1322	0.0000	0.0388	0.0000
ARM share				
Lags	1	1	1	1
Test stat.	1.1818	-0.8533	-0.1169	-3.2923
Prob.	0.9978	0.7969	0.9936	0.0765

Table 6 outlines the unit root test for the additional variables. While the LTV ratio and the mortgage rate are also trend-stationary. The ARM share is only I(1) when a trend is added.[141]

We introduce two more variables to obtain a six variable model. We perform Johnansen tests to identify the number of possible cointegration relationships, as shown in Table 7. In line with the Akaike information criterion, we account for the loss of degrees of freedom associated with the higher number of variables by reducing the lag length to two. The Maximal Eigenvalue Test points to one cointegration relationship at the 95 % confidence level. The results of the Trace Test are less clear. The underlying theory requires us to have one or two cointegration vectors. We estimate the models for *r*=1, treating the results with caution as a different number of cointegration relationships is not implausible.

Table 7:

Cointegration tests five and six variable models

NO. OF CONITEGRATIONS	EIGENVALUE	6 VARIABLES VECM P-VALUE (TRACE TEST)	P-VALUE (MAX. EIGENVALUE TEST)
r=0	0.5227	0.0010	0.0234
r≤1	0.3593	0.0273	0.3317
r≤2	0.3349	0.0579	0.1474
r≤3	0.2086	0.2214	0.4011
r≤4	0.1393	0.2847	0.3118
r≤5	0.0213	0.2642	0.2642

141 Note that in 4.2, we also disentangled the effects of interest rate changes on new loans from their effects on the stock of debt with an interaction term. Specifically, the interaction term is the product of the mortgage rate and the ARM share. We refrain from the interaction term now as its long-run path is already determined by the long-run reaction of the mortgage rate and the ARM share.

As before, we need two restrictions to ensure that the increases in debt are not due to a contemporaneous increase in income. The impact of all other variables remains unrestricted. With this specification, the model closely resembles the OLS model in 4.2.

$$\beta' Y_t = \left(1\ 0\ \beta_{dsb}^{ltv}\ \beta_{dsb}^{rate}\ \beta_{dsb}^{arm}\right) \begin{pmatrix} debt_{t-1} \\ income_{t-1} \\ ltv_{t-1} \\ rate_{t-1} \\ arm_{t-1} \\ hpi_{t-1} \end{pmatrix} \quad (7)$$

Table 8 presents the results of the six variable VECM model.[142] The estimates from both models are qualitatively similar to our findings from Section 4. As before, we see that house price increases are positively associated with household debt. In addition, higher LTV ratios lead to higher debt levels. The real mortgage rate positively affects per capita debt. This is in line with the positive semi-interest rate elasticity observed in 4.2. Recall, that the interest rate affects debt through two distinct channels. Rising interest rates increase the costs for new mortgages, thereby reducing the total amount of mortgage debt. At the same time, debt increases for households that currently have a mortgage credit with a variable interest rate. We observe that the latter effect predominates. Consequently, the recent increase in household indebtedness is not primarily due to the low interest rate environment. Moreover, the ARM share is positively related to debt. All these effects are significant. Most importantly, positive deviations from the cointegration vector negatively affect debt so that a steady state is reached.

Table 8:

VECM Results from the Six Variable Model

PANEL A: COINTEGRATION EQUATIONS							
COINTEGRATING EQ:	debt_(t-1)	income_(t-1)	ltv_(t-1)	rate_(t-1)	arm_(t-1)	hpi_(t-1)	Const.
ß	1	0	-1.558	-2.687	-2.602	-2.006	171.28
T-statistic			[-5.443]	[-4.025]	[-8.218]	[-9.847]	

PANEL B: SHORT-TERM DYNAMICS							
ERROR CORRECTION:	Δ(debt_t)	Δ(income_t)	Δ(ltv_t)	Δ(rate_t)	Δ(arm_t)	Δ(hpi_t)	
$\widetilde{coint}$	-0.2159	-0.0019	-0.0504	0.0229	-0.0023	0.0818	
T-statistic	[-3.891]	[-0.047]	[-1.101]	[1.114]	[-0.365]	[1.697]	

Finally, we check whether the time-varying debt levels hold when we consider the six variable model instead of the four variable VECM from Equation (4). Equation (8) yields the maximum "sustainable" debt level. Again, we correct for the overvaluation of house prices.

$$\widehat{debt}_t^{max} = -const - \beta^{ltv} ltv_t - \beta^{rate} rate_t - \beta^{arm} arm_t - \beta^{hpi} hpi_t \quad (8)$$

142 As before, for the short-run dynamics we only present evidence of the cointegration relationship in Table 8.

Figure 7 displays the corresponding maximum debt levels. The results suggest that household indebtedness in 2020Q1 is above the maximum debt level from the model. Specifically, household indebtedness in 2020Q1 is 1 % above the maximum "sustainable" level. Taking into account the estimates from the OLS model, we show by how much the average LTV ratio has to decline to reduce household indebtedness by 1 %.

6. THE ROLE OF LOAN-TO-VALUE RATIOS

Building on the results from the OLS model in Section 4, we now analyze the nexus between household indebtedness and the loan-to-value ratio. According to Table 3, there is a positive but decreasing effect of the LTV ratio on household debt. In 2020Q1, the average LTV ratio was 78.1 %. Figure 8 shows how different average LTV ratios lead to different debt-to-disposable income ratios while Figure 9 shows log household debt per capita levels along with average LTV values.[143] We assume that all other explanatory variables are at their historical mean in the analyzed sample. Figure 8 displays the nexus between the average LTV ratio and Luxembourg households' debt-to-disposable income in the long-run. Figures 8 and 9 therefore show by how much the LTV ratio would have to decrease to reach "sustainable" debt-to-disposable income and debt-per-capita levels, respectively.

143 We refer to the historical mean so that the comparison with the VECM conducted in Section 5 is straightforward.

Figure 7
Sustainable Debt Levels form a seven variable VECM

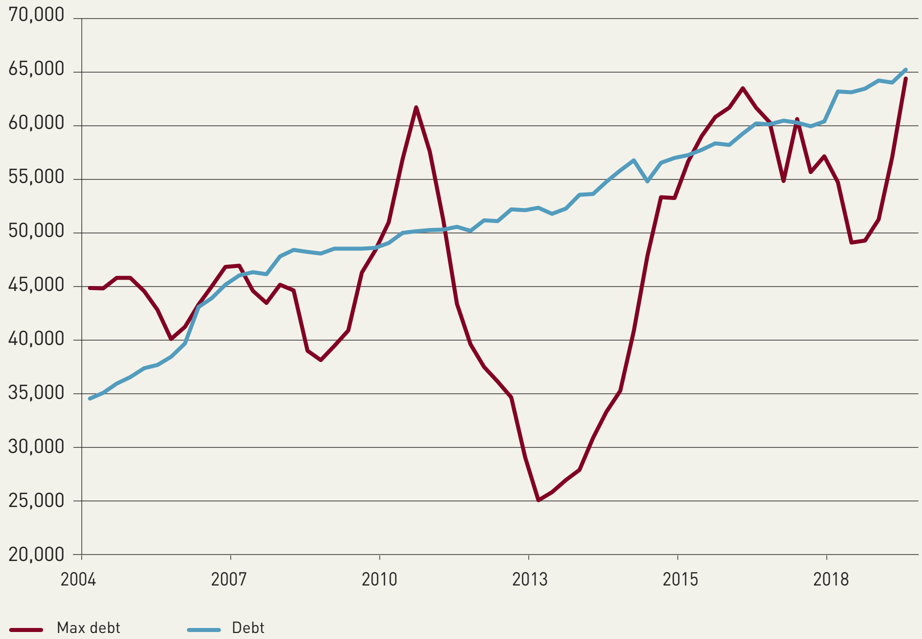
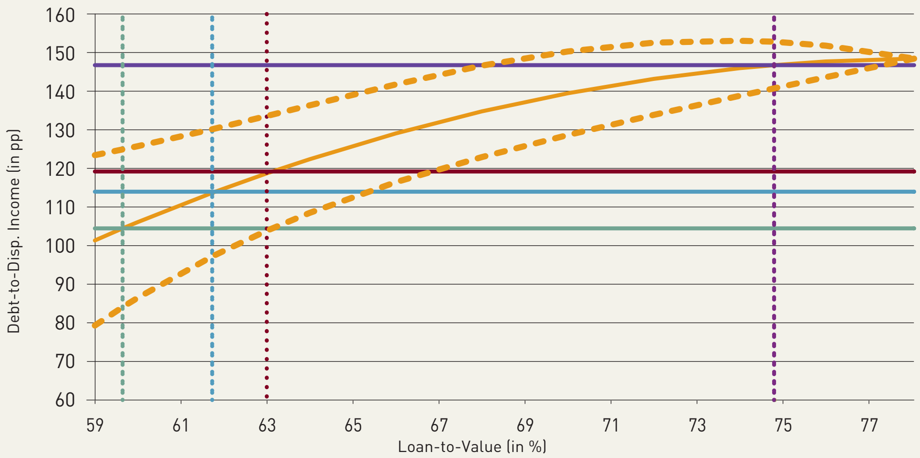
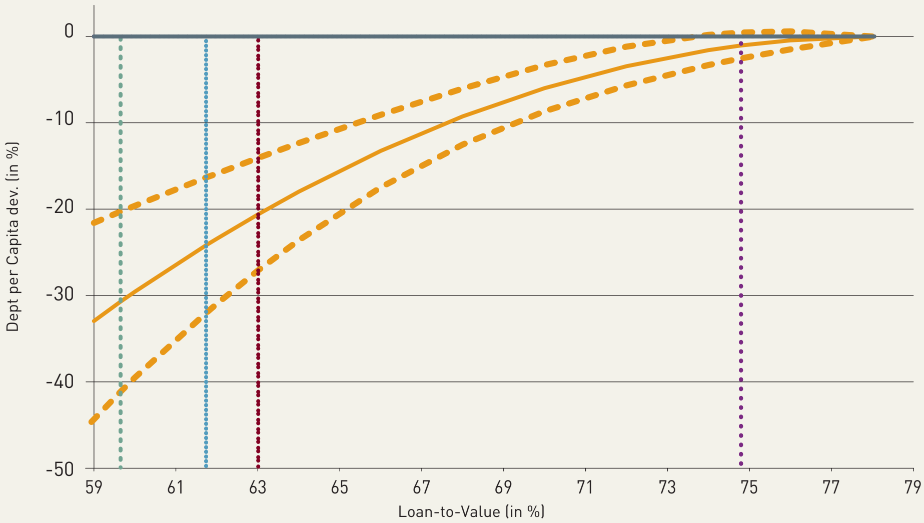


Figure 8
Debt-to-Disposable Income



Source: BCL calculations. Nexus between LTV and debt-to-disposable income in the long-run. The solid orange line indicates the estimated mean response to deviations from this LTV ratio. The dashed orange lines are the 95% confidence bands around the mean. The horizontal purple line displays the "sustainable" debt level from the VECM. To be "sustainable", debt-to-disposable income needs to decline by 1.7 pp from the 2020Q1 observed value of 172.6% to the purple line at 146.8%. Correspondingly, the average LTV ratio should decline by 3.3 pp from the observed 78.1% to 74.8% as indicated by the intersection of the orange and purple lines. The red, blue and green solid lines indicated sustainable debt levels established in the literature. The green line displays the upper quartile of the debt-to-disposable income ratios in Luxembourg from 1999 to 2007. The blue line is the upper quartile of debt-to-income ratios of euro area member states in 2018. The red line indicates the sustainable level from the leverage-perspective.

Figure 9
Debt per Capita



Source: BCL calculations. The dashed lines highlight which LTV ratios correspond to sustainable debt levels identified in the literature and the VECM. These are 59.61%, 61.73%, 63% and 74.8% for the green, blue, red and purple line, respectively. The results derive from Model II where the log of per capita debt is the dependent variable. The solid orange line outlines by how many percent per capita debt increases or decreases if the economy's average LTV ratio changes in comparison to the 2020Q1 observed value. According to the dashed green, blue, red and purple lines, "sustainable" debt levels are reached when per capita debt decreases by 30.71%, 24.17%, 20.59% and 0.99%, respectively.

According to the upper quartile of the debt-to-disposable income ratios in Luxembourg from 1999 to 2007, the average LTV ratios must be lowered to at least 59.65 % in order for debt to be considered as "sustainable" based on the fixed thresholds from the literature. When setting the threshold based on the upper quartile of debt-to-income ratios of euro area member states (the leverage approach), the LTV ratio must not exceed 61.73 % (63 %). Hence, a reduction of 18.41, 16.32 or 15.05 percentage points from the 2020Q1 average ratio is required for "sustainability" when based on the thresholds from the literature.

According to the VECM results shown in Figure 8, for the household debt level to be below the threshold, the average LTV ratio needs to decline by 3.3 pp. This corresponds to a debt-to-disposable income ratio of 146.8 %, which is the time-varying threshold from the VECM and 1.7 pp. below observed household debt –to-disposable income levels in 2020Q1 (172.6 %). Consequently, for household debt levels to be considered "sustainable", our results suggest that the LTV ratio has to decline by at least 3.3 pp from the observed 78.1 % to 74.8 % shown in the figure.

Figure 9 shows how the (log) per capita debt would change if these lower LTV ratios were met. Accordingly, the LTV reductions to 59.61 %, 61.73 %, 63 % and 74.8 % result in a decline in per capita debt of 30.71 %, 24.17 %, 20.59 % and 0.99 %, respectively.

However, these results have to be interpreted with caution. As the three fixed thresholds have been adopted from the literature, they do not specifically correspond to Luxembourg's economy. In addition, they do not result from a model estimation and are time-invariant.

7. CONCLUSION

Since 1999, household debt per capita has more than doubled in Luxembourg. This paper identifies the driving forces of this rapid increase via OLS estimations and a VECM model and evaluates whether current debt levels are considered as "sustainable". We find that strong and sustained house price increases and higher LTV ratios are the major contributors to the increases in household indebtedness in Luxembourg. Low interest rates only play a minor role, as two opposing channels almost offset each other during the period considered in this analysis. On the one hand, new loans are more attractive to households when interest rates are low. On the other hand, lower interest rates decrease repayment obligations for households that signed mortgage debt contracts with an adjustable rate. Additionally, we find no evidence that increases in disposable income contribute to increasing household debt levels.

In particular, the fact that household disposable income has not increased at a similar pace as household indebtedness raises potential policy considerations. Cointegration tests suggest that the two variables do not follow a common trend. Juselius and Drehmann (2015) highlight that not only income levels, but also households' assets are important determinants of debt sustainability. In this respect, an ADF test suggests that Luxembourg households' debt-to-assets ratio is non-stationary. We further assess household debt levels by comparing current debt-to-disposable income values with pre-specified fixed thresholds and observe that household debt levels are above these thresholds. Finally, we apply a VECM that also suggests that current household debt levels can be considered as high.

To evaluate how macroprudential policymakers can address rising household debt levels, we examine the linkage between debt and the aggregate LTV ratio. We observe a positive but decreasing relationship. To lower household debt levels, the results of this work suggest that average LTV ratios in Luxembourg should decline by 3.3 percentage points.

Several extensions of the analysis are of interest, but are beyond the scope of this paper. First, we identify "sustainable" household debt levels via fixed ad-hoc thresholds and empirical models. A natural extension is to determine these thresholds using structural models. Second, although high household debt levels result in increased vulnerability to shocks, we do not address this question for Luxembourg households. Third, the work could be extended by taking into account the effects related to tax regimes.

BIBLIOGRAPHY

Akinci, O., & Olmstead-Rumsey, J. (2018). "How effective are macroprudential policies? An empirical investigation". *Journal of Financial Intermediation*, 33, 33-57.

Albuquerque, B., Baumann, U. & Krustev, G. (2014). "Has US Household Deleveraging Ended? A Model-Based Estimate of Equilibrium Debt". ECB Working Paper, no. 1643.

Alpanda, S. & Zubairy, S. (2017). "Addressing household indebtedness: Monetary, fiscal or macroprudential policy?", *European Economic Review*, 92, 47–73.

Barba, A. & Pivetti, M. (2009). "Rising household debt: Its causes and macroeconomic implications-a long-period analysis". *Cambridge Journal of Economics*, 33(1), 113-137.

Barnes, S., & Young, G. (2003). "The rise in US household debt: assessing its causes and sustainability". Bank of England Working Paper, no. 206. Quarterly Bulletin, 43(4), 458.

Bouis, R., Christensen, A. K., & Cournède, B. (2013). "Deleveraging: Challenges, Progress and Policies". OECD Economics Department Working Paper, no. 1077.

Büyükkarabacak, B., & Valev, N. T. (2010). "The role of household and business credit in banking crises". *Journal of Banking & Finance*, 34(6), 1247-1256.

Cerutti, E., Claessens, S., & Laeven, L. (2017). "The use and effectiveness of macroprudential policies: New evidence". *Journal of Financial Stability*, 28, 203-224.

Chmelar, A. (2013). "Household Debt and the European Crisis". Research Report, 13. Brussels: European Credit Research Institute.

Cuerpo, C., Drumond, I., Lendvai, J., Pontuch, P., & Raciborski, R. (2013). "Indebtedness, deleveraging dynamics and macroeconomic adjustment". European Commission, Directorate-General for Economic and Financial Affairs.

Debelle, G. (2004). "Household Debt and the Macroeconomy". BIS Quarterly Review, March, 51-64.

Dickey, D. A. & 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.

Drehmann, M., Illes, A., Juselius, M., & Santos, M. (2015). "How much income is used for debt payments? A new database for debt service ratios". BIS Quarterly Review, September.

Dynan, K. E. & Kohn, D. L. (2007). "The role of US household indebtedness: causes and consequences". Federal Reserve Board Finance and Economics Discussion Series, 2007-37, August.

European Commission (2012). "Completing the Scoreboard for the macroeconomic imbalance procedure: Financial Sector Indicator". European Commission Staff Working Paper, no. 14.

European Commission (2018). "Technical note - Envisaged revision of selected auxiliary indicators of the MIP scoreboard".

European Systemic Risk Board (2014). "Recommendation of the European Systemic Risk Board of 18 June 2014 on guidance for setting countercyclical buffer rates". Official Journal of the European Union, C 293/1.

Emanuelsson R., O. Melander and J. Molin (2015). "Financial risks in the household sector", Sveriges Riksbank, Economic Commentaries, no. 6.

Filipe, S. Ferreira (2018). "Housing prices and mortgage credit in Luxembourg". BCL Working Papers no. 117, Central Bank of Luxembourg.

Friedmann, M. (1957). "A Theory of the Consumption Function". Princeton: Princeton University Press.

Gerali, A., Neri, S., Sessa, L., & Signoretti, F. M. (2010). "Credit and Banking in a DSGE Model of the Euro Area". *Journal of Money, Credit and Banking*, 42, 107-141.

Glick, R., & Lansing, K. J. (2010). "Global household leverage, house prices, and consumption". FRBSF Economic Letter, 1, 1-5.

Iacoviello, M. (2005). "House prices, borrowing constraints, and monetary policy in the business cycle". *American Economic Review*, 95(3), 739-764.

Iacoviello, M. (2015). "Financial business cycles". *Review of Economic Dynamics*, 18(1), 140-163.

Iacoviello, M., & Pavan, M. (2013). "Housing and debt over the life cycle and over the business cycle". *Journal of Monetary Economics*, 60(2), 221-238.

Johansen, Søren (1991). "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models". *Econometrica*, 59, 1551–1580.

Johansen, Søren (1995). "Likelihood-based Inference in Cointegrated Vector Autoregressive Models", Oxford University Press.

Jordà, Ò., Schularick, M., & Taylor, A. M. (2013). "When credit bites back". *Journal of Money, Credit and Banking*, 45(s2), 3-28.

Juselius, M., Borio, C., Disyatat, P., & Drehmann, M. (2017). "Monetary Policy, the Financial Cycle, and Ultra-Low Interest Rates". *International Journal of Central Banking*, 13(3), 55-89.

Juselius, M. & Drehmann, M. (2012). "Do debt service costs affect macroeconomic and financial stability?". BIS Quarterly Review, September, pp 21-34.

Juselius, M. & Drehmann, M. (2015). "Leverage dynamics and the real burden of debt". BIS Working Papers, no 501.

Lindquist, K. G. (2012). "Sustainable household debt: Towards an operational view and framework". Norges Bank, Staff Memo No. 33.

MacKinnon, J. G., Haug, A. A. & Michelis, L. (1999). "Numerical distribution functions of likelihood ratio tests for cointegration". *Journal of Applied Econometrics*, 14, 563- 577.

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

Meng, X., Hoang, N. T., & Siriwardana, M. (2013). "The determinants of Australian household debt: A macro level study". *Journal of Asian Economics*, 29, 80-90.

Modigliani, F., & Brumberg, R. (1954). "Utility analysis and the consumption function: An interpretation of cross-section data". *Post-Keynesian Economics*, 388–436.

Rinaldi, L., & Sanchis-Arellano, A. (2006). "Household debt sustainability: What explains household non-performing loans? An empirical analysis". ECB Working Paper Series, no. 570.

Tudela, M., & Young, G. (2005). "The determinants of household debt and balance sheets in the United Kingdom". Bank of England Working Paper, no. 266. Quarterly Bulletin.

Turdaliev, N., & Zhang, Y. (2019). "Household debt, macroprudential rules, and monetary policy". *Economic Modelling*, 77, 234-252.

Turinetti, E., & Zhuang, H. (2011). "Exploring determinants of US household debt". *Journal of Applied Business Research*, 27(6), 85-92.

Uusküla, L. (2016). "Explaining Private Debt". *Review of Economic Analysis*, 8(2), 153-176.

Wadhwani, S. (2002). "Household Indebtedness, the Exchange Rate and Risks". Bank of England Quarterly Bulletin, 42(2), 228-236.