

Links between Household Debt and Macroeconomic Stability: Dynamic Conditional  
Correlations GARCH model

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**ABSTRACT**

Many of the policy papers leading up to, and following, the 2008 financial crisis addressed elevated household debt as a central issue for macroeconomic stability. While most papers address recent trends in debt at the macro level or micro issues within the household balance sheet, few papers actually address the movement of debt with other key macroeconomic variables. This paper extends the literature on household debt by characterizing the volatility of debt growth with three main macro variables, namely: house prices, the unemployment rate, and durable good sales. The key finding in this paper is that correlations with household debt and these variables are cyclical in nature, but the dynamic correlations differ when looking at residential mortgage debt versus consumer credit debt. This suggests that recent financial innovations and changes in attitudes towards debt affect the correlations with the separate debt components and key macroeconomic variables differently. The primary concern comes from the increased amount of debt households' hold, and looming changes in the low interest rate environment.

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## 1 Introduction

The 2008 financial crisis revealed the vulnerabilities of highly leveraged households when the housing bubble burst and households were left to pick up the pieces. This has led to a greater degree of concern for policymakers, as the topic of household indebtedness is an important determinant of macroeconomic stability and financial health. For example, the Bank of Canada cited the 'disorderly unwinding' of imbalances in the household sector as one of the main domestic risk factors for their inflation forecasts for 2014-15 (Bank of Canada, 2013, p.26). Throughout the last several decades, as the trend in consumer debt in Canada has continued upward, many policy papers have attempted to tackle the issue of historically high levels of household indebtedness in Canada (see Crawford and Faruqi, 2012; Chawla, 2011; Djoudad, 2011, among others). Despite this, a complete understanding of the consequences of elevated household debt remains ambiguous.

Household indebtedness was a contributing factor to the financial crisis as homeowners were unable to meet their debt obligations, such as rising mortgage payments (Swamy, 2013, p.74). This revealed the role of household debt in aggravating the crisis as households either defaulted on loans, or through gradually paying down debt reduced consumption spending. This problem was much more pronounced in the US than in Canada as the Canadian mortgage market was not as flooded with subprime loans. Household borrowing, however, continues to play a crucial role for households and the growth of the economy. Economic theory – via the permanent income hypothesis – suggests that household borrowing increases welfare by allowing households to smooth consumption over time with debt acting as a buffer in the event of a temporary loss of income (Debelle, 2004, p.24). The fragility of the household sector in

2007-8 coupled with the household's desire to borrow as a means to increase welfare and smooth consumption highlights the complex role household debt plays in the economy.

Following the 2008 financial crisis, most of the industrialized world saw a correction in the upward trend of household debt. However, perhaps owing to a more robust financial system, Canada did not experience the same deleveraging effect (Crawford and Faruqi, 2011, p.3). Over the same period, the housing market experienced a similar trend, as house prices decreased despite the overall sentiment that house prices would continue to rise (see Figure 1). The drop in housing prices that occurred preceded the household deleveraging, as the dominant financial asset on households' balance sheet is the purchase of a new home.

While Canada continues to see rising debt levels and modest house price increases, countries that experienced these concurrent increases have since mid-2008 seen a decline in house prices and deleveraging which has had significant negative impacts (Kartashova and Tomlin, 2013, p.2). One of the most telling examples is that of the US, who experienced the deepest and most prolonged recession and subsequent recovery since the Great Depression (Lavender and Parent, 2012, p.13), earning it the name 'The Great Recession'.

Over the past decade, the rapid increase in household indebtedness "has raised concern regarding the deterioration of the resilience of the household sector to negative shocks" (Djoudad, 2011, p.1). Primary concerns regarding elevated levels of consumer debt focus on the sustainability for the economy and its implications for financial

instability. The concern for financial stability has further implications in the consideration of monetary policy for the central bank if the intended policy shift could adversely affect household welfare. A misunderstanding of the role of the household balance sheet in the transmission of monetary policy could exacerbate the situation as household debt makes up a large portion of Canadian banks loan portfolio (Mishkin and Serletis, 2007, p.215; Debelle, 2004, p.1). In a point highlighted by Swamy (2012), in the event of a negative shock, an increase in debt defaults can significantly affect banks' balance sheets, which can cause a reduction in credit supply, further worsening economic conditions.

Since the financial crisis, macroeconomists shifted their attention to the effects of household debt on the economy. This is in contrast to previous studies which treated debt as a balance sheet entry, such that it is "simultaneously one entity's asset and another entity's liability, which in the aggregate cancel each other" (Knotek and Braxton, 2012, p.33). Debt is a multifaceted subject when analyzing the implications for policy concerns. According to Crawford and Faruqui (2012), proper understanding of historical debt growth "can provide insight into forces likely to affect future changes in [household] indebtedness" (Crawford and Faruqui, 2012, p.5) and can guide analysis of financial stability and monetary policy issues. It is also important to understand how households use these borrowed funds, as it is "important for the conduct of monetary policy and for assessing the macroeconomic effects of increased household borrowing" (Bailliu, Kartashova, and Meh, 2007, p.16). Studies that provide policy makers with a better understanding of the state of household finances can help them predict how their actions will impact the household balance sheet (Meh, Terajima, Chen, and Carter, 2009).

This paper primarily explores time varying correlations between consumer debt and house prices, an important driving factor in household debt. Secondly, this paper will

also look at the dynamic correlations between debt with the unemployment rate and the consumer expenditures. These two variables will help better understand the consequences of high debt by modelling their correlations over time.

The main research question in this paper addresses whether recent trends in household debt may be linked to additional financial instability by looking at the comovement between household debt and key macroeconomic indicators. It is the goal of this paper to measure the trends in correlation of household debt and other macro variables, as means of better understanding the changes in debt trends over the previous 30 years have contributed to financial instability. A higher degree of correlation with the macro variables today would demonstrate that fluctuations in the real economy that affect the household balance sheet could further exacerbate these economic shocks. Iacoviello and Pavan (2008) show how the correlation between household debt and real economic activity in the US has changed since the 1980s. Using Canadian data, the paper uses a dynamic correlation model to better characterize any time varying effects between household debt in Canada and several important macroeconomic variables.

Each model is estimated using Engle's (2002) dynamic conditional correlation (DCC) GARCH model, described in section 3. In this paper, I hope that by modelling the correlations between debt components and house prices helps to better understand the causes and consequences of the 2008 financial crisis. Similarly, the dynamic correlations between household debt and the unemployment rate, we hope to capture any changes in correlation with household debt and the real economy. In this case, two scenarios are possible:

- i) If the correlation coefficient is positive, then in the event of temporary unemployment, we would expect debt to rise as it acts as a buffer against household income;
- ii) If the correlation coefficient is negative, then we might determine that the loss of employment tightens borrowing constraints on households and therefore are unable to borrow additional funds.

The last relationship we are interested in, debt and durable good sales, is important as it highlights the correlation between household borrowing and the uses of borrowed funds. This has important implications if debt is highly correlated with expenditures, then a drastic reduction in spending due to overleveraging in the household sector will create financial instability. In addition, each model produces estimates for the conditional variance of the bivariate equations. This helps to understand whether the volatility in the current period depends more strongly on the previous periods estimated residuals, the previous period's variance, or the long-run variance. This is explained in more detail in section 3.

The rest of the paper is organized as follows. Section 2 presents an in-depth survey of the literature, looking specifically at household debt in economic theory, debt trends in Canada, the various measures of debt when considering policy, and finally consequences of high household debt. Section 3 will discuss Engle's (2002) dynamic conditional correlation GARCH model. Section 4 describes the data used. Section 5 will present the main results. Section 6 concludes.

## **2 Literature Review**

This section is divided into four distinct subsections. Subsection 1 describes the role of household debt in economic theory. Subsection 2 highlights important trends in Canadian household indebtedness. Subsection 3 compares the various different measures of household debt. Lastly, subsection 4 presents the economic consequences of overleveraged households found in the literature.

### **I. Household Debt in Economic Theory**

When situating household debt in economic theory, the typical starting point is Modigliani (1986) and Friedman (1957) with the advent of the lifecycle/ permanent income hypothesis. The lifecycle/ permanent income hypothesis shows that a household's lifetime consumption depends on their lifetime wealth, rather than income in just the current period. The permanent income hypothesis distinguishes between transitory and permanent income, where permanent income is income in the current period plus the present value of expected future income. When credit markets are introduced into the model then households can borrow against future income to fuel consumption in today's period. In economic theory, debt is typically synonymous with savings, as debt is simply negative savings. Thus, if transitory income is less than permanent income, then individuals will borrow to maintain their lifetime path of consumption. Alternatively, if transitory income is greater than permanent income, then individuals will increase savings. This paper hopes to capture this transitory effect through modeling the correlation between household debt and the unemployment rate over time. Higher positive correlations with unemployment and debt would imply that during harder times, households may increase borrowing to substitute a temporary loss

of income. If the correlation is negative, then this may imply that households borrowing constraints have increased due to the temporary loss of employment.

As the name suggests, the lifecycle model presents individuals consumption model over the lifespan that can capture the different stages of the lifecycle. The model creates an inverted U-shape graph to represent the individual's lifetime path of income. Generally, young adults have low income and typically increase borrowing to fuel current consumption, or even big purchases such as a home. As they turn approach their middle ages, their income increase as they accumulate more assets, savings increases as well as they pay down debts. Finally, at the retirement stage of the lifecycle, wage-earned income stops and individuals use savings to fund consumption. This is consistent with empirical findings in Canada (see Crawford and Faruqui, 2012; Chawla, 2011)

Iacoviello (2004) extends the lifecycle model by including a collateral constraint tied to house prices in the lifetime consumption function. This model implies that a rise in house price will relax borrowing constraints, allowing household's to increase consumption. Furthermore, this extended model is consistent with recent trends experience in Canada and US, as households increasingly used higher home values to fund consumption. In this paper, I trace the correlation in house prices and consumer debt over time to better understand how a household's debt position has become increasingly linked to house prices.

Fisher's (1930) intertemporal consumption model lays important fundamental groundwork for Modigliani (1986) and Friedman (1957). Despite the presentation here for simplicity, the mode does not have to be restricted to be set in a deterministic

framework. In this model, the present value of consumption equals the present value of income. The two-period model is then:

$$c_0 + \frac{c_1}{1+r} = y_0 + \frac{y_1}{1+r} \quad (1)$$

where  $c_0$  is consumption in the current period,  $c_1$  is consumption in the second period,  $y_0$  is current income,  $y_1$  is second period income, and  $r$  is the interest rate. In period one, households face the following budget constraint

$$S = Y_1 - C_1 \quad (2)$$

where  $S$  is savings,  $Y$  is income, and  $C$  is consumption. In period two the budget constraint is given by,

$$C_2 = (1+r)S + Y_2 \quad (3)$$

Household debt in this model is also represented as negative savings, such that individuals consume more in the current period than their current period income. Therefore, in the next period, if savings are negative, the consumer will have  $(1+r)S$  less to consume in the second period.

Economic theory tends to fall short of capturing the true dynamics of household debt as it over simplifies the household's financial decisions, which tend to be rather complex, filled with uncertainty, and adjusting over time throughout the lifecycle (Campbell, 2006, p.1554). In relation to this framework, this paper analyzes the comovement of household debt and consumer spending to verify whether volatilities in debt and spending have changed over time. If the correlation is positive, then we can infer that households' growth of debt is concurrent with a growth in consumption. On the

other hand, if the correlation is negative, we might expect that higher debt levels require more of current share of income to be spent on debt service.

## II. Household Debt Trends in Canada

Crawford and Faruqui (2012) provide an in-depth analysis of the household debt trends in Canada. At the core of the trend of rising household debt are several supply and demand factors. Demand-side factors include a shift in household preferences, such that houses prefer current consumption relative to future consumption. They find a positive cohort effect wherein the same age group born in later years has systematically higher debt revealing a shift in attitudes towards debt (Crawford and Faruqui, 2012, p.8). Similarly, using UK data, Benito, Waldron, Young and Zampolli (2007) find evidence of the positive cohort effect (Benito *et al.*, 2007, p.71). These findings lend support to the notion that household attitudes about debt have changed over time. Other demand side factors include changing demographics and higher income. The role of demographics in rising debt levels is best explained by the lifecycle model. Total house hold debt levels rise as a result of the increase in home ownership rates (Crawford and Faruqui, 2012, p.11).

Supply-side factors include below average borrowing costs, and new lending practices coupled with financial innovation (Crawford and Faruqui, 2012, p.8). On the supply side, the deregulation of the financial sector that occurred in the 1980s has contributed to below average borrowing costs, coupled with financial innovations and looser lending practices, which have allowed financially constrained household's access to credit (Debelle, 2004, p.4). This could represent a low level of indebtedness returning to its higher natural equilibrium (Debelle, 2004, p.4).

One of the dominant supply-side catalysts for household borrowing has been low interest rates. Low interest rates mean a lower cost of borrowing to the household over the life of the loan. The bank rate, which is a key determinate of nominal borrowing rates faced by consumers in Canada, has been consistently below its long-run average<sup>1</sup> since March 2008. The bank rate has remained unchanged since the third quarter of 2010 at 1%. Low interest rates support higher asset prices (including housing), which increases household wealth, and thus leads to an increase in spending through the wealth effect (Knotek and Braxton, 2012, p.31). Since high levels of household debt make the economy more vulnerable to asset price movements, these higher asset prices and high levels of debt may cause increased financial instability (Sutherland and Hoeller, 2012, p.7). The instability stems from the effects on consumer demand, which significantly affect aggregate demand. Similarly, low rates make new borrowing more attractive, further inducing households to take on additional debt (Knotek and Braxton, 2012, p.31).

House prices have been an important link to rising household debt, as mortgage debt comprises roughly two-thirds of total debt (Chawla and Uppal, 2011, p.4). It is thus important to understand the dynamics of these macroeconomic variables over time. The rise in mortgage debt is clearly related to changes in house prices over time, as a high house price will demand a higher mortgage loan. Over the period of 1982 to 2008, the average house price quadrupled, and not surprising, so too did the average mortgage loan, from \$41,200 to \$176,200 (Chawla, 2011, p.4). These increases are not unique to Canada, but were prevalent throughout most of the industrialized world. For example, in the UK, 80% of the increase in household debt is held in mortgage debt, which is associated to a rise in house price (Benito *et al.*, 2007, p.71).

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<sup>1</sup> Long-run average (calculated based on monthly data from January 1981 to December 2013) is 6.25%

While higher house prices translate to higher mortgage debt, increases in house prices are also associated with a wealth effect for households (Kartashova and Tomlin, 2013, p.3). This is because higher house prices relax household borrowing constraints as the value of their collateral has increased, allowing them to take. This phenomenon of rising asset prices reducing borrowing constraints to allow for more borrowing has been called the “self-perpetuating cycle” (TD Economics, 2010, p.2). While this cycle loosens borrowing constraints on households, it can exacerbate instability by causing households balance sheets to become overleveraged. Specifically, vulnerabilities to financial instability are amplified “when asset price boom-bust cycles act through the value of collateral and associated margin calls, which accentuate cyclical fluctuations and generate debt-deflation pressures” (Sutherland and Hoeller, 2012, p.7).

An additional driver of household borrowing in Canada has been the increase in home-equity extractions, which has risen concurrently with house prices over the past decade. From 1999 to 2007, home-equity extractions as a share of disposable income grew from 2.2% to 9% (Bailliu *et al.*, 2012, p.18). In their analysis, Bailliu *et al.* (2012) find that the increase in home-equity extractions consisted mainly of net mortgage refinancing, with the use of home-equity lines of credit having increased substantially during the most recent recession in 2008. As households rely on home-equity lines of credit to fund household expenditures, rising house prices have contributed significantly to the rising trend in consumer debt (Crawford and Faruqui, 2011, p.13). As a corollary, this wealth effect not only stems from increases in equity but from increases in income or expected income. Higher household income increases the probability that the household will hold debt, as well as higher than average levels of debt (Chawla and Uppal, 2012,

p.5). This is synonymous with their ability to handle higher levels of debt, as a typically a smaller share of their income will be devoted to debt service.

Kartashova and Tomlin (2013) discuss more specifically how different households are affected through increased house prices on their debt position. Housing purchases represent one of the largest expenditures households will make during their lifetime. On one hand, there are unconstrained, existing homeowners with long expected housing tenure. These households will be perfectly hedged against house price fluctuations, as price movements have no real effects on wealth (Kartashova and Tomlin, 2013, pp.7-8). On the other hand, credit-constrained existing homeowners may not have enough equity in their homes to cover borrowing costs. However, a rise in house price lowers the loan-to-value ratio and could help qualify for home-equity lines of credit or home-equity loans. Specifically, they find that a one-percent increase in home price is associated with a 0.36 percent increase in outstanding non-mortgage debt (Kartashova and Tomlin, 2013, p.28). This result is found by regressing non-mortgage debt on regional house prices. Further, they find that on average, homeowners used 40% of their non-mortgage debt for non-housing consumption and that the 52% rise in house prices over the sample period contributed to a 25% increase in net non-mortgage debt flows (Kartashova and Tomlin, 2013, p.28).

In order to better understand how indebtedness affects real activity, Bailliu *et al.* (2012) explore how households actually use these borrowed funds. They break household spending into 5 categories: consumption, home renovation, financial investment, non-financial investment, and debt payments. They find that the average share of home-equity extraction that is used to finance consumption and home renovations have been significant at about 40%. Further, they find that the majority,

approximately 73% on average, of consumer debt flows were used to finance consumption (Bailliu *et al.*, 2012, p.22). Overall, they find that the share of consumption financed by home-equity extractions more than doubled over the sample period (Bailliu *et al.*, 2012, p.23). Households in the US exhibited similar behaviour, as much of the boom in the 2000s was associated with the rise in house prices, which allowed households to extract equity from their homes to pay for goods and services (Gelain *et al.*, 2013, p.223). Therefore, according to Debelle (2004), homeownership and indebtedness will be positively related to the cost of housing (Debelle, 2004, p.10).

### **III. Measuring Household Indebtedness**

With respect to household debt, there are several different measures that help characterize trends in household balance sheets. One often cited measure in the media is a ratio of household debt to disposable income. Currently, Statistics Canada reports the debt to income ratio at 166% as of the fourth quarter of 2013, which means for every dollar of income earned, the average Canadian household owes \$1.66. Over the sample period of 1980 to 2013, this ratio has more than doubled (Chawla and Uppal, 2012, p.4). There has been criticism regarding this measure, however, as it compares the stock of debt with the flow of income. This poses obvious problems. For example, the purchase of a new house does not demand that it be repaid within the month, or year, but typically over 25 years. This implies that the debt-to-income ratio overestimates the average Canadian household's debt burden. Despite its drawback, the debt to income ratio still provides some useful information of the vulnerabilities of households, especially the assets in the households portfolio are illiquid or prices are volatile (Meh, *et al.*, 2009, p.4). Alternatively, another commonly cited measure of household debt is the debt to asset ratio. This ratio is similar to a company's capital leverage ratio as it provides insight

on the degree of leverage of the household balance sheet. It measures debt as a proportion of household assets.

The final measure of household indebtedness presented from 1990 to 2013 is the debt-service ratio (DSR), which is the sum of interest payments divided by disposable income<sup>2</sup>. This measure provides a measure of the vulnerability of households, in reality it represents a real borrowing constraint faced by households as most lending institutions typically use 40% as a threshold as a criteria for lending (Djoudad, 2011, p.11). Using this same threshold, Djoudad (2011) highlights the importance for policy makers in determining the distribution of the debt-service ratio. Individuals who are at or above the threshold will have a more difficult time obtaining credit. Also, those who are at or above the threshold will also be most vulnerable as a greater share of their disposable income is being used to service debts. It is therefore these households that will be most vulnerable in the event of a negative shock.

Understanding the distribution of the DSR across the population can help policy makers determine how many households are in a high-risk situation (Faruqui, 2008, p.3). Importantly, the DSR will paint dramatically different pictures for households of different means. Therefore, it is important to distinguish at the individual level, calling for a greater need of micro data about the individual characteristics of borrowers (Chawla and Uppal, 2012, p.4).

On an aggregate level, a high DSR would mean that households would be more negatively affected in the event of an adverse shock. If the DSR rises following a

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<sup>2</sup> This is how it is measured by Statistics Canada. Alternate measures include principal repayment as well as interest payment

negative shock, lenders may face higher loan arrears or higher default rates (Faruqui, 2008, p.3). Understanding the distribution of the DSR across the population can help policy makers determine how many households are in a high-risk situation (Faruqui, 2008, p.14). One example of how debt can be distributed across the country is the different regional house prices making debt in metropolitan areas, such as Toronto and Vancouver, relatively higher than national average (Chawla, 2011, p.4). Despite that debt-to-income in Canada remain at historically high levels, Faruqui (2008) maintains that the downward trend in the debt-service ratio reveals that household indebtedness is still highly manageable (Faruqui, 2008, p.1).

#### **IV. Concerns with Elevated Debt Levels**

Evidence throughout the literature suggests that elevated levels of household debt may pose a threat to the health of the economy and the stability of the financial system. Nonetheless, there is not yet consensus whether high debt levels affect consumer spending, or if it affects the size and speed of responsiveness to economic changes (Benito *et al.*, 2007, p.72). Trends in household debt accumulation can have important implication for future policy concerns (Crawford and Faruqui, 2011, p.5). This heightened sensitivity to negative shocks may however be attributed to bank lending activity, as opposed to household balance sheets. Swamy (2013) shows that banks increased sensitivities to negative shocks cause them to decrease their lending activity (measured by the credit-to-deposit ratio) in favour of safer investment activity (measured by the investment-to-deposit ratio), which leads to higher financial instability. The increased financial instability arises from tightening of consumer credit, thereby making household consumption more volatile as they cannot borrow against temporary loss of income. In this case, the instability arises as a consequence of tighter credit supply as opposed to changes in household borrowing demand.

On the other hand, Debelle (2004) shows that highly leveraged households will be more sensitive to changes in interest rates, income, and employment. He finds specific cases where highly leveraged households were more sensitive to changes in their macro environment. These cases include Finland, Norway, Sweden, and the UK in the early 1990s; the Netherlands from 1994-2003; and the US during the 2001 recession. This is in contrast to Benito et al. (2007) who use UK data to find that more indebted households do not respond more to income shocks but they may respond more to interest rate and asset price shocks (Benito *et al.*, 2007, p.72). Nevertheless, the effect of a change in the interest rate is likely to depend on the stage of the lifecycle of the household (Debelle, 2004, p.3). This is based on the assumption that preferences for debt hold across cohorts. However, in the Canadian context, Crawford and Faruqui (2011) find evidence of the existence of a positive cohort effect.

Prior to the financial crisis, Dynan and Kohn (2007) note that US households had become more exposed to shocks in asset prices through greater leverage in their balance sheets (Dynan and Kohn, 2007, p.3). With more debt, household's discretionary cash flows are more sensitive to shocks because an increased share of income is devoted to servicing debt obligations (Dynan and Kohn, 2007, p.3). If we consider the lifecycle model, this could have greater implications for household's early on in the life cycle, such as young adults or new homeowners. It has also been found that as household debt levels rise significantly above the trend, the likelihood of entering a recession also significantly increases (Sutherland and Hoeller, 2012, p.26). Sutherland and Hoeller (2012) use a probit regression across 96 OECD countries to explain whether high household debt induces or aggravates a recessionary period. Specifically, there is a 10% probability of a recession when debt is at the trend level, but when debt rises to

10% above the trend level, the probability of a recession increases to 40% (Sutherland and Hoeller, 2012, p.26). In contrast, greater availability of credit makes it easier for households to smooth their consumption path in the event of temporary losses of income or employment (Dynan and Kohn, 2007, p.23). Therefore, the continued rise of debt levels by Canadian households places a greater risk on the likelihood of a recession.

Looking at the effects of overleveraged households on the transmission of monetary policy in the UK, Benito *et al.* (2007) find that problems with elevated household debt arise if households have to restrict spending or in extreme cases they have to file for bankruptcy. However, these extreme cases make up only a small share of overall spending and therefore they may not be relevant for policymakers considerations in setting monetary policy (Benito *et al.*, 2007, p.70). Likewise, overreliance on debt will reduce households' savings, leaving highly leveraged households more exposed during adverse shocks (Chawla, 2011, p.3) since household savings acts as a safety net in times of hardship. The presence of high levels of debt and increased volatility of consumption holds across most developed countries (Sutherland and Hoeller, 2012, p.9).

Recent international experience demonstrated that excessive indebtedness and looser lending standards could make households more vulnerable to adverse shocks (Crawford and Faruqi, 2012, p.4). When the housing bubble burst, and house prices began to decline, household consumption also decreased (Gelain *et al.*, 2013, p.223). In the US in the wake of the housing bubble of 2007, consumers have been reducing debt despite low interest rates. This deleveraging may pose a drag on the recovery of the economy. Knotek and Braxton (2012) find that riskier borrowers have fueled the modest growth (Knotek and Braxton, 2012, p.32). Typically following a recession, accumulation

of debt for consumption helps heal the economy, however the excessive deleveraging by US households presents one of the main problems for the slow recovery (Lavender and Parent, 2012, p.15).

Despite interest rates being almost zero, households are decreasing debt levels rather than increasing. This is a problem with low interest rates and low levels of borrowing, known as the zero lower bound, as policy makers cannot lower interest rates further to spur borrowing. Therefore, despite extremely low rates, households continue to pay down debts, creating a drag on the economy (Knotek and Braxton, 2012). Moreover, as interest rates remain low and household's ability to service debt obligations remain stable, it is imperative that household's ability to pay down their debts not deteriorate in the likely event that that rates rise in the near future.

An important question is how the rise in household debt has accentuated or dampened the response of household spending to unexpected changes in the economy (Dyran and Kohn, 2007, p.20). Elevated household indebtedness, such as a higher debt-to-income ratio, even in the aggregate, may make households more vulnerable to shocks for a variety of reasons. For example, high interest rates raise the debt-service ratio, which reduces the availability of funds for consumption. Baker (2013) evaluates whether consumption among households with higher levels of debt is more sensitive to a change in income. He finds that a one standard-deviation increase in debt-to-asset ratio increases the income elasticity of consumption by approximately 25% (Baker, 2013, p.15). Qualitative factors that show how debt influences consumption elasticities would be borrowing constraints and liquidity constraints (Baker, 2013). Baker (2013) finds that consumption elasticities are more sensitive to liquid wealth and debt levels than to illiquid wealth (Baker, 2013, p.2). However, due to financial innovations, illiquid wealth such as

housing wealth is now accessible through home-equity lines of credit and home-equity loans.

Alternatively, higher interest rates may cause new debt or variable rate debt to be more costly to households. If households' portfolios are highly leveraged, then household wealth will be more volatile for given swings in equity and home prices, which then lead to consumer spending and aggregate demand being more volatile to changes in asset prices (Dynan and Kohn, 2007, p.9). By the same token, Dynan and Kohn (2007) also highlight how households have become less vulnerable to shocks. The main reason households have become less vulnerable to shocks is due to the greater availability of credit that helps household's smooth consumption spending (Dynan and Kohn, 2007, p.23). Financial innovation has increased the amount of debt held in good times, as well as the availability of additional debt in bad times, which push the volatility of household spending in two different directions. These findings are consistent with Johnson and Li's (2007) finding that households with high debt service payments do not appear to be more sensitive to income shocks than those with low debt payments (Dynan and Kohn, 2007, p.24).

Knotek and Braxton (2012) distinguish between the number of consumers taking on more debt and the dollar amount by which individual consumers are changing debt levels. They find that deleveraging at the aggregate level has occurred through a steep drop in the number of consumers taking on more debt; therefore accommodative monetary policy has been less effective than usual. However, the modest recovery experienced in the US is attributed to riskier borrowers as they seek new credit (Knotek and Braxton, 2012, p.32).

Iacoviello and Pavan (2008) find that changes in the volatility of household income have been a key factor in the changing trends of household debt. Specifically, the cyclical correlation between household mortgage debt and real economic activity was around 0.80 from 1952 to 1982, however over the last 25 years this correlation has been around zero (Iacoviello and Pavan, 2008, p.4).

### **3 Empirical Methodology**

This paper is primarily concerned with understanding the comovement between household debt and other key macroeconomic variables. The comovement between these variables may change over time, and the DCC-GARCH method provides a means of assessing the dynamic correlations. By studying the comovement of these variables, it can reveal whether the correlation has change over the sample period.

Better understanding of responses of macroeconomic variables over time helps to better understand the underlying economic theory, as well as the appropriate economic tools to deal with the time-varying dynamics (Den Haan *et al.*, 2009, p.593). In general, macroeconomists tend to focus on the first moment of a series; however, Hamilton (2008) shows that accurate description of the second moment (variance) of a series can help produce more efficient results. Recently, a plethora of literature has emerged on autoregressive conditional heteroskedastic (ARCH) models since Engle's (1982) flagship paper. These models treat heteroskedastic variance as something to be modeled and estimated, rather than a problem. The generalized (GARCH) version of the model, introduced by Bollerslev (1986), allows for a more flexible lag structure. The goal of GARCH models is to provide a measure of volatility. In this paper, we explore, in turn,

volatilities in consumer credit and residential mortgage debt relating to fluctuations in house prices, the unemployment rate, and durable good sales.

While many strands and extensions of GARCH models exist, in this paper I use Engle's (2002) dynamic conditional correlation (DCC) GARCH to find a model for the volatility of household debt and important macro variables likely to be affected by changes in household debt, described in the previous section. For all estimations of the model, I estimate changes in volatility of consumer credit debt, residential mortgage debt, and the aggregation of the two, which I call total household debt. Each of these debt categories is estimated in turn in a bivariate model with the following macro variables: house prices, the unemployment rate, and durable good sales.

Let  $y_t = [y_{1t} \ y_{2t}]'$  be a 2 x 1 vector containing the data series. The conditional mean equations are represented by the following reduced-form VAR :

$$A(L)y_t = \varepsilon_t, \quad \varepsilon_t \sim N(0, H_t) \quad t = 1, \dots, T \quad (4)$$

Where  $A(L)$  is the matrix of lagged coefficients, and  $\varepsilon_t = [\varepsilon_{1t} \ \varepsilon_{2t}]'$  is a vector of innovations with time-varying correlations. This model extends Bollerslev's (1990) constant conditional correlation (CCC) GARCH by allowing  $R$ , the correlation matrix, to vary with time. Therefore the  $\varepsilon_t$  vector has the following conditional variance-covariance matrix:

$$H_t = D_t R_t D_t, \quad \text{where } D_t = \text{diag} \left\{ \sqrt{h_{it}} \right\} \quad (5)$$

and  $D_t$  contains the time-varying standard deviations from the univariate GARCH models. Engle (2002) defines the time-varying correlation matrix as a geometrically weighted average of standardized residuals.

The GARCH(P,Q) structure allows for a broader lag structure. A broader lag structure allows the researcher to include  $p$  lagged residuals squared and  $q$  lagged variances. This means the variance to be modelled can take into consideration more than simply the previous period's variance or residuals, but multiple periods before it. However the most commonly model used is the GARCH(1,1) as the inclusion of more lags does not significantly help explain the model (Engle, 2001, p.160). Because of this, the GARCH(1,1) model has become one of the most popular structure for financial econometric work (Poon and Granger, 2003, p.484). The standard deviations in  $D_t$  are governed by the following univariate GARCH(1,1) process:

$$h_{i,t} = \gamma_i + \alpha_{i,t} \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} \quad (6)$$

where  $\gamma$  is the constant term,  $\alpha$  gives the estimated proportion of today's variance explained by the lagged residual squared, and  $\beta$  gives the estimated proportion of today's variance explained by the estimated coefficient on the lagged variance. Thus the current period's variance is explained proportionally by the previous period's residuals squared and the previous period's variance, such that  $\alpha + \beta < 1$ .

The GARCH(P,Q) structure allows for a broader lag structure, the most common model used is the GARCH(1,1) as many believe that the inclusion of more lags doesn't significantly help explain the model. In addition, Engle's (2002) DCC framework is given by

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \quad (7)$$

where

$$Q_t = \left( 1 - \sum_{m=1}^M a_m - \sum_{n=1}^N b_n \right) \bar{Q} + \sum_{m=1}^M a_m (\varepsilon_{t-m} \varepsilon_{t-m}') + \sum_{n=1}^N b_n Q_{t-n} \quad (8)$$

The coefficient  $a$  gives the speed at which the correlation matrix changes between periods, which the coefficient  $b$  gives the persistence of the correlation over time, with an estimate of 1.0 being constant correlation. Then, the best predictor for the conditional variance is a weighted average of the long-run variance,  $\bar{Q}$ , the residuals squared, and previous periods variance. The equations used in the estimation of the model in this paper follow directly from the equations above.

In order to estimate the DCC-GARCH model, maximum likelihood estimating must be used as the model is non-linear. After specifying the appropriate conditional mean and conditional variance equations, the log-likelihood function is specified. The log likelihood function is given by:

$$L = -\frac{1}{2} \sum_{t=1}^T (n \log(2\pi) + 2 \log |D_t| + r_t' D_t^{-1} D_t^{-1} r_t - \varepsilon_t' \varepsilon_t + \log |R_t| + \varepsilon_t R_t^{-1} \varepsilon_t) \quad (9)$$

In each model, a bivariate DCC GARCH model is estimated using the above estimator. At each time period, the model produces a correlation matrix. Each of these correlations is then plotted to form the dynamic correlations over the sample period.

This model was implemented using RATS software (version 8.30)<sup>3</sup>, using a mean equation in each model. Each model is estimated using the Berndt, Hall, Hall, Hausman (1974) algorithm as the equations are non-linear. Note that the only exception for each model is that containing consumer credit debt. Estimating using this data series was found to be integrated and estimated with no drift, meaning that the constant term was assumed to be zero<sup>4</sup>.

Before estimation, this paper sets forth hypotheses for the expected sign of the correlation between the variables. Each model contains: a) total household debt, b) residential mortgage debt, and 3) consumer credit debt. The expected sign of correlation for Model 1 with the three debt components and house prices is positive. A positive relation between these variables is expected as higher house prices lead to a wealth effect, relaxes borrowing constraints and thus households increase borrowing against new equity. Further, a positive correlation implies that new homeowners will face higher house prices and thus higher mortgage debt.

Model 2 estimates the comovement between the three debt components and the unemployment rate. The expected sign of correlation is positive for consumer credit debt with the unemployment rate (Model 2c). A positive correlation between consumer credit debt and the unemployment rate would lend evidence to the lifecycle/permanent income hypothesis as households borrow against their temporary loss of wage income. The expected correlation with residential mortgage debt and the unemployment (Model 2b) is assumed to be negative as job loss is likely to increase borrowing constraints as lenders

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<sup>3</sup> I must thank Eric Olson and Paul Jones for their code

<sup>4</sup> See appendix for description of specific options used in estimation of each model

fear job instability or greater probability of job loss. The expected sign correlation of correlation on total household debt (Model 2a) will depend on which relation is stronger.

Model 3 estimates the correlation between the debt components and expenditures on durable goods. As suggested by several authors (Kartashova and Tomlin (2013); Crawford and Faruqui (2012); Baker (2013), etc), households finance consumption through debt spending, including home equity loans from mortgage refinancing. Therefore, the expected sign for all three debt components is positive. Especially as the series used to proxy monthly consumer spending is expenditures on durable goods which tend to be larger purchases that are typically purchased through financing, such as auto loans.

## **4 Data**

This paper uses monthly data over the sample period of January 1981 to November 2013. All data sources are collected from Statistics Canada's CANSIM database. *Consumer credit* (Table 176-0027; seasonally adjusted at months end) is defined as individual credit for the financing of personal consumption, and excludes auto loans and residential mortgages. *Residential mortgages* (Table 176-0069; seasonally adjusted at months end) are outstanding balances of major private institutional lenders. The *New House Price Index* (nationally, with 2007=100) captures the changes in house prices across Canada. The *unemployment rate* (Table 282-0087) is used to capture changes in volatility in the real economy. Finally, *durable good sales* (Table 377-0003)

are used as a proxy for monthly household consumption (see appendix). The durable good sales series is used as proxy for consumer expenditures as monthly data on consumer expenditures are not available in Canada. To be sure that this proxy is appropriate, the two series are plotted over time in Appendix B. The levels of the series of quarterly durable good sales and household expenditures, as well as the growth rate of both series. In order to verify the correlation between these two series, they must be detrended by taking the growth rates. This was done using:  $g_t = (\ln X_t - \ln X_{t-4}) * 100$ . The correlation coefficient is 0.2033, which is relatively low all things considered. However, plotting an 8-period (2 year) moving average we see that the trends are rather similar, especially following the mid-1990s. The correlation over 1994 to 2011 is found to increase slightly to 0.261. This suggests that the two series behave somewhat similarly, and that the durable good sales as a proxy for household expenditures are relatively strong. Overall, the durable good sales series well reflects the pattern of consumption expenditures.

Also, data on the debt-service ratio in Canada is available only at quarterly intervals, and thus has been excluded. All variables, with the exception of the unemployment rate, are deflated using the total consumer price index. For graphs of the levels and the log difference of variables used in this paper see Appendix B.

Typically GARCH models use high data frequency, such as daily or weekly, which helps determine more accurate estimates of volatility. Therefore it was important to capture the effects over a long sample period, which provides a total of 391 observations. Note that all variables in the model are estimated as the log monthly change as a proxy for the growth rate. This allows comparison of variables of different

magnitudes, while maintaining trend-stationary data. While I described earlier different measures of debt, I follow Kartashova and Tomlin (2013) and choose not to normalize debt by income or assets as it could convolute the analysis between variables. (Graphs for the levels of the variables and the growth rates of variables are provided in Appendix A and B, respectively).

Before I begin estimation of the DCC model, I perform the Augmented Dickey-Fuller unit root test for heteroskedasticity and use Engle's (1982) ARCH test to test for ARCH effects. The results for the unit root tests and the ARCH-LM test are presented in Table 1 and Table 2, respectively.

Using the Augmented Dickey-Fuller unit root test, all variables are found to be stationary as we reject the null hypothesis of a unit root with 99% significance level for all variables, except for consumer credit debt which is still found to be significant at the 95% level. I chose a fixed lag length of 8 based on the Akaike Information Criterion.

Similarly, using Engle's ARCH-LM test we conclude that all variables as monthly changes in growth rates possess ARCH effects. We reject the null hypothesis that each series has homoskedastic variance in favour of the alternative, that the series exhibit conditional heteroskedasticity. The results of this test thereby justify the use of ARCH-type models as a means to model the volatility of the series.

## **5 Main Results**

This section will present the results from the DCC-GARCH model between the household debt components and house prices, the unemployment rate, and durable good sales. The primary findings with respect to household debt and house prices are

consistent with our expectations, such that the correlation over time between both components of debt is strictly positive. There are also several notable points in time when the magnitude of correlation between these variables decreases leading up to recessionary periods. Secondly, the findings reveal that the correlation between the unemployment rate and both components of household debt to be consistently negative, however while consumer credit debt remains relatively constant over time, the correlation between unemployment and residential mortgage debt has trended from negative to neutral over the sample period. Finally, our results regarding the correlations between household debt and durable good sales prove to be typically insignificant, with the exception of total household debt and expenditures which was  $DCC(2) = 0.97$ . This means that the persistence in volatility is very high, such that a value of 1 would suggest the use of a constant correlation. This result clearly shows that the DCC-GARCH model is not fit to explain dynamic correlations between household debt and consumer expenditures on durable goods as they are very near constant.

### **I. House Prices and Household Debt**

Recent working papers have identified rising house prices as one of the main drivers in the rising levels of household debt. Since mortgage debt comprises the majority of household debt, and an increase in house price provides a wealth effect for households, changes in house prices can have significant effects on a household's debt position. Understanding correlations between house prices and debt is important since house prices make up the single largest component on the household balance sheet, changes in its value can alter spending behaviour (Tsounta, 2009, p.3). This relationship would imply that the correlation between house prices and household debt should be positive. For example, if house prices rise, then the mortgage amount for new home buyers would increase. Similarly, for existing homeowners, rising house prices would relax borrowing

constraints through a real wealth effect, which allows them to take on more debt through increased equity of their collateral. Figure 3 shows the dynamic correlations between total household debt and house prices from 1981 to 2013.

The graphs plot the correlation at each month over the sample period 1981 to 2013. On the left axis is the correlation coefficient ( $\rho_{ij,t}$ ) which is by definition bounded between -1 and 1. The solid black line represents the dynamic correlations estimated by the model, while the dashed lines represent the upper and lower confidence level at 90%.

Over the sample period, the correlation between total household debt and house prices has been significantly positive, typically in the neighbourhood of 0.6 to 0.9, with the exception of a dramatic decrease from 1985 to 1988, and then rebounded back by 1991. Looking at national house prices in Canada (see Figure 15 in Appendix F), we see that over the same time period, house prices rose by 60% from the end of 1984 to the peak in April 1990, followed by a slight 10% correction over the following year until March 1991. The increased volatility of house prices is likely a key factor for the decrease in correlation between house prices and consumer debt levels from 1984 to 1990.

Naturally, the time varying correlations of residential mortgage debt and house prices follow a remarkably similar pattern as that of total household debt despite being only slightly greater in magnitude (see Figure 4 in Appendix B).

Dynamic correlations of consumer credit debt and house prices tend to be relatively lower than the previous two cases, ranging from 0.3 to 0.85. The highest value was hit in 1991, the same period as the previous two. Interestingly, correlations between

consumer credit debt and house prices do not stabilize following 1991. Rather, they follow a gradual downward from 0.85 in 1991 to 0.4 in 1998. Subsequently, from 1998 to 2004 the correlations between consumer credit debt and house prices gradually return to a more normal elevated level. Furthermore, unlike total household debt and residential mortgage debt, the correlations between consumer credit debt and house prices remain stable over the most recent recession in 2007-8. This fact could be attributed to the central causes of the crisis, which were the proliferation of subprime mortgage loans and the subsequent burst of the housing bubble. Though subprime mortgages were not nearly as rampant in Canada as in the US, the linkages between the two countries created a higher degree of uncertainty.

Now we move on to the analysis of the conditional variance estimates presented in Table 4. Table 4 presents the conditional variance estimates from the DCC-GARCH estimation. Recall the conditional variance equation is given by equation 6:

$$h_{i,t} = \gamma_i + \alpha_{i,t} \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} \quad (6)$$

where  $\gamma$  is the constant term,  $\alpha$  gives the estimated proportion of today's variance explained by the lagged residual squared, and  $\beta$  gives the estimated proportion of today's variance explained by the estimated coefficient on the lagged variance

The DCC component of the model is estimated by the coefficients  $a$  and  $b$ . Recall the DCC structure is given by equation 7:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \quad (7)$$

where

$$Q_t = \left( 1 - \sum_{m=1}^M a_m - \sum_{n=1}^N b_n \right) \bar{Q} + \sum_{m=1}^M a_m (\varepsilon_{t-m} \varepsilon_{t-m}) + \sum_{n=1}^N b_n Q_{t-n} \quad (8)$$

As mentioned in Section 3, the coefficient  $a$  gives the speed at which the correlation matrix changes between periods, which the coefficient  $b$  gives the persistence of the correlation over time, with an estimate of 1.0 being constant correlation.

First, we look at the conditional variance of house prices and total household debt. The findings show that variations in the current period depend primarily on the variance of the previous period, about 80%, and then around 12% of the variance in today's period is explained by the previous period's residuals, all significant above the 99% level. Second, the results from total household debt show that 68% of the current period's variance is determined by the previous period's variance, with 24% explained by the previous period's residuals. Finally, we turn to the DCC components. DCC (1) reveals the speed at which the correlations matrix changes, while DCC (2) shows the level of persistence, with 1 being constant correlations. Our results show that there is a relatively high level of persistence in the correlation between house prices and total household debt (Model 1a).

Similarly, with model 1b we see that the current period variance in house prices is largely determined by the previous periods variance ( $\beta = 0.89$ ) and much less is explained by the lagged residuals squared. Alternatively, the results for variation in consumer credit debt reveal that very little is explained by both the lagged squared residuals and the lagged variance. A more sophisticated lag structure may help better explain the variance in residential mortgage debt.

Finally, model 1b is presented in a slightly different structure than the previous two models. When applying the DCC-GARCH model with consumer credit debt and house prices (and unemployment and durable good sales, as we will see) the model is run as an integrated-GARCH (IGARCH), with the constant terms constrained to zero. This restriction was necessary for convergence. The results show for house prices almost all of the variance in today's period is explained by the previous periods variance, and very little is explained by the lagged residuals squared. Further, very little in this model explains the current period's variance in consumer credit debt.

## **II. Unemployment and Household Debt**

The unemployment rate provides a measure of real activity in the economy, as an increase in the unemployment rate generally means the economy is shrinking and shedding jobs. This has real implications for households as they can suffer from temporary loss of income. During these tough times, households may rely on their safety net, borrow against future expected income, or both. In this view, we would expect a positive correlation between the unemployment rate and household debt. In contrast, a loss of unemployment could tighten borrowing constraints faced by households during period's income instability.

The results from the DCC estimation are presented in Figures 6-8. We find that the correlations between both debt components are typically negative, with several exceptions. However, the correlations are relatively insignificant as they tend toward -0.2 over the sample period. Regardless, a negative time varying correlation would suggest that the increased borrowing constraints faced by households due to job loss outweighs the need to smooth income over the same period. The time-varying correlations between

unemployment and total household debt are presented in Figure 6. These correlations range from -0.3 to 0.1, with 1993 and 2003-4 as the low and high, respectively.

Figure 7 presents the dynamic correlations between unemployment and residential mortgage debt. We observe an upward trend, such that the correlation between unemployment and residential mortgage debt has moved from around -0.2 to close to zero over the sample period. Therefore, from this estimation we find that the relationship between fluctuations in the unemployment rate and residential mortgage debt is negligible. A negative correlation between the unemployment rate and residential mortgages suggests that rising unemployment may increase borrowing constraints on households as lenders become worried about job stability. The move from negative to no correlation may suggest that aggregate unemployment rates are a poor indicator for the determination of debt levels.

In a preliminary paper, Iacoviello and Pavan (2008) find that the correlation between mortgage debt and real economic activity in the US in 2008 was near zero, at 0.04 (Iacoviello and Pavan, 2008, p.2). These results are remarkably similar to the correlation between residential mortgage debt and the unemployment rate using Canadian data found in this paper. They attribute the change in correlation between mortgage debt and real activity to the increased volatility of household income, which leads to greater uncertainty about future income and thus a reduction in debt accumulation (Iacoviello and Pavan, 2008, p.2).

The relationship between the unemployment rate and consumer credit debt is presented in Figure 8 of the Appendix. The time varying correlations appear to be highly volatile, ranging from -0.6 to 0.2, however, they appear to be on average around the -0.2

mark. The consistently negative correlation may suggest that credit constraints are tighter in times of high unemployment with respect to consumer credit loans. The lowest points on the graph typically fall within a year after a major recession (e.g. 1982, 1993, and 2009).

Comparing Figure 7 and Figure 8, correlations differ substantially with the unemployment rate when residential mortgage debt or consumer credit debt is used. This result reveals that looking only at the correlation between the unemployment rate and total household debt may mask important differences between components of debt. One of the most important differences between the two debt components is the amortization period. Mortgage loans typically mature after 25 years, whereas consumer credit could be open (such as credit card debt) which is billed monthly. Even auto loans have shorter amortization periods, approximately 5 years. Furthermore, anecdotally, it may be unlikely that a household experience temporary job loss is seeking a new mortgage loan, but rather refinancing to draw on existing equity in their home.

Turning to the conditional variance estimates presented in Table 5, we see from DCC(2) that dynamic correlations are highly persistent in the case of residential mortgage debt and total household debt with the unemployment rate, but not credit debt. In each model, around two-thirds of the variance in the unemployment rate in the current period is explained by the variance in the previous period. In model 2a and 2b, approximately 20% of the variance in unemployment rate depends on the lagged squared residuals.

Model 2a –total household debt and the unemployment rate – shows that the variance today in total household debt is partially explained by the previous period's

variance, around 53%, while the lagged residuals squared explain approximately 22%. In model 2b, a significant proportion of today's variance in household mortgage debt (~88%) is explained by the previous period's variance. These findings are similar to those in model 2c, as variance in consumer credit debt is heavily influenced by the lagged variance. Also, in model 2c, we find that the correlations between the unemployment rate and consumer credit debt change are not very persistent, but the results are not significant. Further, we find with significance at the 95% level that the  $DCC(1) = 0.54$ , which suggest rather rapid changes in the correlations matrix.

### **III. Durable Good Sales and Household Debt**

As highlighted by Kartashova and Tomlin (2013), understanding how households use their borrowed funds is important in determining how highly leveraged households may affect economic stability and the transmission of monetary policy. If households use the borrowed funds for current consumption, we would expect a positive correlation between household debt and durable good sales. By examining the time-varying correlations between debt and expenditures, we can see if households today rely more or less heavily on debt to fuel current consumption.

From the results presented in Figures 9-11 in the Appendix, the dynamic correlations between both components of household debt and durable good sales have been fairly constant over time. Although the overall correlations are relatively stable, the differences in the 1990-1991 recession and 2008 recession are rather striking. In the 1990-1991 recession, the predicted correlation spikes upward, whereas the predicted correlation of the 2008 recession spikes downward. In both cases, the predicted correlation is still positive, however in 1990-1991, the comovement between debt and durable good sales grew stronger, while in 2008 the relationship between debt and

durable good sales grew weaker. When normalizing for business cycle effects, I find that mortgage debt and consumer credit debt grew at much quicker pace in the 2008 recession than the 1990-1991 recession, while durable goods remained relatively stable, but trending slightly downward (see Figure 24 and 25).

Table 6 presents the estimated results from the DCC-GARCH model with total household debt and consumer expenditures on durable goods. The estimated coefficient of DCC(2) shows the persistence in the dynamic correlation. We find that DCC(2) is estimated to be 0.98, which shows very near constant correlation over time, which is consistent with what we see in the graph. As such, the DCC-GARCH model may poorly characterize the relationship between the chosen variables. A more appropriate model for the comovement of these two series would be Bollerslev's (1990) constant conditional correlation (CCC) GARCH.

Similarly, for each individual debt component, residential mortgage debt and consumer credit debt, the estimated coefficient on DCC(2) is 0.40 and 0.80 respectively, but neither of these results are significant, which points to another problem with this method of modelling the correlations.

Our estimated results for model 3a with total household debt show that almost all of the current period's variance in durable good sales is determined by the previous period's variance. At the same time, the variance in total household debt is split relatively evenly between the lagged residual squared and the lagged variance.

In model 3b, we find that a majority of the variance in durable good sales depends on the previous period's variance, and less so on the previous period's residuals squared. In this model, the estimates for the conditional variance equation for

residential mortgage debt are poorly described by the previous period's squared residuals as well as the previous period's variance. This suggests that a different lag structure might be more fitting for this model.

Interestingly, in model 3c we find that the current variance in durable good sales is primarily influenced by the previous periods residuals squared, rather than the other way around as all the previous models. This reveals that current period's variance in durable good sales is primarily determined by the previous period's lagged residuals, approximately 85%, while the coefficient on the lagged variance is 0.15, it is not significant. Consistent with our previous results, we find that the variance in the current period is mostly determined by the lagged variance (~89%), with the rest explained by the lagged residuals squared.

## **6 Conclusion**

The goal of his paper is to determine whether the sustained increase in household debt may have negative consequences for the macro-economy. This is determined by verifying if the correlations between debt and other macro variables have changed over time. The results of this paper show that the correlations between total household debt and key macroeconomic variables have not changed materially overtime. However, when evaluating the correlations between the individual debt components, residential mortgage debt and consumer credit debt, the results reveal an interesting distinction. The motivation for the study comes in response to the renewed views on household debt in the wake of the financial crisis. This analysis can help develop a full and proper understanding of how household finance can serve to both mitigate and exacerbate financial instability. By better understanding how debt interacts

with other macroeconomic variables, policy makers can develop better policies to prevent future crises or to be better equipped in dealing with the subsequent aftermath.

I find that the volatility of house hold debt and most the key variables presented tends to be relatively volatile and typically persistent through time. Iacoviello and Pavan (2008) found that the correlation of US household debt and aggregate economic activity changed in the early 1980s. This paper went far beyond that to analyze findings on the changing characteristics of household debt correlations would emerge in different recessionary periods in Canada. Rather than painting a picture of the correlation over a standard time frame, this paper has portrayed the correlations throughout time to provide a more thorough understand of the interaction between debt and the macro economy. The sample size used covers the three different recessionary periods: 1981-1983, 1990-1991, and the most recent 2008-2009. While the correlation with debt and almost every other series experiences an increase in variability in the correlation during these periods, the magnitudes varied by series. Further research could be conducted to examine underlying fundamentals in the difference in correlation between consumer credit debt and mortgage debt with the unemployment rate.

Magnitudes of the shocks to the correlation between house prices and household debt were the greatest and those of household debt and durable good sales were the smallest. Furthermore, using the DCC-GARCH model I derive a model for the volatility of indebtedness. I find that, safe for consumer credit debt and durable good sales, the current periods volatility is best predicted in each model by the previous period's variance, and to a lesser degree, by the previous periods residuals squared. In conclusion, the coming months (or years) presents a unique challenge for highly

leveraged households as the low cost of borrowing will inevitably rise, straining the household's pocketbook, one can only hope that policymakers will be prepared *ex ante*.

## 7 Appendix

### Appendix A List of Tables

**Table 1 List of Variables**

| <b>Variable Name</b>   | <b>Variable Code</b> | <b>Description</b>   |
|--|----------------------|--|
| Total household debt   | LDTC                 | Log first difference of total household debt (monthly)                                   |
| Residential mortgage debt  | LDCM                 | Log first difference of residential mortgage debt (monthly)                              |
| Consumer credit debt   | LDCC                 | Log first difference of consumer credit debt (monthly)                                   |
| House prices*  | LDHPI                | Log first difference of the house price index (monthly)                                  |
| Unemployment rate*   | UR                   | Calculated as the number of unemployed divided by the size of the labour force (monthly) |
| Durable good sales   | LDDURS               | Log first difference of durable good sales (monthly)                                     |
| *Variables not deflated by total consumer price index<br>Note: Where {1} appears it represents a lag of one period |                      |  |

**Table 2 Results from the Augmented DF Test**

| <b>Augmented Dickey-Fuller Unit Root Test</b>             |                       |
|---|-----------------------|
| <b>Regression Run From 1981:11 to 2013:11</b>             |                       |
| <b>Observations</b>                                       | <b>386</b>            |
| <b>Variable</b>   | <b>Test Statistic</b> |
| Total Household Debt                                      | -3.82438**            |
| Residential Mortgage Debt                                 | -3.96362**            |
| Consumer Credit Debt                                      | -3.39840*             |
| House Prices  | -3.90328**            |
| Unemployment Rate   | -4.98704**            |
| Durable Good Sales <sup>a</sup>                           | -5.51874**            |
| <sup>a</sup> Durable Good Sales has only 351 observations |                       |
| * Significant at the 95% level                            |                       |
| ** Significant at the 99% level                           |                       |

**Table 3 Results from ARCH-LM Test**

| <b>Test for ARCH Effects</b>   |                       |
|--------------------------------|-----------------------|
| <b>Using LM Test Statistic</b> |                       |
| <b>Variable</b>                | <b>Test Statistic</b> |
| Total Household Debt           | 31.582686**           |
| Residential Mortgage Debt      | 39.916571**           |
| Consumer Credit Debt           | 10.02975**            |
| House Prices                   | 29.3099**             |
| Unemployment Rate              | 11.257636**           |
| Durable Good Sales             | 9.685814**            |
| **Significant at the 99% level |                       |

**Table 4 Conditional variance estimates for household debt and house prices**

| Conditional Variance Estimates                           |           |           |           |           |
|--|-----------|-----------|-----------|-----------|
| <b>Model 1a: House Prices/ Total Household Debt</b>      |           |           |           |           |
|  | h_hpi     |           | h_tc      |           |
|  | Coeff     | Signif    | Coeff     | Signif    |
| $\gamma_1$   | 0.0000020 | 0.0070201 | 0.0000024 | 0.0272211 |
| $\alpha_1$   | 0.1197762 | 0.0000606 | 0.2144076 | 0.0000708 |
| $\beta_1$  | 0.7978607 | 0.0000000 | 0.6819605 | 0.0000000 |
| <i>a</i>   | 0.0989401 | 0.0000064 |           |           |
| <i>b</i>   | 0.8974155 | 0.0000000 |           |           |
| <b>Model 1b: House Prices/ Residential Mortgage Debt</b> |           |           |           |           |
|  | h_hpi     |           | h_cm      |           |
|  | Coeff     | Signif    | Coeff     | Signif    |
| $\gamma_1$   | 0.000001  | 0.000000  | 0.000001  | 0.071927  |
| $\alpha_1$   | 0.084267  | 0.019500  | 0.136392  | 0.000578  |
| $\beta_1$  | 0.880533  | 0.029633  | 0.790139  | 0.000000  |
| <i>a</i>   | 0.103994  | 0.024284  |           |           |
| <i>b</i>   | 0.888530  | 0.027962  |           |           |
| <b>Model 1c: House Prices/ Consumer Credit Debt</b>      |           |           |           |           |
|  | h_hpi     |           | h_cc      |           |
|  | Coeff     | Signif    | Coeff     | Signif    |
| $\gamma_1$   | 0         | 0         | 0         | 0         |
| $\alpha_1$   | 0.045515  | 0.00000   | 0.004201  | 0.00002   |
| $\beta_1$  | 0.954485  | 0.000000  | 0.004201  | 0.000000  |
| <i>a</i>   | 0.015279  | 0.000935  |           |           |
| <i>b</i>   | 0.023703  | 0.000000  |           |           |

**Table 5 Conditional variance estimates for household debt and the unemployment rate**

| Conditional Variance Estimates                                |          |          |          |          |
|---|----------|----------|----------|----------|
| <b>Model 2a: Unemployment Rate/ Total Household Debt</b>      |          |          |          |          |
|   | h_ur     |          | h_tc     |          |
|   | Coeff    | Signif   | Coeff    | Signif   |
| $\gamma_1$  | 0.004594 | 0.006213 | 0.000004 | 0.020636 |
| $\alpha_1$  | 0.221605 | 0.000374 | 0.222715 | 0.002386 |
| $\beta_1$   | 0.659187 | 0.000000 | 0.528434 | 0.000104 |
| $a$   | 0.077568 | 0.386294 |          |          |
| $b$   | 0.917239 | 0.000000 |          |          |
| <b>Model 2b: Unemployment Rate/ Residential Mortgage Debt</b> |          |          |          |          |
|   | h_ur     |          | h_cm     |          |
|   | Coeff    | Signif   | Coeff    | Signif   |
| $\gamma_1$  | 0.004018 | 0.015918 | 0.000002 | 0.020753 |
| $\alpha_1$  | 0.189657 | 0.000766 | 0.008217 | 0.026468 |
| $\beta_1$   | 0.713484 | 0.000000 | 0.885082 | 0.000000 |
| $a$   | 0.010415 | 0.000000 |          |          |
| $b$   | 0.989585 | 0.000000 |          |          |
| <b>Model 2c: Unemployment Rate/ Consumer Credit Debt</b>      |          |          |          |          |
|   | h_ur     |          | h_cc     |          |
|   | Coeff    | Signif   | Coeff    | Signif   |
| $\gamma_1$  | 0.002819 | 0.009616 | 0.000078 | 0.027498 |
| $\alpha_1$  | 0.333027 | 0.000000 | 0.096735 | 0.001348 |
| $\beta_1$   | 0.666973 | 0.000000 | 0.903265 | 0.000000 |
| $a$   | 0.543472 | 0.039846 |          |          |
| $b$   | 0.363407 | 0.297554 |          |          |

**Table 6 Conditional variance estimates for household debt and durable good sales**

| Conditional Variance Estimates                            |          |          |          |          |
|---|----------|----------|----------|----------|
| <b>Model 3a: Durable Good Sales/ Total Household Debt</b> |          |          |          |          |
|   | h_exp    |          | h_tc     |          |
|   | Coeff    | Signif   | Coeff    | Signif   |
| $\gamma_1$  | 0.000207 | 0.090788 | 0.000140 | 0.008116 |
| $\alpha_1$  | 0.091132 | 0.000407 | 0.559791 | 0.000007 |
| $\beta_1$   | 0.908868 | 0.000000 | 0.440209 | 0.000425 |
| $a$   | 0.014157 | 0.457508 |          |          |

|  |          |          |          |          |
|--|----------|----------|----------|----------|
| <b><i>b</i></b>  | 0.975387 | 0.000000 |          |          |
| <b>Model 3b: Durable Good Sales/ Residential Mortgage Debt</b> |          |          |          |          |
|  | h_cm     |          | h_exp    |          |
|  | Coeff    | Signif   | Coeff    | Signif   |
| $\gamma_1$   | 0.000002 | 0.000000 | 0.000350 | 0.000000 |
| $\alpha_1$   | 0.196338 | 0.000000 | 0.193961 | 0.000050 |
| $\beta_1$  | 0.699163 | 0.000000 | 0.210677 | 0.000001 |
| <b><i>a</i></b>  | 0.043221 | 0.502017 |          |          |
| <b><i>b</i></b>  | 0.404699 | 0.614773 |          |          |
| <b>Model 3c: Durable Good Sales/ Consumer Credit Debt</b>      |          |          |          |          |
|  | h_exp    |          | h_cc     |          |
|  | Coeff    | Signif   | Coeff    | Signif   |
| $\gamma_1$   | 0.000236 | 0.000052 | 0.000008 | 0.053778 |
| $\alpha_1$   | 0.851465 | 0.000000 | 0.113742 | 0.000383 |
| $\beta_1$  | 0.148535 | 0.192188 | 0.886258 | 0.000000 |
| <b><i>a</i></b>  | 0.024521 | 0.700230 |          |          |
| <b><i>b</i></b>  | 0.801729 | 0.265559 |          |          |

**Table 7 Legend linking tables with raw output**

| Table           | Output | Variable Label | Variable Name  |
|-----------------|--------|----------------|--|
| $\gamma_1$      | C      | h_tc           | Conditional variance estimate for total household debt |
| $\alpha_1$      | A      | h_cm           | Conditional variance estimate for residential mortgage |
| $\beta_1$       | B      | h_cc           | Conditional variance estimate for consumer credit debt |
| <b><i>a</i></b> | DCC(1) | h_hpi          | Conditional variance estimate for house price          |
| <b><i>b</i></b> | DCC(2) | h_ur           | Conditional variance estimate for unemployment         |
|                 |        | h_exp          | Conditional variance estimate for durable good sales   |

**Table 8 Estimated results for total household debt and house prices**

| <b>Model 1a: LDTC/ LDHPI</b>          |              |            |             |            |
|---------------------------------------|--------------|------------|-------------|------------|
| <b>Mean Estimates</b>                 |              |            |             |            |
|                                       | House Prices |            | Total Debt  |            |
|                                       | Coeff        | Signif     | Coeff       | Signif     |
| 1. Constant                           | 0.00064732   | 0.36416454 | 0.00193301  | 0.00373969 |
| 2. LDTC{1}                            | -0.04120635  | 0.57433085 | 0.20498812  | 0.00962501 |
| 3. LDTC{2}                            | -0.05832479  | 0.41835952 | 0.23706326  | 0.00133998 |
| 4. LDTC{3}                            | 0.10490757   | 0.16344539 | 0.17705861  | 0.01715999 |
| 5. LDHPI{1}                           | 0.31837237   | 0.00000003 | 0.02114254  | 0.69557851 |
| 6. LDHPI{2}                           | 0.18561917   | 0.01801138 | 0.00628057  | 0.92481329 |
| 7. LDHPI{3}                           | 0.11631581   | 0.07699133 | 0.00358159  | 0.94474356 |
| 8. HHS(1,1)                           | 18.5512114   | 0.50206473 | 33.29146193 | 0.12666305 |
| 9. HHS(2,2)                           | -51.6535546  | 0.08080681 | -61.1527012 | 0.07316071 |
| <b>Conditional Variance Estimates</b> |              |            |             |            |
|                                       | h_hpi        |            | h_tc        |            |
|                                       | Coeff        | Signif     | Coeff       | Signif     |
| 19. C(1)                              | 0.00000197   | 0.00702018 | 0.00000235  | 0.02722107 |
| 21. A(1)                              | 0.11977623   | 0.00006063 | 0.21440759  | 0.00007075 |
| 23. B(1)                              | 0.79786071   | 0.00000000 | 0.68196051  | 0.00000000 |
| 25. DCC(1)                            | 0.09894007   | 0.00000639 |             |            |
| 26. DCC(2)                            | 0.89741554   | 0.00000000 |             |            |

**Table 9 Estimated results for residential mortgage debt and house prices**

| <b>Model 1b: LDCM/ LDHPI</b>          |              |           |               |           |
|---------------------------------------|--------------|-----------|---------------|-----------|
| <b>Mean Estimates</b>                 |              |           |               |           |
|                                       | House Prices |           | Mortgage Debt |           |
| 1. Constant                           | 0.000593     | 0.00074   | 0.001717      | 0.000692  |
| 2. LDCM{1}                            | 0.007279     | 0.066136  | 0.221558      | 0.069765  |
| 3. LDCM{2}                            | -0.085082    | 0.071627  | 0.258441      | 0.06794   |
| 4. LDCM{3}                            | 0.127998     | 0.072985  | 0.153701      | 0.066212  |
| 5. LDHPI{1}                           | 0.303946     | 0.056353  | 0.031108      | 0.05033   |
| 6. LDHPI{2}                           | 0.212608     | 0.080922  | 0.007461      | 0.065758  |
| 7. LDHPI{3}                           | 0.089162     | 0.066445  | 0.018374      | 0.045076  |
| 8. HHS(1,1)                           | 0.641947     | 26.363782 | 35.788257     | 19.694775 |
| 9. HHS(2,2)                           | -34.9361     | 39.055804 | -54.060371    | 42.155653 |
| <b>Conditional Variance Estimates</b> |              |           |               |           |
|                                       | h_hpi        |           | h_cm          |           |
|                                       | Coeff        | Signif    | Coeff         | Signif    |
| 19. C(1)                              | 0.000001     | 0.000000  | 0.000001      | 0.071927  |
| 21. A(1)                              | 0.084267     | 0.019500  | 0.136392      | 0.000578  |
| 23. B(1)                              | 0.880533     | 0.029633  | 0.790139      | 0.000000  |
| 25. DCC(1)                            | 0.103994     | 0.024284  |               |           |
| 26. DCC(2)                            | 0.888530     | 0.027962  |               |           |

**Table 10 Estimated results for consumer credit debt and house prices**

| <b>Model 1c: LDCC/LDHPI</b>           |              |          |                      |          |
|---------------------------------------|--------------|----------|----------------------|----------|
| <b>Mean Estimates</b>                 |              |          |                      |          |
|                                       | House Prices |          | Consumer Credit Debt |          |
|                                       | Coeff        | Signif   | Coeff                | Signif   |
| 1. Constant                           | 0.001609     | 0.099952 | 0.00285              | 0.02199  |
| 2. LDCC{1}                            | -0.121735    | 0.026943 | 0.130824             | 0.051889 |
| 3. LDCC{2}                            | -0.04271     | 0.405038 | 0.237613             | 0.000435 |
| 4. LDCC{3}                            | 0.03606      | 0.505671 | 0.188818             | 0.009896 |
| 5. LDHPI{1}                           | 0.41101      | 0        | 0.069116             | 0.304438 |
| 6. LDHPI{2}                           | 0.164063     | 0.024952 | 0.002074             | 0.977965 |
| 7. LDHPI{3}                           | 0.123799     | 0.069712 | -0.042068            | 0.566098 |
| 8. HHS(1,1)                           | -28.098947   | 0.358828 | -33.632351           | 0.237023 |
| 9. HHS(2,2)                           | -12.811213   | 0.79487  | -9.61587             | 0.861465 |
| <b>Conditional Variance Estimates</b> |              |          |                      |          |
|                                       | h_hpi        | Signif   | h_cc                 | Signif   |
|                                       | Coeff        | Signif   | Coeff                | Signif   |
| 19. C(1)                              | 0            | 0        | 0                    | 0        |
| 21. A(1)                              | 0.045515     | 0.00000  | 0.004201             | 0.00002  |
| 23. B(1)                              | 0.954485     | 0.000000 | 0.004201             | 0.000000 |
| 25. DCC(1)                            | 0.015279     | 0.000935 |                      |          |
| 26. DCC(2)                            | 0.023703     | 0.000000 |                      |          |

**Table 11 Estimated results for total household debt and the unemployment rate**

| <b>Model 2a: LDTC/UR</b>              |                   |          |            |          |
|---------------------------------------|-------------------|----------|------------|----------|
| <b>Mean Estimates</b>                 |                   |          |            |          |
|                                       | Unemployment Rate |          | Total Debt |          |
|                                       | Coeff             | Signif   | Coeff      | Signif   |
| 1. Constant                           | 0.059986          | 0.400307 | 0.003135   | 0.026342 |
| 2. LDTC{1}                            | -4.190058         | 0.102047 | 0.213681   | 0.000362 |
| 3. LDTC{2}                            | 2.192705          | 0.325853 | 0.215947   | 0.000042 |
| 4. LDTC{3}                            | -3.558425         | 0.128754 | 0.16921    | 0.003991 |
| 5. UR{1}                              | 0.943387          | 0.000000 | -0.00149   | 0.091038 |
| 6. UR{2}                              | -0.008038         | 0.925411 | -0.00006   | 0.959354 |
| 7. UR{3}                              | 0.047637          | 0.405693 | 0.001413   | 0.126074 |
| 8. HHS(1,1)                           | 0.331792          | 0.356422 | -0.003457  | 0.002479 |
| 9. HHS(2,2)                           | 3966.266968       | 0.020057 | -1.948007  | 0.958945 |
| <b>Conditional Variance Estimates</b> |                   |          |            |          |
|                                       | h_ur              |          | h_tc       |          |
|                                       | Coeff             | Signif   | Coeff      | Signif   |
| 19. C(1)                              | 0.004594          | 0.006213 | 0.000004   | 0.020636 |
| 21. A(1)                              | 0.221605          | 0.000374 | 0.222715   | 0.002386 |
| 23. B(1)                              | 0.659187          | 0.000000 | 0.528434   | 0.000104 |
| 25. DCC(1)                            | 0.077568          | 0.386294 |            |          |
| 26. DCC(2)                            | 0.917239          | 0.000000 |            |          |

Table 12 Estimated results for residential mortgage debt and the unemployment rate

| <b>Model 2b: LDCM/UR</b>              |              |          |               |          |
|---------------------------------------|--------------|----------|---------------|----------|
| <b>Mean Estimates</b>                 |              |          |               |          |
|                                       | Unemployment |          | Mortgage Debt |          |
|                                       | Coeff        | Signif   | Coeff         | Signif   |
| 1. Constant                           | -0.777219    | 0.000842 | 0.008495      | 0.076009 |
| 2. LDCM{1}                            | -2.760702    | 0.194004 | 0.201392      | 0.000027 |
| 3. LDCM{2}                            | 1.536037     | 0.495588 | 0.19572       | 0.000004 |
| 4. LDCM{3}                            | -0.948139    | 0.673235 | 0.162103      | 0.000837 |
| 5. UR{1}                              | -0.016898    | 0.78539  | -0.000897     | 0.430313 |
| 6. UR{2}                              | -0.024414    | 0.688645 | -0.000785     | 0.472679 |
| 7. UR{3}                              | 0.053989     | 0.345285 | -0.00126      | 0.296152 |
| 8. HHS(1,1)                           | 0.479188     | 0.493616 | -0.022021     | 0.048358 |
| 9. HHS(2,2)                           | 46822.61031  | 0.000337 | -352.489475   | 0.21838  |
| <b>Conditional Variance Estimates</b> |              |          |               |          |
|                                       | h_ur         |          | h_cm          |          |
|                                       | Coeff        | Signif   | Coeff         | Signif   |
| 19. C(1)                              | 0.004018     | 0.015918 | 0.000002      | 0.020753 |
| 21. A(1)                              | 0.189657     | 0.000766 | 0.008217      | 0.026468 |
| 23. B(1)                              | 0.713484     | 0.000000 | 0.885082      | 0.000000 |
| 25. DCC(1)                            | 0.010415     | 0.000000 |               |          |
| 26. DCC(2)                            | 0.989585     | 0.000000 |               |          |

**Table 13 Estimated results for consumer credit debt and the unemployment rate**

| <b>Model 2c: LDCC/UR</b>              |              |          |                      |          |
|---------------------------------------|--------------|----------|----------------------|----------|
| <b>Mean Estimates</b>                 |              |          |                      |          |
|                                       | Unemployment |          | Consumer Credit Debt |          |
|                                       | Coeff        | Signif   | Coeff                | Signif   |
| 1. Constant                           | 0.179006     | 0.00194  | 0.050092             | 0.031244 |
| 2. LDCC12{1}                          | -0.256982    | 0.048121 | 0.176183             | 0.007954 |
| 3. LDCC12{2}                          | 0.18402      | 0.266213 | 0.197286             | 0.003174 |
| 4. LDCC12{3}                          | -0.452438    | 0.002957 | 0.160885             | 0.02469  |
| 5. UR{1}                              | 0.951661     | 0        | -0.012305            | 0.489117 |
| 6. UR{2}                              | -0.008086    | 0.933364 | 0.001211             | 0.956084 |
| 7. UR{3}                              | 0.028873     | 0.635286 | 0.00945              | 0.577801 |
| 8. HHS(1,1)                           | 0.340765     | 0.083989 | -0.051184            | 0.000001 |
| 9. HHS(2,2)                           | 8.556517     | 0.202349 | -1.86347             | 0.477559 |
| <b>Conditional Variance Estimates</b> |              |          |                      |          |
|                                       | h_ur         |          | h_cc                 |          |
|                                       | Coeff        | Signif   | Coeff                | Signif   |
| 19. C(1)                              | 0.002819     | 0.009616 | 0.000078             | 0.027498 |
| 21. A(1)                              | 0.333027     | 0.000000 | 0.096735             | 0.001348 |
| 23. B(1)                              | 0.666973     | 0.000000 | 0.903265             | 0.000000 |
| 25. DCC(1)                            | 0.543472     | 0.039846 |                      |          |
| 26. DCC(2)                            | 0.363407     | 0.297554 |                      |          |

**Table 14 Estimated results for total household debt and durable good sales**

| <b>Model 3a: LDTC/LDDURS</b>          |            |          |                    |          |
|---------------------------------------|------------|----------|--------------------|----------|
| <b>Mean Estimates</b>                 |            |          |                    |          |
|                                       | Total Debt |          | Durable Good Sales |          |
|                                       | Coeff      | Signif   | Coeff              | Signif   |
| 1. Constant                           | 0.128916   | 0.000000 | 0.001097           | 0.756466 |
| 2. LDTC{1}                            | 0.527626   | 0.252513 | 0.113604           | 0.185928 |
| 3. LDTC{2}                            | 0.814829   | 0.072719 | 0.035272           | 0.676977 |
| 4. LDTC{3}                            | 0.635256   | 0.170636 | -0.01089           | 0.889583 |
| 5. LDDURS{1}                          | -0.023704  | 0.935283 | -0.3207            | 0.000009 |
| 6. LDDURS{2}                          | -0.000037  | 0.999909 | -0.11339           | 0.113069 |
| 7. LDDURS{3}                          | -0.197703  | 0.524205 | -0.14589           | 0.018836 |
| 8. HHS(1,1)                           | -3.632017  | 0.007122 | -0.02751           | 0.765321 |
| 9. HHS(2,2)                           | 19.723791  | 0.058819 | -0.07047           | 0.984323 |
| <b>Conditional Variance Estimates</b> |            |          |                    |          |
|                                       | h_exp      |          | h_tc               |          |
|                                       | Coeff      | Signif   | Coeff              | Signif   |
| 19. C(1)                              | 0.000207   | 0.090788 | 0.00014            | 0.008116 |
| 21. A(1)                              | 0.091132   | 0.000407 | 0.559791           | 0.000007 |
| 23. B(1)                              | 0.908868   | 0.000000 | 0.440209           | 0.000425 |
| 25. DCC(1)                            | 0.014157   | 0.457508 |                    |          |
| 26. DCC(2)                            | 0.975387   | 0.000000 |                    |          |

Table 15 Estimated results for residential mortgage debt and durable good sales

| <b>Model 3b: LDCM/LDDURS</b>          |               |           |                    |          |
|---------------------------------------|---------------|-----------|--------------------|----------|
| <b>Mean Estimates</b>                 |               |           |                    |          |
|                                       | Mortgage Debt |           | Durable Good Sales |          |
|                                       | Coeff         | Signif    | Coeff              | Signif   |
| 1. Constant                           | 0.001171      | 0.000000  | 0.003803           | 0.001264 |
| 2. LDDURS{1}                          | -0.0254       | 0.0002370 | -0.295995          | 0.000000 |
| 3. LDDURS{2}                          | -0.011785     | 0.1435650 | -0.108813          | 0.043579 |
| 4. LDDURS{3}                          | 0.000123      | 0.9868320 | -0.137639          | 0.002471 |
| 5. LDCM{1}                            | 0.228849      | 0.0000000 | 0.376806           | 0.029885 |
| 6. LDCM{2}                            | 0.316367      | 0.0000000 | 0.015438           | 0.930671 |
| 7. LDCM{3}                            | 0.125625      | 0.0000720 | -0.042062          | 0.812429 |
| 8. HHS(1,1)                           | 11.331599     | 0.3690370 | -1.706135          | 0.978548 |
| 9. HHS(2,2)                           | 0.457382      | 0.1202060 | -4.763161          | 0.022406 |
| <b>Conditional Variance Estimates</b> |               |           |                    |          |
|                                       | h_cm          |           | h_exp              |          |
|                                       | Coeff         | Signif    | Coeff              | Signif   |
| 19. C(1)                              | 0.000002      | 0.000000  | 0.00035            | 0.000000 |
| 21. A(1)                              | 0.196338      | 0.000000  | 0.193961           | 0.000050 |
| 23. B(1)                              | 0.699163      | 0.000000  | 0.210677           | 0.000001 |
| 25. DCC(1)                            | 0.043221      | 0.502017  |                    |          |
| 26. DCC(2)                            | 0.404699      | 0.614773  |                    |          |

Table 16 Estimated results for consumer credit debt and durable good sales

| <b>Model 3c: LDCC/LDDURS</b>          |                      |          |                    |          |  |
|---------------------------------------|----------------------|----------|--------------------|----------|--|
| <b>Mean Estimates</b>                 |                      |          |                    |          |  |
|                                       | Consumer Credit Debt |          | Durable Good Sales |          |  |
|                                       | Coeff                | Signif   | Coeff              | Signif   |  |
| 1. Constant                           | 0.010322             | 0.009866 | -0.004914          | 0.168896 |  |
| 2. LDCC{1}                            | 0.169278             | 0.013093 | 0.073194           | 0.227314 |  |
| 3. LDCC{2}                            | 0.23134              | 0.000671 | 0.243297           | 0.000000 |  |
| 4. LDCC{3}                            | 0.174015             | 0.010268 | -0.029838          | 0.651795 |  |
| 5. LDDURS{1}                          | -0.021696            | 0.661220 | -0.309031          | 0.000008 |  |
| 6. LDDURS{2}                          | -0.061337            | 0.251865 | -0.178307          | 0.004637 |  |
| 7. LDDURS{3}                          | -0.071395            | 0.138372 | -0.218966          | 0.000012 |  |
| 8. HHS(1,1)                           | 1.824557             | 0.152994 | -0.08504           | 0.974546 |  |
| 9. HHS(2,2)                           | -6.132798            | 0.453362 | 8.798354           | 0.028842 |  |
| <b>Conditional Variance Estimates</b> |                      |          |                    |          |  |
|                                       | h_exp                |          | h_cc               |          |  |
|                                       | Coeff                | Signif   | Coeff              | Signif   |  |
| 19. C(1)                              | 0.000236             | 0.000052 | 0.000008           | 0.053778 |  |
| 21. A(1)                              | 0.851465             | 0.000000 | 0.113742           | 0.000383 |  |
| 23. B(1)                              | 0.148535             | 0.192188 | 0.886258           | 0.000000 |  |
| 25. DCC(1)                            | 0.024521             | 0.700230 |                    |          |  |
| 26. DCC(2)                            | 0.801729             | 0.265559 |                    |          |  |

## Appendix B List of Figures

Figure 1 Aggregate household debt and house prices

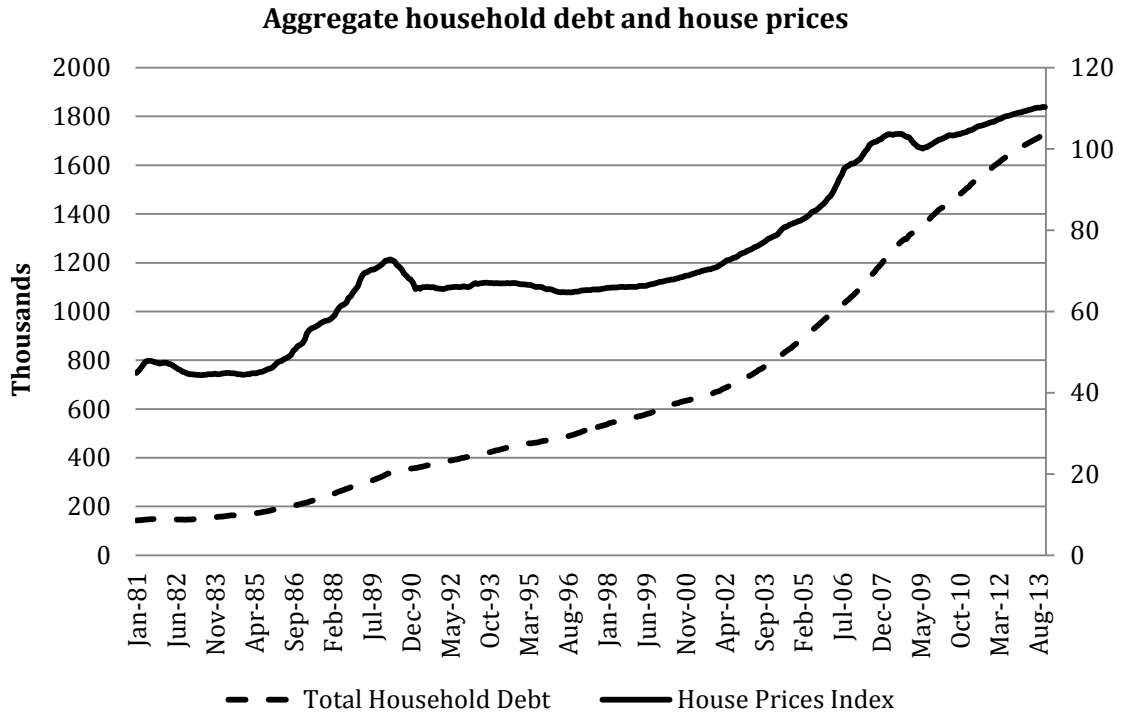


Figure 2 Select debt service ratios

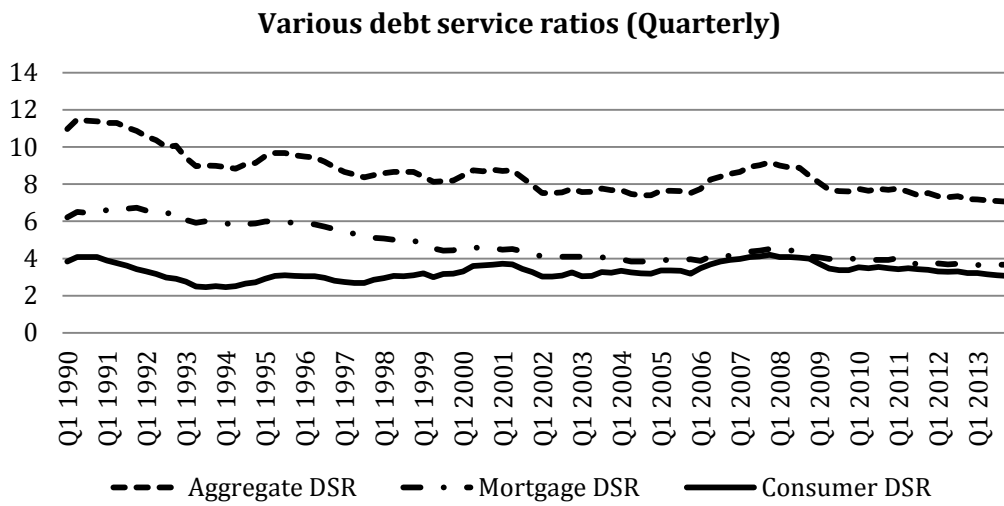


Figure 3 Correlations between total household debt and house prices

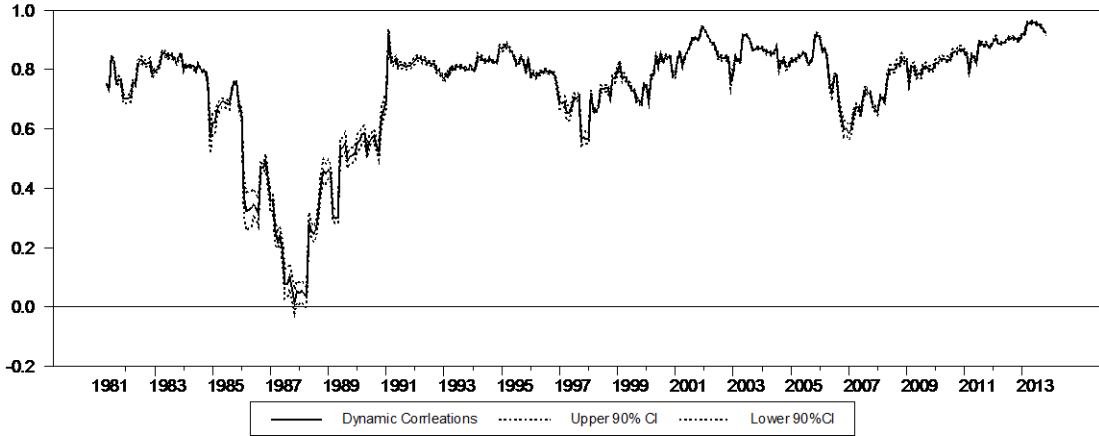


Figure 5 Correlations between residential mortgage debt and house prices

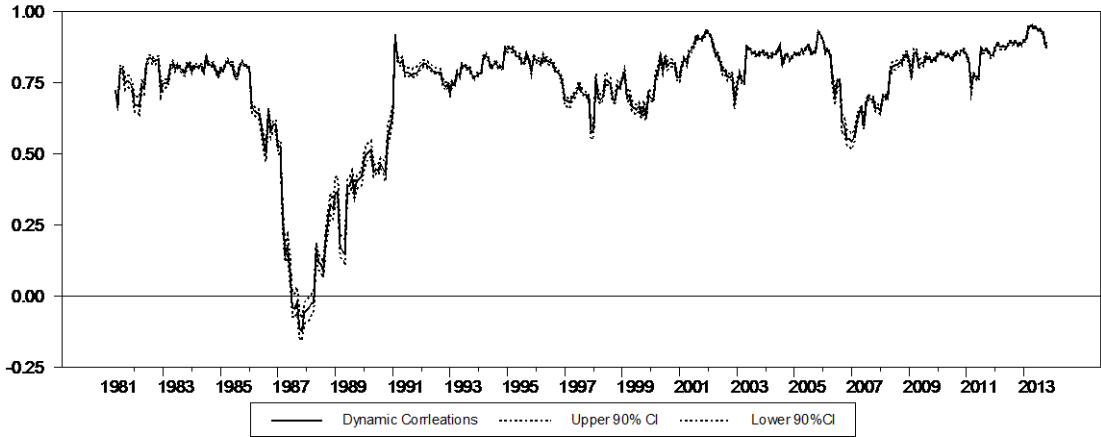
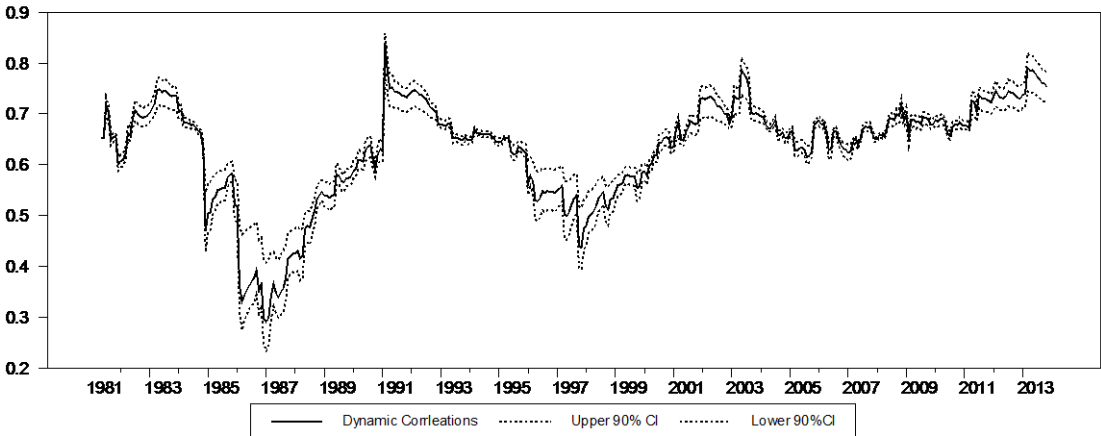
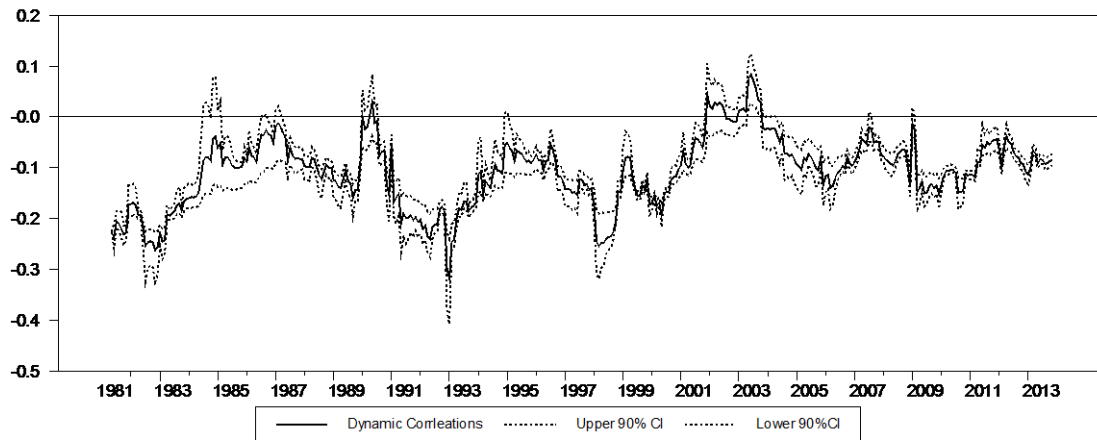


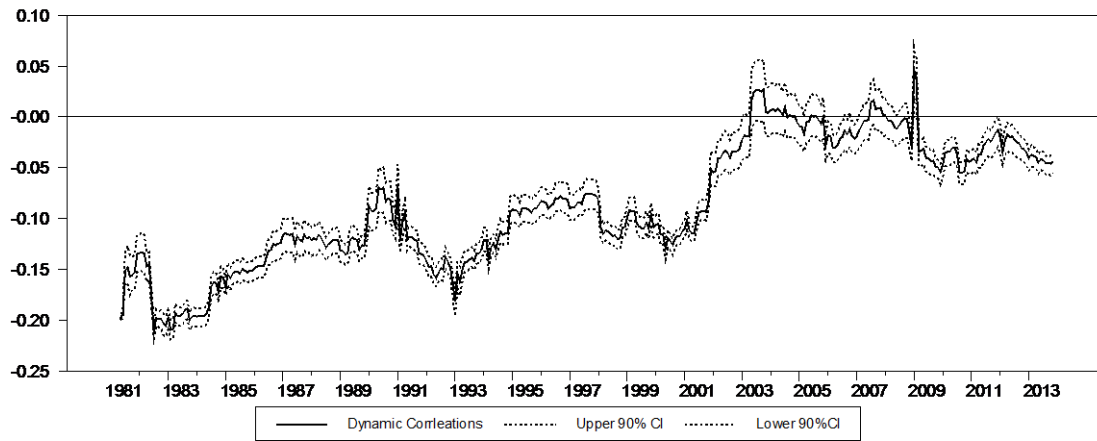
Figure 4 Correlations between consumer credit debt and house prices



**Figure 6 Correlations between total household debt and the unemployment rate**



**Figure 7 Correlations between unemployment and residential mortgage debt**



**Figure 8 Correlations between the unemployment rate and consumer credit debt**

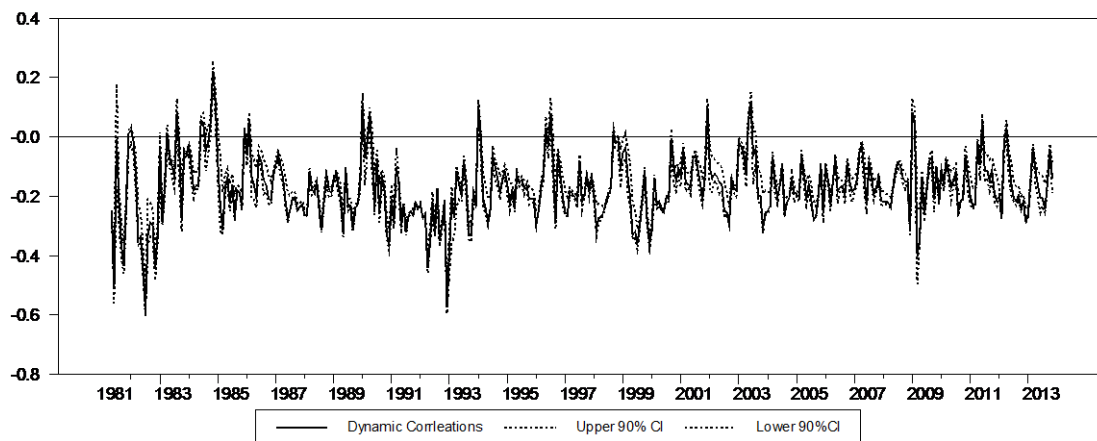


Figure 9 Correlations between total household debt and durable good sales

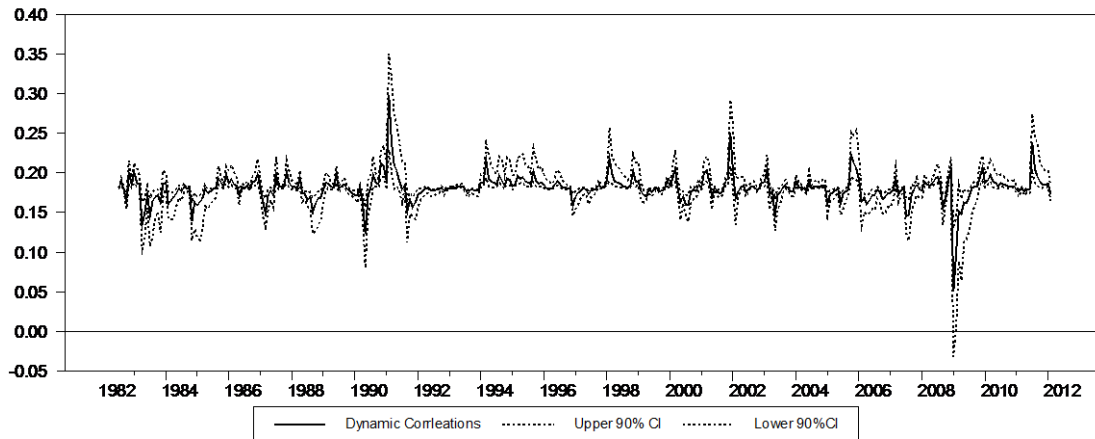


Figure 10 Correlations between residential mortgage debt and durable good sales

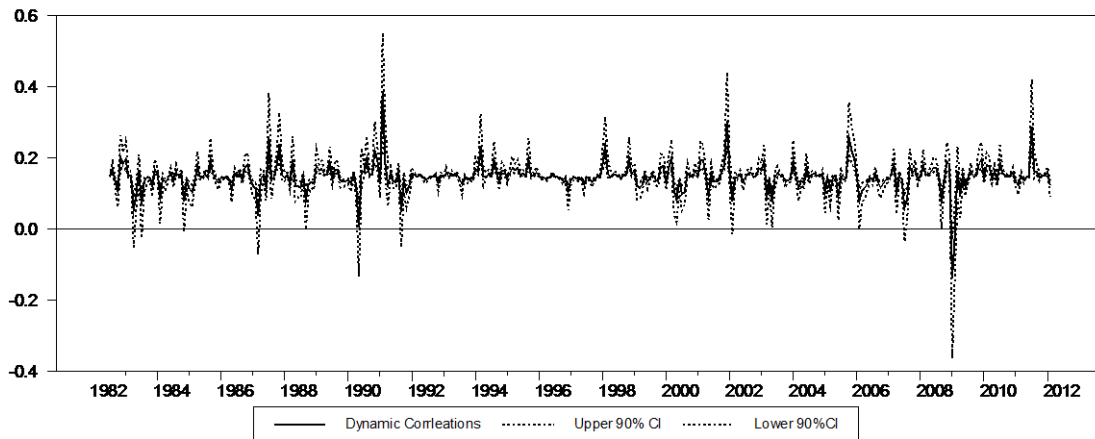
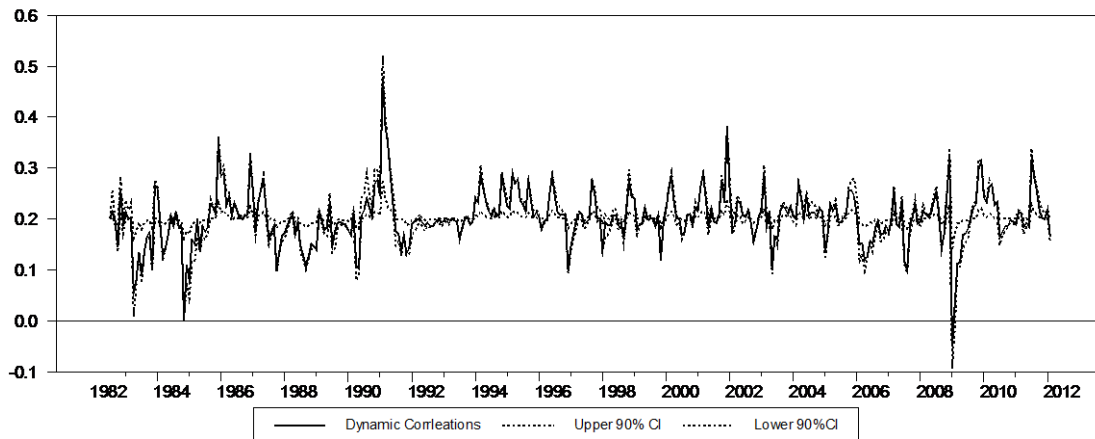


Figure 11 Correlations between consumer credit debt and durable good sales



## Graphs of Levels of Variables

Figure 12

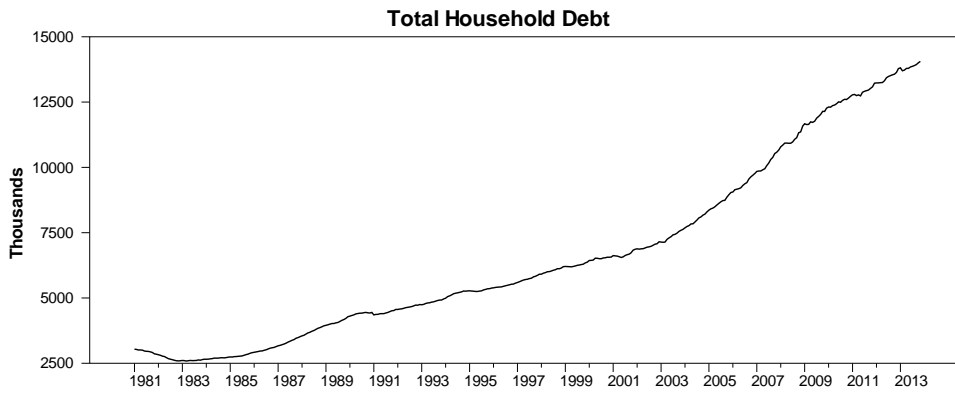


Figure 13

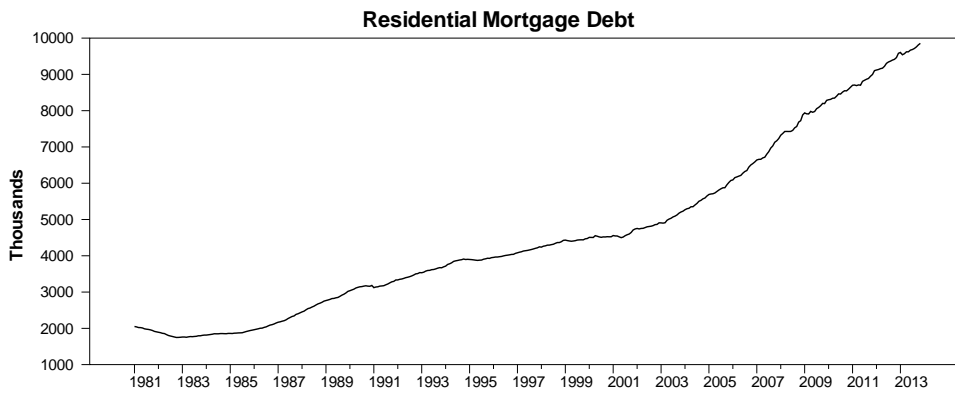
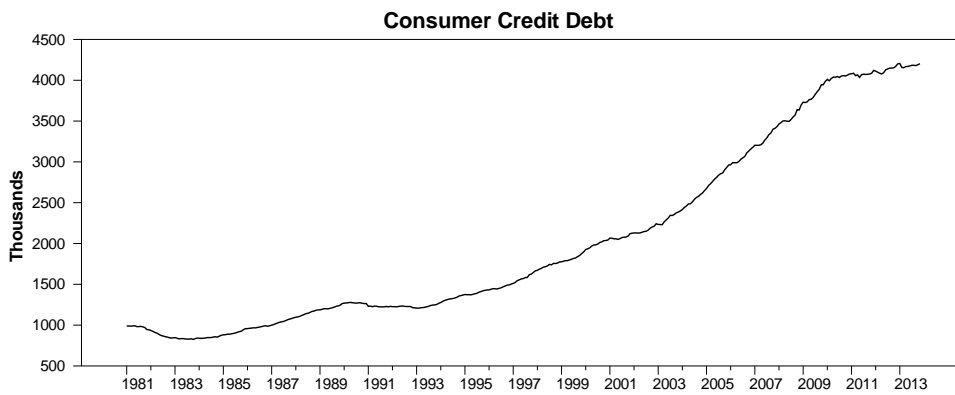
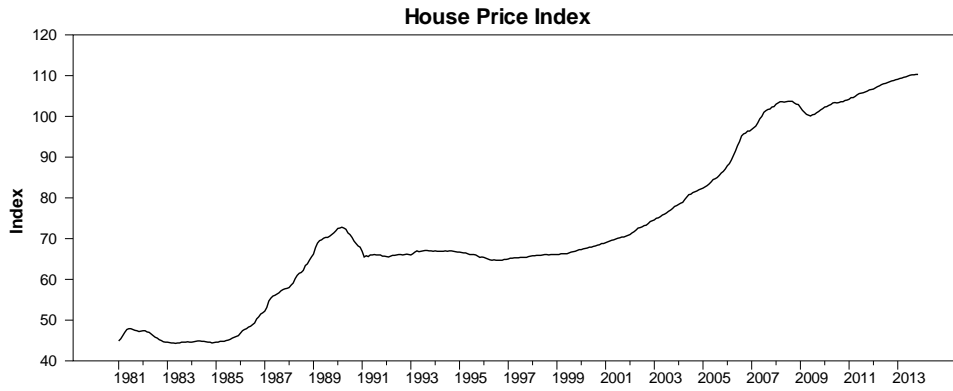


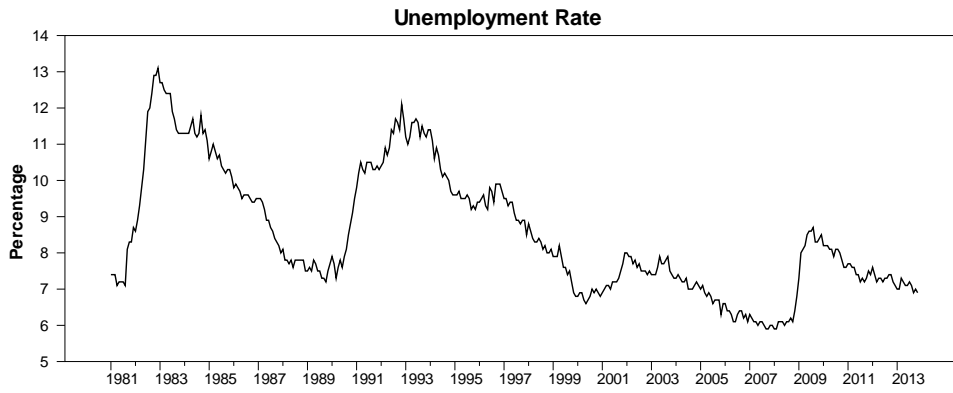
Figure 14



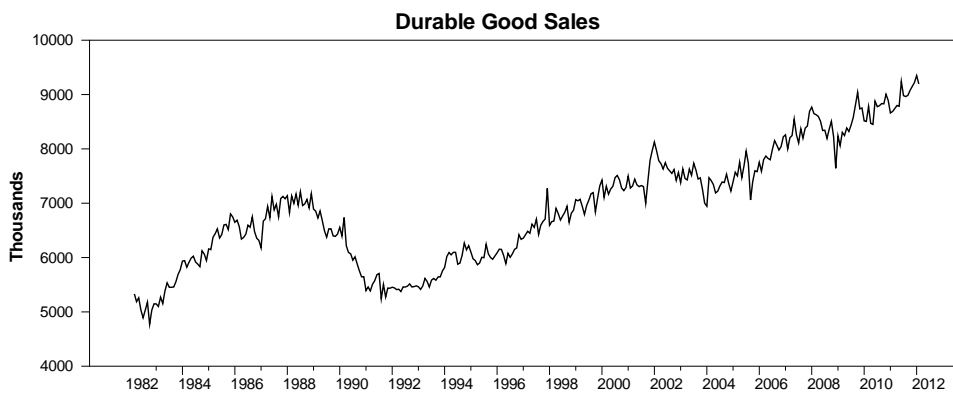
**Figure 15**



**Figure 16**



**Figure 17**



## Graphs of Log Difference Variables

Figure 18

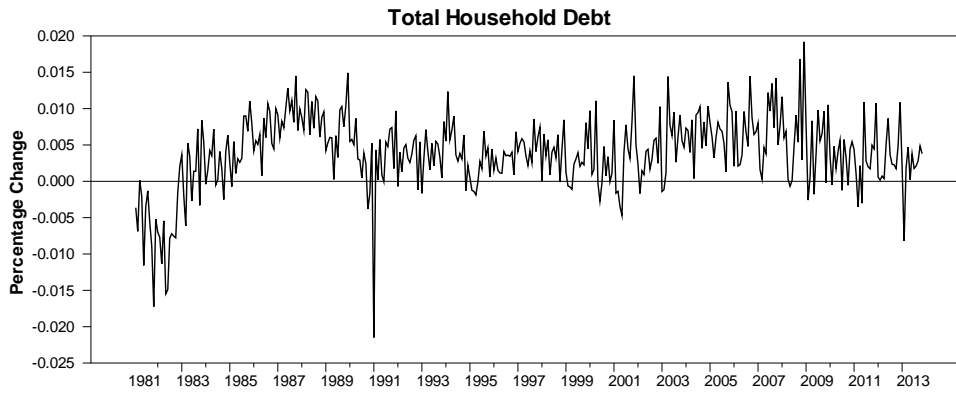


Figure 19

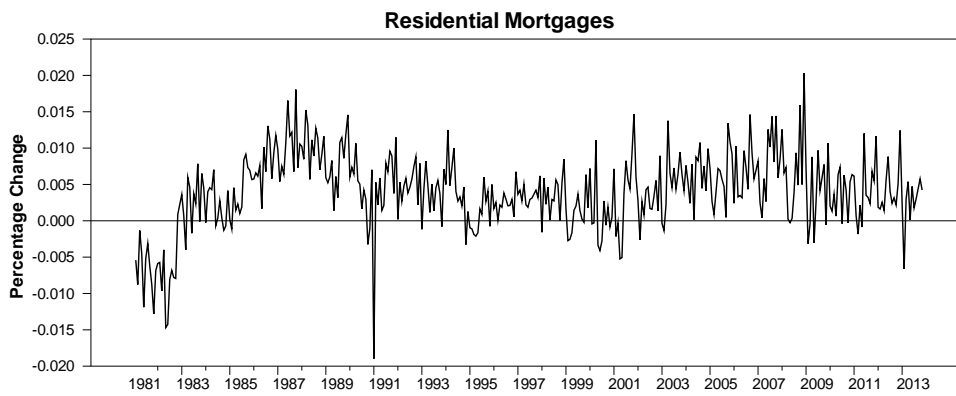
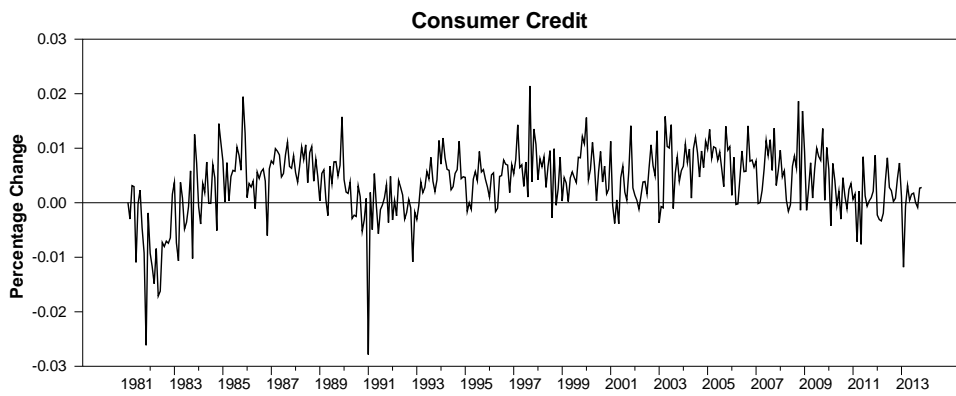
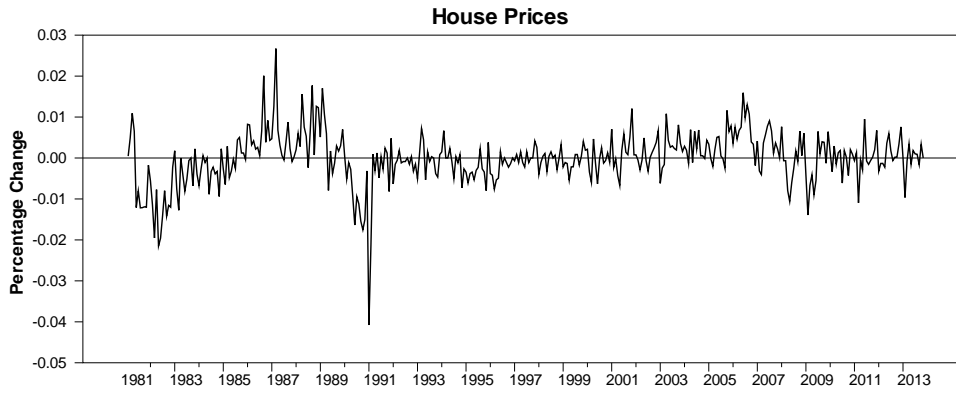


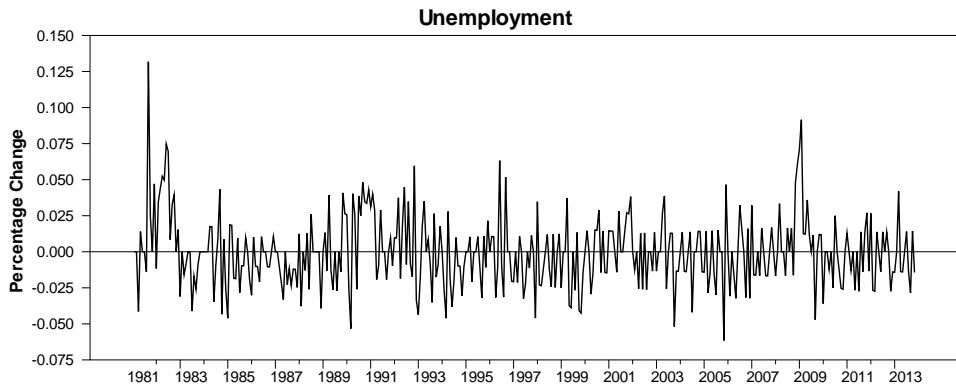
Figure 20



**Figure 21**



**Figure 22**



**Figure 23**

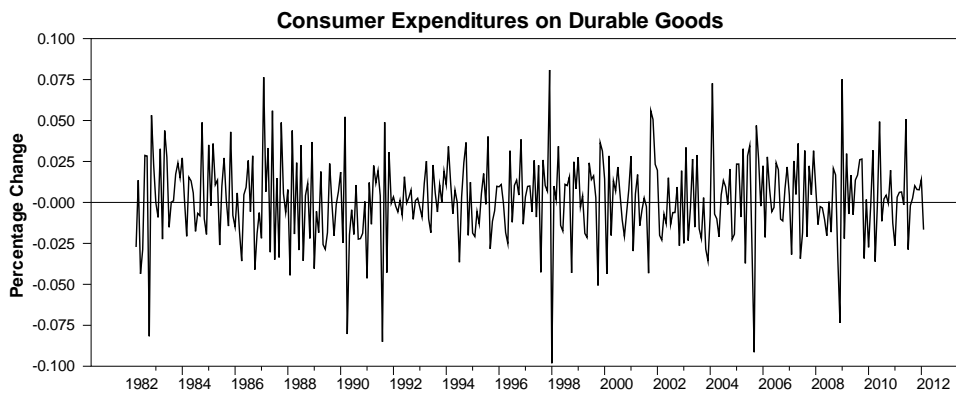


Figure 24 Normalized business cycle effects from the 1990-1991 recession

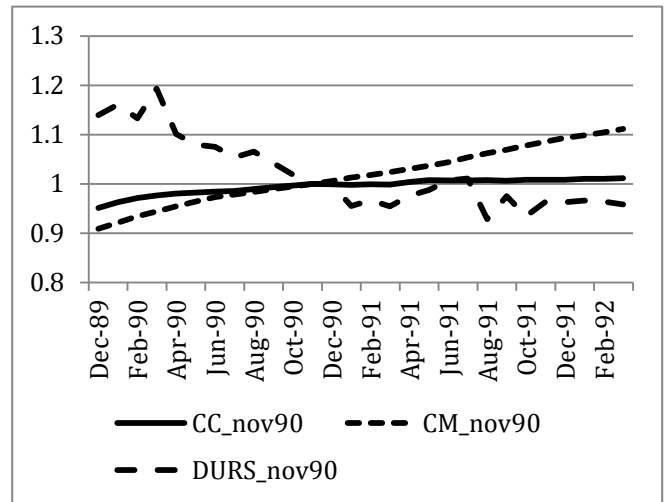
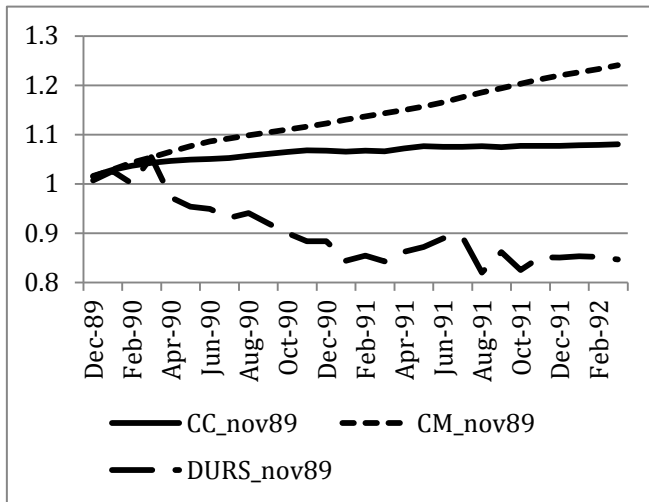


Figure 25 Normalized business cycle effects from the 2008 recession

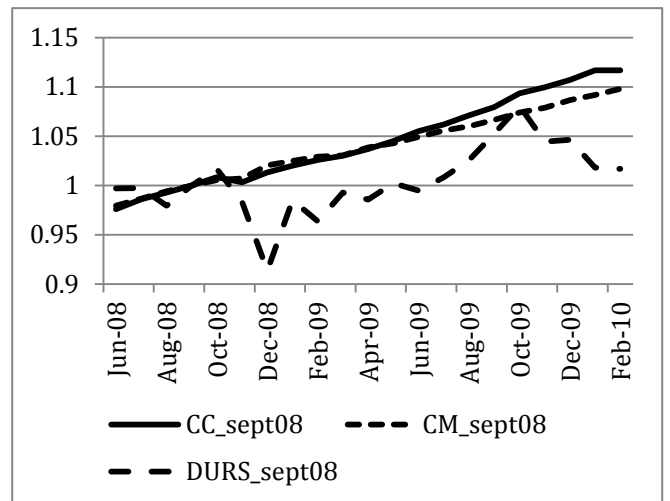
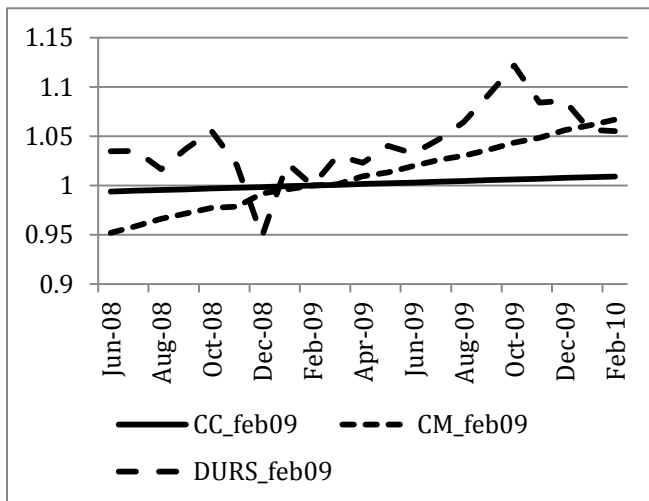


Figure 26 Real durable good sales

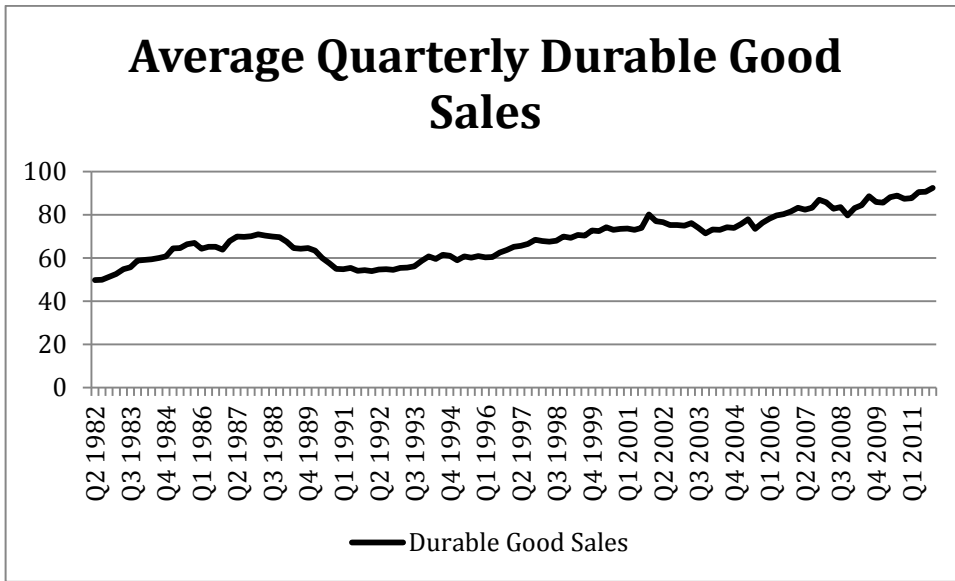


Figure 27 Real household expenditures

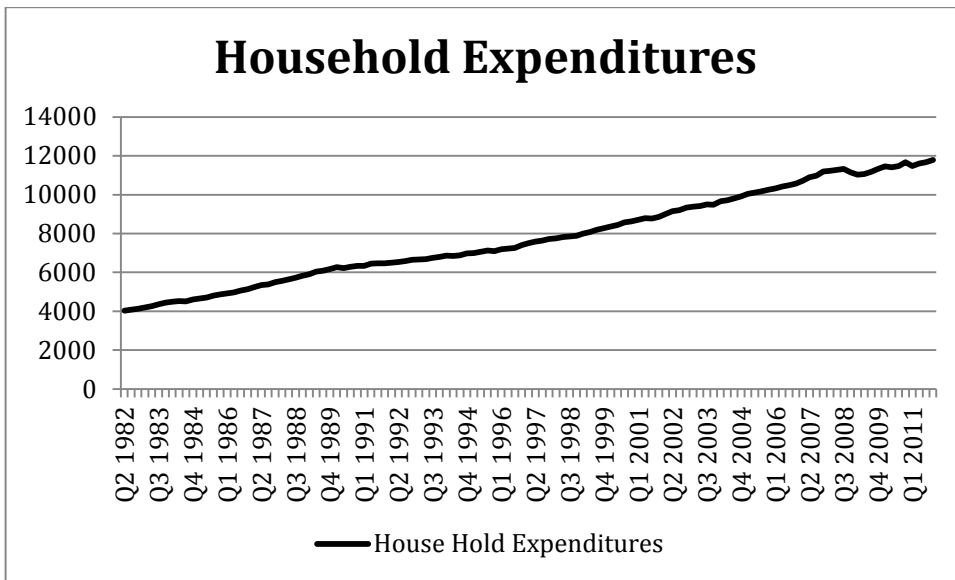


Figure 28

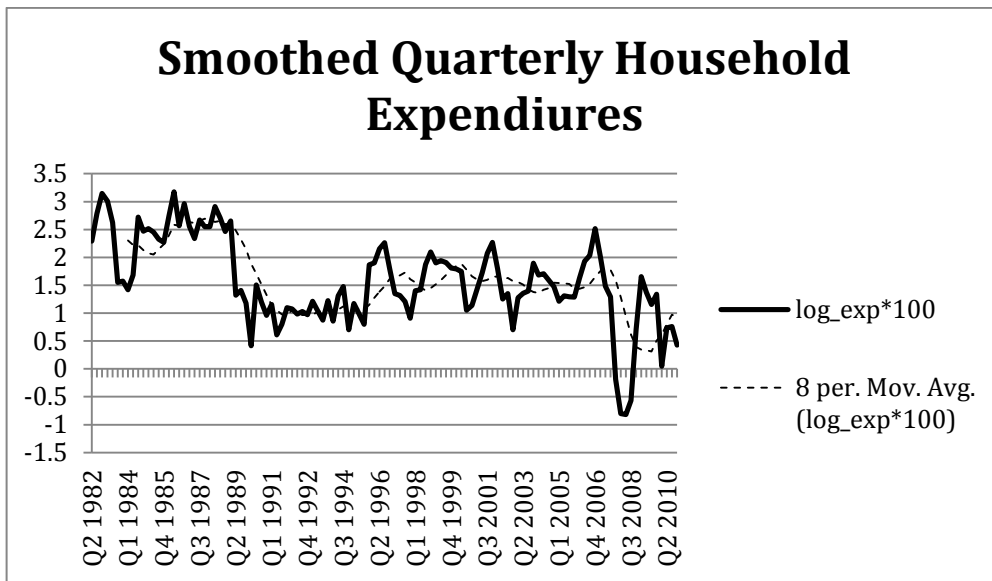
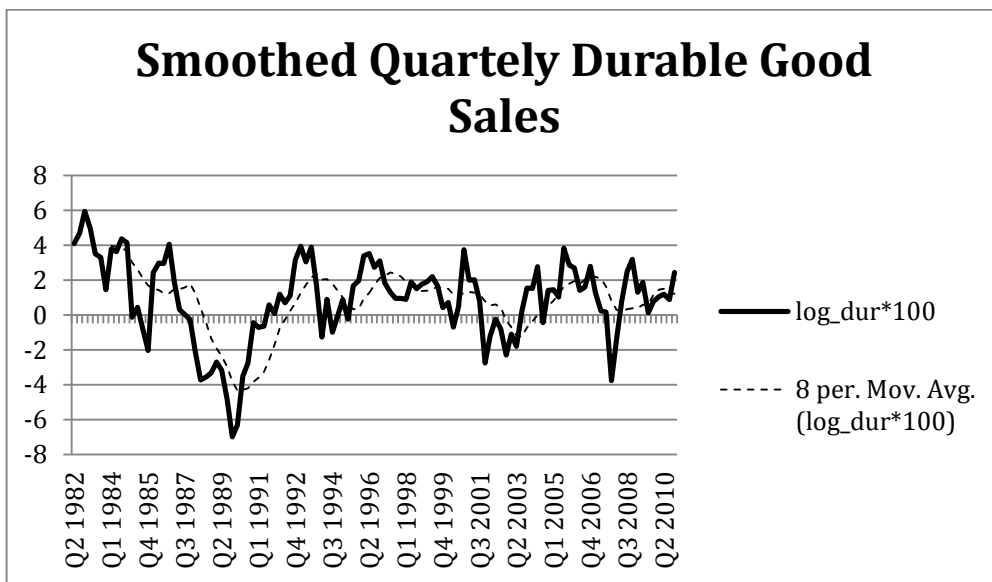


Figure 29



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