The Response of Canadian Household Debt to Interest Rate and Unemployment Shocks

by

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Abstract:

Canadian household debt levels are now at historically high levels after increasing steadily over the past 20 years due primarily to deregulation, financial innovation and low interest rates. Using Canadian macroeconomic data and vector autoregression techniques, a preliminary model is built to estimate the effects of an increase in the Bank of Canada overnight interest rate and the unemployment rate on household debt levels. Results show that an increase in in the overnight interest rate has a negative effect on the aggregate debt-to-income ratio and a positive effect on the aggregate debt-service ratio. Increases in unemployment have a negative effect on the aggregate debt-service ratio and neither shocks to interest rates or unemployment appear to have an effect on the aggregate debt-to-asset ratio.

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1 Introduction

Bank of Canada governor Mark Carney recently stated that the current record levels of household debt are the biggest domestic risk to the fragile Canadian economic recovery. In Canada, as in most Western industrialized countries, household debt has been steadily increasing since the early 1980s both in absolute terms and relative to household incomes.[1] Rising debt levels make households more vulnerable to shocks in the economy such as spikes in unemployment or interest rates. This could have significant implications for monetary policy, financial stability, and the economy as a whole.

While there has been extensive research studying the origins and consequences of increasing household debt in the American and European economies, there has been comparatively little research done on Canada. This essay provides a brief review of existing explanations of the recent increases in national household debt levels in other industrialized economies and relates the relevant examples back to the Canadian experience. As in many other advanced economies, one finds that deregulation and financial innovation were major catalysts for increases in Canadian household debt levels by enabling individuals to take advantage of increased liquidity to smooth lifetime consumption and increasing overall utility. These factors, along with low interest rates and rising home prices, have brought debt levels to extraordinarily high levels.

As Canadian household debt levels continue to climb, the sensitivity of the household sector to macroeconomic shocks increases as well. Despite this increasing vulnerability, no statistical analysis has been published to estimate the effects of macroeconomic shocks on household debt levels. With the goal of developing a baseline method for estimating the response of household debt levels to macroeconomic shocks, this essay uses Canadian macroeconomic data and vector autoregression techniques to build a model that estimates the effect of interest rate and unemployment shocks on various measures of household debt.

Overall, the effects of interest rate and unemployment rate shocks on household debt levels depend on which measure of debt is used. In the event of a shock to interest rates, the relevant impulse response functions show that the growth rate of the debt-to-income ratio will decrease while the growth rate of the aggregate debt-service ratio will increase. The effects of an unemployment rate shock on the aggregate debt-to-income ratio is less certain but most likely points to an increase in the growth rate of debt-to-income levels. Neither a shock to interest rates nor

[1] Debelle 2004

a shock to the unemployment rate appears to have an effect on the growth rate of the debt-to-asset level.

Section 2 provides a brief review of the literature that explains why Canadian household debt levels have risen to such historic heights, drawing on the experiences of other major industrialized economies. Section 3 looks at the potential consequences of high household debt. Section 4 provides a review of the relevant available macroeconomic data. Section 5 describes the theoretical framework behind a vector autoregression techniques and impulse response functions. Section 6 outlines the empirical model used to generate the impulse response functions presented in Section 7.

2 Factors Influencing Household Debt

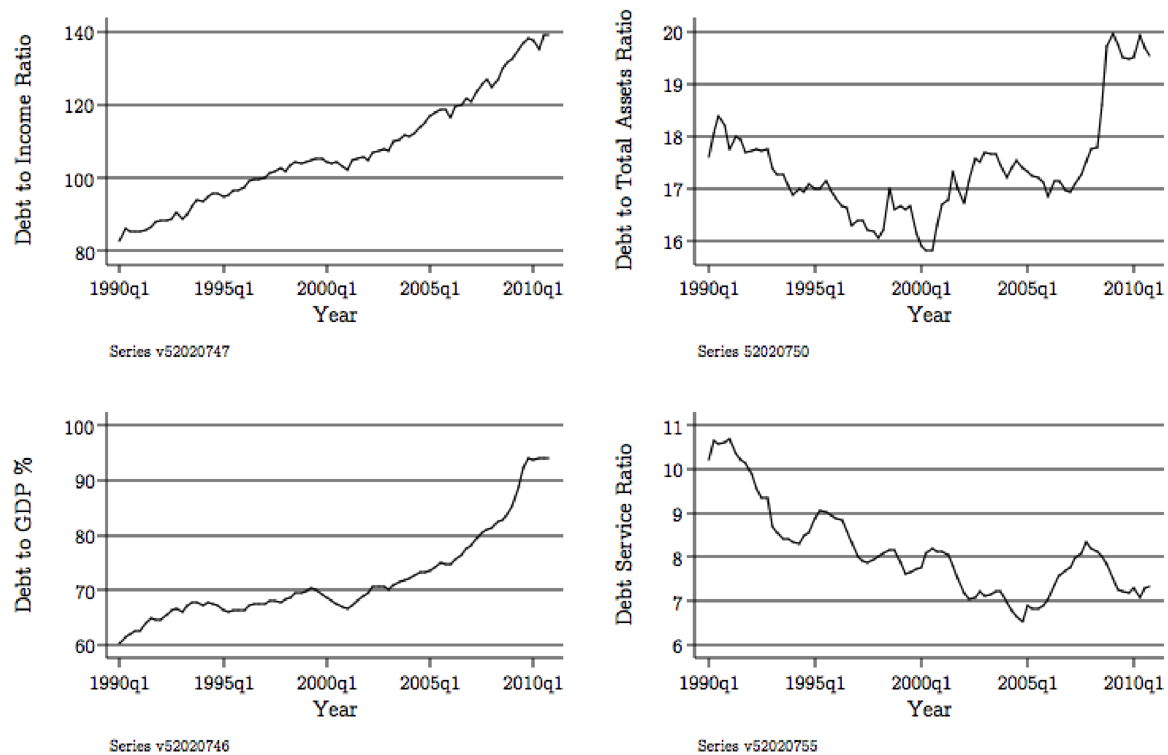
When quantifying household debt, it is important to consider various measures. Information contained in one measure may provide evidence towards one conclusion while information in another measure could point to the opposite conclusion. For example, an increase in the debt-to-income ratio for a given country reflects an overall increase in household leveraging, all other things being equal. However, this does not necessarily mean that households are more vulnerable to macroeconomic shocks. If a rise in the debt-to-income ratio is not accompanied by a similar increase in the debt-to-asset ratio, then it can be inferred that household borrowing was used to finance primarily new asset purchases as opposed to consumption. If policymakers only look at the debt-to-income ratio, then they miss this crucial piece of information and could potentially make misinformed decisions.

No matter what debt measure is used to study the Canadian experience over the past twenty years, however, it is clear that Canadians are now more indebted than ever. Figure 1 provides evidence that in both absolute terms and relative to income, overall household debt levels have risen steadily in Canada since 1990. Furthermore, the debt-to-asset ratio, which was relatively stable throughout the 1990s, has risen steadily since 2001.

Although such increases in household debt are alarming, concerns have not yet shown serious implications for the household or financial sectors. Canadians continue to be able to afford persistently high debt levels because the aggregate debt service burden, which is an estimate of national required household debt payments divided by disposable income, has not risen along with household debt levels.[2]

[2]Dynan and Kohn 2007

Figure 1: Canadian Household Debt Measures



Source: Statistics Canada CANSIM Database

While a low debt service burden does not reflect vulnerability of households to macroeconomic shocks, it does provide evidence that under current economic conditions, households are not as susceptible to financial stress as the other panels of figure 1 may be interpreted to suggest.

There has been extensive research done on household debt in Europe and the US over the past three decades and many of the overlying concepts and arguments transfer directly to the current Canadian situation. The following overview of factors influencing Canadian household debt levels draws on relevant explanations of the American and European experience.

2.1 Deregulation

One of the most widely accepted explanations among existing literature attributes the increase in household indebtedness to a rational response by individuals to easing liquidity restrictions.[3] In a world without borrowing constraints, households choose a consumption path that maximizes lifetime utility.[4] Constraints on financial institutions, such as restrictions in collateral requirements, were lifted in Europe and North America during the early 1980s and many liquidity restrictions on households were removed as a result. Among other initiatives, interest rate caps were removed, credit ceilings were abolished, and banks were given more freedom to structure both lending subsidiaries and loans themselves. For example, in 1980 Canada allowed banks to have mortgage loan subsidiaries for the first time.

Deregulation and the resulting ease in household liquidity constraints led to a steady increase in the mean level of debt for all age groups and income levels.[5] Indeed, almost all explanations as to why debt levels have increased steadily over the past twenty years have their roots in deregulation. With fewer restrictions, financial institutions were able to give more households access to credit. Individuals took advantage of this access to credit to increase liquidity, smooth lifetime consumption and increase overall welfare by borrowing while young and repaying later when they had higher incomes.[6] This hump-shaped pattern in lifetime borrowing is not unique to Canada; household microdata in Australia, the Netherlands, Norway, Sweden, and the United States all show similar borrowing patterns, providing evidence for the assertion that individuals act rationally and smooth lifetime

[3] Debelle 2004 and Simon 2005
[4] Dynan and Kohn 2007
[5] Debelle 2004
[6] La Cava and Simon 2005

consumption.[7]

2.2 Financial Innovation

When financial regulations such as interest rate caps, lending controls, and restrictions on private banks in mortgage markets were removed, financial institutions were given room to innovate and find new ways to lend money to households. Furthermore, technological advances in software and computing power cut monitoring costs on loans to a fraction of what they had been. As a result, younger households were able to access increasing amounts of credit earlier in life than ever before and more mature homeowners were able to tap into home equity through secured lines of credit. Household indebtedness then began to rise steadily in France, Japan, and the UK in the 1980s and in Australia and the Netherlands in the 1990s. In the United States, it rose steadily in both decades.[8] In all countries, debt levels rose sharply after regulations were lifted and financial institutions were free to innovate. In the United Kingdom, for example, secured lines of credit were not widely used until regulations were lifted but grew in popularity soon after. Secured lines of credit have accounted for most of the growth in total consumer credit for older age groups as more homeowners tap into their home-equity to fund consumption.[9]

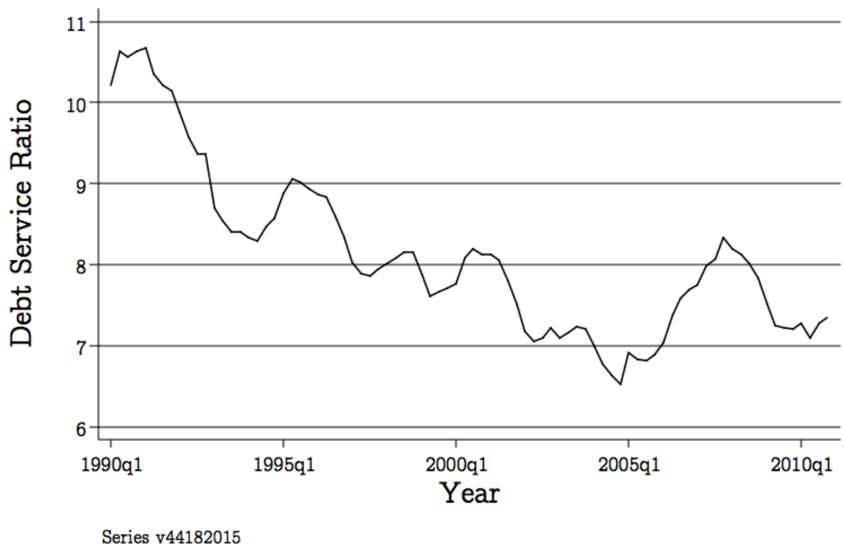
2.3 Low Interest Rates

While borrowed funds became more accessible through deregulation and the resulting financial innovation, it was persistently low interest rates that pushed household leveraging to record heights by making debt more affordable. In the United States and Europe, a decreasing interest burden has offset the increase in principal repayments.[10] As shown in figure 2, the ratio of Canadian household disposable income going to servicing debt has remained well below 10% despite increasing debt loads. In addition to encouraging borrowing, low interest rates have contributed to lower savings rates as returns on deposits barely compensate for inflation.[11] As a result of low debt-service costs and low savings returns, households have chosen

[7]Debelle 2004
[8]Debelle 2004
[9]Tudela and Young 2005
[10]Rinaldi and Sanchi-Arellano 2006
[11]Barba and Pivetti 2009

levels of debt and savings that makes sense in their current environment as characterized by low debt-service costs and low savings returns.[12] However, the current rock-bottom interest rates will inevitably rise and households will be forced to cut back on consumption to pay for increased debt-service costs.

Figure 2: Canadian Debt-Service Burden



Source: Statistics Canada CANSIM Database

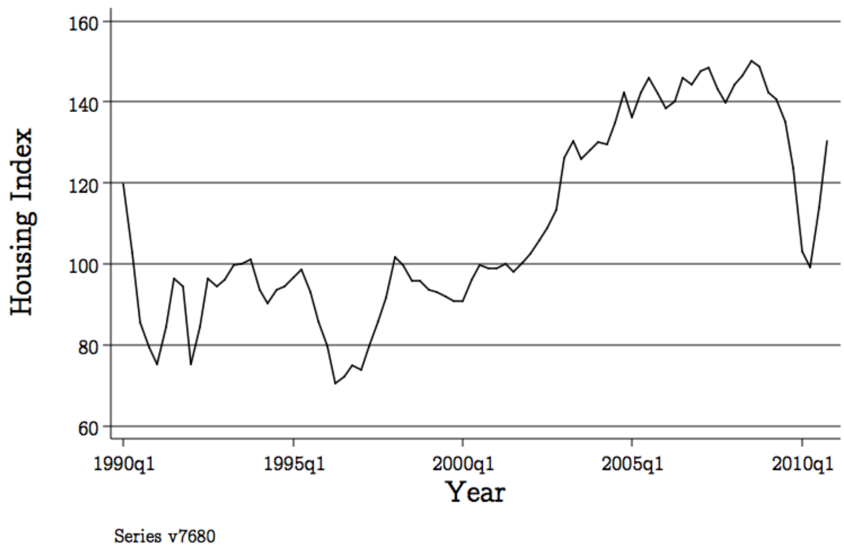
2.4 House Prices

In addition to increasing consumption levels, low interest rates have contributed to rising household debt by increasing the demand for housing. In the United States prior to the 2008 financial crisis, low interest rates made homeownership possible for many people who previously would have been unable to afford such high debt burdens. The resulting influx of the now infamous sub-prime borrowers into the housing market was the equivalent of a demand shock and home prices were driven to unprecedented levels. As housing prices rose, first time homeowners required access to increasing amounts of credit in order to buy a home.[13] High home prices also gave mature homeowners the ability to withdraw more from secured lines of

[12]Nandha 2004
[13]Crawford and Faruqui 2012

credit, further perpetuating the rise in household debt levels. While Canada has been largely protected from sub-prime borrowers in the housing market, figure 3 low interest rates continue to drive up home prices and fuel high debt levels by requiring young homeowners to borrow more to purchase their first home and enabling existing homeowners to withdraw equity via secured lines of credit.

Figure 3: Canadian Housing Price Index



Source: Statistics Canada CANSIM Database

2.5 Age Distribution

Across most major industrialized countries, the age of a household is cited as having a major impact on household borrowing. Debt levels generally peak for households in their mid 30s and net financial assets are negative until around age 50.[14] Canadian households follow the same hump-shaped pattern but despite Canada's aging population, overall indebtedness has increased. This increase in debt levels can be seen across all age groups and suggests that there is a variety of factors at work.

In the United Kingdom, Tudela and Young (2005) observed that as each cohort enters an older age group it is more indebted than the previous cohort. In Canada

[14] Tudela and Young 2005

before the mid-1990s, increasing debt-to-income levels were driven primarily by mortgages but the contribution of consumer credit has since grown significantly.[15] This implies that increases in Canadian household debt levels over the last 30 years were initially caused primarily by young households financing new home purchases and later by older households financing consumption. From 2006 to 2009, the Canadian household debt-to-asset ratio spiked to 19.6%, its highest level in 35 years,[16] which further suggesting that Canadians have more recently taken on debt to finance consumption as the population ages rather than to acquire assets.

Essential to understanding the implications of increases in household debt on the Canadian economy is the distribution of debt across households.[17] The risks and macroeconomic effects of increasing debt levels from young households financing new home purchases or from mature homeowners financing consumption are different. Heavily indebted young households are more vulnerable to shocks to unemployment while mature households are more vulnerable to shocks to wealth.[18] Increases in unemployment will likely lead to higher default rates, while fluctuations in the stock market will force mature households to work longer due to the reduced value of retirement assets. Unfortunately, for Canada household-level data is only found in the *Canadian Financial Monitor*, a poll produced by Ipsos-Reid, and is only available at an enormous expense. However, it is possible to measure the aggregate effect on household debt from macroeconomic shocks using widely available macroeconomic data.

2.6 Inequality

An interesting argument brought forth by Barba and Pivetti (2009) attributes increases in household debt levels in the United States to changing income distribution and growing income inequalities. They argue that stagnant real wages in low and middle-income ranges have led such households to use debt as a substitute for income in order to finance increasing levels of consumption.[19] Their argument is based on the well-established notion that households struggle to maintain not only absolute but also relative standards of consumption.[20] Rajan further elaborates on this idea in his 2010 book *Fault Lines*. He provides a convincing argument

[15] Crawford and Faruqi 2012
[16] Hurst 2011
[17] Debelle 2004
[18] Debelle 2004
[19] Barba and Pivetti 2009
[20] Duesenberry 1949

that rather than address the causes of the growing income divide, politicians have responded to public discontent in the short term by making it possible for more people to own homes.[21] Increased home ownership and higher consumption then came as a result of more debt as opposed to higher incomes.

There is strong evidence supporting the claim that rising debt levels in the US have been used to finance consumption among low and middle-income households. While households with higher incomes tend to have the greatest share of all types of debt, it is those households in the low and middle-income ranges that have the highest debt-to-income, debt-to-assets, and debt service ratios. Most consumer debt in the United States is now heavily concentrated in the bottom 80% income range, with debt levels increasing further down the range. This rise in indebtedness among low and middle-income groups has reflected a growing tendency of households to extract equity from their homes through secured lines of credit; increases in the debt-to-asset ratio of these households show that such funds were not used to invest in new assets but were used instead to increase consumption.[22] However, since income inequality is not as severe in Canada as in the United States, this explanation of the rise in household indebtedness is perhaps less relevant to the Canadian experience.

3 Consequences of High Household Debt

The steady increase in household debt levels in most major industrialized economies over the past two decades accelerated in the years leading up to the 2008 financial crisis. Debt-to-assets ratios rose sharply as existing homeowners borrowed against continually rising home values to fund consumption and a whole new class of sub-prime borrowers were, for the first time, given access to the credit needed to buy a new home.[23] In 2007, the United States' household debt-to-GDP ratio reached its highest level since the onset of the Great Depression as households took advantage of easy access to cheap liquidity and increased their overall utility by smoothing lifetime consumption. However, this was not without potential risks to the long-run health of the overall macroeconomy.[24] In their 2009 study, Mian and Sufi showed that household leverage is an early and powerful predictor of the 2007 to 2009 recession and that dramatic increases in household leverage from

[21] Rajan 2010
[22] Barba and Pivetti 2009
[23] Mian and Sufi 2009
[24] Barba and Pivetti 2009

2000 to 2007 were a primary driver of the recession.[25] Gorton and Metrick (2012) provide a comprehensive summary of the consequences this recession, including, but not limited to, decreases in the credit supply and tightened lending conditions, decreased corporate investment, and increased overall unemployment.[26]

Fortunately, the Canadian housing market avoided the catastrophic collapse seen in the United States as sub-prime mortgages accounted for only 3% of total outstanding mortgages compared to 14% in the United States in 2007.[27] However, Canadian household debt levels are now approaching levels seen in the United States prior to the 2008 financial crisis.[28] While an imperfect measure of household financial vulnerability, high debt-to-income ratios at the very least demonstrate that Canadians are becoming more leveraged. The aggregate debt-to-income ratio in Canada rose to a record 151% by the end of 2011.[29]

While the debt-to-income ratio highlights the increased leverage of Canadian households, it does not provide a great deal of insight into the extent of financial risk associated with household debt. The problem with using debt-to-income as a measure of overall indebtedness is that the ratio is between a stock (debt) and a flow (income).[30] As mentioned above, declining interest rates have allowed households with the same income to service larger amounts of debt.[31] In their 2005 study of Australian households, La Cava and Simon claim that the rise in household debt was caused by a voluntary choice and was not associated with increases in household financial stress. They claim there is little evidence that households were more financially fragile than in the past.[32] In Canada, the best measure we have into financial stress comes from an Ipsos-Reid poll on the balance sheets of 4000 households. By this measure, personal debt obligations are currently manageable with debt service costs at historically low levels.[33]

However, shocks to the Canadian economy could potentially leave many households vulnerable to falling into financial arrears. As mentioned above, young and mature households are particularly vulnerable to shocks in unemployment and wealth, respectively. Furthermore, households of all ages are vulnerable to interest-rate shocks. If interest rates were to increase by 2%, roughly 10% of

[25] Mian and Sufi 2009
[26] Gorton and Metrick 2012
[27] Crawford and Faruqi 2012
[28] Alexander 2012
[29] Alexander 2012
[30] Alexander 2012
[31] Barba and Pivetti 2009
[32] La Cava and Simon 2005
[33] Alexander 2012

Canadian households would have trouble meeting commitments because around 40% of all disposable income would be required to service existing debt.[34] Rising default rates could then weaken financial institutions and result in tightened borrowing conditions.[35] As was seen during the most recent financial crisis, tightened borrowing conditions (*i.e.* a credit crunch) have extremely adverse affects on the macroeconomy as a whole, as businesses and individuals lose access to the liquidity required to pay wages and finance production as well as consumption.

Surprisingly, there are no statistical studies that measure the sensitivity of Canadian households and the response of household debt levels to macroeconomic shocks. The analysis in sections 6 and 7 are aims to develop a preliminary framework for analyzing the sensitivity of household debt to these macroeconomic shocks.

4 Macroeconomic Data

All data used in this analysis consists of macroeconomic variables taken from Statistics Canada's CANSIM database. Variables can be divided into two main categories: measures of household indebtedness and factors that either have some effect on household debt levels or are affected by household debt.

Household indebtedness is measured in either relative and absolute terms. Relative measures include the national household debt-to-income ratio, household debt-to-asset ratio, and household debt-to-GDP ratio. Absolute measures of debt include consumer credit excluding mortgages, residential mortgage credit, total outstanding household debt, and consumer bankruptcies.

Factors that are either affected by or have an effect on household debt include the Bank of Canada overnight interest rate, inflation, the 5-year average residential mortgage rate, Canadian seasonally adjusted GDP, GNI, total household disposable income, the unemployment rate, debt-service obligations as a percentage of income, new orders for durable goods (as a proxy for consumption), total national savings, and the housing price index.

Table 1 provides a complete list of widely available data that could potentially be included in a model of household indebtedness as recommended by the literature. With the goal of building only a preliminary model, this essay includes the debt-to-income ratio, the debt-to-asset ratio, the debt service ratio, and the total debt

[34] Alexander 2012

[35] Bank of Canada release 2011

levels along with the seasonally adjusted unemployment rate and the Bank of Canada overnight interest rate. Future work on this topic can build on this basic framework to include more variables. All analysis is performed using quarterly data from the first quarter of 1990 to the fourth quarter of 2010.

Table 1: Canadian Macroeconomic Data

Debt Variables			
Variable	**Definition**	**Dates Available**	**Frequency**
dti_t	household debt-to-income ratio at time t	1990-2011	Quarterly
dta_t	household debt-to-asset ratio at time t	1990-2011	Quarterly
$dtGDP_t$	household debt-to-GDP ratio at time t	1990-2011	Quarterly
$bankrupt_t$	bankruptcies at time t	1991-2011	Monthly
$concred_t$	seasonally adjusted consumer credit excluding mortgages at time t	1969-2012	Monthly
$morgcred_t$	seasonally adjusted residential mortgage credit at time t	1969-2012	Monthly
$debt_t$	total outstanding household debt at time t	1990-2011	Quarterly
Macroeconomic Variables			
Variable	**Definition**	**Dates Available**	**Frequency**
int_t	Bank of Canada overnight interest rate at time t	1935-2012	Monthly
GDP_t	seasonally adjusted gross domestic product at time t	1961-2012	Quarterly
GNI_t	gross national income at time t (2002 = 100)	1990-2011	Quarterly
$income_t$	total household disposable income at time t	1990-2011	Quarterly
$unempl_t$	seasonally adjusted unemployment rate at time t	1976-2011	Monthly
$consump_t$	new orders for durable goods at time t	1952-2011	Monthly
hp_t	housing price index at time t (2002 = 100)	1952-2011	Monthly
dsr_t	seasonally adjusted household debt service ratio at time t	1990-2011	Quarterly
$morgrate_t$	5-year mortgage rate at time t	1951-2012	Monthly
$savings_t$	total national savings at time t	1961-2011	Quarterly
inf_t	consumer price index at time t (2002 = 100)	1971-2011	Monthly

5 Vector Autoregressions

A vector autoregression (VAR) is a multi-equation estimation system first proposed as a replacement for large scale macroeconometric models estimated using Ordinary Least Squares (OLS) or Generalized Method of Moments (GMM) techniques when it is unclear whether or not a variable is exogenous.[36] Broadly speaking, the path of each variable in a VAR is explained by its own lags as well as the current and lagged values of all other variables in the model.

All variables included in a VAR must achieve *stationarity*. A series is *stationary* if it has time-invariant first and second moments.[37] In other words, it fluctuates around a constant mean (does not have a trend, for example) and has a constant variance that does not depend on t. While it is not unanimously accepted that the variables in a VAR need to be stationary, the majority view is that for VAR analysis variables are stationary and not cointegrated.[38]

In the two-variable example, let the time path of random variable y_t be affected by current and past realizations of the series z_t. Consider the following bivariate system:

$$y_t = b_{10} - b_{12}z_t + \gamma_{11}y_{t-1} + \gamma_{12}z_{t-1} + \epsilon_{yt} \quad (1)$$

$$z_t = b_{20} - b_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}z_{t-1} + \epsilon_{zt} \quad (2)$$

where it is assumed

1. both y_t an z_t are stationary
2. ϵ_{yt} and ϵ_{zt} are white-noise disturbances with standard deviations of σ_y and σ_z respectively
3. ϵ_{yt} and ϵ_{zt} are uncorrelated white-noise disturbances

Equations (1) and (2) are a *first-order* vector autoregression since the longest lag length is one. This simple two-variable, one-lag example is useful to help one understand larger VAR models like the empirical model explained later in this essay. The structure of the above system is such that contemporaneous values of

[36] Ajluni 2005
[37] Lütkepohl and Krätzig 2004, p. 11-12
[38] Enders 301

y_t and z_t are allowed to affect each other. That is, so long as -$b_{12} \neq 0$, the current value of z_t will have an effect on the current value of y_t. Note that ϵ_{yt} and ϵ_{zt} are pure innovations (*i.e.* shocks) in y_t and z_t, respectively, and a shock to the contemporaneous value of y_t will have an effect on the contemporaneous value of z_t.[39]

Equations (1) and (2) are not reduced-form equations since y_t has a contemporaneous effect on z_t and vice-versa. Using linear algebra it is possible to transform the system of linear equations into a more usable form. We can write the system in the compact form:

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{yt} \\ \epsilon_{zt} \end{bmatrix}$$

or

$$Bx_t = \Gamma_0 + \Gamma_1 x_{t-1} + \epsilon_t$$

where

$$B = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}, \qquad x_t = \begin{bmatrix} y_t \\ z_t \end{bmatrix}, \qquad \Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix},$$
$$\Gamma_0 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}, \qquad \epsilon_t = \begin{bmatrix} \epsilon_{yt} \\ \epsilon_{zt} \end{bmatrix}$$

Premultiplication by B^{-1} allows us to obtain the first-order vector autoregressive (VAR) model in *standard* form:

$$x_t = A_0 + A_1 x_{t-1} + e_t \tag{3}$$

where

$$A_0 = B^{-1}\Gamma_0$$
$$A_1 = B^{-1}\Gamma_1$$
$$e_t = B^{-1}\epsilon_t$$

Equation (3) can be generalized into a VAR with k variables and p lags:

$$x_t = A_0 + A_1 x_{t-1} + A_2 x_{t-2} + ... + A_p x_{t-p} + e_t \tag{4}$$

[39]Enders 1995, p. 294-295

where x_t is an $n \times 1$ vector containing each of the n variables included in the VAR, A_0 is a $k \times 1$ vector of intercept terms, the A_i is are $k \times k$ matrices of coefficients, and e_t is a vector of error terms.

Notice that the right hand side of Equation (4) contains only predetermined variables and the error terms are assumed to be serially uncorrelated with constant variance. As a result, each equation in the system can be estimated using OLS. Moreover, OLS estimates are consistent and asymptotically efficient.[40]

It is important to note that the errors in e_t are correlated across equations. Returning to the two-variable, one lag example, for notational purposes define a_{i0} as element i of the vector A_0, a_{ij} as the element in row i and column j of the matrix A_1, and e_{it} as the element i of the vector e_t . Using this new notation, rewrite equation (3) in standard form.

$$y_t = a_{10} + a_{11} + a_{12}z_{t-1} + e_{1t} \tag{5}$$

$$z_t = a_{20} + a_{21} + a_{22}z_{t-1} + e_{2t} \tag{6}$$

The system represented by equations (1) and (2) is called a structural VAR (or the primitive system) and the system represented by equations (5) and (6) is called a VAR in standard or reduced form. The error terms e_{1t} and e_{2t} are composites of the two shocks ϵ_{yt} and ϵ_{zt} and have zero means, constant variance, and individually are serially uncorrelated since ϵ_{yt} and ϵ_{zt} are white-noise processes.[41] It is critical to note that e_{1t} and e_{2t} are correlated and that a shock to one variable will have a contemporaneous effect on the other. Since $e_t = B^{-1}\epsilon_t$, we can compute e_{1t} and e_{2t} as:

$$e_{1t} = (\epsilon_{yt} - b_{12}\epsilon_{zt})/(1 - b_{12}b_{21}) \tag{7}$$

$$e_{2t} = (\epsilon_{zt} - b_{21}\epsilon_{yt})/(1 - b_{21}b_{21}) \tag{8}$$

The implication of correlation between e_{1t} and e_{2t} becomes clear after an explanation of impulse response functions (IRF). An *impulse response function* traces out the response of current and future values on a variable to a one-unit increase in the current value of one of the VAR errors.[42]

[40] Lütkepohl and Krätzig 2004, p. 88-93
[41] Enders 1995, p. 295-296
[42] Stock and Watson 2001

To build an impulse response function from the two-variable, one lag example, take equation (3) and iterate backwards:

$$\begin{aligned} x_t &= A_0 + A_1(A_0 + A_1 x_{t-2} + e_{t-1}) + e_t \\ &= (I + A_1)A_0 + A_1^2 x_{t-2} + A_1 e_{t-1} + e_t \end{aligned}$$

After n iterations one obtains, as long as stability is assumed:

$$x_t = \mu + \sum_{i=0}^{\infty} A_1^i e_{t-i} \tag{9}$$

where

$$\mu = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix}$$

and

$$\begin{aligned} \bar{y} &= [a_{10}(1 - a_{22}) + a_{12}a_{20}]/\Delta \\ \bar{z} &= [a_{20}(1 - a_{11}) + a_{21}a_{10}]/\Delta \\ \Delta &= (1 - a_{11})(1 - a_{22}) - a_{12}a_{21} \end{aligned}$$

Returning to matrix form, equation (9) can be written so that y_t and z_t are written in terms of the e_{1t} and e_{2t} sequences:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} e_{1t-i} \\ e_{2t-i} \end{bmatrix} \tag{10}$$

However, it is insightful to rewrite in terms of the ϵ_{yt} and ϵ_{zt} sequences. Using equations (7) and (8), equation (10) is rewritten as:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = \begin{bmatrix} 1/(1 - b_{12}b_{21}) \end{bmatrix} + \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_{yt} \\ \epsilon_{zt} \end{bmatrix} \tag{11}$$

Combine equations (10) and (11) to form:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \begin{bmatrix} 1/(1 - b_{12}b_{21}) \end{bmatrix} \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_{yt} \\ \epsilon_{zt} \end{bmatrix}$$

To simplify the notation, define the 2×2 matrix ϕ_i with elements $\phi_{jk}(i)$:

$$\phi_i = \left[A_1^i/(1 - b_{12}b_{21})\right] \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}$$

With this notation defined, it is now possible to write equation (10) in terms of ϵ_{yt} and ϵ_{zt}:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{bmatrix} \begin{bmatrix} \epsilon_{yt-i} \\ \epsilon_{zt-i} \end{bmatrix}$$

or more compactly:

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i \epsilon_{t-i} \tag{12}$$

Under this representation, the four sets of coefficients of ϕ_i are called the *impulse response functions* and can be used to model the effects of ϵ_{yt} and ϵ_{zt} shocks on the time paths of y_t and z_t sequences.[43] Plotting the impulse response functions is a practical way to visualize the reaction of a series to different shocks.

It is only possible to trace out the time paths of the effects of pure ϵ_{yt} or ϵ_{zt} shocks by knowing all the parameters of the primitive system represented by equations (1) and (2). Due to the feedback inherent in the system, the parameters of the primitive system cannot be estimated directly. The problem is that z_t is correlated with the error term ϵ_{yt} and y_t is correlated with the error term ϵ_{zt} and standard OLS estimation techniques require that the regressors be uncorrelated with the error term. However, notice that this problem does not exist when estimating the VAR system in standard form using equations (5) and (6). Under the standard form VAR, OLS can provide estimates of the intercepts A_0 and the parameters A_1 as well as the variance and covariance of e_{1t} and e_{2t}. The issue is whether or not it is not possible to recover all the information in the primitive system using the estimated system.[44]

The only way to properly identify the impulse response functions is to appropriately restrict the primitive system. The reason this must be done is clear when

[43] Enders 1995, p. 305-306
[44] Enders 1995, p.306-307

the parameters of the primitive system and the standard form VAR are compared. Estimating equations (5) and (6) will result in nine parameters while estimation of equations (1) and (2) will yield ten (when all coefficient estimates, variance estimates, and covariances are counted). Unless one of the parameters of the primitive system is restricted, equations (1) and (2) are under identified. If exactly one parameter of the primitive system is restricted, then the system is exactly identified.[45]

A possible way to properly identify the model is to construct the recursive system along with the Choleski decomposition.[46] In a *recursive VAR*, the error terms are constructed such that error terms in each regression equation are not correlated with the error in the preceding equations.[47] Suppose a particular economic theory or model suggests that b_{21} from equations (1) and (2) equals zero. Writing the equations with this constraint yields:

$$y_t = b_{10} + b_{12}z_t + \gamma_{11}y_{t-1} + \gamma_{12}z_{t-1} + \epsilon_{yt} \tag{13}$$

$$z_t = b_{20} + b_{21}y_{t-1} + \gamma_{22}z_{t-1} + \epsilon_{zt} \tag{14}$$

Imposing the restriction also changes B^{-1} to yield:

$$B^{-1} = \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix}$$

Premultiplication of the primitive system by B^{-1} results in:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \epsilon_{yt} \\ \epsilon_{zt} \end{bmatrix}$$

or

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} - b_{12}b_{20} \\ b_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} - b_{12}\gamma_{21} & \gamma_{12} - b_{12}\gamma_{22} \\ \gamma_1 & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{yt} - b_{12}\epsilon_{zt} \\ \epsilon_{zt} \end{bmatrix}$$

[45] Enders 1995, p.302
[46] Sims 1980
[47] Stock and Watson 2001

And estimating the system using OLS yields the theoretical parameter estimates such that:

$$y_t = a_{10} + a_{11}y_{t-1} + a_{12}z_{t-1} + e_{1t} \tag{15}$$

$$z_t = a_{20} + a_{21}y_{t-1} + a_{22}z_{t-1} + e_{2t} \tag{16}$$

where $a_{10} = b_{10} - b_{12}b_{20}$, $a_{11} = \gamma_{11} - b_{12}\gamma_{21}$, $a_{12} = \gamma_{12} - b_{12}\gamma_{22}$, $a_{20} = b_{20}$, $a_{21} = \gamma_{21}$, and $a_{22} = \gamma_{22}$. Finally, the error terms are given by:

$$e_{1t} = \epsilon_{yt} - b_{12}\epsilon_{zt} \tag{17}$$

$$e_{2t} = \epsilon_{zt} \tag{18}$$

An ϵ_{zt} shock directly affects e_{1t} and e_{2t} but an ϵ_{yt} shock does not affect e_{2t}. The decomposition subjected the system to a potentially important asymmetry since ϵ_{zt} has contemporaneous effects on both y_t and z_t and ϵ_{yt} has no direct effect on z_t. The restriction imposed on the system is said to imply an *ordering* of the variables.[48] In this case, z_t is prior to y_t.

There is no theoretical argument suggesting whether a financial shock in the form of a sudden increase in interest rates or an economic shock in the form of a rise in the unemployment rate should be ordered first. Therefore, in the forthcoming empirical analysis two different orderings will be used. First, the Bank of Canada overnight interest rate will be ordered prior to the unemployment rate level and second, the unemployment rate will be prior to the overnight interest rate, with the debt-to-income ratio always being ordered last. Both orderings will be used to estimate the effects of both an *a priori* interest rate shock through the economy and an *a priori* unemployment rate shock, respectively, with the goal of generating impulse response functions using debt-to-income as the response variable.

6 Empirical Model

Given the goal of estimating the effect of an increase in the overnight interest rate and unemployment rate on household debt levels, the most practical method is

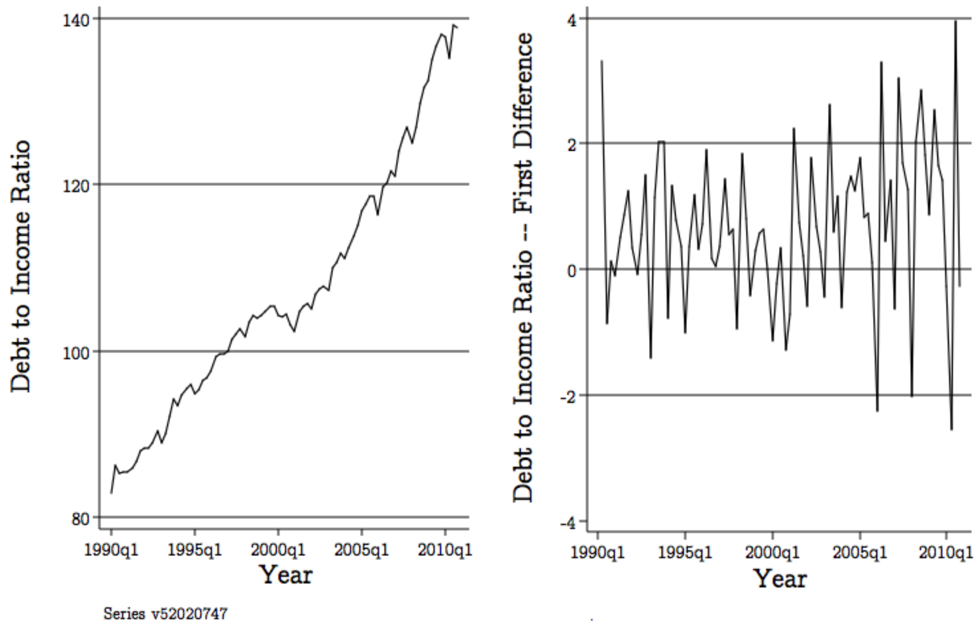
[48] Enders 1995, p. 307

to use VAR analysis. VARs have the unique ability to generate impulse response functions that are capable of identifying the effects a shock to one variable will have on another variable. While cointegration analysis is also capable of producing impulse response functions, initial tests for cointegration did not provide evidence that such a relationship existed between the selected variables.

The simple VAR built to generate impulse response functions includes only debt-to-income ratio, interest rates, and unemployment from all available data outlined in table 1. While it is almost certain that other variables such as GDP, consumption, and housing prices have an effect on household debt levels, the goal of this essay is to establish a working baseline model. Future research can add or subtract variables to this baseline model to build a more complete picture of the relationship between household debt levels and the macroeconomy.

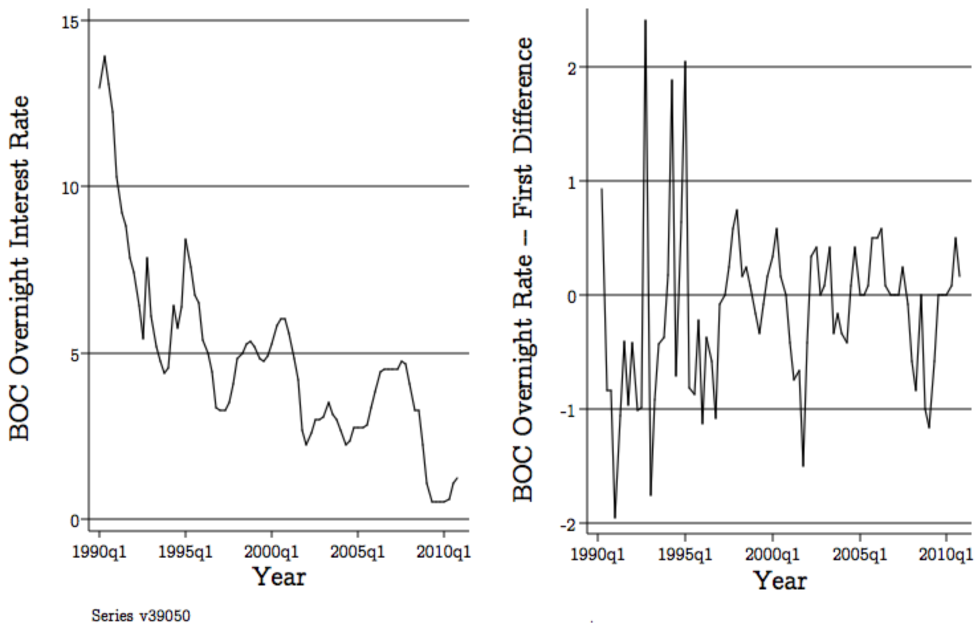
In order to build a working VAR model, it is first necessary to check the stationarity of all included variables using an Augmented Dickey-Fuller test. While none of the selected series were stationary, it took only first-order differencing to achieve stationarity. Figure 4, 5, and 6 show the selected series before and after differencing, while table 2 provides statistical evidence for the stationarity of the differenced series.

Figure 4: Debt to Income – First Difference



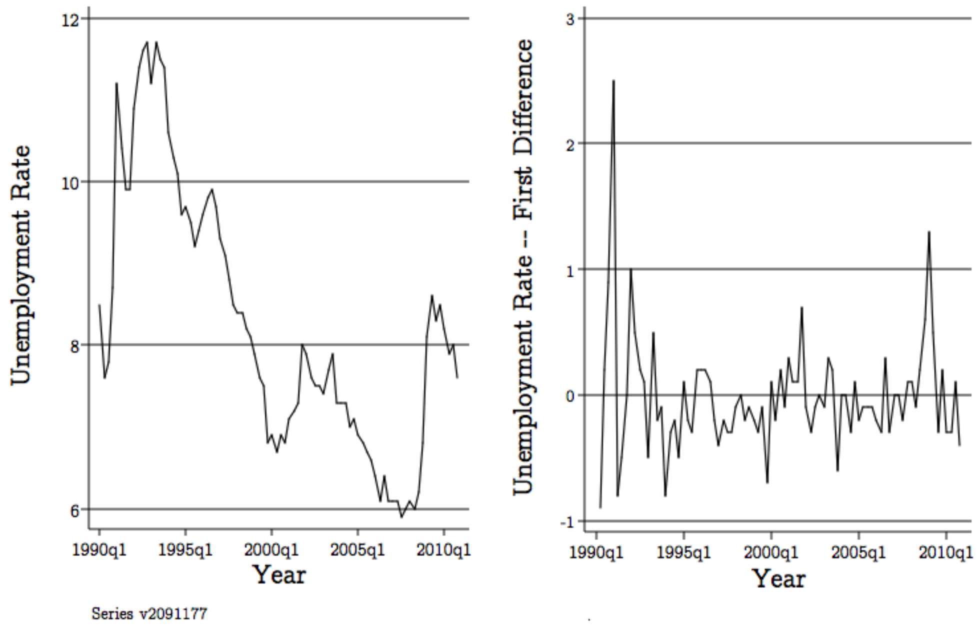
Source: Statistics Canada CANSIM Database

Figure 5: BOC Overnight Rate – First Difference



Source: Statistics Canada CANSIM Database

Figure 6: Unemployment Rate – First Difference



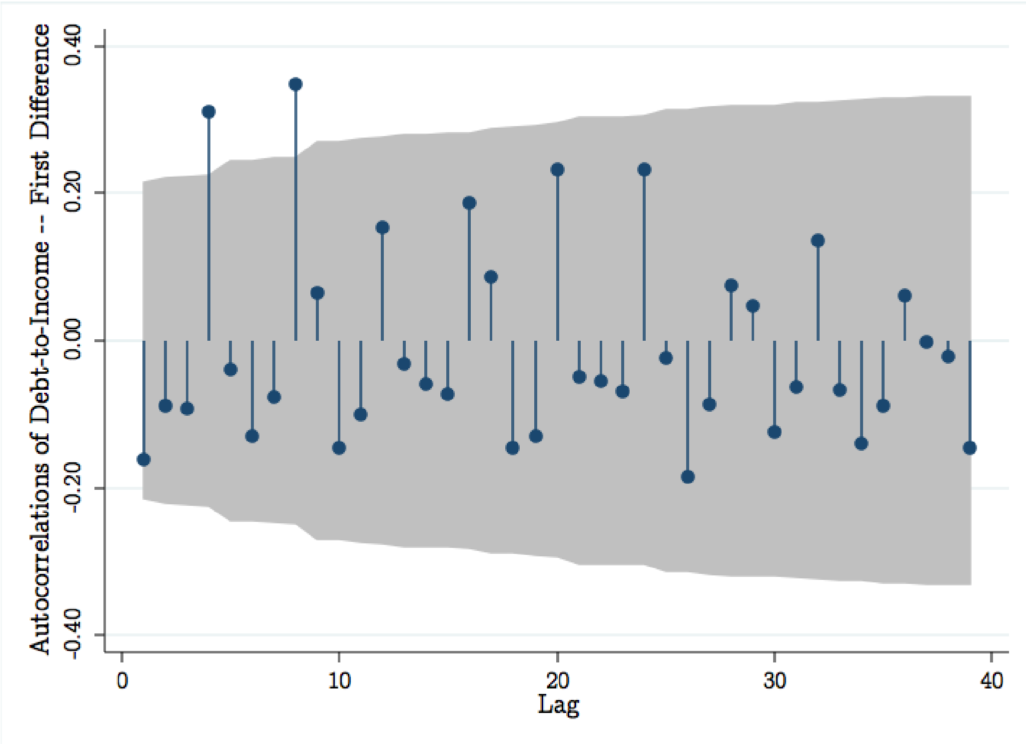
Source: Statistics Canada CANSIM Database

Table 2: Augmented Dickey-Fuller Tests for the Unit Root

		Original Series		Differenced Series	
Variable	5% Critical Value	Test Statistic	p-value	Test Statistic	p-value
dti_t	-2.904	0.84	0.9923	-10.800	0.0000
int_t	-2.904	-2.850	0.0515	-7.612	0.0000
$unempl_t$	-2.904	-1.269	0.6434	-7.719	0.0000
H_0: not stationary					

Furthermore, for a VAR to work properly, any seasonality must be accounted for. There is evidence of possible seasonality in the differenced debt-to-income series as shown in the graph of the autocorrelation function or in figure 4. Figure 7 reveals autocorrelation of the errors in the fourth and eighth lags. This is not surprising considering that personal debt levels tend to spike each year in the months leading up to and shortly after the Christmas shopping season. To adjust for seasonality, dummy variables for quarters one, two and three were included as exogenous variables.

Figure 7: Debt to Income Autocorrelation



In addition to selecting the appropriate series for a VAR, it is necessary to choose the proper lag length. While it is possible to choose different lag lengths for different variables, to preserve symmetry and use OLS efficiently it is common to use the same lag length across all equations.[49] To determine a proper lag-order, the Akaike Information Criterion (AIC) and the Schwarz Bayesian Information Criterion (BIC) were consulted. According to the AIC, one lag was the appropriate length.

The resulting VAR(1) did not provide satisfactory results for several possible reasons. First, when using a VAR(1), it is possible that explanatory power of the system may be lost because such a small model was used. Furthermore, according to the results of the Lagrange Multiplier Test for residual autocorrelation in

[49]Lütkepohl and Krätrig 2004, p.112

Table 3: Selection Order Criteria

Lags	AIC	BIC
0	5.89211	6.25203*
1	5.86607*	6.49592
2	5.99726	6.89705

table 4, the errors were not white noise since lags four and seven rejected the null hypothesis of no residual autocorrelation.

Table 4: Lagrange Multiplier Test for Residual Autocorrelation–VAR(1)

Lags	χ^2	Degrees of Freedom	Prob $>\chi^2$
1	8.9389	9	0.44293
2	3.7297	9	0.92828
3	10.2103	9	0.33373
4	17.9875	9	0.03532
5	10.5620	9	0.30693
6	4.3453	9	0.88725
7	25.2918	9	0.00266
8	7.8988	9	0.54437
9	12.6577	9	0.17872
10	2.7052	9	0.97485
11	3.3683	9	0.94789
12	7.6077	9	0.57411
H_0: no autocorrelation at lag order			

Additional models needed to be tested in order to adjust for residual autocorrelation and increase explanatory power. The lag-length was increased until the resulting VAR(5) model provided the best fit for for the data. As shown in figure 5, the residuals are uncorrelated and figure 8 shows that it is highly stable. With a working VAR identified, further analysis of impulse response functions could be carried out.

Figure 8: Stability Test – VAR(5)

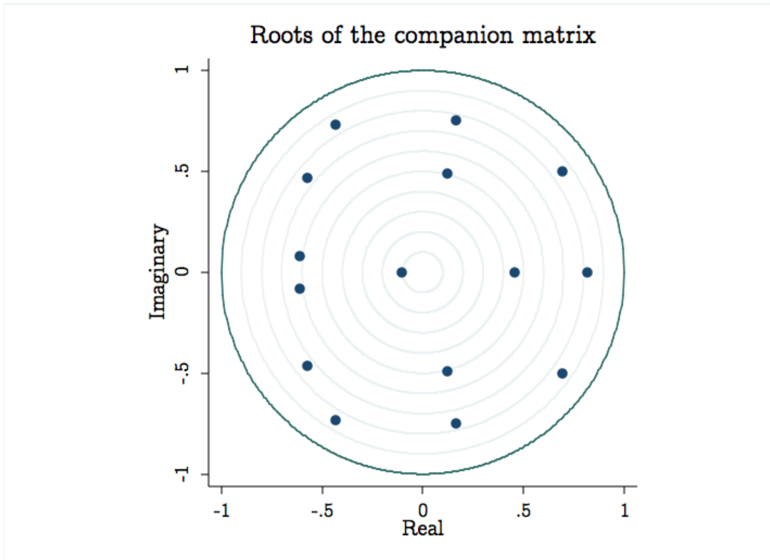


Table 5: Lagrange Multiplier Test for Residual Autocorrelation–VAR(5)

Lags	$\chi 2$	Degrees of Freedom	Prob $>\chi^2$
1	4.2403	9	0.89490
2	9.6089	9	0.38307
3	12.6159	9	0.18077
4	14.3058	9	0.11186
5	4.7288	9	0.85728
6	3.5787	9	0.93690
7	9.1963	9	0.41936
8	14.0647	9	0.12004
9	9.2852	9	0.41137
10	4.6195	9	0.86613
11	7.0139	9	0.63568
12	13.1373	9	0.15649

H_0: no autocorrelation at lag order

7 Results

The above procedure provides a working vector autoregression model necessary to generate impulse response functions (IRFs). Recalling that all series have been differenced in order to achieve stationarity, the resulting IRFs measure the effect of a shock to a *change in* the overnight interest rate and a *change in* unemployment rate on the *change in* the aggregate debt-to-income ratio. Therefore, a positive shock to the change in the overnight interest rate reflects the fact that interest rates are increasing (decreasing) at a faster (slower) rate than previously. In other words, a positive increase in the rate of change of the overnight interest rate reflects the fact that the overnight interest rate is increasing (decreasing) at a faster (slower) rate.

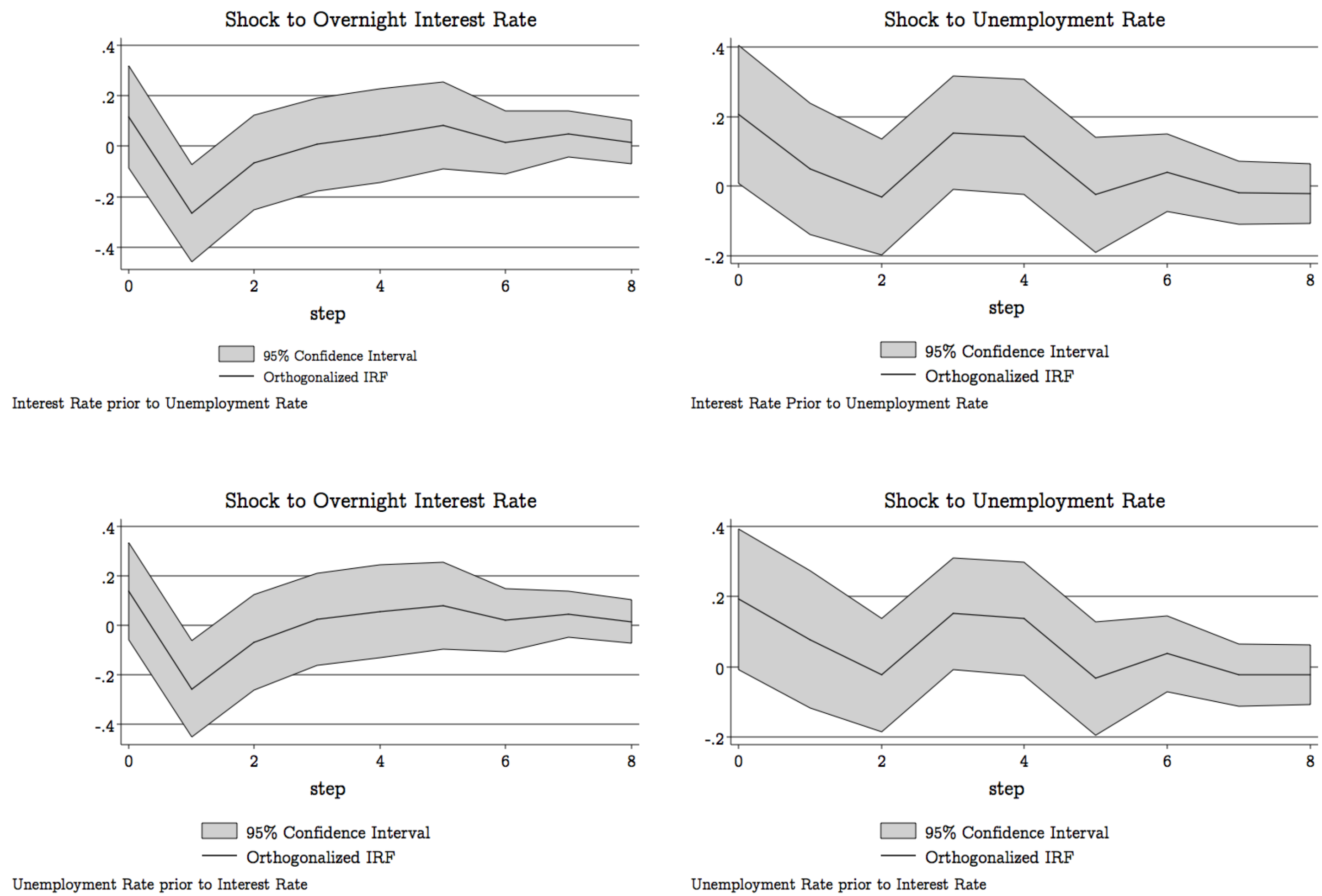
As mentioned in section 3, while the debt-to-income ratio does provide some insight on the household debt level, it is best to look at different measures of household indebtedness to gain a better understanding of the overall effects of microeconomic shocks on household debt. With this in mind, a similar method was followed in order to estimate the effects of shocks to a change in the overnight interest rate and unemployment rate on a change in debt-to-asset ratio and a change in debt-service ratio. Similar to debt-to-income, both models yielded best results when fitted with a VAR(5).

Since we are interested in the response to household debt from a single shock (in either the overnight interest rate or unemployment rate), it is difficult to identify the effects if the errors are correlated. With this in mind, the variance-covariance matrices were orthogonalized in order to yield orthogonalized IRFs. The orthogonalized errors have the convenient property of being uncorrelated across both time and equations. As mentioned in section 5, orthogonalization of the variance-covariance matrix imposes a restriction on the system that is said to imply an ordering of the variables. While it is clear that the relevant debt measure should be ordered last there is no strong theoretical evidence that suggests either the overnight interest rate or the unemployment rate should be ordered first. As a result, orthogonalized IRFs were generated using both orderings and any differences have been noted.

7.1 Debt-to-Income Ratio

From the resulting impulse response functions, there is credible evidence that a positive shock to the rate of change of the overnight interest rate (*i.e.* acceleration) will have a negative effect on the rate of change of aggregate debt-to-income levels

Figure 9: Debt-to-Income Ratio Impulse Response Functions



in Canada (*i.e.* deceleration). It is clear from figure 9 that after one quarter there is a decrease in the growth rate of debt-to-income ratio of roughly -.1% to -.4% with 95% accuracy when the overnight interest rate increases (decreases) more rapidly (slower). After two quarters, there is no substantial evidence that debt-to-income levels are affected by the initial shock to a change in the overnight interest rate, as the IRF climbs to around zero at $t = 0$. Furthermore, ordering appears to have no effect on the results as the top-left and bottom-left panels of figure 9 show very similar results.

Interestingly, there is little evidence that the immediate effects of a shock to the rate of change of the overnight interest rate is an increase in debt levels. One might expect debt-to-income ratios to increase initially after a shock to interest rates, as individuals take time to adjust to higher interest rates, but this cannot be definitively concluded from the graph of the IRF. While above zero at time $t = 0$, the IRF's 95% confidence interval includes zero. It appears as though Canadians react almost immediately after a spike in interest rates to slow increasing debt levels and accelerate debt repayments.

It is less certain in figure 9 if a positive shock to the rate of change in the unemployment rate will have any effect on household debt-to-income levels. When the overnight interest rate is ordered prior to the unemployment rate, the rate of change of debt-to-income levels exhibits some possibility of initial positive increases, with the 95% confidence interval sitting just above zero before moving to zero after $t = 0$. However, no definitive conclusion can be drawn because ordering the unemployment rate prior to the interest rate brings the lower band of the confidence interval down to below zero. One would presume that increasing unemployment would accelerate the growth rate of aggregate debt-to-income as households are required to take on debt in order to replace lost income. However, as was seen recently in the US, spikes in unemployment may lead to increases in mortgage and other debt defaults. This would have the effect of potentially decreasing the national debt-to-income ratio even as unemployment increases.

7.2 Debt-to-Asset Ratio

There was no evidence that shocks to the growth rate of the overnight interest rate or unemployment rate has any effect on the growth rate of the national aggregate debt-to-asset ratio. In figure 10, zero is included in the 95% confidence interval of all IRFs both initially and over time and therefore no conclusive evidence of any effect can be drawn.

The ineffectiveness of monetary policy on the national aggregate debt-to-asset ratio could potentially be explained to the increasing returns that accompany higher interest rates. When interest rates increase, the higher rates of return on financial assets may entice savers to purchase more assets and therefore any increases in aggregate debt levels from borrowers could be offset. This would have the effect of increasing both debt and assets levels at roughly the same pace and nullifying the effects of monetary policy on the national debt-to-asset level.

Furthermore, unemployment and overall economic wellbeing as a whole need not necessarily have an effect on debt-to-asset ratios. After an increase to the unemployment rate, many Canadiens who lose their jobs may choose to sell their homes and move into more affordable accommodations. This would have the effect of decreasing mortgage debt and asset levels at roughly the same pace.

While there is no conclusive evidence presented to support either of these explanations, it remains clear that shocks to the rate of change of the overnight interest rate and unemployment rate have little to no effect on the national aggregate debt-to-asset ratio.

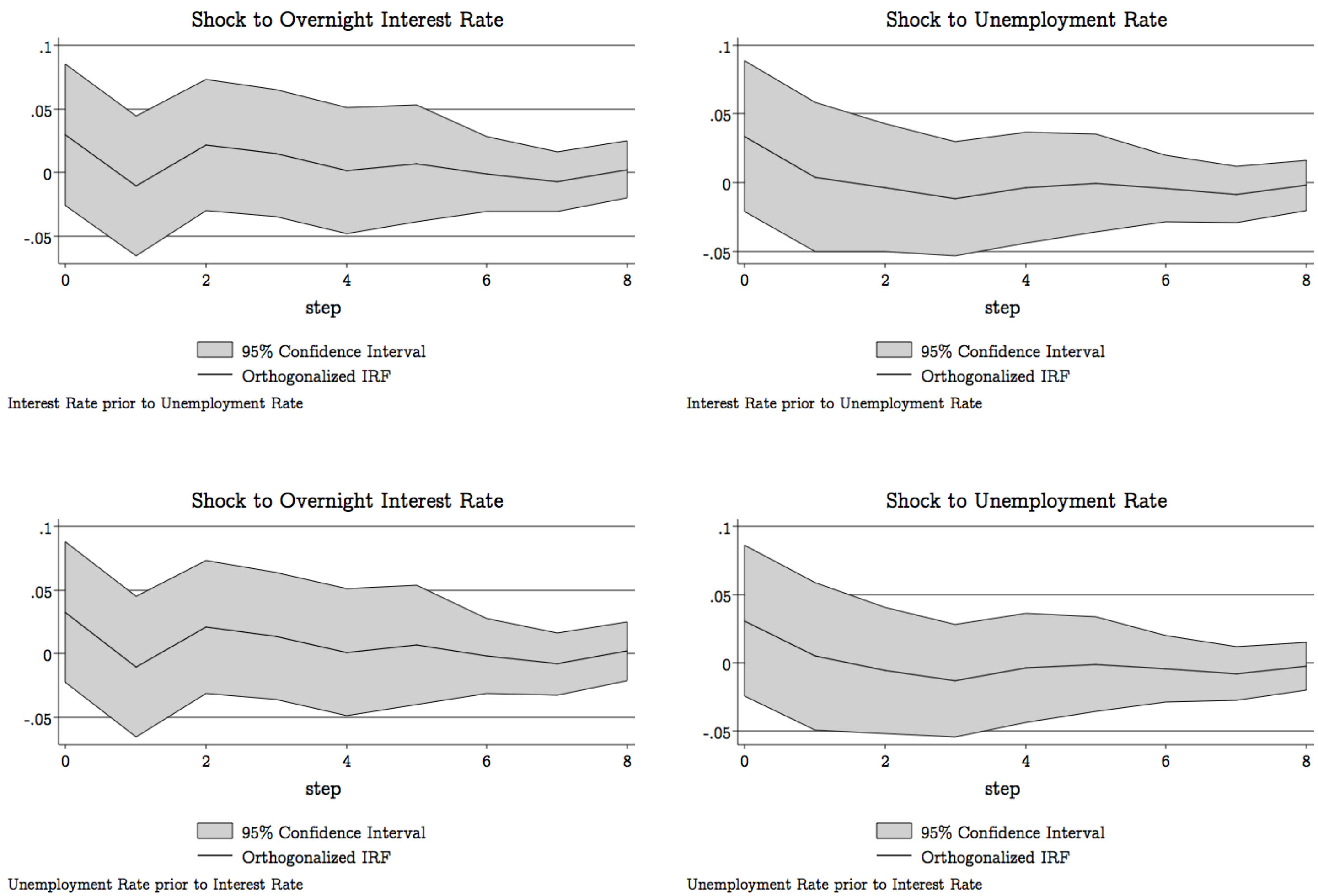
7.3 Debt-Service Ratio

In contrast, there is strong evidence that both the overnight interest rate and the unemployment rate have a significant effect on the aggregate household debt-service ratio. Figure 11 shows that a positive shock to the growth rate of the overnight interest rate will increase the growth rate of the Canadian aggregate debt-service ratio while a positive shock to the growth rate of the unemployment rate will decrease the aggregate debt-service ratio. In either case, ordering of the variables makes little difference.

The immediate effect of a shock to the growth rate of the overnight interest rate on the growth rate of the aggregate debt-service ratio is, not surprisingly, very strong. The IRF predicts that if interest rates were to spike tomorrow, all Canadians with a variable rate loan would immediately be forced to use more income to service their debt as the aggregate debt-service ratio would increase immediately by roughly .05% to .1% with a certainty of 95%. This effect remains for up to two quarters, as individuals are forced to cut back on consumption and other purchases before debt-service costs grow to unmanageable levels.

Figure 11 shows that a shock to the growth rate of unemployment has the opposite effect. While there is no evidence of an immediate effect on the growth rate of the

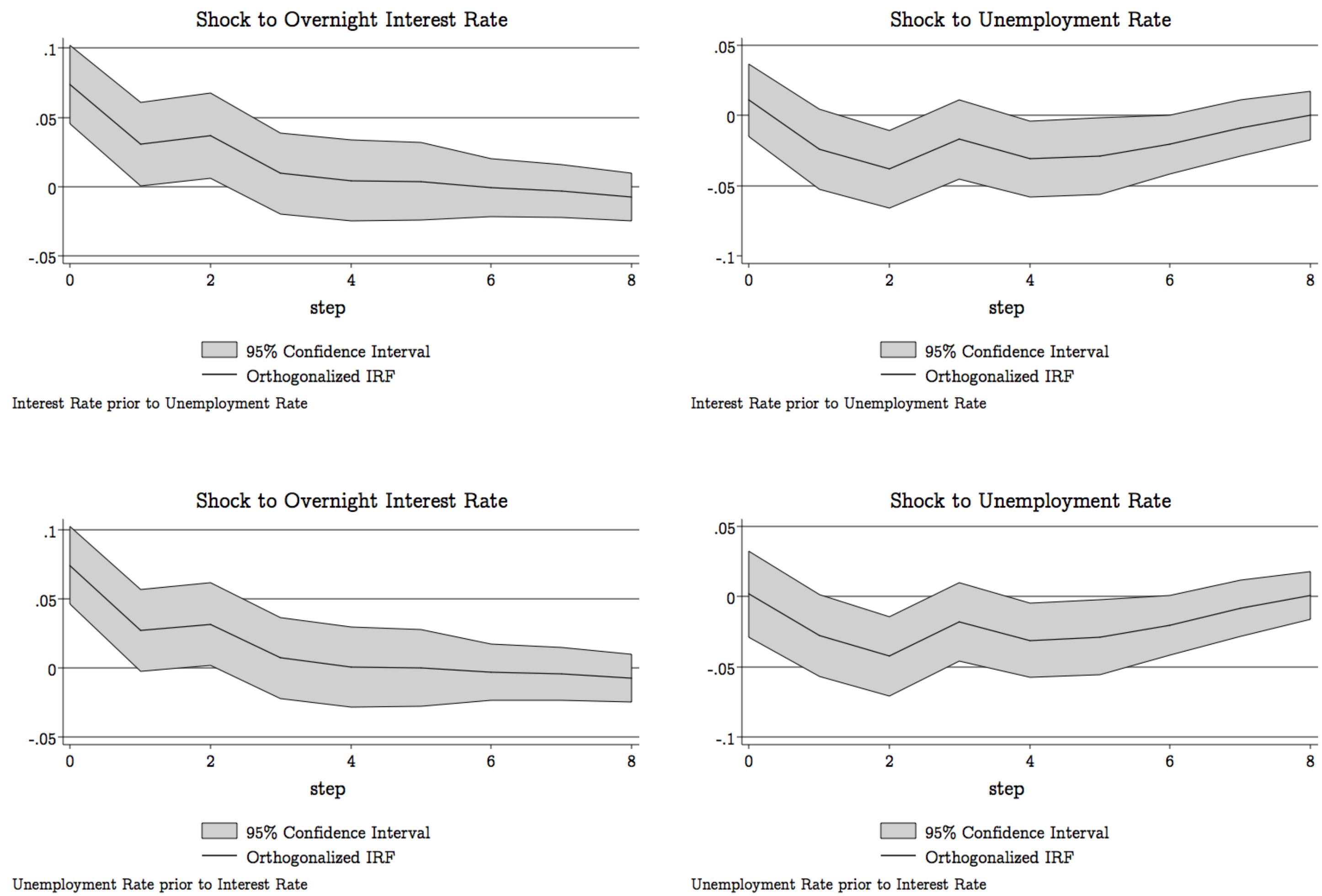
Figure 10: Debt-to-Asset Ratio Impulse Response Functions



debt-service ratio, after two quarters there is a significant negative effect of up to -.05% that could be sustained for up to the fourth or fifth quarter.

The decrease in debt-service ratio as a response to a shock in the unemployment rate could be attributed to a number of different factors. It is possible that some households default on debt obligations after an increase in the unemployment rate and therefore have fewer or no debt service obligations. Perhaps more relevant is the response of policymakers at the Bank of Canada during periods of increasing unemployment. A graph of the IRF of interest rates confirms that the growth rate of interest rates drops sharply immediately after a shock to unemployment. This, accompanied by the unwillingness of financial institutions to lend money during economic downturns, would lead to a significant decrease in the aggregate debt-service ratio.

Figure 11: Debt-Service Ratio Impulse Response Functions



8 Conclusion

As in many other advanced economies, the analysis presented here suggests that deregulation and financial innovation were major factors in the steady increase of Canadian household debt levels over the past two decades. These factors, along with low interest rates and rising home prices, have brought debt levels to extraordinarily high levels although persistently low debt-service ratios have thus far made such levels affordable.

Using vector autoregression techniques to build impulse response functions, this essay found that the effects of a shock to the growth rate in the Bank of Canada's overnight interest rate or the national unemployment rate on various measure of household indebtedness depends on which measure of household debt levels is used. The relevant impulse response functions show that the growth rate of the debt-to-income ratio will decrease in the event of a shock to interest rates while the growth rate of aggregate debt-service ratios will increase. The effects of an unemployment rate shock on the debt-to-income ratio is less certain but likely points to an increase in the growth rate of debt-to-income levels over time. Neither a shock to interest rates nor a shock to the unemployment rate appear to have an effect on the growth rate of the debt-to-asset level.

These findings suggest that tightening of monetary policy by the Bank of Canada in the form of an increase in the overnight interest rate will lead to a decrease in household debt levels and increased debt-service burdens. However, the limited scope of the model does not show the impact on other macroeconomic variables such as home prices, consumption, and GDP. Therefore, using interest rates alone to address the current Canadian household debt problem may have unseen consequences. Future research should build on this preliminary framework and to build a more comprehensive model of household indebtedness that includes more than three variables and more measures of household indebtedness. Further research will thus help to better explain movements in household debt levels by measuring the simultaneous effects on other macroeconomic variables such as home prices, consumption and GDP growth.

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