UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Buy now, default later.

- To what extent does the interest rate of consumption loans impact the future purchasing power in Sweden?

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Abstract

How does an increase in the interest rate affect the share of household income devoted to monthly debt payments? Over recent decades, loans and credits to consumption in Sweden have risen at a pace higher than that of other types of debt, such as mortgages. Although loans and credits to consumption still account for a relatively small portion of the total debt, (about 20% of the aggregated Swedish private debt) they amount to a substantial part of the households' monthly debt payments. These types of loans and credits have been issued at a relatively high interest rates even as lending rates in general have remained at record low levels. Taken together, this leaves many borrowers vulnerable to an increase of the interest rates. We examine the effect on household income devoted to monthly debt payments from a change in the interest rate using a VAR-model and by estimating the associated impulse response functions to trace out the impact of a shock to the interest rate. The analysis is based on Swedish quarterly time series data spanning from Q4 2005 to Q2 2021. The results indicate that a positive shock to the interest rate induces a lasting increase in the share of income devoted to monthly debt payments.

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Table of content

1. Introduction

Debt and debt claim payments bear an essential importance to the households' finances. Debt can act as a driving force for the economy, enabling consumption in times of scarcity or by enabling investments. At the same time, debt may pose a risk to the economy since accumulating too much debt may leave the borrower in dire strait, in the case of either a decrease in income or increase in the cost of debt. If interest rates increase, the share of income devoted to pay interest and amortization on consumption loans increases as well and the household's purchasing power decreases since room for other consumption shrinks. In order to examine the potential effect of a change in the interest rate to the future purchasing power, we consider how a change in the interest rate affects the share of household income devoted to monthly debt payments.

The debt (or credit) in relation to GDP in Sweden has risen substantially during the last 15 years as it has increased with more than 70% (See graph 1.1 appendix 1.0). In 2019, Swedish households held the second highest debts in the world with an average of 39.000 euros in debt per household (ECB, 2019). As of 2021, the stock of debt in Sweden consists of mortgages (80% of the total debt) and consumption loans (20% of the total debt). Although the portion accounted for by the consumption loans is relatively small, these loans account for more than half of the average household's monthly interest payments. Despite most consumption loans have installment periods shorter than those of mortgages, they often have enough time left to maturity to endure severe changes to the interest rate (FI, 2020). For this reason, this paper examines the impact of an increase in the interest rate on the debt payments to income, and hence how such an increase might affect the future purchasing power of households that holds consumption debts. More specifically, this paper aims to address the question: "*To what extent does the interest rate impact the debt-to-income ratio?*"

To measure the share of income devoted to meet the debt obligations, we consider the Debt Service Ratio (hereafter referred to as DSR). The DSR is defined as the ratio of interest payments plus amortization to income. As such, the DSR provides a comparison of monthly debt service payments divided by the monthly income. The DSR depends on both the size of the loan, the interest rate tied to these loans and the income of the household. Specifically, we consider the DSR solely on the consumption debt, stated as the percentage of income used to meet the monthly debt obligations connected to consumption debt. We examine the impact on the DSR of a shock to the interest rate by the framework of a Vector Autoregressive model (VAR) that allows us to examine the effect on DSR of a shock to the interest rate and to forecast how the effect of shock traces out over time.

The findings of this paper suggest that positive shock to the interest rate implies a lasting increase of the DSR and hence a restriction to future consumption. The relationship between the interest rate and the DSR can be evaluated using the framework of the life-cycle model (Ando and Modigliani, 1963), that divides the full lifespan of an economic agent in a two-period structure in which consumption choices can be modelled. The allocation of consumption can be altered either by saving in the first period and thus consuming relatively more in the second period, or by borrowing in the first period to consume relatively more in the first period. The interest rate enters the model as a mean to transfer money across the periods. This allocation of consumption has not, to our knowledge, been empirically modelled on Swedish data. Previous research has provided evidence in favor of the predictive power of debt on the future consumption growth (see, e.g., Murphy 1999). However, this paper aims to fill this gap and open possibilities for further research on the matter, based on Swedish data. Thus, our results add to the previous literature and provides further empirical evidence on the relationship between debt and the interest rate.

Continuously, the paper has the following structure: First, we present the relevant literature and theory followed by the empirical methodology. Next, the results are presented after which we provide a thorough analysis and lastly the conclusion that summarizes our findings and give recommendation to future research.

2. Literature review

In this section we summarize the most relevant previous research related to our topic. In specific, we mainly relate to two strands of the literature: firstly, papers that consider the effect of household debt on future consumption, and secondly, those that examine the effect of debt on the aggregate as well as the household level economy. Below we summarize two main papers that belong to the first strand and point to our contribution relative to the literature. Next, we briefly summarize three papers that examine the effect on debt on various aspects of the economy.

In the 1999 paper "Household Debt and Aggregate Consumption Expenditures" Robert G. Murphy aims to investigate to what extent the debt service burden of households is helpful in explaining aggregate consumer spending. The debt service burden is the ratio of the households required debt payments relative to their disposable income, which is the equivalent to our definition of DSR. Murphy examines the relationship between the debt service burden and future aggregate spending growth on both durable and non-durable goods. However, the focus lies primarily on durable goods due to the fact that non-durable goods (such as food and clothes) are almost non-affected by a small change in income.

Murphy uses a regression analysis, where the growth rate of various categories of real consumer spending is regressed on lagged values of the debt service burden relative to personal income. The regressions are based upon quarterly data of national income in the US, ranging from 1960 to 1997 which includes consumer spending and debt service burden. With this method, Murphy (1999) shows that the households' debt burden have proven helpful to forecast future growth of consumption, which challenges the stated classical theories of the standard life-cycle model along with the permanent income theories of consumption. According to these theories, current spending by households should reflect all available information so that future changes in spending are unpredictable. Although Murphy concludes that a rising debt service burden leads to a slowdown in consumption growth, he stresses that the underlying reason for this slowdown is not fully established. In this paper, we build on Murphy's finding that the debt burden is helpful to forecast future growth of consumption and we contribute by examining the role of the interest for predicting the debt service ratio. Our paper also differs from Murphy's as we use a different methodological approach.

A related report by Dean M. Maki for the Board of Governors of the Federal Reserve System published in the year 1999, "The Growth of Consumer and the Household Debt Service Burden", also uses the debt service burden as a main variable to predict future consumption and tries to establish whether the increase in household debt poses a financial risk to the economy. He assesses not only the aggregated level of debt for US households, but also a measure of the amount of payments an individual household makes to meet the debt obligations. Maki documents that while the size of consumer debt is only about one third the size of mortgage debt, the required payments on consumer debts are higher than those on mortgage debt.

Maki uses a simple error-correction model to predict future consumption spending based on the debt service burden and other household credit variables. Maki (1999) could not directly show that high debt burdens by themselves cause slowed consumption growth but suggested that the expectations of future income may be lowered due to an increase in future interest payments, which in turn could affect the future consumer spending negatively. For our paper, we consider an analytical framework which is close to that of Maki. However, we consider the link between the interest rate and the DSR directly, and we use a more recent dataset.

A recent contribution by Mian, Sufi and Verner 2015, addresses the effect of household debt on economic activity. They examine the question of how the rise in household debt affects global economic growth (Mian et al, 2015). The conceptual point of their paper lies in the countermeasures of the standard open economy macro model that predicts a positive relationship between debt growth and growth in the GDP. Thus, recent theoretical work together with this paper highlights the potential danger of debt; since the implications of their results are that hasty growth in private debt may negatively affect the forecasted future economic growth. Using a panel dataset spanning from 1960 to 2012, they deploy a panel vector-autoregression (VAR) to examine the relationship between private debt and GDP growth at different lags for 30 advanced economies. Additionally, they consider impulse response functions to trace out the impact following a shock to the household debt over 5 to 10 years. Mian et al (2015), provide evidence of households' debts as an important channel through which underlying shocks affect global growth. Specifically, they find that over a three to four year period, household debt to GDP ratio robustly forecasts lower GDP growth. The econometric approach in this paper is similar to that of our paper, however, we deploy the usage of the impulse response function for prediction not of the effect of changes in debt on economic activity but of the interest rate on the debt service ratio using Swedish data.

Another influential contribution on the effect of debt, not the aggregate economy, but the household level economy is “Identifying ‘Tipping points’ in Consumer Liabilities Using High Frequency Data” (Garriga, Rickets & Schlagenhauf, 2016). Their paper investigates the potential contraction in the household level economy due to an increase in private debt. To do this, they identify a threshold in the household’s DSR, after which the observed household can no longer meet its debt obligations and default on the installment payments. They make several noteworthy discoveries, for example: among individuals filing for bankruptcy, the average person held a DSR of approximately 30% 12 months ahead of bankruptcy. This ratio then increased steadily to 40% one month prior to the bankruptcy. These findings point to the importance of the DSR for households’ future consumption possibilities.

A related study which examines the relationship between household debt and monetary policy and revealing the cash-flow channel is “Household Debt and Monetary Policy: Revealing the Cash-Flow Channel” written by Flodén, Kilstrom, Sigurdsson & Vestman (Flodén et al, 2021). They examine how consumptions is affected by monetary policy depending on the debt-to-income ratio and type of mortgage rates (adjustable- or fixed interest rates). The analysis is done using an administrative data set called LINDA (Longitudinal Individual Data for Sweden) on balance sheets and consumption expenditure of a random sample of 300 000 households.

The main regression specification is based upon an OLS that includes fixed effects for individuals and years as well as control variables. The dependent variable is the percentage change in consumption spending of households in a specific year. The focal point of their paper is to display how consumption responses varies differently among indebted households to changes in the interest rate, depending on the debt-to-income ratio. They highlight that monetary policy is more potent in economic environments where households hold high levels of debts relative to their income. Such households’ answer more strongly to changes in policy interest rate than those who are less indebted. Their paper points out a potential threat to the Swedish economy in terms of reduced future consumption as response to an increase in the policy rate. Thus, the aim of their paper is, in essence, closely related to that which our paper seek to investigate further.

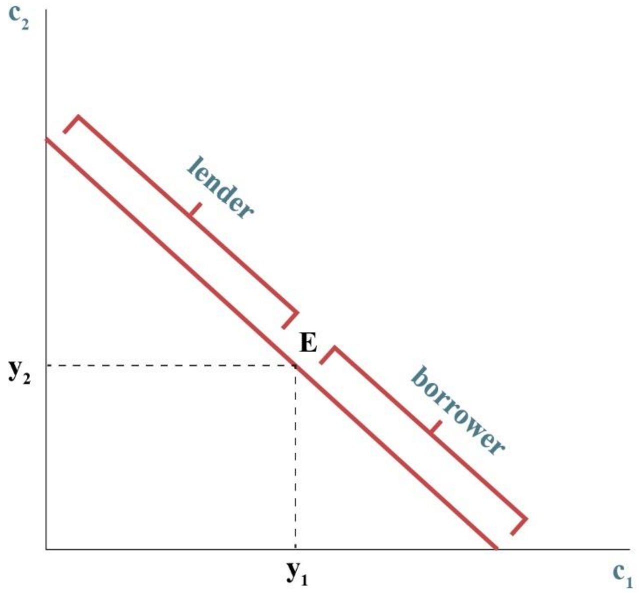
3. Theory

This section outlines the theoretical framework in which we seek to explain the relationship between the DSR and the interest rate. The dynamics of this relationship is put in context of the classical intertemporal two period life cycle model. This model was first introduced by Ando and Modigliani in (1963) to determine consumption patterns over periods and how they rely on the time dependent preferences of consumption and the intertemporal interest rate. These two parameters jointly determine the individual’s consumption patterns.

The model lets an individual’s choices of consumption levels be observed over two periods, the first being the current period and the second an undefined future period. These two periods constitute equal parts of the remainder of the individual's life. The individual has income y1 and consumes c1 in period one, for the second period, the income and consumption levels are labeled y2 and c2.

During these two periods, the individual consumes all of her income and hence, at the endowment point, the consumption in period one equals the income, minus savings, in period one. Likewise, the consumption in period two, equals the income in period two. The dynamics of this model lets the individual make decisions to transfer funds across periods. Essentially, these decisions regard whether to save money for future consumption or to borrow money for current consumption. Such intertemporal decisions involve trade-offs across the time periods. The costs of these decisions are decided by the interest rate that enters the model as a means to reallocate funds between the two periods in time.

Figure 1



In this setting, the individual can either consume at a point below the income of the first period, saving to consume at a point above the income in the second period. In figure 1, this would indicate a point that lies left of “y1” on the horizontal axis and above “y2” on the vertical axis. When transferring funds from the first period to the second, the individual receives interest on savings, making her eligible to consume more in the next period. The trade-off is a decrease in the current period’s consumption.

An individual that wishes to consume an amount that surpasses the current income, can transfer funds from the income in period two by borrowing money at the same intertemporal interest rate. This utility, derived from the increase in current consumption, comes at the cost of a lower level of consumption in period two, as some of the income in period two is paid in interest to the creditor.

The model assumes that the average individual prefers consumption today over consumption in the future. Hence, the interest rate used to transfer funds between the periods make it so that a borrower must give up more future consumption than the additional entitled consumption in period one. In turn, this makes an individual that saves to have a total consumption higher than a borrower, at the cost of having to postpone consumption. Therefore, the consumption pattern depends on both how eager the individual is to consume as well as the intertemporal interest rate. Put together, these two parameters bear the power to jointly determine whether the individual saves or borrows money in the first period.

The mechanics of this model gives a clear notion that borrowing money is equivalent to borrowing from the individual's future self, as that person will have to bear the cost of lowering the consumption in the second period to meet the debt claims and repay the creditor.

Many factors are vastly simplified in the universe of this model and differ largely from the real world. For example, the model assumes that an individual is either a borrower or a saver, with a single stream of income. In practice, many people are both borrowers and savers (although always a net borrower or a net saver) at the same time.

Furthermore, the rate of interest earned by saving money is the same as the interest rate paid when borrowing money. In practice, the interest rate earned on savings and paid on loans differ. In a generalizing statement one could claim that the interest rate to borrow money likely exceeds the interest gained on savings.

Lastly, the interest rate in the universe of this model is assumed fixed between the two periods. Even though interest rates can be contracted, they can differ depending on the policy implemented by the central bank and typically follow the rate imposed by this institute.

In sum, the classical two period life cycle model predicts that an individual that borrows money for consumption in the current period (relative to a non-borrower or lender) has to consume relatively less in the future (compared to a non-borrower or lender) and more so, if the interest rate increases. However, as Murphy (1999) points out, this theory states that the individual's spending decision in the current period should reflect all available information. This means that a known change to the interest rate should not have any predictive power of future consumption, while and unexpected change to the interest rate should change the consumption decision.

Other theories point out that increased private debt and interest payments may cause an economic contraction. For instance, Piketty (2014) argues that such contraction may spur a rise of inequality. The main argument from Piketty comes from the simple relation: $r > g$, in which r denotes the return on capital and g the growth rate of output. According to Piketty, the relation: $r > g$ illustrates an amplification of the mechanism that increases inequality and he show mathematically that as long as capital can be accumulated and this property withstands, inequality will increase if left unaltered by public policies. Here, we generalize the interpretation of "r" as the interest paid to creditors on private debt, and "g" as the growth rate in the economy. This relationship is a standard property of efficient markets in most modern models. When this property holds, it is more costly to consume for those in need to take up credit to fund the consumptions, as these individuals pay interest to capital owners. This leads to a reallocation of wealth and spurs an increase in inequality.

In sum, theories as Piketty (2014)'s suggest that an increase in interest payments risks increasing inequality and may harm the most efficient use of funds to promote a stable future consumption rate.

The classical Permanent Income Hypothesis developed by Milton Friedman (1957) assumes that the consumption level chosen by a person is determined not by the short and (sometimes) fickle cashflows, but the permanent income. The permanent income is a notion describing the regular income that a person expects to earn continuously during the longer time span. According to Friedman, it is these expected income streams that determine a person's long run spending rate and short-term fluctuations in the size of the income will be smoothened out. If a person is temporarily laid off work, that person uses savings, or borrows money, to keep the consumption spending at a relatively constant rate. If a person is granted an unexpected one-time payment, this too will not affect the spending rate at large.

With logic from the Permanent Income Hypothesis, credits or loans to consumption is taken to smoothen out consumption over periods with alterations in income and will not give short term changes in factors affecting income any large predictive power to future consumption spending.

However, John Y. Campbell and N. Gregory Mankiw (1990) developed a theoretical framework where changes in such factors may indeed bear predictive properties of future spending. Their framework assumes that some households are forward-looking and sets consumption levels optimally according to the life-cycle model, whilst others set consumption equal to income. In this setting, the DSR could very well bear properties to predict the future consumption spending since, if increased, it does impact future income negatively. Some of this effect spring from the consumption changes made by households' who consume all of their income without accumulating assets or debts to smoothen out consumption as predicted by Friedman. Using US post-war data on consumption Campell & Mankiw (1990) they show that several instrument seams to show strong correlations with future spending, a particularly strong instrument was the nominal interest rate. Thus, in contrast with the prediction of the classical Permanent Income Hypothesis, they show that short-term alterations in income may in fact impact consumer spending.

4. Data

The data consists of monthly and quarterly observations for the DSR, interest rate and unemployment rate, during the period 2005 to 2021 from various Swedish and international institutions (SCB, BIS and the Riksbank)[1]. Since not all observations are available on a monthly frequency, for estimation purposes all monthly data is converted into quarterly data by averaging the monthly interest rate by quarters of three months. Once we have converted all observations to quarterly intervals, we are left with a data set covering 63 quarters.

The DSR is obtained and derived from the Bank of International Settlements (BIS, 2022a), and is defined as the mandatory monthly settlement payment required to fulfill the debt obligation in relation to income on household level. The method for constructing this variable follows the approach used by the Federal Reserve Board (Dynan et al (2003)) and uses the standard formula (1) for the DSR at time t below:

$$DSR_t = \frac{i_t}{(1-(1+i_t)^{-s_t})} \cdot \frac{D_t}{Y_t}, \qquad (1)$$

in this formulation, D_t denotes the total debt (consumption loans), Y_t denotes quarterly income, i_t denotes the average interest rate on these loans and s_t denotes the average remaining maturity in quarters.

All input data to this ratio is obtained via the national accounts according to the following details. The input for debt is compiled by BIS and represents the actual stock of debt after different categories, consumption loans being the one used for the analysis conducted in this paper. The average interest rate on these loans reflects the average interest rate on this specific category of debt, containing new and old loans with different fixed and floating interest rates attached to them. The income used in this formula is estimated using the gross disposable income (GDI), reflecting the amount of money available to economic agents to pay debt service costs.

Figure 2 below, illustrates a timeline for the DSR for Swedish households and consumption loans from Q4 2005 until Q2 2021. An extra noteworthy fluctuation is the sharp decline in

[1] SCB (Statistic Sweden) is the Swedish government agency that makes statistics for Sweden. BIS (Bank for International Settlements) is an international financial institution owned by central banks. The Riksbank is the central bank of Sweden.

the ratio around the time for the financial crisis in 2008. The process has a clear upward trend, which we account for when performing tests for stationarity in the following section.

Figure 2

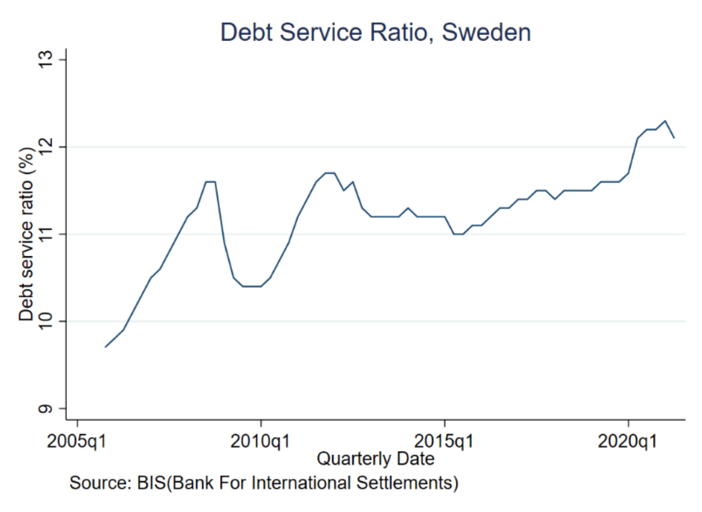


Figure 2 shows the development and upward trend of the DSR from the years Q4 2005 to Q2 2021.

The average interest rate to consumption loans both from outstanding agreements and newly issued agreements are obtained from Statistics Sweden (SCB, 2022a). The interest rate is an aggregated weighted average of interest rates on consumption loans that are reported from Swedish banks. These institutions are required, by law, to submit this information and neglection of this process is not common (SCB, 2022a). The data used for our research disregards mortgage loans and focuses solely on the interest rate for consumption loans. For the remainder of this paper, we refer to the interest rate for consumption loans simply as the interest rate. Figure 3 illustrates the historical movements of the average interest rate together with the repo rate, ranging from Q4 2005 to Q2 2021. Displayed in the figure 3 are some large fluctuations. For instance, in 2008, the world economy experienced a financial crisis, and in 2011, Euro area crisis affected the interest rates, as shown below. However, we cannot detect any general trend for the interest rate and will thus not account for such when conducting stationarity tests.

Figure 3

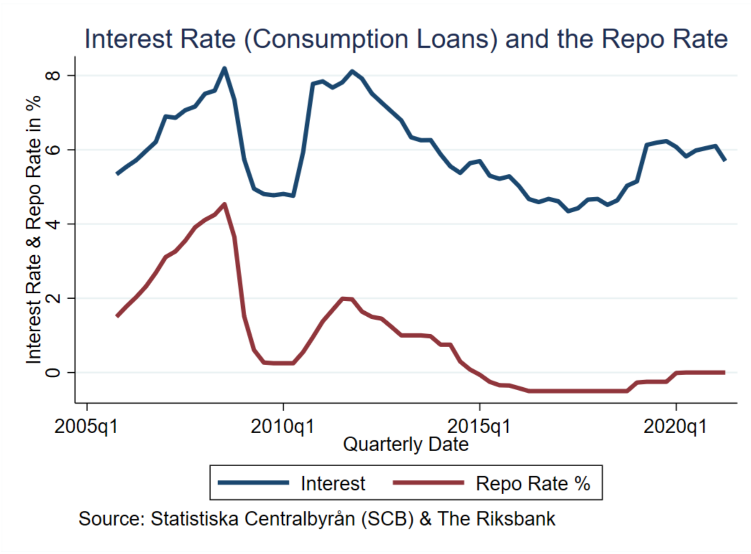


Figure 3 shows the Repo Rate imposed by the Riksbank as well as the interest rate on consumption loans from the period Q4 2005 to Q2 2021.

The repo rate, which is imposed by the Swedish central bank (the Riksbank) for funds to commercial banks, is given in quarterly intervals and obtained from the Riksbank database (Riksbank, 2021). This rate, in essence, is equal to the cost for commercial banks to acquire capital. Hence, as shown in figure 3, the lending rate on consumption loans is highly correlated with the repo rate.

The unemployment rate is obtained from Statistics Sweden (SCB, 2022b), and is reported on a monthly frequency from Q4 2005 until 2021 Q4 2021 and given as percentage share of the population between the age of 20 and 64 that are currently unemployed. The conversion from monthly to quarterly frequency is conducted by taking the average value for the percentage of unemployed for each quarter. The unemployment is visualized in figure 4, and is shown with two general spikes, one in the wake of the financial crisis in 2008 due to forcibly diminishing demand for labor. Also, in the beginning of 2020, where the unemployment rate increased considerably due to the economic consequences of the Covid-19 pandemic. Reading from the figure below, we do not observe a general trend or slope for the unemployment, which is quite expected. In general, one can think of unemployment as having a long-run equilibrium with short-term fluctuations, or drifts. The time interval of approximately 16 years displayed below shows some of the movements that can be explained by the drift of the process. This is considered when assessing the stationarity tests in proceeding sections.

Figure 4

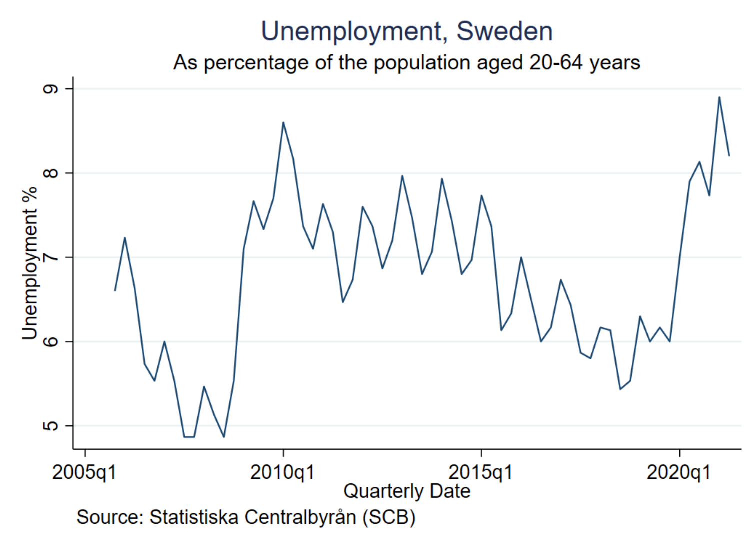


Figure 4 shows the Unemployment as percentage of persons aged 20-64.

Table 1

Descriptive Statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Debt service ratio	63	11.184	.567	9.7	12.3
Interest	63	5.984	1.104	4.345	8.195
Unemployment	63	6.735	.96	4.867	8.9

The above table contains a statistical summary of the DSR, the consumption interest rate, and the unemployment rate. The mean value for DSR tells us that the average household is required to pay approximately 11% of its monthly income to cover the required payments for interest rate and amortization for consumption loans. The minimum and maximum values of the DSR are quite close to the mean, indicating small fluctuations over time. This is also indicated by its standard deviation which is relatively moderate compared to that of the interest rate on consumption loans. The interest rate on consumption loans spans from 4.3% up to 8.2% with its mean centered at approximately 6%, where we have some occasional fluctuations, thus, over time it's quite centered around its mean. The unemployment variable ranges from approximately 4.9% to 8.9% with a mean centered around approximately 6.7%, where it visualizes fluctuations over time from quarter to quarter, thus, a quite low standard deviation to illustrate that the fluctuations are minimal in relation the mean.

In terms of restrictions on our analysis imposed by the data, conducting a regression analysis in order to examine our hypothesis proceeds with some limitations. In the best of worlds, we would have liked to use individual observations on both the DSR, and the interest rate paid on consumption loans for all Swedish households. However, observations of individual households are limited due to personal secrecy reasons and consequently, the data used in this paper corresponds to an average of the whole population. This limits our ability to make predictions based on differences in population characteristics. The dataset ranges from 2005 to 2021 due to the availability of the variable DSR, which contains values starting from 2005. Optimally, we would want a longer time span to capture the long run relationship between the interest rate and DSR. Yet, with our existing data we are able to model this relationship representative enough to give good predictive properties to our analysis through the VAR structure.

5. Empirical Methodology

To evaluate the relationship between the interest rate and the DSR and to display what may follow a shock to the interest rate, we make use of a Vector Autoregression (VAR) model and the following impulse response function to make projections that illustrate the impact to the DSR. This section outlines the step-by-step approach taken to estimate the Vector Autoregression model and the tests conducted in order to ensure the adequacy of the model.

5.1 Vector Autoregression (VAR)

The VAR model expresses the variables as a linear function of its own past values together with the past values for all variables considered in the model and serially uncorrelated error terms.

The choice of number of lags to include in the model are taken from the standpoints of both theoretical motivation and statistical testing. We use the Bayesian Information Criteria (BIC) and Akaike Information Criteria (AIC). We find that these two criteria give different results implying different lag lengths. The BIC suggests an optimal lag length of 1 quarter, but the AIC proposes the use of 5-step lag length. Due to both the nature of our variables and the frequency by which we observe them, we conclude that using 3-6 lags is appropriate. Including too few lags risk giving biased estimates and having too many lags bears the risk of reducing the statistical power of the model (Enders, 2010). With quarterly data, the consensus suggests the use of 1-8 lags (Wooldridge, 2018). For what we are estimating, the average time to maturity on a consumption loan is 10 years, and as shown in figure (3), we observe large fluctuations in the interest rate with peaks all lasting only for 1-2 years. For that reason, we believe that limiting our number of lags to 6 quarters (1.5 years) gives us good margins to model the impact of shocks to the interest rate. Thus, we proceed by the 5-step lag length as proposed by the AIC (see Table 2.2 in Appendix 2.0).

With the main purpose of observing the reaction in the DSR due to a chock to the interest rate, we specify our VAR-equations (2), (3) and (4) as below:

$$DSR_t = \beta_{11}DSR_{t-1} + .. + \beta_{15}DSR_{t-5} + \gamma_{11}INT_{t-1} + .. + \gamma_{15}INT_{t-5} + \phi_{11}UNE_{t-1} + .. + \phi_{15}UNE_{t-5} + u_{1t}, \quad (2)$$

$$INT_t = \beta_{21}DSR_{t-1} + .. + \beta_{25}DSR_{t-5} + \gamma_{21}INT_{t-1} + .. + \gamma_{25}INT_{t-5} + \phi_{21}UNE_{t-1} + .. + \phi_{25}UNE_{t-5} + u_{2t}, \quad (3)$$

$$UNE_t = \beta_{31}DSR_{t-1} + .. + \beta_{35}DSR_{t-5} + \gamma_{31}INT_{t-1} + .. + \gamma_{35}INT_{t-5} + \phi_{31}UNE_{t-1} + .. + \phi_{35}UNE_{t-5} + u_{3t}, \quad (4)$$

where INT denotes the nominal average interest rate for consumer debt and UNE denotes the unemployment rate. The parameter β denotes the change in the DSR, the parameter γ denotes the change in the INT and ϕ denotes the change in UNE. u_{nt} denotes the error term for each equation n=1, 2, 3, and the lower index t represents the time periods (quarters), i.e., t = 1, 2, 3, …, T. In addition to the interest rate, the level of unemployment (measured as percentage of the population aged 20-64) is added to the system of equations. Unemployment affects the households' income and may thereby also directly impact the DSR[2], and for this reason, we include it in the VAR-model.

The VAR-model consists of an endogenous system of equations, as the VAR approach comes with the desirable property of describing the dynamic evolution of variables that are endogenous. Even though the error terms of the model may be correlated with each other, they are assumed to be white noise processes with mean value of zero, constant variance and individually serially uncorrelated[3] (Enders, 2010). Therefore, the VAR model may be estimated with OLS-equations, which is also the first required assumption for the adequacy of the model estimates.

In line with this logic, the white noise processes may not be serially correlated, an assumption that can be examined by conducting a Lagrange-multiplier test in order to test for autocorrelation in the residuals of the VAR model at the chosen lag order (Johansen, 1995). Autocorrelation means that previous error terms help predict the next error term, which would violate the assumption that the error terms should occur randomly and not be serially

[2] Recall the definition of the DSR introduced in section 4, where the households, income enters in the denominator: $DSR_t = \frac{i_t}{(1-(1-i_t)^{-s_t})} \cdot \frac{D_t}{Y_t}$

[3] In a reduced form VAR, such as the one considered in this paper, each of the error terms, u_{nt}, is given by a combination of the structural error terms, which implies that the reduced form error terms are correlated with each other (Enders, 2010. pp 297-299).

correlated. Formally, the Lagrange-multiplier test evaluates the null-hypothesis of no autocorrelation at our chosen lag order, contrary to the alternative hypothesis which states that there exists autocorrelation at the given lag order.

Third, it must be established whether the variables are stationary or non-stationary i.e., whether the statistical properties (mean and variance) of the time series do not change over time. In other words, the time series are stationary if a shift in time does not cause a change in the shape of the distribution. The stationarity of each variable is examined by conducting an ADF (Augmented Dickey-Fuller)-test, that evaluates the null hypothesis whether each of the variables has a unit root, implying that the series is non-stationary.

As pointed out in the data section, we observe an upward trend in the DSR, and for this reason a stochastic trend must be allowed for in the ADF test. Doing so allows for a rejection of the null hypothesis at the 5% confidence level. As noted earlier for the interest rate, there is no observable general trend or drift for this variable. We find that the ADF test for the interest rate does not allow for a rejection of the null hypothesis of non-stationarity at any confidence level. For this reason, we must alter the variable with the purpose of obtaining stationarity. Namely, we take the first difference of that variable according to the following equation (5) $Interest.d1_t = Interest_t - Interest_{t-1}$, (see graph 1.2 appendix 1.0). Although the differencing of a variable comes with the risk of losing relevant information, it is a common practice mean of obtaining stationarity of a variable (Enders, 2010, p.189). The ADF-test on the first differenced interest rate leads to a rejection of the null hypothesis at the 1% confidence level. For unemployment, we have pointed out earlier that one would expect the variable to inherit a drift, allowing for such drift in unemployment makes the test reject the null hypothesis at 1% confidence level. Detailed results and motivations for all tests (as well as alternative test specifications) are presented in appendix 2.0, table 2.1.

After estimating the model, we also conduct post-estimation tests to examine whether the model satisfies the stability conditions (implying stationarity). If the characteristic roots (eigenvalues) are less than one in absolute values, we consider the VAR-model to be stable. Stability in this sense always implies stationarity, however, unstable VAR-models may also be stationary. To conclude that the characteristic roots are less than unity (one) in absolute terms, means that they lie inside the unit circle (which is a circle centered around zero with a radius of one). Failing to conclude stability in this way imply that the results following the VAR model may be invalid (Enders, 2010, p.29).

5.2 Impulse Response Function (IRF)

Based on the VAR model, an impulse response function is a key tool for the purposes of tracing potential changes in the DSR from a shock to the interest rate. The impulse response function can be defined as the reaction of the VAR model equations to a positive (or negative) realization of the exogenous shock. For purposes of tracing out these effects we can consider the matrix (1) below (Terrance and Patterson, 2009. p 276).

Matrix 1

$$\begin{bmatrix} DSR_t \\ INT_t \\ UNE_t \end{bmatrix} = \begin{bmatrix} p11 & p12 & p13 \\ p21 & p22 & p23 \\ p31 & p32 & p33 \end{bmatrix} \begin{bmatrix} DSR_{t-1} \\ INT_{t-1} \\ UNE_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \\ u_{3,t} \end{bmatrix}$$

In the above formulation, the three variables contained in our system of VAR equations are located in the left-hand side vector. The right-hand side shows that their values depend both on past values of themselves, as well as past values of the two other variables, marked here by the subscript t-1 and an error term or innovation, u. The matrix of coefficients on the right-hand side shows to what extent the value at time depends at the value of the respective variables at time t-1. A representation of how the impulse response traces out for subsequent lags can be obtained by a recursive scheme. Such representation can be found in Appendix 4.0, Derivation 4.2. For our purposes, we let the IRF display five consecutive quarters and our result shows how the impact of a shock traces out, taking to account five lagged values. As a means of evaluating the results of the IRF:s we also conduct a Granger Causality test, which is a post-estimation test that evaluates if one variable helps predicting other variables in the model.

6. Empirical Results

This section outlines the empirical results. First, we show the VAR results in tandem with its post-estimation tests and secondly, we show the impulse response function (IRF) together with the Granger Causality test.

6.1 VAR

Table 2 below summarizes the results following the estimation of the equations (2), (3) and (4). The coefficient for the first lag of the DSR following from equation (2) is significant different from zero and displays a positive correlation (1.151) between DSR_t and DSR_{t-1} (current value and value for one lagged period of DSR). The rest of the past lagged values for DSR lacks a statistically significant impact on the current value of DSR[4]. The lags alternate in sign, so that the second and fourth lag are negative in sign while the first, third and fifth are positive.

Considering instead the effect on DSR rate in equation (2) from the lags of the first difference of the interest rate, we observe a positive relationship for the first lag (0.135). This means that there is a positive correlation between the current value of DSR and the previous value for the first difference of the interest rate. Indeed, all lags are of positive sign, which suggest that a positive shock to the interest rate has a lasting positive effect on the DSR. The effect is the greatest for the first lag and then diminishes with the lags. For unemployment, the first and third lag are of negative sign, which means that an increase in unemployment has a negative impact on the DSR in the directly following period as well as the third period. The second, fourth and fifth lags are positive, meaning that a positive shock to unemployment positively affects the DSR in these respective periods.

In equation (3) the interest rate is the response variable, and we can observe coefficients linked to the past values of the DSR. We observe an alternating pattern in the lags, in which the first lag is positive in sign, the three subsequent coefficients are negative and the last coefficient, again, is positive. For the own past values of the interest rate, we observe the

[4] Although the presence of statistical significance in general is interpreted as presence of classical causality, we do not attach too much emphasis on this as we are interested in how well the variables can create projections. For this reason, we instead test for Granger Causality which is discussed further in the coming sections.

coefficient of the first lag to be positive. The coefficient of the next lag is negative and followed by three consecutive positive coefficients. Lastly, for the coefficients of the lagged values of unemployment we note that the first coefficient is negative, followed by a positive coefficient. The remaining three coefficients are all negative.

In the last equation (4), which has unemployment as the response variable, we can observe coefficients linked to the past values of the DSR which alternative in sign. The first and last lags are negative while the second and third are positive. This pattern may be interpreted as seasonal effects in which the coefficients consequently change direction from positive to negative. The next five coefficients display the effect of the lagged interest rate, and they also have signs varying in direction between negative and positive, and may hence also be interpreted as showing seasonal effects. When put in relation to its own past values, we see that the coefficient of the lags of unemployment too follows a pattern that fluctuates between positive and negative values for the coefficients. The first coefficient is positive and of a large magnitude. The two last coefficients are negative (lag 4) and positive (lag 5) and are also of a large magnitude.

Table 2

	(2)	(3)	(4)
VARIABLES	Debt service ratio	Interest_d1	Unemployment
L1.Debtserviceratio	1.151***	0.026	-0.194
	(0.144)	(0.407)	(0.341)
L2.Debtserviceratio	-0.309	-0.044	0.307
	(0.221)	(0.625)	(0.523)
L3.Debtserviceratio	0.122	-0.218	0.359
	(0.226)	(0.640)	(0.536)
L4.Debtserviceratio	-0.247	-0.136	-1.160**
	(0.222)	(0.628)	(0.526)
L5.Debtserviceratio	0.202	0.136	0.838**
	(0.143)	(0.405)	(0.339)
L1.Interest_d1	0.135**	0.422***	-0.133
	(0.052)	(0.149)	(0.124)
L2.Interest_d1	0.018	-0.100	0.084
	(0.056)	(0.160)	(0.134)
L3.Interest_d1	0.014	0.006	-0.118
	(0.056)	(0.159)	(0.133)
L4.Interest_d1	0.073	0.094	0.274**
	(0.056)	(0.160)	(0.134)

L5.Interest_d1	0.026	0.016	0.244**
	(0.049)	(0.138)	(0.116)
L1.Unemployment	-0.045	-0.146	0.870***
	(0.045)	(0.127)	(0.106)
L2.Unemployment	0.119	0.376*	-0.053
	(0.073)	(0.206)	(0.172)
L3.Unemployment	-0.093	-0.122	-0.036
	(0.077)	(0.219)	(0.183)
L4.Unemployment	0.018	-0.032	0.755***
	(0.078)	(0.220)	(0.185)
L5.Unemployment	0.018	-0.007	-0.770***
	(0.049)	(0.139)	(0.117)
Constant	0.825	2.169	-0.064
	(0.549)	(1.554)	(1.301)
Observations	57	57	57

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The results presented in table (2) are due to their extensiveness difficult to fully grasp at first sight, as the regression output produced by the VAR model consists of 45 coefficients. Therefore, we illustrate the results with impulse response functions. The remainder of the result section and analysis are devoted to those as well as post-estimation tests.

6.1.1 Stability condition (Unit Root Circle)

To confirm valid estimations results we perform post-estimation analysis of the results. First, we conduct a unit root circle test to ensure that dynamic stability of the system holds for the VAR model.

The test analyzes whether the eigenvalues computed from the system of VAR equations are strictly less than one, and these are presented in full detail in Table 3.2 and Figure 3.1 in appendix 3.0. We find that the eigenvalues are strictly less than one and lies within the unit root circle. Concluded, our VAR model satisfies the stability condition and hence, the system of our model is stable.

6.1.2 Autocorrelation (Lagrange-Multiplier Test)

Next, we use the Lagrange-multiplier test as a post-estimation test for autocorrelation. The test results are illustrated in the table below, where we perform the Lagrange-multiplier test from the first to the fifth lag order of our VAR model. These results enable us to conclude that we cannot reject the null hypothesis and hence, the residuals of the estimated model do not inherit any autocorrelation at our lag orders.

Table 3

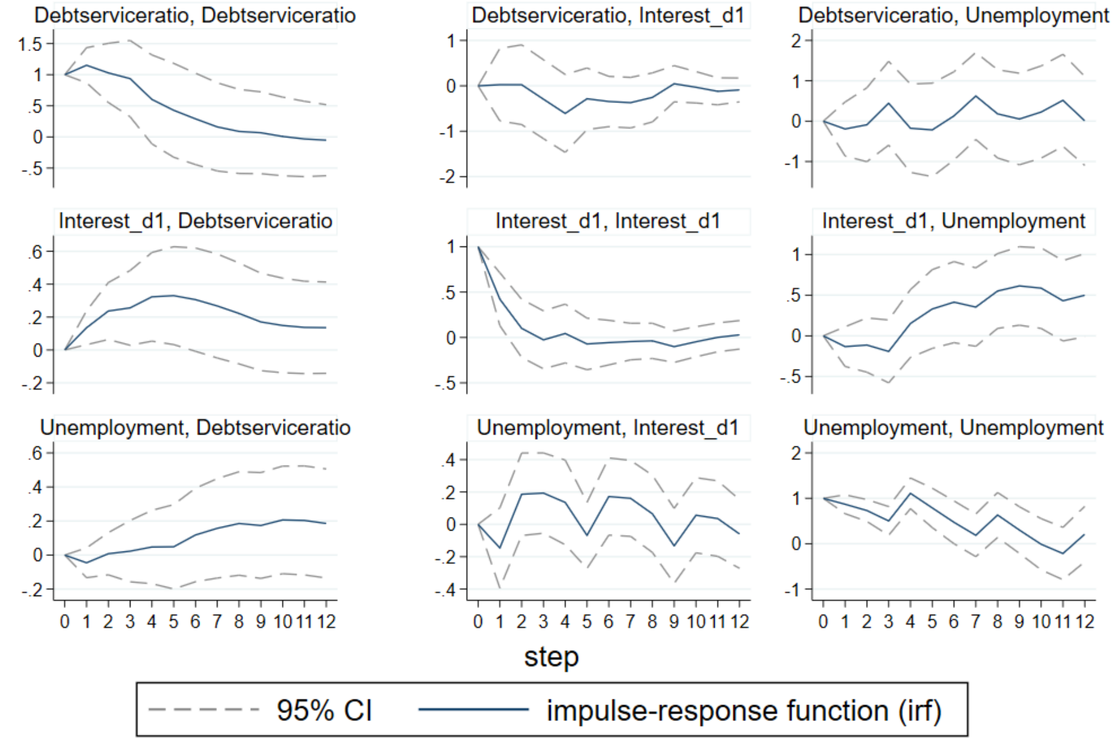
Lagrange-multiplier test

Lag	Chi2	df	Prob > Chi2
1	9.3866	9	0.40238
2	7.4056	9	0.59497
3	17.2225	9	0.04534
4	11.8155	9	0.22391
5	9.7777	9	0.36878

6.2 IRF

The Impulse Response functions lets us trace out the dynamic response of a variable, given a one-unit shock to another variable. Our system of three VAR-equations generates nine IRF graphs, as each variable can be modelled as an impulse variable that the others respond to. Hence, the impulse variable is the variable upon which the shock is imposed, and the response variable displays the respective reactions. Figure (5) below shows all generated IRF graphs, where the first row displays the graphs with the DSR as the impulse variable, the second row shows the interest rate as an impulse variable and the third row shows unemployment as an impulse variable.

Figure 5



Graphs by impulse variable and response variable

Note: The dashed lines represent the 95% confidence interval for our impulse-response function (IRF)

Starting with row one in figure (5), we see the impulse responses following a one-unit shock to the DSR. The first graph shows how the DSR reacts to a shock to the DSR itself. The first period increase illustrates the initial one-unit shock to the DSR. We note that following such a shock, the DSR first increases and then decreases continuously and reaches its initial value after approximately 10 quarters. The second graph shows how the interest rate reacts to a shock to the DSR. From this graph, we see that the interest rate does not responds immediately, and that the response is quite moderate with some disturbances from quarters 2 to 9 after which it returns to its initial level. The third graph of the first row shows how unemployment reacts to a positive one-unit shock to the DSR. Unemployment initially decreases and thereafter displays three peaks at approximately 3, 7 and 11 lags. However, during the span of 12 quarters, we do not observe any sustained impact on unemployment of a shock to the interest rate.

The second row shows the interest rate as an impulse variable. The first graph shows the impact on the DSR following a one-unit shock to the interest rate. This graph is further revisited in the analysis, as it models the relationship of main focus in this paper. At first glance, we note that the DSR displays a gradual increase which lasts for approximately 5 quarter after which the DSR begins to decrease again. The DSR continuously decreases for approximately 9 to 10 quarters and then stabilizes, well above its initial value. Thus, an unexpected one-unit shock to the interest rate leads to an increase in the DSR reaching 0.35% after approximately 6 quarters. The second graph, in the second row, shows how the interest rate reacts to a one-unit shock in the interest rate itself. We see that the interest rate decreases quite fast after the initial one-unit shock, suggesting a rapid correction, in that after a one-unit increase, the interest rate tend to decline towards the initial value. The last graph shows how unemployment reacts to a one-unit shock to the interest rate. We observe an initial decrease which lasts for approximately three quarters and thereafter a gradual increase of the unemployment. It is not surprising to observe that some time passes before the increase is shown in the unemployment, as unemployment tends to adapt slowly to changes since the market for labor take time to respond. For example, employment contracts and union agreements prevent firms from firing employees. During times of economic hardship or recession, which are correlated with higher unemployment rate, the central bank may lower the interest rate to stimulate the economy and thus increase employment. In the case of an increase of the interest rate, the inverse tends to hold true.

The third row considers the unemployment rate as the impulse variable. The first graph displays how the DSR reacts to a one-unit shock to unemployment. We observe that after a small initial drop in the first lag, DSR increases continuously. The increase in the DSR is not surprising, as the implied potential decrease in income directly following an increase in unemployment affects the DSR so that it increases. The second graph shows the reaction of the interest rate to a one-unit chock to unemployment, which initially drops and thereafter displays no general trend in the direction of the effects. Instead, we observe seasonal fluctuations with peak at approximately lag 3, 6 and 10. The last graph shows how unemployment reacts, following a one-unit shock to unemployment itself. We see unemployment appears to display a cyclical pattern, but gradually decreases back to zero after the initial one-unit shock.

6.3 Granger Causality test

With the purpose of concluding whether the past values of the interest rate in fact can help predict the DSR we conduct a Granger Causality test to evaluate the null hypothesis whether the interest rate does not Grange cause DSR contrary to the alternative hypothesis that the interest rate Granger causes DSR. A similar set of hypotheses is tested in the same manner, but for unemployment, and the results are presented in Table 3.3 in Appendix 3.0.

When considering the Granger Causality for the interest rate, it is worth to stress that to conclude Granger Causality is not the equivalent of concluding causality by the classical formulation but rather conclude that the interest rate helps in predicting the DSR. To put it clear, Granger Causality in the VAR model implies that a correlation exists between the current values of DSR and the past values of interest rate. The results let us reject the null hypothesis at a 90% confidence level, meaning that we have valid reasons to assume that the interest rate Granger causes the DSR at the stated confidence level.

7. Analysis

In this section we analyze the results in relation to our research question, and thus we mainly focus on the impulse responses of the DSR following a shock to the interest rate.

If we start at the formula that defines the DSR (shown in equation (1) in the Data section), we can deduce that the marginal ceteris paribus effect of the interest rate is positive. In other words, an increase in the interest rate, all else equal, leads to an increase of the DSR[5]. However, the marginal effect of the interest rate on the DSR does not speak to what the effect looks like over time and if considered in an endogenous system. The impulse response functions display just this and shows that the DSR answers to a single positive shock to the interest rate (figure 6) with a relatively sharp increase which peaks at 5 quarters and then decreases steadily to quarter 10, after which it is stabilized at a higher level of the DSR than initially found.

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[5] By considering the partial derivative of equation (1) w.r.t the interest rate, we gain the following expression (9) (full derivations in appendix 4.0 equation 4.1).

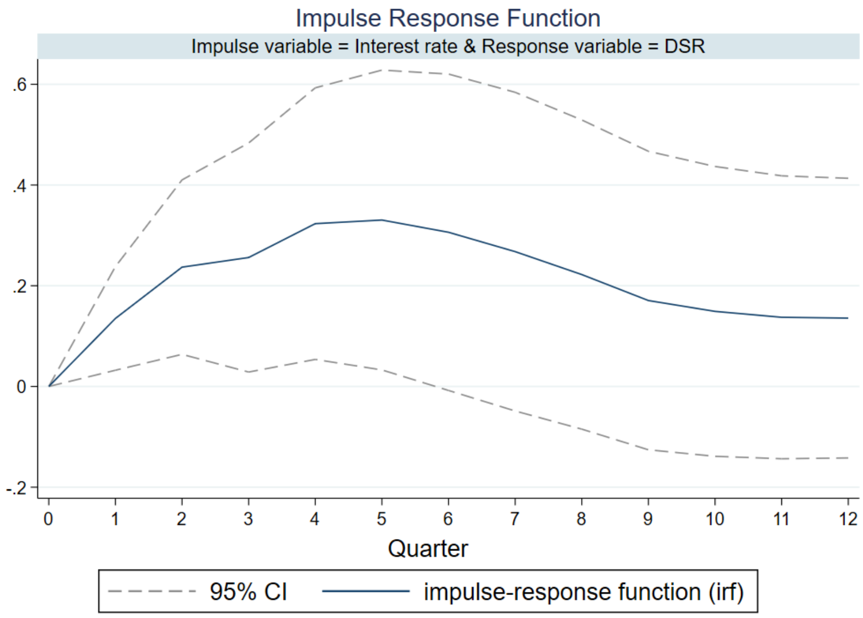
$$\frac{\partial DSR}{\partial i_t} = \frac{(1+i_t)^{s_t}}{(1+i_t)^{s_t-1}} \cdot \frac{D_t}{Y_t} \cdot \left[\frac{1+i_t+i_t \cdot s_t}{1+i_t} - \frac{i_t \cdot s_t \cdot (1+i_t)}{(1+i_t)^{s_t-1}}\right], \quad (9)$$

we make a few initial assumptions: $D_t \geq 0,\ Y_t \geq 0$ and $s_t \geq 0$. To be clear, this states that debt, income and time to maturity are all non-negative. The full expression of equation (9) denotes the marginal effect on the DSR. In order to conclude that this effect is positive, meaning that an increase in interest rate corresponds to an increase of the DSR, the expression above must be greater than zero. With the initial assumptions, we conclude that the first two terms of the equation are positive, so whether the full expression is positive boils down to whether the difference within the brackets is positive:

$$\left[\frac{1+i_t+i_t \cdot s_t}{1+i_t} - \frac{i_t \cdot s_t \cdot (1+i_t)}{(1+i_t)^{s_t}-1}\right] > 0,$$

Here, we note that this expression is positive as long as s>0 and i>0, which are reasonable assumptions since they mean that there is some time left to maturity of the loans and that the interest rate on the issued loans is greater than zero.

Figure 6



Note: The dashed lines represent the 95% confidence interval for our impulse-response function (IRF)

When assessing how the effect on the DSR of the interest rate in turn may impact future consumption, one should bear in mind that we can think of the DSR as an important determinant for consumption. The relationship is intuitive, since the DSR is the share of income that is devoted to pay the debts, on a monthly basis, i.e., the portion of income that cannot be used for consumption. Therefore, we argue that an increase in the DSR should restrict future individual consumer spending, as a larger portion of the disposable income hence is allocated to meet the debt obligations and cannot be used for consumption. Moreover, we support this argument on the findings from Roberth G. Murphy, who in the paper "Household Debt and Aggregate Consumption Expenditure" focuses on how well the DSR itself can predict future consumption spending (Murphy, 1999). He finds that the DSR bears strength as a powerful predictor of just that.

Given that the DSR indeed can assist in predicting future consumption, our result that an increase in the DSR is induced by a positive shock to the interest rate, should thus imply a decrease of future consumption. Our results states that a shock to the interest rate has a lasting impact on the DSR and the Granger Causality test gives the interest rate valid properties as a predictor of the DSR. We argue that this gives extra merit to the conclusions that an (unexpected) increase to the interest rate may lead to a reduction of future consumption, since the shock to the interest rate in turn increases the share of income devoted to debt repayment.

The relationship between the interest rate and consumption may be interpreted from the framework of the life cycle model, where a shock to the interest rate in the current period reduces the amount possible for a borrower to consume in the next period when debt also needs to be repaid. In other words, a shock to the interest rate may be interpreted as inducing a decrease in future purchasing power of borrowers. Given the importance of the DSR for future consumption (see, e.g., Murphy 1999), our results thus appear to be in line with the life-cycle model since we establish that there is a relationship between the interest rate and the DSR. On the other hand, one of the assumed facts in the setting of the life-cycle model is that all economic agents in the model are fully informed and have rational expectations. This means that historical observations of the variables in the model, as well as expected changes to them, should not have any predictive power for decisions regarding future consumption. Murphy (1999)´s finding that past values of the DSR have predictive power for future consumption growth is thus at odds with the life-cycle model. In our results, we establish using a Granger causality test that past values of the interest rate can help predict the DSR which thus also, given the link between DSR and future consumption, may be interpreted as being at odds with the life-cycle model.

In the real world, we would expect "economic agents" to have some information about past and future interest rates, although perhaps not perfect and full information. We would also expect rationality to range widely among these agents, where some base their actions more on rational arguments than others. However, we abstract from these aspects since they are beyond the scope of this paper and leave to future research to explore whether our results can be interpreted in the light of the predictions of a model with e.g., incomplete information or non-rational agents. Furthermore, interest rates are seldomly increased at one point in time, and 6 months later, decreased to the initial point. The repo rate, imposed by the Riksbank, often inflicts a graduate shift to the repo rate in order to smoothen out the effects and meet the inflation target. For this reason, one can suspect that an increase in the interest rate, may be followed by an additional increase. In this paper we consider the changes to the interest rate to be represented by completely unexpected shocks, while in real life a change to e.g., the repo rate would have to be decomposed in to an expected and an unexpected component.

In a broader perspective, one should also take into account that when evaluating the effect on DSR of the interest rate, in a comprehendible way, one must consider the cost of using credit for the borrower i.e., consuming by increasing debt, versus the gain for the credit issuer. The empirically observed relatively high interest rates imposed on consumption loans explain why these loans amounts to over half of all debt service paid by individual households (although consumption loans only account for 20% of the total stock of debt). Considering the interest rate paid on these loans, i.e., the cost of acquiring capital to consume for the borrower, and the return on capital for the creditor makes the relation to the remarks of Piketty apparent. Piketty argues that as long the return on capital exceeds the growth in the economy, an increase in inequality follows (Piketty, 2014). Interpreted loosely in our setting, the lasting effect on the DSR of a shock to the interest rate could imply not only that individual households can consume less in the future, but also, in aggregate, can contribute to increasing inequality.

Dean M. Maki gives slightly less dispirited view, suggesting that DSR is not a negative constraint in and of itself, but should be viewed as a problem depending on what future constraints it poses for the borrower, and for what reason the debt is accumulated. How well a borrower is equipped to manage the accumulated debt depends on the future variables affecting the DSR. In specific, Maki makes the remark that a high DSR is not a problem per se, but risk becoming an issue to the extent that the expectation of future income on which the borrowing was based were too high (Maki, 2000).

8. Conclusion

The purpose of this paper is to examine the potential effect on the future purchasing power of households that holds consumption debt of changes to the interest rate, which we operationalize by posing the research question; "*To what extent does the interest rate impact the debt-to-income ratio?".* The study is conducted using time series data for Sweden and the time frame studied ranges is Q4 2005 to Q2 2021, i.e., 63 quarters. The empirical methodology of this paper consists of a VAR model and the following impulse response function which illustrates an external shock to the interest rate and its effect on the DSR.

The VAR-analysis suggests that an increase in the interest rate imposes an increase in the DSR. The analysis further asserts that a one-unit shock to the interest rate, should lead to an increase the of DSR by 0.35%. Given that the DSR is a predictor of future consumption, we argue that our results declare a restriction to the future purchasing power following an increase of the interest rate, as higher debt implies that an additional portion of the income is devoted to down-pay the current debt. Murphy (1999) finds that the DSR bears predictive power over future consumer spending, and in the context of these findings our results also add to the existing literature by establishing one of the possible mechanisms behind this relationship, i.e., that the interest rate has a lasting impact on the DSR (which, in turn, affects future consumption). Continuously, our results are at odds the theoretical framework used in this paper, namely the life-cycle model, that assumes rationality and full information among all economic agents which means that past values of the interest rate should not bear predictive power for the future consumption. Our results indeed suggest that the interest rate helps to predict the DSR, which in turn may affect future consumption.

Although our findings provide an intuition for how a change of the interest rate impacts the borrower's future consumer spending, these results are by no means exhaustive. When evaluating the contribution of this paper, we have identified interesting paths that we suggests future research to pursue. Piketty (2014) states that an increase in debt risks increasing economic inequality by increasing the gap in accumulated net worth between individuals. However, to grasp the full picture of how inequality reacts to an increased consumer debt, one needs to consider what the borrowed capital is used for. Just measuring the aggregate sum of all loans would not completely discern the net effect, as different borrowers act differently and operate their debt in contrasting manners. One borrower could for example take up large credits in order to consume goods at a pace higher than what her income allows for. Another borrower could take up credit to acquire goods that generates a positive return and accumulates more capital than is actually paid in interest. For this reason, we urge future research to focus on what purchases that are made using these consumption loans.

Further, the positive effect on the DSR following an increase in the interest rate that we estimate represents an average effect of the aggregate population. However, the average effects may not be representative for certain subgroups of the full population and investigating whether the impact is larger on certain sub samples, could inform and guide policy makers to prevent financial hardship for certain groups. We therefore encourage future research to use micro data that would allow to divide the sample into smaller samples based on for example, the percentile distribution of income, or those individuals that have the highest interest rates on their loans. One could also think of dividing the population into subsamples based on strictly demographical traits such as age, educational level, or socioeconomic background. Being able to do so would enable the detection of groups that are at risk of being impacted to a greater extent by an increase to the interest rate, which in turn may have important policy implications.

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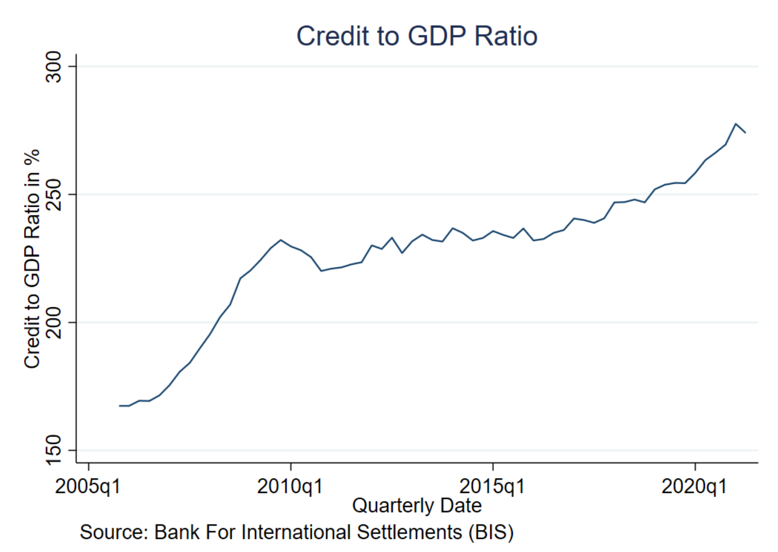
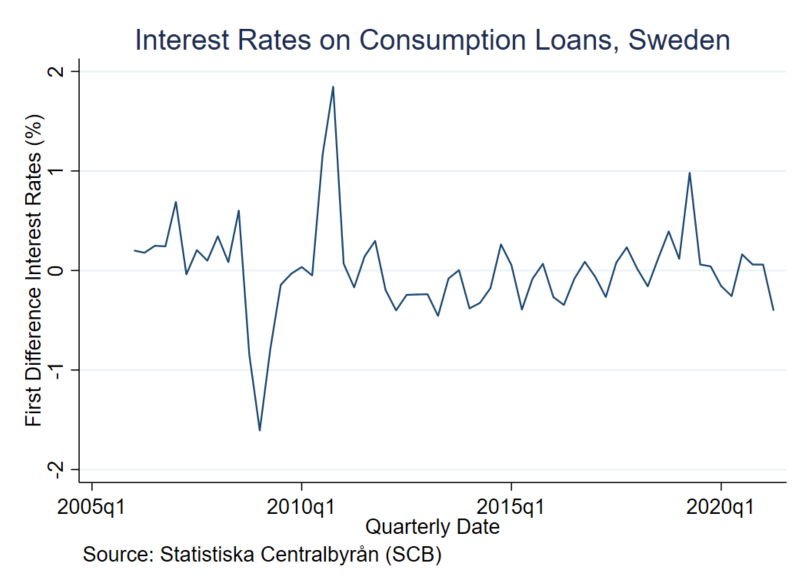
10. Appendices

Appendix 1.0: Variable Graphs

Graph 1.1 Credit to GDP Ratio



Graph 1.2 Interest Rates on Consumption Loans



Appendix 2.0: Pre-estimation test

Table 2.1 Augmented Dickey-Fuller Test (ADF)

The ADF-test is conducted after a stepwise approach. First, we test the variables only including the intercept, secondly, we allow for a trend/drift together with the intercept and lastly, for the interest variable solely, we include the first difference with an intercept.

The DSR does not makes us able to reject the null hypothesis at any given confidence interval, however allowing for a trend option (as motivated in the data section) allows us to reject the null hypothesis at the 5% confidence interval at the test statistic value of –3.587.

The Interest rate is shown non-stationary as we cannot reject the null hypothesis at any confidence level when including both solely an intercept as well as when including the intercept and allowing for a trend. We do not either find motivation for using the trend option for the interest rate, as too discussed in the data section. For this reason, we deploy the ADF-test on the first difference of the Interest, which allows us to reject the null hypothesis at the 1% confidence level with a test statistic of –3.950.

The unemployment can be rejected at the 5% confidence level straight out of the spreadsheet, however, as motivated in the data section, we believe that allowing for a drift for this variable will better capture the true dynamics of unemployment. Conducting the test and including a drift gives us even better precision in rejecting the null hypothesis, which now is done at the 1% confidence level with a test statistic of –3.419.

Augmented Dickey-Fuller test for unit root (5 lags)   Number of observations = 57

Variables	***Test Statistics***	***1% Critical Value***	***5% Critical Value***	***10% Critical Value***	***Mackinnon approximate p-value for Z(t)***
Debt service ratio					
Intercept	-2.132	-3.570	-2.924	-2.597	0.2317
Intercept, Trend	-3.587	-4.135	-3.493	-3.176	0.0310
Interest					
Intercept	-2.518	-3.570	-2.924	-2.597	0.1112
Intercept, Trend	-3.063	-4.135	-3.493	-3.176	0.1154
First difference	-3.950	-3.572	-2.925	-2.598	0.0017
Unemployment					

Intercept	-3.419	-3.570	-2.924	-2.597	0.0103
Intercept, Drift	-3.419	-2.403	-1.676	-1.299	0.0006

Table 2.2 Selection-order Criterions

Selection-order criteria
Sample: 2007q1 - 2021q2 Number of obs = 58

Lag	*LL*	*LR*	*df*	*p*	*FPE*	*AIC*	*HQIC*	*SBIC*
0	-145.553				0.040431	5.30546	5.34752	5.41396
1	-35.9743	219.16	9	0.000	0.001114	1.71337	1.88163*	2.14737*
2	-27.1235	17.702	9	0.039	0.001124	1.7187	2.01316	2.4782
3	-13.0858	28.075	9	0.01	0.000946	1.53878	1.95943	2.62379
4	-9.88573	6.4002	9	0.699	0.00118	1.74592	2.29277	3.15643
5	13.2678	46.307*	9	0.000	0.000729*	1.24044*	1.91349	2.97645
6	20.7055	14.875	9	0.094	0.000798	1.29623	2.09548	3.35775

Endogenous: Debt service ratio & Interest
Exogenous: _cons

Appendix 3.0: Post-estimation tests

Table 3.1 Variance inflation factor

Variables	*VIF*	*1/VIF*
Unemployment	1.058	.945
Interest d1	1.058	.945
Mean VIF	1.058	.

Table 3.2 Eigenvalue stability condition

Eigenvalues		*Modulus*
-0.01015684 +	0.9741964i	0.974249
-0.01015684 -	0.9741964i	0.974249
-0.9481532		0.948153

0.8954552 +	0.1510324i	0.908103
0.8954552 -	0.1510324i	0.908103
0.832129 +	0.2704408i	0.874972
0.832129 -	0.2704408i	0.874972
0.4398645 +	0.5269634i	0.686419
0.4398645 -	0.5269634i	0.686419
-0.4027576 +	0.4758823i	0.62344
-0.4027576 -	0.4758823i	0.62344
-0.3823496		0.38235
0.071037 +	0.3690508i	0.375825
0.071037 -	0.3690508i	0.375825
0.1222569		0.122257

Figure 3.1 Roots of the companion matrix

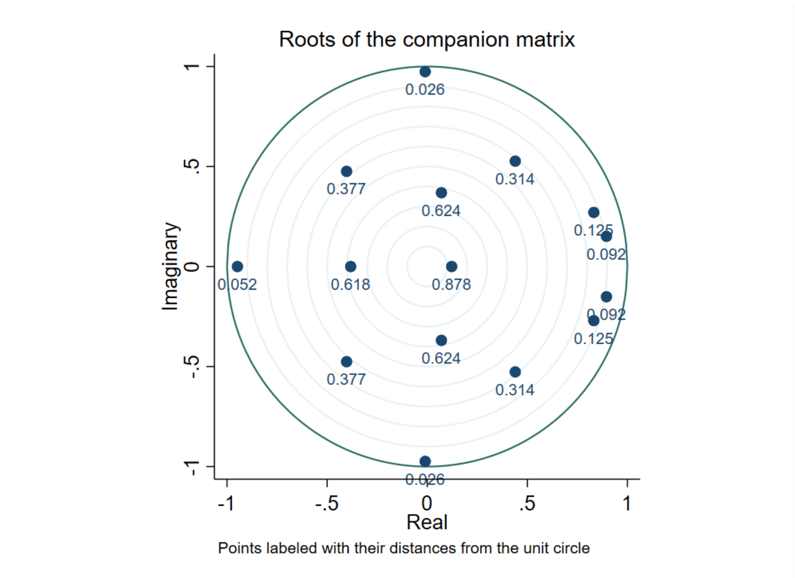


Table 3.3 Granger Causality Wald test

Equation	Excluded	Chi2	Df	Prob > Chi2
Debt service ratio	Interest_d1	9.3267	5	0.097
Debt service ratio	Unemployment	6.3641	5	0.272
Debt service ratio	All	16.355	10	0.090
Interest_d1	Debt service ratio	3.8597	5	0.570

Interest_d1	Unemployment	9.5145	5	0.090
Interest_d1	All	14.185	10	0.165
Unemployment	Debt service ratio	8.2937	5	0.141
Unemployment	Interest_d1	13.7	5	0.018
Unemployment	All	21.893	10	0.016

Appendix 4.0 Derivations

Equation 4.1 Partial derivate with respect to the interest rate

$$DSR = \frac{i_t}{1-(1+i_t)^{-s_t}} \cdot \frac{D_t}{Y_t}$$

$$\frac{\partial DSR}{\partial i_t} = \frac{(1+i_t)^{s_t}}{(1+i_t)^{s_t}-1} \cdot \frac{D_t}{Y_t} + \frac{i_t \cdot s_t \cdot (1+i_t)^{s_t-1}}{(1+i_t)^{s_t}-1} \cdot \frac{D_t}{Y_t} - \frac{i_t \cdot (1+i_t)^{s_t} \cdot (1+i_t) \cdot s_t}{((1+i_t)^{s_t}-1)^2} \cdot \frac{D_t}{Y_t}$$

$$= \frac{(1+i_t)^{s_t}}{(1+i_t)^{s}-1} \cdot \frac{D_t}{Y_t} \cdot \left[\frac{1+i_t+i_t \cdot s_t}{1+i_t} - \frac{i_t \cdot s_t \cdot (1+i_t)}{(1+i_t)^{s_t}-1}\right]$$

Derivation 4.2

Suppose that we observe the true values of the three variables at time t , and that the values at time $t-1$ are zero, we can simulate a one-unit shock to the e.g., interest rate by letting that error term ($u_{t,2}$), take on the value. This will make the full expression take the value as below, in matrix (2).

Matrix 2

$$\begin{bmatrix} DSR_t \\ INT_t \\ UNE_t \end{bmatrix} = \begin{bmatrix} p11 & p12 & p13 \\ p21 & p22 & p23 \\ p31 & p32 & p33 \end{bmatrix} \begin{bmatrix} DSR_{t-1} \\ INT_{t-1} \\ UNE_{t-1} \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

The forecasts of how all the variables will respond to this one-unit shock can be further modelled by recursively applying the same method. This, in turn, provides the projections, based on a one-unit shock to the interest rate, take the values as displayed in Matrix (3).

Matrix 3

$$\begin{bmatrix} DSR_{t+1} \\ INT_{t+1} \\ UNE_{t+1} \end{bmatrix} = \begin{bmatrix} p11 & p12 & p13 \\ p21 & p22 & p23 \\ p31 & p32 & p33 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} + \begin{bmatrix} u_{1,t+1} \\ u_{2,t+1} \\ u_{3,t+1} \end{bmatrix} = \begin{bmatrix} p12 \\ p22 \\ p32 \end{bmatrix}$$

Matrix 4

$$\begin{bmatrix} DSR_{t+2} \\ INT_{t+2} \\ UNE_{t+2} \end{bmatrix} = \begin{bmatrix} p11 & p12 & p13 \\ p21 & p22 & p23 \\ p31 & p32 & p33 \end{bmatrix} \begin{bmatrix} p12 \\ p22 \\ p32 \end{bmatrix} + \begin{bmatrix} u_{1,t+1} \\ u_{2,t+1} \\ u_{3,t+1} \end{bmatrix} = \begin{bmatrix} p11 * p12 + p12 * p22 + p13 * p32 \\ p21 * p12 + p22 * p22 + p23 * p32 \\ p31 * p12 + p32 * p22 + p33 * p32 \end{bmatrix}$$

The same multiplication can be applied recursively to the desired number of lags in order to trace out the effect, or impulse response, following such one-unit increase to the interest rate.