BI Norwegian Business School - campus Oslo

# GRA 19703

Master Thesis

Thesis Master of Science

High Household Debt and the Transmission of Monetary Policy: A Canadian Case Study

Navn: Ian Rae Sanderson

Start: 15.01.2021 09.00

Finish: 01.07.2021 12.00

# High Household Debt and the Effects on Monetary Policy Transmission: A Canadian Case Study

Ian Sanderson

Hand-in date:
18.06.2021

Campus:
BI Oslo

Examination code and name:
Masters Thesis

Advisor:
Leif Anders Thorsrud

Programme:
Master of Science in Applied Economics

# Content

# Abstract

This thesis investigates whether the transmission of monetary policy in Canada is affected by the level of household indebtedness. The answer to this has remained distinctly unclear in the literature across countries. Further, rising levels of household debt in Canada has created financial stability concerns for many policy makers. Using state dependent local projections, I show no significant non-linearity in the responses of key macroeconomic variables to contractionary monetary policy shocks. My analysis provides insights into the sensitivity of empirical analysis in the literature to detrending methods and shock specifications. I point to potential explanations for these results through the home equity loan channel and the structure of the mortgage market in Canada.

# 1. Introduction

Household debt levels have been rising in Canada and globally since the Great Recession. Figure 1 illustrates the growth of household indebtedness as a percentage of disposable income of roughly 100% to over 180%. From a policy makers perspective, this creates vulnerabilities in the economy and makes it less resilient to future shocks that may occur. This has prompted the Bank of Canada to highlight high household debt as a key vulnerability in the Canadian economy in its Annual Financial System Review dating back to 2013 (see *Financial System Review—2019*, n.d.). This pattern of growing household indebtedness has been seen in other nations including Sweden, Norway, and Australia (See Zabai (2017)). Common features among these economies include steadily rising housing prices, high rates of homeownership, and well-developed mortgage markets with varying levels of flexibility. The COVID-19 epidemic has only served to exacerbate household borrowing. Record levels of unemployment and economic shutdown have shocked economies and forced banks to once again slash rates.

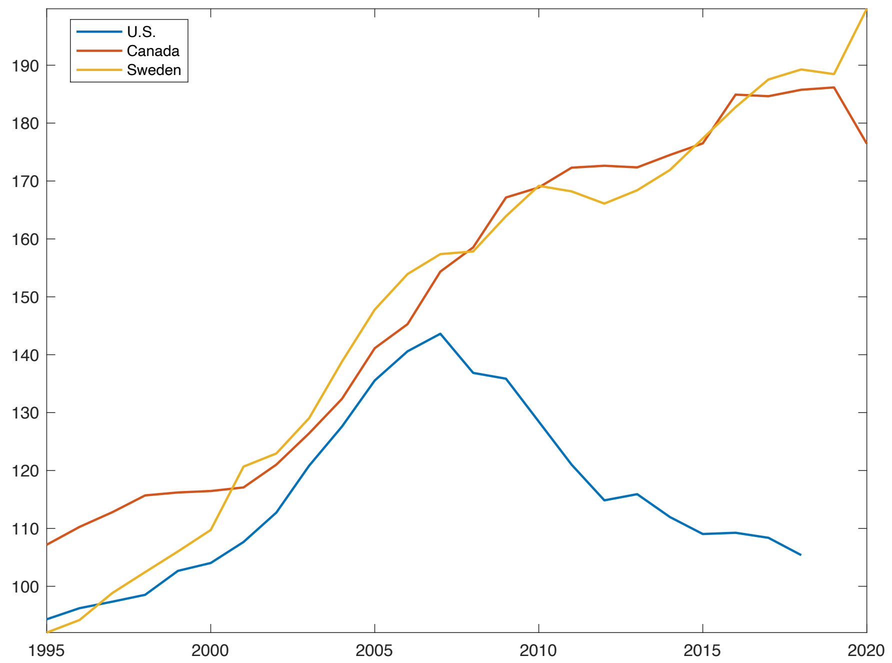



FIGURE 1: HOUSEHOLD DEBT AS A PERCENTAGE OF NET DISPOSABLE INCOME

SOURCE: OECD (2021), HOUSEHOLD DEBT (INDICATOR). DOI: 10.1787/F03B6469-EN (ACCESSED ON 01 JUNE 2021)

The relationship between household debt and the effectiveness of monetary policy has been a question asked by researchers as advanced economies have experienced tepid growth since the Great Recession. While much has been written, the answer to this question has remained distinctly unclear. In the U.S., there is evidence to suggest that when high levels of household debt prevail in the economy, the effectiveness of monetary policy is limited. Alpanda & Zubairy (2019) concluded that the response to monetary stimulus in the U.S. is muted during periods of high household debt across several key economic variables. They attribute this to credit constrained households not being able to access additional home equity caused by increasing asset prices and lower debt servicing costs[1]. Beraja et al. (2017), using U.S. loan level data, conclude that regions with low levels of home equity (high levels of leverage) responded less to monetary stimulus after the Great Recession. They point to households inability to refinance and extract equity when expansionary monetary policy was implemented. Mian & Sufi (2014, 2015) suggest precautionary savings motives, following the Great Recession, as making expansionary monetary policy ineffective. Highly leveraged households increase savings due to high equity loans and heightened risk of future employment. Prior to the Great Recession, Iacoviello  (2005) has shown that the effectiveness of monetary policy in the U.S. is limited during periods of high household debt across several key economic variables in a new-Keynesian dynamic equilibrium model (DSGE)[2].

Conversely, outside the U.S. the literature points consistently towards there being a greater effectiveness of monetary policy when households are highly indebted. Using panel data from 23 countries, Kim & Lim (2020) argue that monetary policy, both contractionary and expansionary, has a stronger effect on real economic activity when households are highly indebted. Flodén et al. (2019) find evidence to support that households with high levels of debt relative to their income respond substantially more to contractionary monetary policy compared to those with lower debt in Sweden. They also find shocks in the financial system have a greater impact when households are highly indebted, making the economy more vulnerable to those financial shocks. Calza et al. (2013) show the transmission mechanism of monetary shocks to consumption is stronger in countries with a higher debt-to-GDP ratio and a higher share of adjustable-rate mortgages, using vector autoregression (VAR).

[1] Alpanda & Zubairy (2019) call this the home equity loan channel and interest rate channel. See section 5 for further discussion

[2] This model provided the basis for significant research in the area, including DSGE modeling sited in this paper.

One key distinction stands out when comparing these two strands of research. The literature suggesting a muted response focuses on the U.S. market while contradictory evidence has predominantly come from research focused on panel data and E.U. countries. One may simply conclude that any state dependent effects caused by household debt levels in the Canadian economy will likely follow that of the U.S., given the similarities between the two economies. However, Kartashova & Zhou (2020) show that results in the literature surrounding the transmission of monetary policy to households from the U.S. are difficult to generalize to Canada given the differences in mortgage markets. Further, household debt levels in Canada and the U.S. have diverged significantly over the past decades (figure 1). Instead, Canada has seen debt levels continue to increase similar to economies such as Sweden, where the literature has shown stronger responses to monetary policy when households are highly indebted.

My thesis first answers the question of how the effectiveness of monetary policy is impacted by varying levels of household debt in Canada. I use state dependent local projections methods, as in Alpanda & Zubairy (2019) and Jordà (2005), to generate impulse responses for various macroeconomic variables to a contractionary Bank of Canada monetary policy shock. Much of the previous literature has focused on expansionary shocks in search of trying to explain the lack of economic growth following the Great Recession. I focus my analysis on a contractionary policy shock for two reasons. First, policy rates are once again at the effective zero lower bound. Second, there are rising concerns that inflation will accelerate due to unprecedented fiscal and monetary policy responses to the COVID-19 epidemic. This in turn will force central banks to respond by raising rates. The state of the economy is determined by deviations of the level of household debt in the economy from its long term trend for a sample period running Q1 1969 to Q4 2017. My analysis finds little evidence to support significant nonlinearity in the response of macroeconomic variables such as real GDP, inflation, consumption, savings rate, and house prices.

Secondly, this thesis sheds light on potential causes for differing results in the literature by comparing results across different detrending methods, monetary policy shock specifications, and definitions of household debt. While much of the research has focused on DSGE modelling, more recent works utilize empirical methods. I show that the filtering method chosen to detrend data when constructing a state variable in empirical research has a significant effect on the outcomes generated by state dependent analysis. I also show that the choice of identification method for monetary policy shocks can impact outcomes.

Thirdly, I discuss potential pathways of transmission and the role the mortgage market plays in monetary policy transmission. Differences across the literature can partially be explained by different economies having varying degrees of flexibility in their mortgage markets. This has knock-on effects to transmission pathways that can serve to amplify or dampen policy shocks. While empirical methods are limited in their ability to show transmission pathways, I present impulse responses using state dependent local projections to uncover evidence of potential pathways at work in Canada. I find little evidence that the response through the home equity channel is state dependent. An analysis of the Canadian mortgage market specifically leads me to hypothesis that the predominance of short-term fixed rate loans could help explain the lack of state dependence in my results. Lastly, I consider the potential for differing outcomes in the literature being explained by asymmetric responses to contractionary and expansionary policy shocks when undertaking empirical research.

This thesis contributes to the literature in two ways. First, I contribute to the growing body of literature utilizing empirical methods in studying the state dependence of monetary policy as it relates to the level of household debt. This follows the work of Alpanda & Zubairy (2019) who use state dependent local projections in their analysis, and Kim & Lim (2020) who utilize an integrated panel vector autoregression approach to uncover state dependent responses. Secondly, I contribute to the body literature by specifically studying Canada. While Canada has been studied in panel VAR approaches, such as that used by Kim & Lim (2020), there has been no specific analysis of Canada conducted to my knowledge.

The remainder of this paper is laid out as follows. Section 2 provides a breakdown of the data used in my analysis. Section 3 outlines the methodology used and the construction of key variables. Section 4 presents the main results of my analysis. Section 5 provides a discussion of potential channels and the role of the mortgage market. Section 6 summarizes my findings and presents further avenues of research.

## 2. Data

| Data Series | Description | Measurement | Frequency | Availability | Source |
|---|---|---|---|---|---|
| Real GDP | Expenditure Based - Chained 2012 CAD | Chained 2012 CAD | Quarterly | 1961 - Current | Stats Canada |
| CPI | Consumer Price Index - All Items Base Year 2015 | All Items Base Year 2015 | Quarterly | 1961 - Current | Stats Canada |
| FX Rate | BIS Effective Exchange Rate | CAD/USD | Monthly | 1970 - Current | BIS |
| BCPI | Bank of Canada Commodity Price Index | USD | Monthly | 1972 - Current | Bank Of Canada |
| BoC | Overnight Bank of Canada Rate | Nominal rate | Quarterly | 1961 - Current | FRED |
| Disposable Income | Household disposable income | Seasonally adjusted at annual rates | Quarterly | 1961 - Current | Stats Canada |
| HELOC | Home equity lines of credit | Seasonally adjusted | Monthly | 1990 - Current | Stats Canada |
| Savings | Household savings rate | Seasonally adjusted at annual rates | Quarterly | 1961 - Current | Stats Canada |
| Consumption | Household final consumption expenditure | Seasonally adjusted at chained 2012 CAD | Quarterly | 1961 - Current | Stats Canada |
| Unemployment | Unemployment rate: Age 15 and over | Seasonally adjusted at annual rates | Quarterly | 1960 - Current | FRED |
| Household Debt | Total household credit | Seasonally adjusted | Monthly | 1969 - Current | Bank Of Canada |
| Mortgage Debt | Total residential mortgage debt | Seasonally adjusted | Monthly | 1969 - Current | Bank Of Canada |
| House Prices | Residential property prices | Base year 2010 = 100 | Quarterly | 1970 - Current | FRED |

TABLE 1: DATA SOURCES

For conducting my analysis, I utilize quarterly data for Canada with a considered sample period of Q1 1972 – Q4 2017 (See Table 1 for sources and uses). Quarterly data is used since real GDP is only available at a monthly frequency dating back to 1997[3]. The beginning of the sample is dictated by the availability Bank of Canada Commodity Price Index. One method I use in determining the state of the economy is the Hodrick & Prescott (1997) (HP) filter. This filter has a well-known end-point problem. To address this, I extend the sample to Q1 1969 – Q4 2019 for determining the state variable and remove the last 8 quarters in my analysis, giving an end date for my analysis of Q4 2017. I do not consider 2020 in my sample to avoid economic data that was affected by the COVID-19 epidemic. Monthly data series are aggregated to quarterly by taking the average over 3 months. All variables are available in Canadian dollars except for the BCPI, which I convert to Canadian dollars using the BIS Effective Exchange Rate[4]. Nominal variables are converted to real values using CPI to deflate them.

The policy rate I choose to measure is the Overnight Bank of Canada rate. The bank directly controls and targets the overnight rate therefore, innovations of this rate represent a better measure of policy shocks[5]. Total household credit is a combination of both consumer credit and residential mortgage credit to capture

[3] It is common to use the monthly industrial production index as a proxy due to its high correlation with real GDP. However, the state variable must be determined using GDP and therefore precludes me from using it.

[4] BCPI is a chain Fisher price index constructed based on spot or transaction prices in U.S. dollars of 26 commodities produced in Canada and sold internationally.

[5] This follows Champagne & Sekkel (2018) who use the overnight rate in constructing both VAR and local projection models. Their analysis was also robust to using the 3 month treasury rate over a similar sample period.

households overall leverage. A common alternate measure of CPI is CPIX which excludes volatile components such as energy prices and food. I have tested the robustness of my results to CPIX and note no significant change[6]. All variables are measured in logs except for the overnight rate, savings rate, and unemployment rate. Further details are provided in the methodology section.

## 3. Methodology

I follow the methodology outlined in Alpanda & Zubairy (2019) for estimating state-dependant models and calculating impulse responses utilizing local projections. This follows the local projection methodology outlined in Jordà (2005) which is extended to account for state dependence in Ramey & Zubairy (2018)[7]. The Jordà method involves estimating a series of regressions for each horizon, $h$, and for each variable. The linear model is then:

$$z_{t+h} - z_{t-1} = \alpha_h + \psi_h(L)y_t + \beta_h shock_t + \varepsilon_{t+h} \quad \text{for} \quad h = 0, 1, 2, \ldots, \tag{1}$$

With $z$ is the variable of interest, $y$ is a vector of control variables, $\psi_h(L)$ is a polynomial in the lag operator, and $shock$ is the identified monetary policy shock. $\beta_h$ is the estimated coefficient giving the percentage (point) change of $z$ at horizon $h$ to the shock at time $t$. Therefore, impulse responses are constructed as a sequence of $\beta_h$'s estimated in a series of separate regressions. For control variables, all models include four lags of the Bank of Canada overnight rate in levels and four lags of log real GDP, annual change in the log of CPI, log real effective exchange rate, and log Bank of Canada Commodity Price Index, all in differences[8]. For analysis of additional macroeconomic variables, I add four lags of the variable of interest, in log differences, to the set of controls.

[6] Champagne & Sekkel (2018) find their results to be robust to alternate measure of CPI on a similar sample period.

[7] Ramey & Zubairy (2018) do not use the difference in $z$. However, this methodology is common and follows Champagne & Sekkel (2018) and Holm et al. (2020) to achieve the interpretation of impulse responses as percentage (point) change.

[8] I use 4 lags to represent 1 year of lags which is standard. I note BIC and AIC tests suggests a lag structure of 5 but this had no effect on results.

The Jordà method is adapted to estimating a state dependent model simply by estimating a set of regressions for each horizon as follows:

$$z_{t+h} - z_{t-1} = I_{t-1}\left[\alpha_{A,h} + \psi_{A,h}(L)y_t + \beta_{A,h}shock_t\right] + (1 - I_{t-1})[\alpha_{B,h} + \psi_{B,h}(L)y_t + \beta_{B,h}shock_t] + \varepsilon_{t+h} \quad (2)$$

where $I_{t-1} \in \{0, 1\}$ is a dummy variable that represents the state of household indebtedness before the monetary policy shock occurs. For example, if the policy shock occurs in 2008, the state of the economy is determined by the state in 2007. More specifically, $I_{t-1}$ has a value of 1 in the high-debt state and a value of 0 in the low-debt state. Further discussion of how this variable is determined is discussed in the following subsection. All coefficients of the model (other than deterministic trends) are allowed to vary according to the state of the economy. A consequence of using the Jordà method is serial correlation in the error terms caused by the successive leading of the dependent variable. Therefore, I account for this by using the Newey-West correction for the standard errors (Newey & West (1987)).

A similar analysis could also have been conducted using various vector autoregression (VAR) approaches. This includes threshold VAR, switching VAR, and interacted panel VAR (as used in Kim & Lim (2020)) methods. However, the Jordà method offers the benefit of being able to estimate the model by simple OLS regression techniques. Further, as noted by Alpanda & Zubairy (2019), the local projection methodology does not impose any underlying restrictions on the dynamics of the system and therefore makes it more robust to model misspecification. They also note the benefit over a regime switching VAR in that there is no need to define the length of any given state of the economy or how transitions between the states occur. The coefficients $\beta_h s$ capture the average effect of the policy shock as determined by the initial state of the economy. Since the coefficients are capturing the average effect, they also encapsulate any changes in the state of the economy. Furthermore, the lagged control variables on the right-hand side accounts for any changes between the two states caused by other parameters in the economy.

There are two distinct challenges related to equation (2). First, a method for determining the state of the economy, $I_{t-1}$, must be justified. This involves choosing a data series that reflects the prevailing level of household debt in the economy and applying a detrending method to determine high and low debt states. Secondly, monetary policy shocks must be identified. There are several methods for doing this, of which two are presented.

### 3.1 Defining Low and High Debt States

Alpanda & Zubairy (2019) construct their *debt gap* by measuring deviations from a smooth trend using the HP Filter with a high smoothing parameter, $\lambda = 10^4$. This follows the methodology used in other works including Drehmann & Tsatsaronis (2014), Bernardini & Peersman (2018), and later by Kim & Lim (2020). Measuring deviations from trend as opposed to deviations from an equilibrium level of debt better controls for changes in the economy including economic growth, financial progress, and demographic factors.[9] This effectively captures the relative debt burden households face rather than simply the level of household debt.

A key component of my analysis is testing different filtering methods for constructing the *debt gap* to determine if it influences outcomes. The works cited above utilize the two sided HP filter (hereafter HP filter). Hamilton (2018) argues that the HP filter introduces spurious relations that are unrelated to the underlying data-generating process. He instead suggests that running a regression of the growth rate of a variable on lagged values offers a more robust method to detrending data (hereafter the Hamilton filter). Rather than argue for which one is correct, I run separate models using each method for detrending. In addition, I have chosen to use the one-sided HP filter, as utilized in Alpanda & Zubairy (2019). The one sided HP filter is strictly backward looking and therefore eliminates the end point problem at the end of the sample. One key component of these filters is determining the length of the cycle being measured. The credit cycle is on average twice as long as the business cycle[10]. This implies the use of a

[9] Bernardini & Peersman (2018) state that financial progress represents the set of slow-moving factors allowing the debt-to-GDP ratio to increase over time following a long-run trend but without actually increasing the underlying cost of servicing it. These effect the two key factors in determining the debt burden including the average interest rate and average maturity remaining on loans.

[10] The use of a high smoothing parameter is justified in that the credit cycle is longer than the business cycle therefore a smoother trend better captures the cycle. Alpanda & Zubairy (2019) and Kim & Lim (2020) regard the credit cycle as twice as long as the business cycle.

very high smoothing parameter, $\lambda = 10^4$, for the HP filter[11]. Hamilton (2018) suggests using the five year growth rate when analysing debt cycles.

The second component required to construct the *debt gap* is an appropriate measure of household debt. Household debt to GDP is commonly used as GDP better captures population growth and changes in the economy over the sample period. It also reflects the total leverage that households have undertaken. Therefore, I use this as my main measure when conducting my analysis. For the purposes of robustness, I include two alternate specifications of household debt as an additional exercise in the results section.

Figure 2 plots household debt to GDP. Both household debt and GDP are measured in nominal terms for the purpose of constructing the variable. Over the sample period, Canada experienced 5 recessions. The recessions in 1980 and 1982 were followed by periods of deleveraging as interest rates increased sharply to fight inflation during this time. The 1990 and 2009 recessions were both led by periods of increasing household debt. However, these recessions were not followed by periods of deleveraging. It is worth noting why this deleveraging did not occur, particularly after the 2009 recession. First, Canada's financial institutions withstood the crisis due to a much tighter regulatory environment and kept lending throughout the crisis. Second, the majority of loans are originated by banks and therefore do not have incentive for high risk or sub-prime lending. This meant that banks were able to continue to lend throughout the crisis and onwards. The lack of deleveraging gives the series an overall upwards trend, providing some evidence for the theory of financial progress leading to an increasing trend in household debt overall.

[11] Appendix A.1 plots the *debt gap* with the HP Filter using alternate values of $\lambda$.

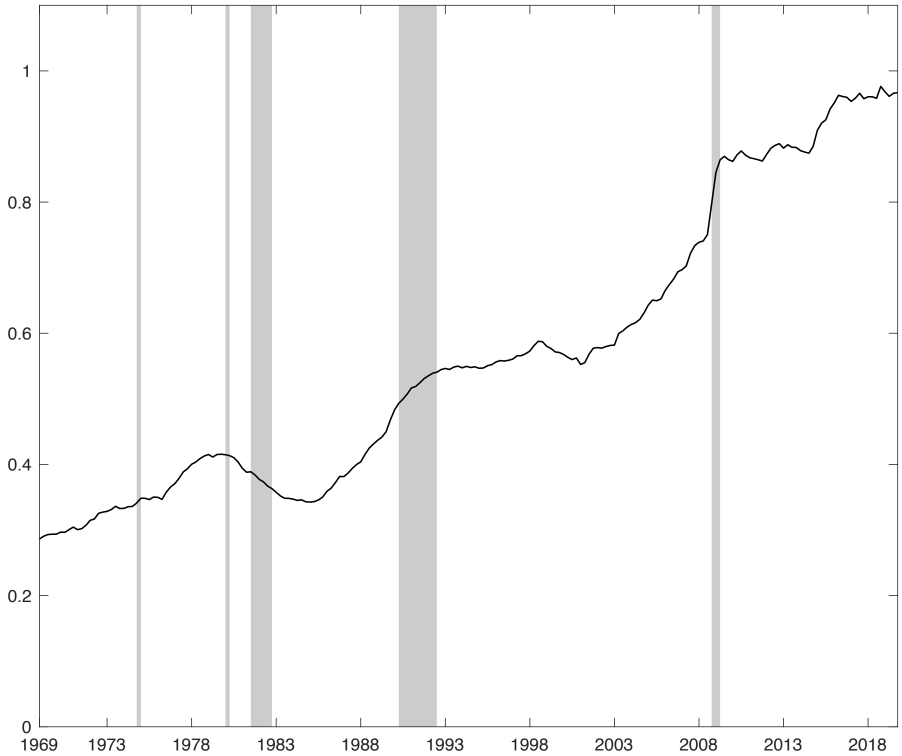



FIGURE 2: HOUSEHOLD DEBT-TO-GDP FOR CANADA.

*NOTE: GREY SHADED BANDS CORRESPOND TO RECESSIONS IN CANADA AS DETERMINED BY THE C.D. HOWE INSTITUTE.*

Figure 3 plots the implied *debt gap* for the three filtering methods applied to household debt to GDP. This is represented as the percentage deviation of household debt to GDP from its respective trend. For the main analysis I use a threshold of zero, meaning any deviation above trend is considered to be a high debt state. Again, the magnitude of the deviation does not matter, only when the gap occurs. I run an additional model where this threshold is increased in the results section to consider only very high debt states.

It is evident from inspection that the one sided HP filter and Hamilton filter largely capture the same periods of high and low debt. This could be attributed to the forward looking nature of the two sided HP filter capturing the increasing trend overtime. A clear difference between the filters occurs around the 1990 recession and leading into the 2009 recession. Regardless of the filtering method used, approximately 50% of the sample is considered to be in the high debt state and is fairly evenly distributed across the sample period. This is beneficial for my analysis as it means results are unlikely to be driven by one specific period over the sample.

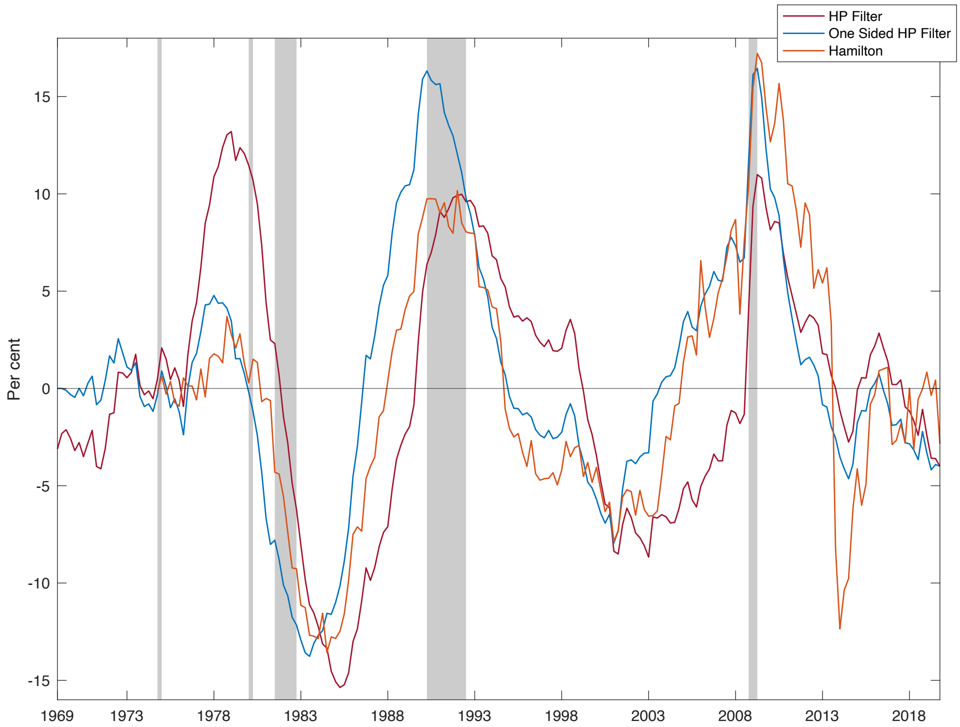



FIGURE 3: ALTERNATE FILTERING METHODS.

*NOTE: GREY SHADED BANDS CORRESPOND TO RECESSIONS IN CANADA AS DETERMINED BY THE C.D. HOWE INSTITUTE. FOR BOTH HP FILTERS I USE $\lambda = 10^4$. HAMILTON FILTER IS CALCULATED USING THE 5 YEAR GROWTH RATE.*

### 3.2 Identifying Monetary Policy Shocks

The second component that must be specified in equations (1) and (2) is the $shock$ variable. To accomplish this, I entertain two potentially different shock series utilizing different identification methods[12].

First, I follow the methods outlined by Christiano et al. (1996) in constructing policy shocks by recovering structural residuals from a multivariate VAR using the Cholesky decomposition. The multivariate VAR model is given by the following equation:

$$X_t = A_0 + A_1 X_{t-1} + A_2 X_{t-2} + \cdots + A_q X_{t-q} + u_t \quad (3)$$

where $X_t$ represents a vector of variables and $u_t$ represent a vector of VAR disturbances which are assumed to be serially uncorrelated. Underlying structural, or economic shocks, $\varepsilon_t$, can be related to $u_t$ by:

$$u_t = C\varepsilon_t \quad (4)$$

[12] This follows the methodology used in Alpanda & Zubairy (2019). They first construct a VAR shock using the structural residuals from a 3 variable VAR using the Cholesky decomposition on U.S. data. They then test the robustness using the Romer & Romer (2004) narrative shock series.

where C is a lower triangular matrix and $\varepsilon_t$ has a covariance matrix equal to identity. The variables included in (3) are the log of real GDP ($lGDP$), annual change in the log of CPI ($Infl$), log of the real effective exchange rate ($lFXrate$), log of the Bank of Canada Commodity Price Index which has been converted from $USD to $CAD using the real effective exchange rate ($lBCPI$), and the policy rate which is represented by the Bank of Canada overnight rate ($BoC$)[13]. I employ a recursive identification strategy utilizing the ordering $X_t = [lGDP\ \ Infl\ \ lBCPI\ BoC\ lFXrate]$. This assumes that the policy rate responds contemporaneously to non-policy variables with the exception of the foreign exchange rate, similar to that from Christiano et al. (1996)[14]. As Canada is a small open economy, it is common to include the foreign exchange rate ordered after the policy rate in the Cholesky Decomposition. This assumes the policy makers do not contemporaneously respond to shocks of the FX rate[15]. The commodity price index is included in the information set of the policy maker as an indicator for future inflation and to help solve the well-known "price puzzle" in VAR models. The model is estimated with 4 lags which represents one year[16]. This method provides a shock series from Q1 1973 to Q4 2019 and is hereafter referred to as the VAR shock.

A second common approach used in identifying monetary policy shocks is the narrative approach, as initially outlined by Romer & Romer (2004). I turn to a narrative shock series constructed by Champagne & Sekkel (2018) for the Bank of Canada policy rate (hereafter the narrative approach). The shock series is constructed utilizing real-time data and forecasts from the Bank of Canada's staff projections from Q1 1974 – Q3 2015[17]. This series captures the structural break in monetary policy in 1991 when the Bank of Canada adopted an interest targeting mandate. The authors argue this is necessary to successfully recover an accurate shock series.

[13] The Bank of Canada directly controls and targets the overnight rate therefore, innovations of this rate represent a better measure of policy shocks.

[14] see Christiano et al. (1999) for an extensive review of identification strategies.

[15] Eichenbaum & Evans (1995) use this methodology to help with the "price puzzle".

[16] To further justify lag selection, BIC and AIC tests determine an optimal lag structure of 5.

[17] The series ends in 2015 as this is when staff projetions stopped being made available.

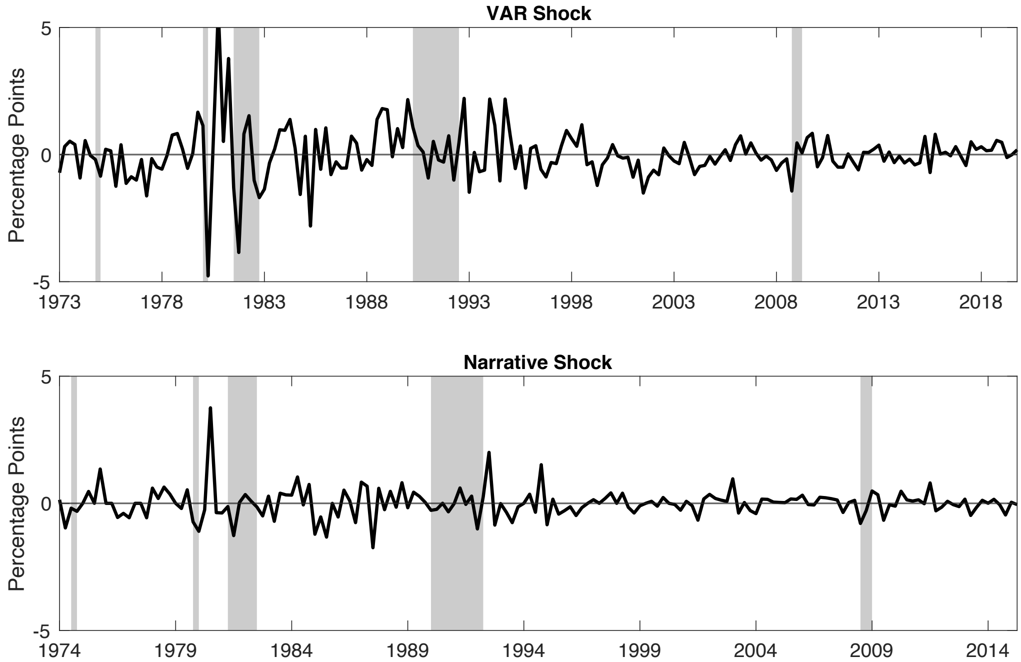



FIGURE 4: POLICY SHOCKS GENERATED BY STRUCTURAL VAR UNDER TIMING RESTRICTIONS AND NARRATIVE APPROACH BY CHAMPAGNE & SEKKEL (2018)

*NOTE: GREY SHADED BANDS CORRESPOND TO RECESSIONS IN CANADA AS DETERMINED BY THE C.D. HOWE INSTITUTE.*

A comparison of the shock series is provided in figure 4. Both shock series follow a similar pattern with regards to the direction of shocks, however the VAR shocks are typically of a greater magnitude. Both series exhibit greater amounts of volatility at the start of the sample due uncertainty in the Canadian economy surrounding the three recessions spanning the 1980's into the early 1990's. We see evidence of a big contractionary shock preceding the 1982 recession which led to the significant deleveraging in the housing market. In the second half of the sample, volatility decreases significantly. Champagne & Sekkel (2018) attribute this to the Bank of Canada's adoption of an interest rate targeting regime in 1992. While these series are similar, they provide two distinctly different identification methods making them fit for testing the sensitivity of my model. Appendix A.2 provides a histogram of the dispersion of shocks across high and low debt states as defined using the HP filter. Both series are well distributed around 0 with an ample number of shocks for each state of the economy.

## 4. Results

This section reports the results of the linear model, outlined by equation (1), and various specifications of state dependant models, outlined by equation (2). First, I present the linear model for both shock series to define the response of the macroeconomy to a 100 basis point (bps) contractionary Bank of Canada policy shock. Next, I look to uncover the presence of any non-linearity based on the debt state by analysing the results of various state dependent models using different filtering methodologies. Finally, I extend this analysis to look at alternate definitions of household debt and *debt gap* threshold.

### 4.1 Linear Model

Figure 5 provides a comparison of linear impulse responses to a 100 bps contractionary monetary policy shock to the Bank of Canada overnight rate for the main macroeconomic variables, using both shock series. Generally, the models follow very similar dynamics. GDP displays an initial overshoot before declining, becoming statistically significant after 6 periods with a peak decline of -0.6%. Under the VAR shock, inflation exhibits the well documented "price puzzle" whereby it initially increases in response to a contractionary shock before declining after 14 periods. This is not seen in the Narrative shock[18]. The policy rate shows signs of interest-rate inertia as the rate declines slowly in response to the shock, returning to steady state after 8 periods, before reversing and declining. This is consistent with what is deemed to be good monetary policy as set out in Woodford (2003).The response of the exchange rate is not significant at any horizon. It appears to initially appreciate with the shock before declining in the long run. This is in line with uncovered interest rate parity (UIP) conditions and the Dornbusch overshooting hypothesis (Dornbusch (1976)).

[18] Champagne & Sekkel (2018) show that accounting for the structural break in monetary policy in their shock series helps solve the "price puzzle".

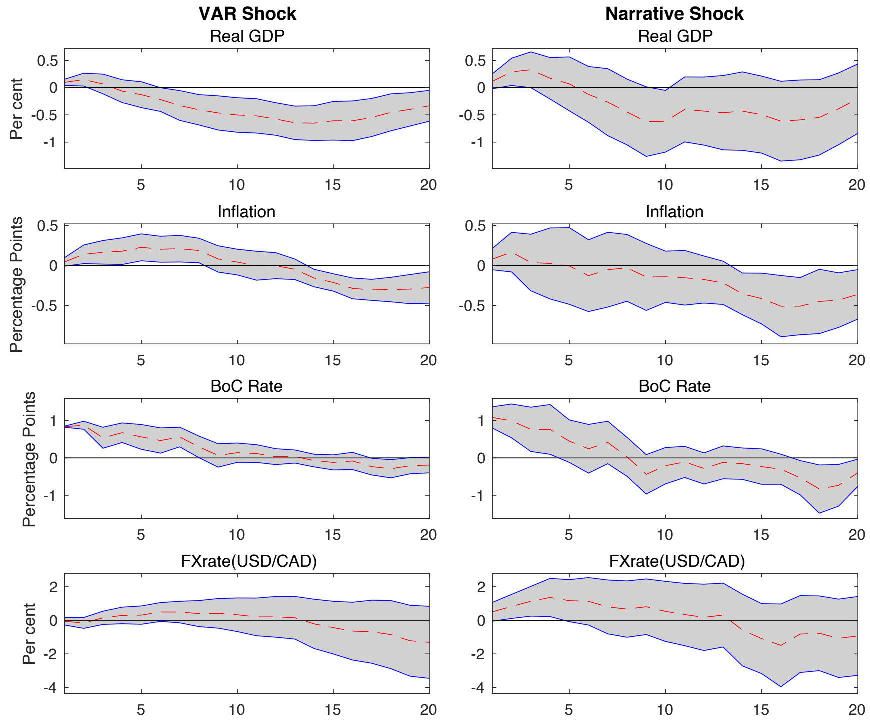



FIGURE 5: LINEAR MODEL IMPULSE RESPONSES FOR BASELINE MACROECONOMIC VARIABLES

*NOTE: COLUMN 1 USES POLICY SHOCKS IDENTIFIED USING THE VAR METHOD. COLUMN 2 USES POLICY SHOCKS IDENTIFIED USING THE NARRATIVE APPROACH. GREY SHADED AREA REPRESENTS 90 PERCENT CONFIDENCE BANDS.*

Figure 6 provides impulse responses for various other macroeconomic variables of interest. Again, both models follow similar dynamics but variables do respond more when using the VAR shock. Unemployment and savings rates increase while consumption, house prices, and household debt decline. This is the standard result in response to a contractionary monetary policy shock.

This analysis shows that the economy overall has a limited but contractionary response to a 100 bps contractionary monetary policy shock. Both shock series produce roughly the same dynamics and the peak responses are in line with one another. However, the Narrative shock model is poorly estimated compared to the VAR shock.

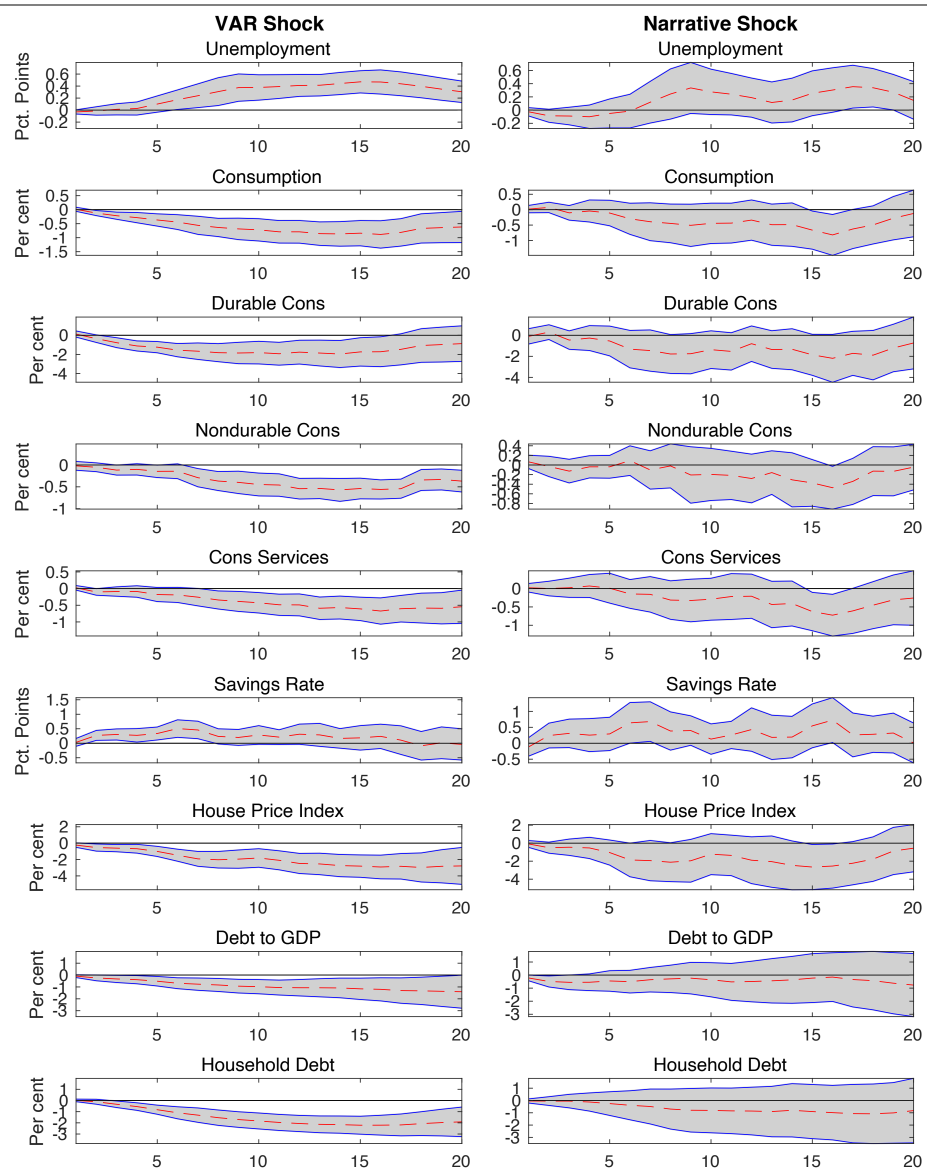



FIGURE 6: LINEAR MODEL IMPULSE RESPONSES FOR EXTENDED MACROECONOMIC VARIABLES

*NOTE: COLUMN 1 USES POLICY SHOCKS IDENTIFIED USING THE VAR METHOD. COLUMN 2 USES POLICY SHOCKS IDENTIFIED USING THE NARRATIVE APPROACH. GREY SHADED AREA REPRESENTS 90 PERCENT CONFIDENCE BANDS.*

## 4.2 State Dependant Model

Next, I present the results for the state dependant models. These results are presented according to the shock type and provide a comparison of impulse responses across three different filtering methods.

*VAR Shock Identification*

Figure 7 plots state dependant impulse responses of key macroeconomic variables to a 100 bps contractionary monetary policy shock to the Bank of Canada overnight rate, identified using the VAR approach.

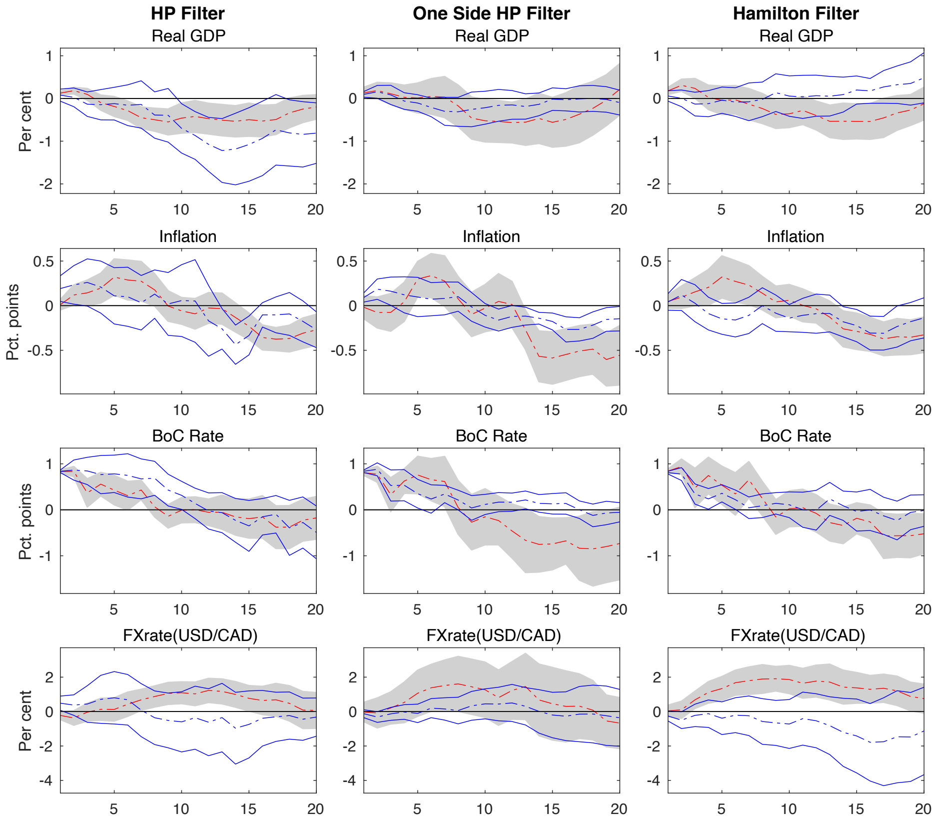



FIGURE 7: STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

There is little evidence to suggest a difference in response between states. In the low debt state, the response of GDP varies across the filtering methodologies. In the high debt state, GDP initially overshoots before declining by 0.5% after 10 periods. The long run response is similar, with no permanent impact on GDP. Inflation exhibits the well-known “price puzzle”, particularly in the high debt state. Again, there is no significant difference in the response of inflation across low and high debt states. The peak decline is approximately the same and occurring after 15 periods.

The policy rate is largely unaffected by the state of the economy. One point to highlight is that the rate is more likely to be reversed and declines for some periods in the high household debt state. The exchange rate responds more in the high debt state, appreciating between 1- 2% across models. This has implications as the Bank of Canada has historically responded to exchange rate movements by leaning against them, as shown in Zettelmeyer (2004). This may indicate why the policy rate reverses more in the high debt state as the central bank fights exchange rate appreciation.

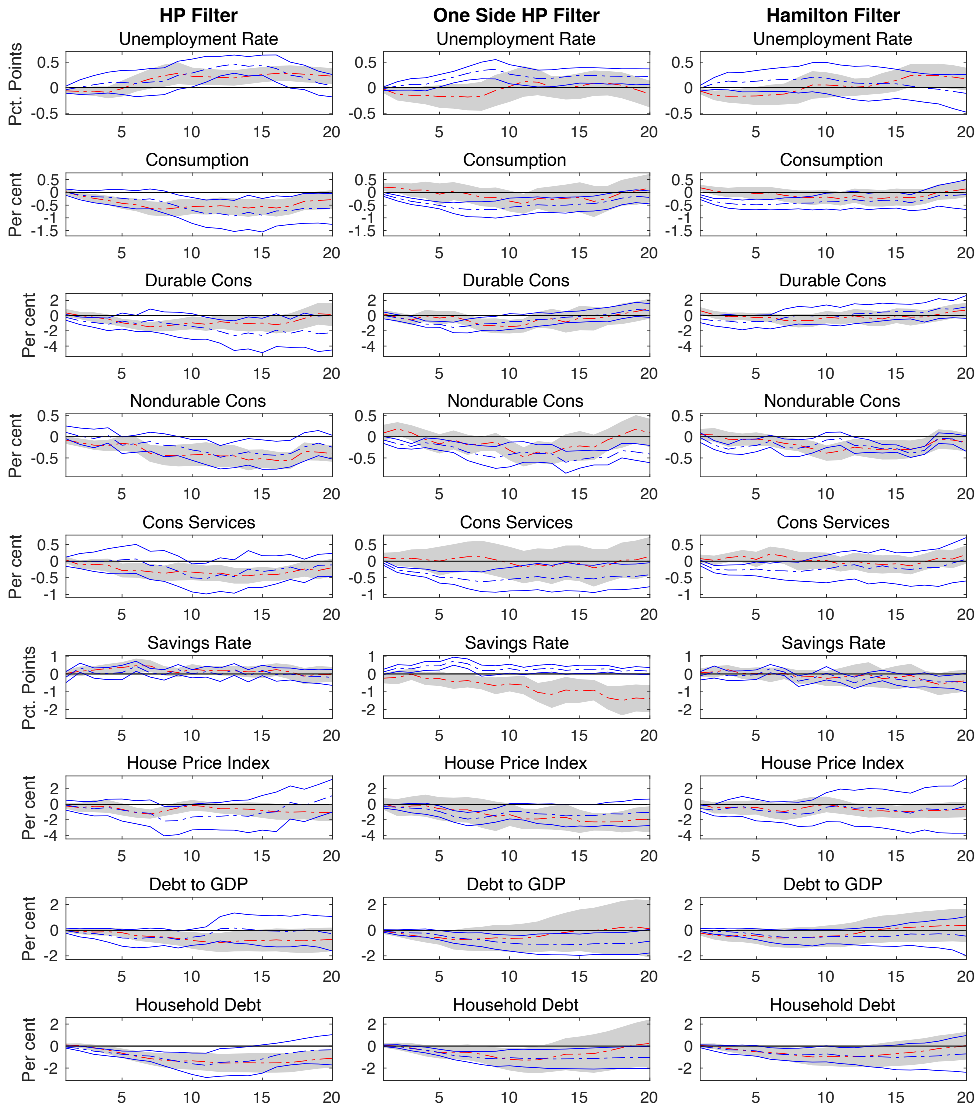



FIGURE 8: EXTENDED STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

Figure 8 plots the responses of other macroeconomic variables across the two states. As with the key macroeconomic variables, there exists little evidence of nonlinearity in the response of the economy. There is some evidence to suggest a greater peak response in the low debt state. Consumption consistently declines and unemployment exhibits a greater peak response. However, long run effects are broadly the same. The savings rate does not respond significantly except for under the one-sided HP filter, where it declines significantly in the high debt state. Household variables, including prices, debt to GDP, and debt, all decline as in the linear model and do not show any significant differences in responses across states.

In general, the results using the VAR shock do not point to the presence of significant non-linearity. Outcomes vary across the filtering methods, but the conclusions remain the same. That is, the prevailing level of household debt does not significantly impact the transmission of monetary policy. Results are more consistent across the filters in the high debt state. Impulse responses are similar in dynamics and magnitude. The low debt state is somewhat poorly estimated and exhibits sensitivity to the filtering methodology applied. Responses do appear to be more transitory during periods of low debt, but this could be due to estimation error.

*Narrative Shock Identification*

Next, I conduct the same analysis using the narrative shock series constructed by Champagne & Sekkel (2018). This shock series covers a slightly shorter sample period, running from 1974 Q2 to 2015 Q3[19]. Figure 9 reports state dependant impulse responses for the main macroeconomic variables. GDP's response is insignificant at a 90% confidence level in either state of the economy, following that of the linear response. Peak decline in GDP in the high debt state is larger than in the VAR model, declining by up to 1% in the Hamilton and HP filtered models. Inflation generally declines across the filters with similar long run effects in both states. There is some evidence of the "price puzzle" in the high debt state, potentially due to GDP overshooting on impact of the shock. The policy rate responds approximately the same across the filters, but with greater policy rate inertia in the high debt state. The response of the FX rate is insignificant at most horizons across the states but points to an appreciation in both states, consistent with UIP.

[19] I continue to calculate the *debt gap* on the full length of the sample from Q1 1969 TO Q4 2019.

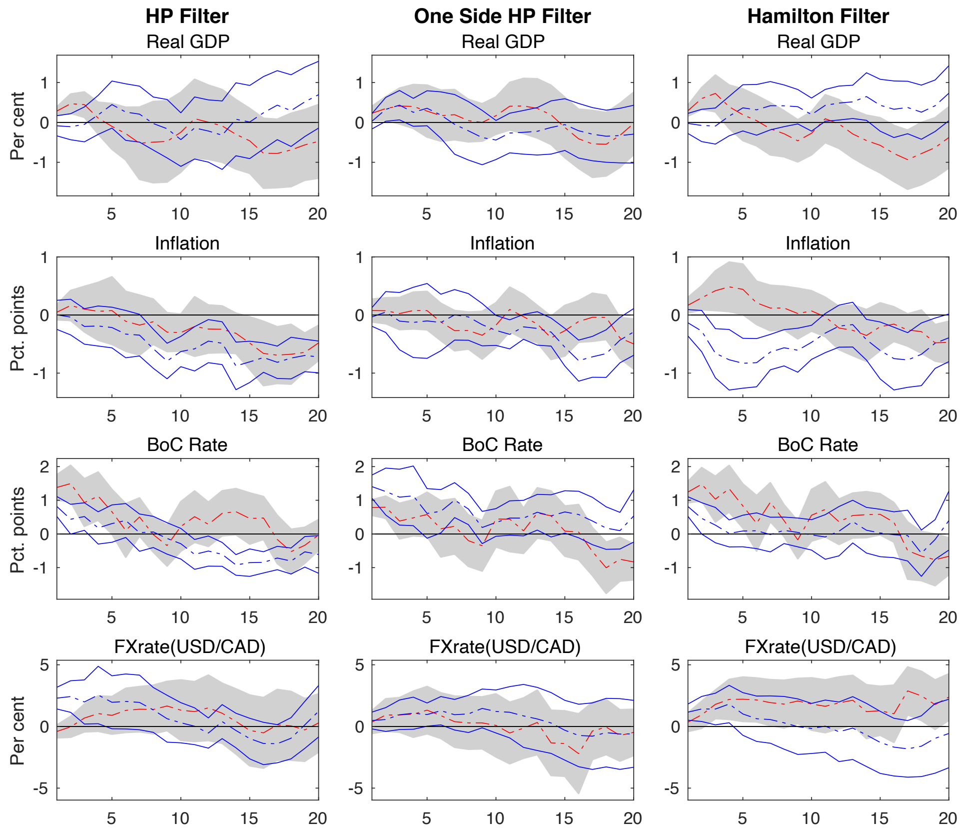



FIGURE 9: STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

Figure 10 outlines the response of other macro variables to a contractionary shock represented by the narrative shock series. As with the models using the VAR shock identification, it is difficult to point to a consistent result and there exists greater variability across the filters. As with consumption and savings, the response in unemployment varies across both states depending on the filter used. Real house prices consistently decline more in the low debt state across the filters, falling by 2%. Responses of household debt remain mixed across the filters but are predominately insignificant at most horizons.

Using the narrative shock, it is again hard to disentangle the results to draw any strong conclusions that the response of the economy to monetary policy is state dependent on household debt. When compared to the VAR shock, responses exhibit greater sensitivity to filtering specification, further suggesting results are impacted by the filtering method chosen. As with the linear model, estimation is generally not as accurate relative to the VAR shock, leading to largely insignificant conclusions.

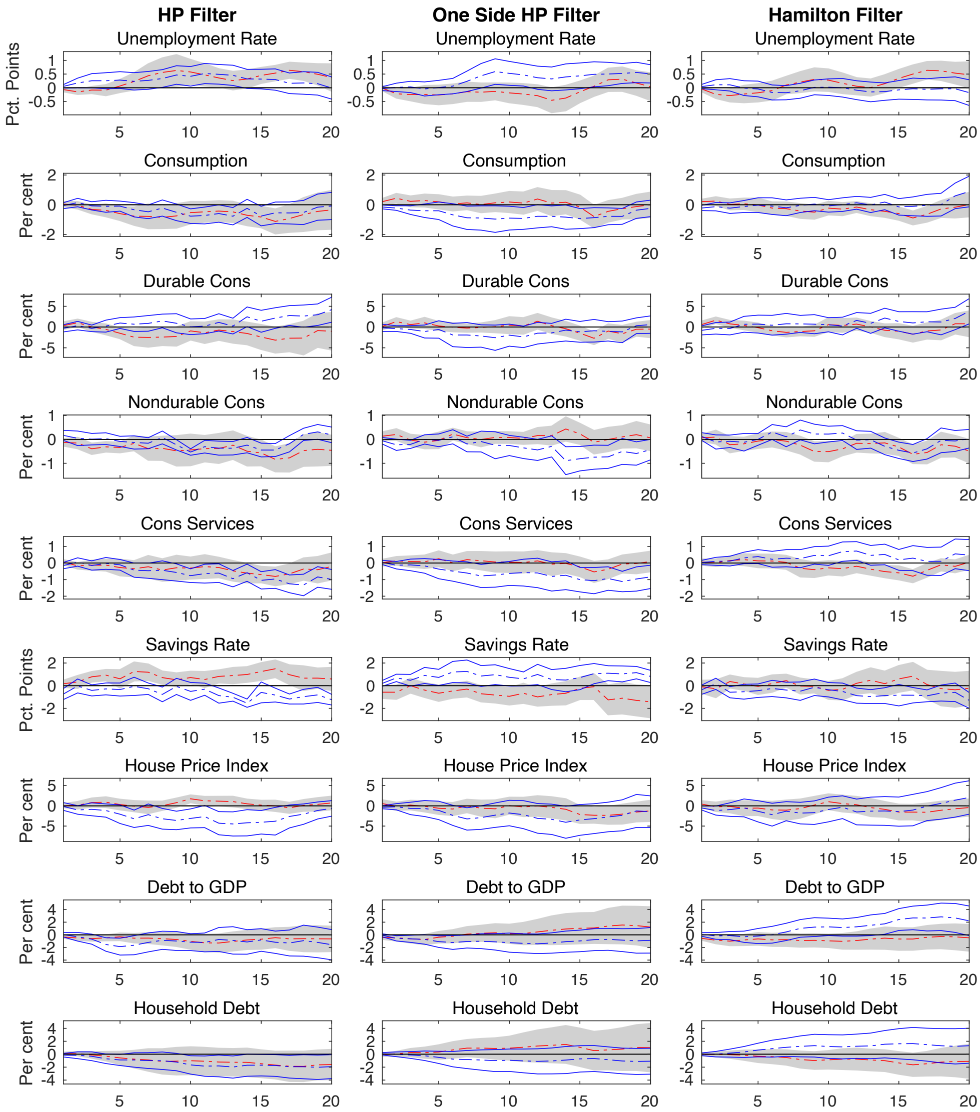



FIGURE 10: EXTENDED STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

## 4.3 Alternate Debt Measures

Next, I turn to uncover whether selecting alternate measures of household debt can change the conclusions drawn above. In the base model, the *debt gap* is constructed using total household debt to GDP. Here I consider two additional measures. First, I use mortgage debt in place of total household credit. On average, residential mortgage credit represents 69% of total household credit. Mortgages are also sensitive to interest fluctuations as they can directly impact debt servicing costs for households (see section 5.2 for further discussion).

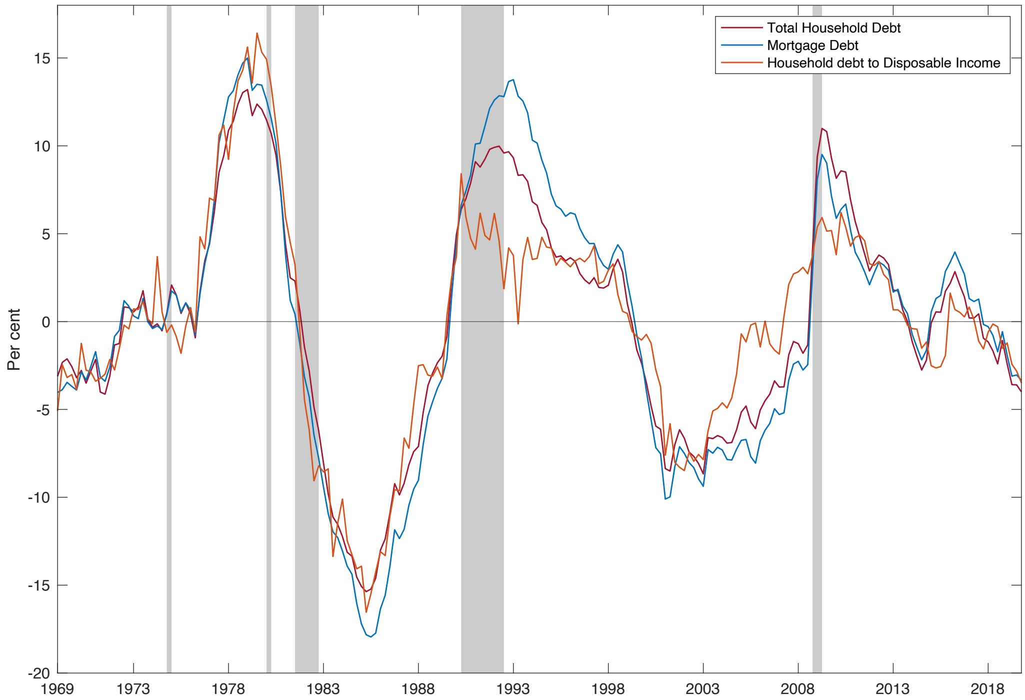



FIGURE 11: ALTERNATE SPECIFICATIONS OF STATE VARIABLES

*NOTE: DEBT GAP DETERMINED USING THE HP FILTER WITH $\lambda = 10^4$. SHADED BARS REPRESENT RECESSIONS AS DETERMINED BY THE C.D. HOWE INSTITUTE.*

Second, I determine the state variable as the ratio of household debt to disposable income. This represents how well households can service their existing debt with current income. Typically, the higher the ratio, the more households are susceptible to shocks in the economy and in theory should respond more to monetary policy shocks as more of their disposable income is directed towards debt repayment.

The implied *debt gap* for each series is plotted in Figure 11. For simplicity, I plot the gap only using the HP filter but still run my analysis using all three methodologies. These additional data series are available for the full sample period. From inspection, there is no significant difference between the periods that are considered high debt amongst the different measures. Mortgage debt tracks total household debt as it represents the majority of household liabilities. Household debt relative to disposable income deviates slightly with the addition of high debt periods leading into the 2009 recession. Again, approximately 50% of the sample period is in the high debt state across each different measure.

For my analysis here I present results for the VAR shock and refer narrative shock responses to appendix A.3. Impulse responses using mortgage debt are almost identical to figures 7 and 8 and therefore I report them in appendix A.4. Figure 12 and figure 13 display impulse responses to a 100 bps contractionary

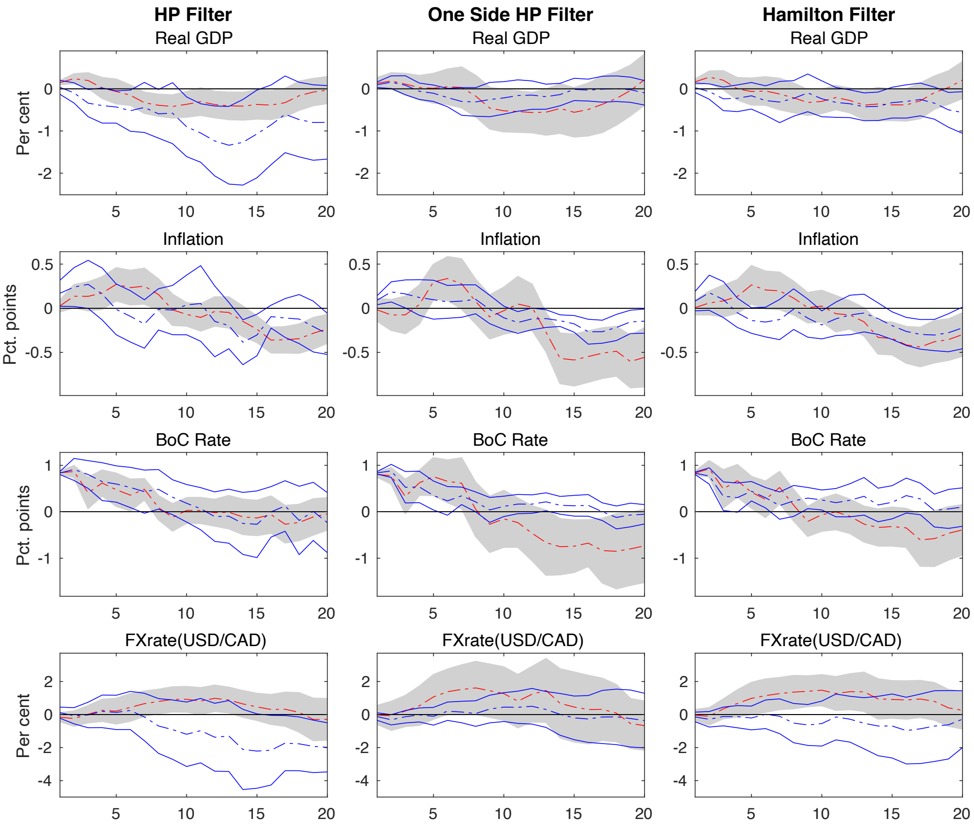



FIGURE 12: STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY HOUSEHOLD DEBT TO DISPOSABLE INCOME.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

monetary policy shock using the VAR shock identification and the *debt gap* defined using household debt to disposable income. Looking at the main economic variables, the responses again do not indicate that one state of the economy responds more to monetary policy. GDP declines by 0.5% across all three filters in the high debt state while the response in the low debt state ranges between no significant response and a decline of 1%. Inflation broadly follows the same path in both states, declining by approximately 0.5% after 15 quarters. The FX rate shows a stronger appreciation in the high debt state. This is consistent across all three filters and previous results. Looking to other macroeconomic variables, there is some evidence that variables respond more in the low debt state. Both HP filters show heterogeneity with consumption, unemployment, house prices, and household debt all responding more. This runs counter to the intuition that households with higher levels of debt relative to disposable income are more responsive to shocks. However, this increased response in other macro variables does not coincide with a greater response of GDP in the low debt state.

Another worthwhile comparison is seeing if there exists a difference in impulse responses when controlling for filtering method and changing the measure used in the *debt gap.* In Appendix A.5, I provide a comparison of state dependent impulse responses with VAR shock, using both total household debt to GDP and household debt to disposable income. Responses for the main macroeconomic variables are largely the same across the debt states for each *debt gap.* However, differences arise when looking at some key household variables. In the low debt state consumption declines more, along with house prices and household debt, when using disposable income. The savings rate also increases more. Meanwhile, the high debt state exhibits similar or even smaller responses. This again runs counter to the intuition that households with lower levels of disposable income relative to household debt respond more to shocks.

Specifying the *debt gap* using different measures does not significantly change the conclusion previously made. This can largely be attributed to there being little difference across which periods are considered low and high debt states, as seen in figure 11. There may be some evidence to show that when considering household debt to disposable income, households adjust consumption and debt levels more in the low debt state. Although strong conclusions about the roles of disposable income and the response of households to policy shocks lie outside the scope of this paper, I provide some evidence that runs counter to the current intuition and leave it to future literature to investigate.

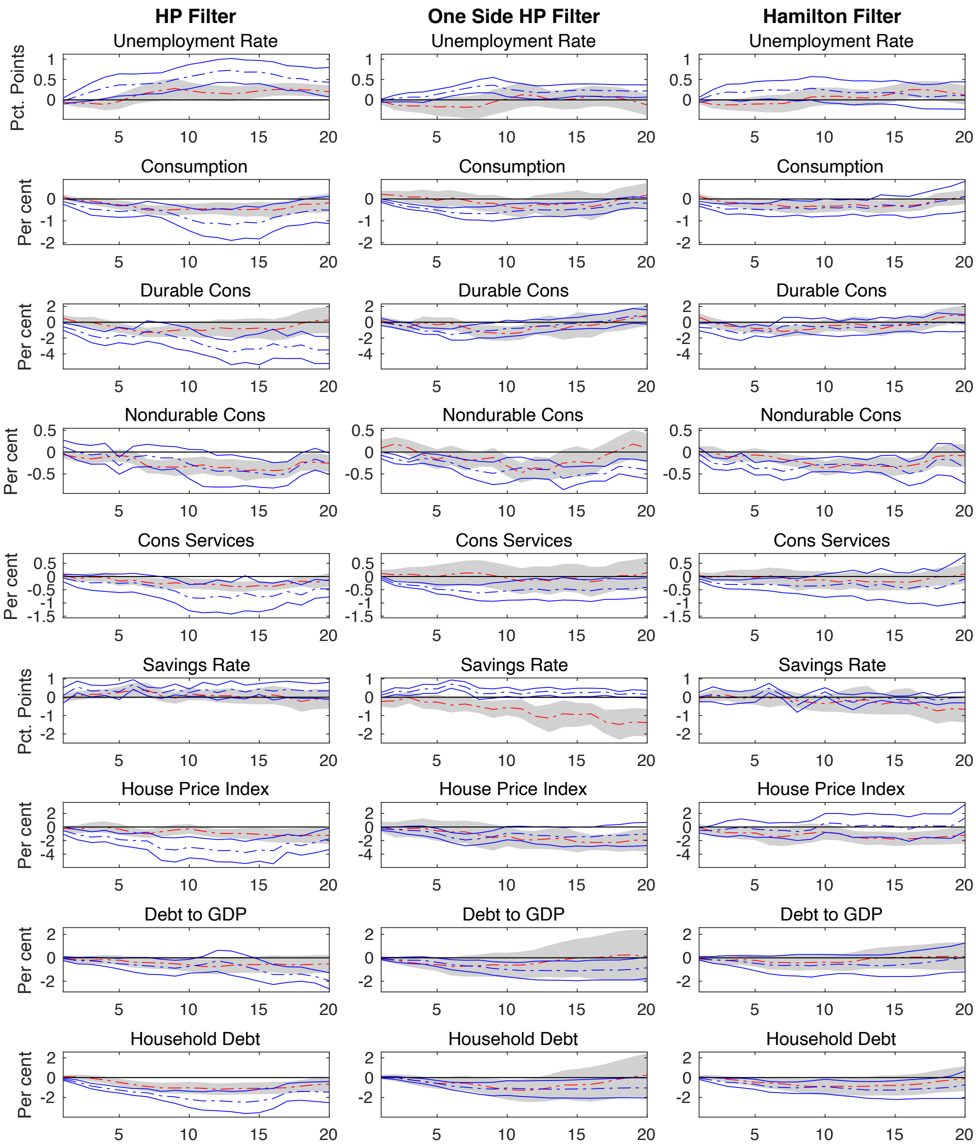



FIGURE 13: EXTENDED STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY HOUSEHOLD DEBT TO DISPOSABLE INCOME.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

## 4.4 Alternate Debt Threshold

In the previous sections, the high debt state is determined by any deviation greater than 0 above each filter's respective trend. While there appears to be little evidence of state dependence, perhaps the assumption that a deviation greater than 0 is too lenient and captures periods where household debt isn't "high" enough. This assumption can easily be tested by simply increasing the threshold from 0 to capture only very "high" debt states. Alpanda & Zubairy (2019) conduct a similar exercise. They determine this increased threshold to be when the *debt gap* is greater than the median. Across the three filters, the median deviation ranges from 3.5-4%. I use 3.5% for all filters so at least 30% of the sample is considered to be

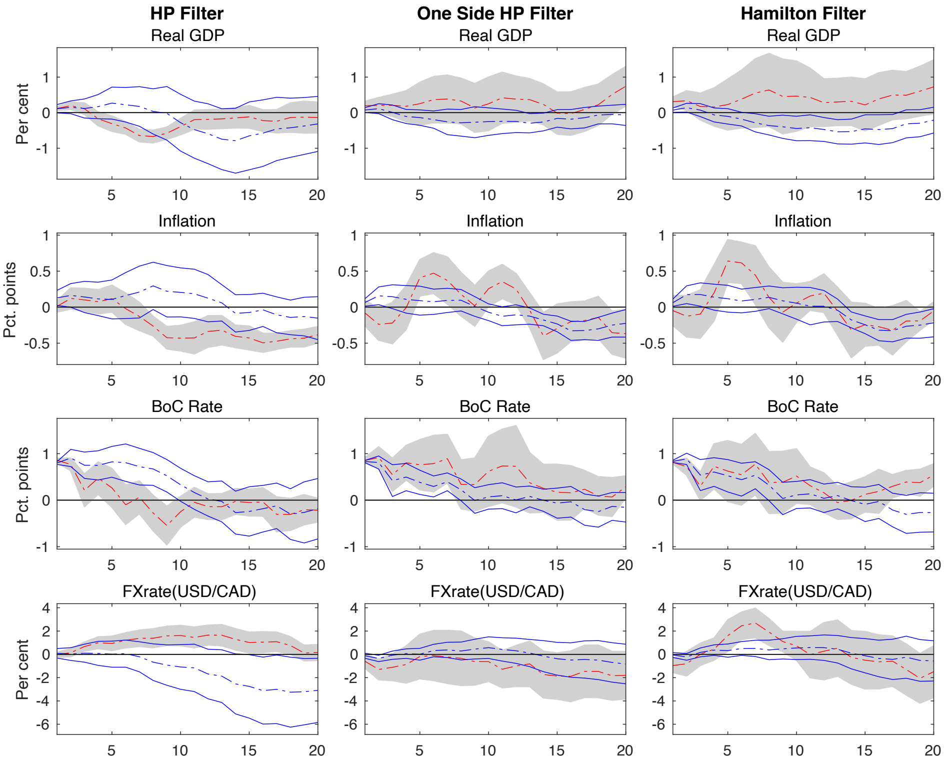



FIGURE 13: STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION USING HIGH DEBT THRESHOLD OF 3.5% ABOVE TREND.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

in the high debt state for estimation purposes. Figure 14 plots the main outputs using the VAR shock. Again, there continues to be no clear evidence of nonlinearity. The HP filter indicates that the economy responds more contemporaneously in the high debt state but long run effects on GDP are the same. Peak responses also match that of the findings in section 4.2. Looking at the other filters, responses are largely insignificant and even pointing to an expansionary response in the high debt state for GDP. Appendix A.6 provides impulse responses of the other macro variables, also showing no significant nonlinearity. Long run responses of unemployment and consumption are broadly the same across the filtering methods, demonstrating small contractionary responses. Household debt and housing prices show the same response across states. Increasing the threshold to only include very high debt states does not produce any evidence to conclude the existence of state dependence. This analysis highlights the robustness of the findings.

### 4.5 Alternate Sample Period

As a final robustness exercise, I test whether there exists any evidence of state dependence prior to the Great Recession. This has the added benefit of limiting the sample from including periods when the overnight rate reached the effective lower bound. For this, I end the sample in Q4 2008 which is the period before which interest rates reached the effective lower bound in Canada[20]. I continue to construct the *debt gap* considering the full sample length to avoid unnecessary trimming of data[21]. This still leaves roughly half of the sample as high debt periods. Figure 14 outlines linear and state dependent impulse responses, using the VAR shock and *debt gap* determined using the HP filter for state dependent responses. The economy responds as expected to a contractionary policy shock in the linear case, evidencing a slightly greater response when compared to the full sample. The state dependent responses again show no significant signs of non-linearity. Appendix 7 provides a comparison of state dependent responses across the different filtering methods and results from the narrative shock series. There is no consistent evidence across filters of non-linearity for any variables and responses look similar to that of the full sample period.

[20] The policy rate fell to 25 bps from 2009-2011 which The Bank of Canada stated was the effective lower bound Witmer & Yang (2015).

[21] Results were not significantly changed when constructing the debt gap stopping the sample in Q4 2008 and running local projections on a sample ending Q4 2006.

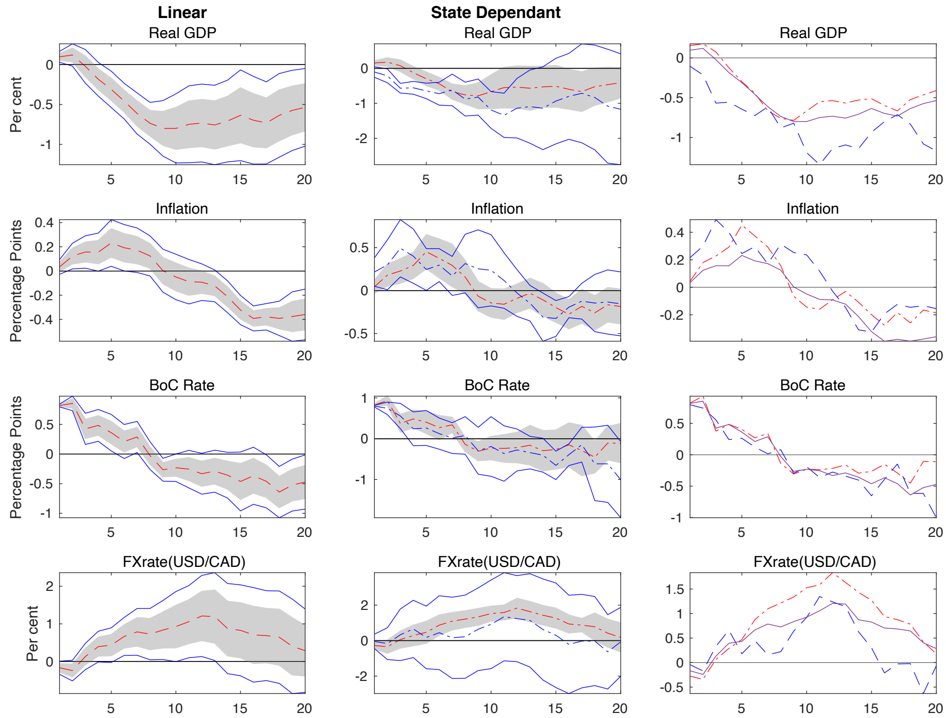



FIGURE 14: LINEAR AND STATE DEPENDENT MODELS WITH VAR SHOCK IDENTIFICATION AND SAMPLE ENDING Q4 2008. STATE DEPENDENCE DETERMINED BY HP FILTERING.

*NOTE: COLUMN 1 PRESENTS LINEAR RESULTS WITH 90% CONFIDENCE INTERVAL SHADED IN GREY. COLUMN 2 PRESENTS STATE DEPENDENT RESULTS. RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE. COLUMN 3 SHOWS A COMBINATION OF THE 3 RESULTS. RED DASHED LINE REPRESENTS THE HIGH DEBT STATE, BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE, AND SOLID PURPLE LINE REPRESENTS THE LINEAR MODEL.*

## 5. Further Discussion

In this section I highlight possible explanations for the results arrived at. This will include a brief discussion of transmission channels and the role of the mortgage market in the transmission of monetary policy shocks. Strong conclusions about either mechanism lie outside the scope of this paper. However, the discussion provides a useful framework for thinking about these results along with recommendations for further research.

### 5.1 Transmission Channels

Extensive research has been carried out on monetary transmission channels (see Ireland (2005) for complete review). Bernanke & Gertler (1995) point to the credit channel, composed of the balance sheet channel and lending channel, as one key mechanism in explaining monetary policy transmission[22]. They describe the balance sheet channel as the main pathway through household balance sheets. It acts by directly impacting borrowers' financial position through asset prices and net cash flows. From the asset side, homeownership is typically the biggest asset on household balance sheets and therefore acts as a key source of equity. From the cash flow side, monetary policy causes rates to change through the interest rate channel which impacts debt servicing requirements for households. More specifically, Flodén et al. (2019) develop the concept of a *cash flow channel* by examining the direct effects on consumption of monetary policy through household disposable income. The intuition is that when monetary policy is tightened, households face higher debt servicing costs and therefore reducing disposable income. Combining these two channels, Alpanda & Zubairy (2019) attribute their results of a muted response during periods of high household debt to a weakening of the home equity loan channel. Household borrowing costs and asset values increase in response to an expansionary monetary policy shock. Households with low levels of debt are able to tap into this increase in equity by borrowing more. Meanwhile, credit constrained households are not able to access this additional equity and therefore respond less to policy shocks.

Households can access home equity either through Home Equity Lines of Credit (HELOC) or mortgage refinancing. HELOC's in Canada allow homeowners to borrow up to 65% of their home equity, not exceeding 80% when combined with an outstanding mortgage. HELOC's have been growing in popularity among homeowners as house prices have been rising rapidly, steadily increasing to 10% of total household liabilities over the past decade. When house prices rise, households can increase borrowing and consequently increase household spending. Since households borrow against their homes, changes in real house prices indirectly effect households ability to spend, known as the "collateral effect". Ho et al. (2019) point out that if this effect is large, the Canadian economy can be increasingly vulnerable to adverse shocks, particularly if households rely on equity extraction in normal times. This suggests a link

[22] Bernanke & Gertler (1995) suggest that the credit channel may not be considered an independent channel but as a "financial accelerator".

between household spending and house prices which are acutely affected by economic conditions, ultimately driven by monetary policy.

To uncover the potential role of channels and if there exists any state dependence, I use the model previously developed and analyse the linear and state dependent responses of disposable income and HELOC to a contractionary monetary policy shock. Data on HELOC's are only being available after 1990 Q1 therefore the sample used is from 1990 Q1 to 2019 Q4. For simplicity, I use the VAR shock and determine state dependence using the HP filter. Note, I measure HELOC's relative to total outstanding household credit as this better reflects the fluctuations in their use. Figure 14 presents the results of both linear and state dependent models. In the linear model, HELOC's decline in response to a contractionary monetary policy shock along with the house price index, disposable income, and household debt. Disposable income initially does not respond but declines by 2% in the long run. Consumption correspondingly declines by 1% after 15 periods. The response of GDP is largely insignificant or even increasing. This has been seen in the literature due to the difficulty of successfully identifying monetary policy shocks in more recent samples (see Ramey (2016)). In the state dependent model, there is some evidence that credit constrained households are forced to adjust upon impact of the shock. In the high debt state, both house prices and HELOC's decline contemporaneously with the shock. The decline in HELOC in the low debt state is coupled with rising total household credit which implies it is largely unchanged. Disposable income responds the same across the states in the long run, with greater persistence in the high debt state. There is no response of GDP in the high debt state whereas there is a large decline of almost 2% in the low debt state, before recovering after 20 periods.

While I present this model for illustrative purposes, there does appear to be some evidence suggesting that credit constrained households are forced to reduce HELOC more in response to a contractionary monetary policy shock. During periods of low debt, households can access additional credit to avoid having to adjust consumption upon impact of the shock. However, these effects do not translate to GDP declining more in the high debt state, and instead it declines more in the low debt state.

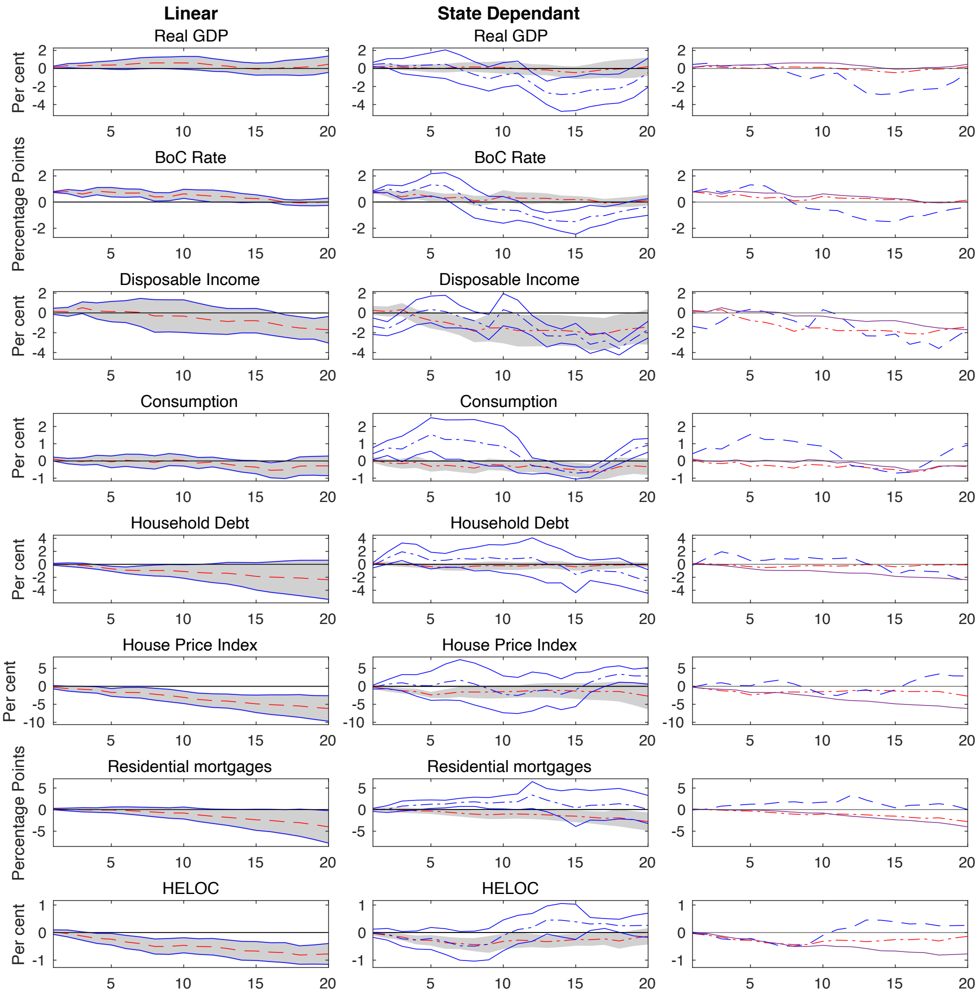



FIGURE 14: LINEAR AND STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION. STATE DEPENDENCE DETERMINED BY HP FILTERING.

*NOTE: COLUMN 1 PRESENTS LINEAR RESULTS WITH 90% CONFIDENCE INTERVAL SHADED IN GREY. COLUMN 2 PRESENTS STATE DEPENDENT RESULTS. RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINE REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE. COLUMN 3 SHOWS A COMBINATION OF THE 3 RESULTS. RED DASHED LINE REPRESENTS THE HIGH DEBT STATE, BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE, AND SOLID PURPLE LINE REPRESENTS THE LINEAR MODEL.*

This could be due to the difficulties of successfully identifying policy shocks over the sample period as previously noted. However, this analysis may indicate that the home equity channel Alpanda & Zubairy (2019) point to, does not play a significant role in monetary policy transmission in Canada. Credit constrained households lower their use of HELOC as home equity declines but this does not translate into a greater contraction of the broader economy. Strong conclusions about pathways are outside the scope of this paper but I leave this as a potential opportunity for further research.

### 5.2 Role of the Mortgage Market

Another factor that impacts the effectiveness of monetary policy transmission is the structure of the mortgage market through the pathway of mortgage refinancing. While HELOC's represent a flexible way for households to access home equity, mortgages vary greatly in the flexibility they can provide. Mortgages can largely be separated into two categories: fixed rate mortgages (FRM), and floating rate or adjustable mortgages (ARM). The proportion of these types of mortgages in an economy varies significantly between countries. For example, in the U.S. only 8% of mortgages are ARM while in Australia, ARM make up 88% of the mortgage market (see Badarinza et al. (2018)). This has implications for the transmission of monetary policy shocks to households through the credit channel. The intuition is that when monetary policy is tightened, households first face higher debt servicing costs and therefore reduces disposable income. A secondary effect is households who have ARM may choose to refinance their mortgage if asset prices decline or they wish to reduce debt servicing costs by making a lump sum payment. In markets with predominately FRM this can only be done for households with expiring term limits. Flodén et al. (2019) and Kim & Lim (2020) both find a stronger effect of monetary policy in economies with higher numbers of ARM. This is attributed to the credit channel being more active in the transmission of policy as changing rates directly affect interest expenses, net cash flows, and households financial position. Further, Alpanda & Zubairy (2019) show in a partial equilibrium model that households respond less to monetary policy under fixed rate loans. This is due to households not being able to refinance until some periods after the shock has hit, at which point the effects of the shock are diminished. Thus, this strand of literature indicates that the mortgage market plays a role in the transmission of monetary policy. Further, this could provide a possible explanation for differing results across the literature in the state dependence of monetary policy in relation to household debt.

Canada's mortgage market is unique in that it is largely composed of short term (usually 2 to 5 years) FRM's, accounting for over 80% of the market[23].While providing some level of flexibility over a traditional FRM, these still present higher degrees of nominal rigidities when compared to ARM's. Following the

[23]Kartashova & Zhou (2020) provide an indepth breakdown of the Canadian mortgage market

conclusions from Alpanda & Zubairy (2019), this could suggest why there is limited evidence for nonlinearity in the response to monetary policy shocks. The fixed term on mortgages do not allow households to respond immediately to policy shock regardless of the underlying levels of household debt. With mortgages representing the largest part of household credit, this may negate some state dependent effects of monetary policy transmission.

### 5.3 Expansionary Versus Contractionary Shocks

Another consideration is differing responses to contractionary and expansionary shocks. Kartashova & Zhou (2020) show there exists an asymmetric response to monetary policy in the Canadian economy[24]. Their results for expansionary shocks follow the standard outcomes found in the literature linked to the cash flow channel. When rates decline, households increase consumption caused by reduced debt servicing costs[25]. However, when rates increase at the time of reset, borrowers do not reduce durable consumption and continue to pay down debt at the same rate. Intuition would suggest consumption must be cut through the negative cash flow channel effects or borrowing would increase. The authors instead suggest this result is due to consumers expectations about future interest rates, causing them to continue to pay down debt. Further, they show no significant heterogeneity between borrowers with high and low credit scores.

This recent paper provides evidence that coincide with the results of this thesis. While I do not study expansionary shocks, it’s important to consider that the economy may not just simple respond the same with the opposite sign. It could in fact lead to different conclusions about the presence of non-linearity in the Canadian economy. Further, it may be an explanation for differing results in the literature. I leave this as a possible avenue for future inquiry.

[24] They exploit the exogenous variation in the timing of mortgage resets due to the short-term fixed rate loan structure in Canada

[25] The authors also find that households with low credit scores respond less to monetary stimulus

## 6. Conclusion

This paper set out to investigate two questions. Firstly, to determine if the response of the Canadian economy to a contractionary monetary policy shock is state dependent when conditioned on the level of household debt. To this, using state dependent local projections I find no significant evidence of nonlinearity in the response. This result is robust across various specifications of monetary policy shocks, definitions of household indebtness, debt thresholds, and sample periods. Secondly, to explore potential causes for the dichotomy between results in the literature with regards the impact of household debt on the transmission of monetary policy. My findings indicate that empirical outcomes are sensitive to the filtering methodolgy chosen when determining debt trends and method of determining monetary policy shocks. This can be pointed to as a potential driver for the differences in the empircal literature. Outside of model specification, I explore other factors such a transmission channels, mortgage market structure, and direction of the policy shock applied as potential drivers of contradicting evidence found in the literature.

To rationalize my empirical results, a useful extension would be to develop a DSGE model to further investigate transmission pathways. This could help uncover why the state dependent responses seen in other economies are not present in Canada. I leave this to future endevours as it lies outside the scope of this paper. A further useful extension would be to test other empircal methods, such as a threshold VAR, to see if my results still hold and to further uncover if this is driving differing results across the literature.

## References

Alpanda, S., & Zubairy, S. (2019). Household Debt Overhang and Transmission of Monetary Policy. *Journal of Money, Credit and Banking*, *51*(5), 1265–1307. https://doi.org/10.1111/jmcb.12548

Badarinza, C., Campbell, J. Y., & Ramadorai, T. (2018). What Calls to ARMs? International Evidence on Interest Rates and the Choice of Adjustable-Rate Mortgages. *Management Science*, *64*(5), 2275–2288. https://doi.org/10.1287/mnsc.2016.2629

Beraja, M., Fuster, A., Hurst, E., & Vavra, J. (2017). *Regional Heterogeneity and Monetary Policy* (Working Paper No. 23270; Working Paper Series). National Bureau of Economic Research. https://doi.org/10.3386/w23270

Bernanke, B. S., & Gertler, M. (1995). Inside the Black Box: The Credit Channel of Monetary Policy Transmission. *Journal of Economic Perspectives*, *9*(4), 27–48. https://doi.org/10.1257/jep.9.4.27

Bernardini, M., & Peersman, G. (2018). Private debt overhang and the government spending multiplier: Evidence for the United States. *Journal of Applied Econometrics*, *33*(4), 485–508. https://doi.org/10.1002/jae.2618

Calza, A., Monacelli, T., & Stracca, L. (2013). Housing Finance and Monetary Policy. *Journal of the European Economic Association*, *11*(s1), 101–122. https://doi.org/10.1111/j.1542-4774.2012.01095.x

Champagne, J., & Sekkel, R. (2018). Changes in monetary regimes and the identification of monetary policy shocks: Narrative evidence from Canada. *Journal of Monetary Economics*, *99*, 72–87. https://doi.org/10.1016/j.jmoneco.2018.06.002

Christiano, L. J., Eichenbaum, M., & Evans, C. (1996). The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds. *The Review of Economics and Statistics*, *78*(1), 16–34. https://doi.org/10.2307/2109845

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (1999). Chapter 2 Monetary policy shocks: What have we learned and to what end? In *Handbook of Macroeconomics* (Vol. 1, pp. 65–148). Elsevier. https://doi.org/10.1016/S1574-0048(99)01005-8

Dornbusch, R. (1976). Expectations and Exchange Rate Dynamics. *Journal of Political Economy*, *84*(6), 1161–1176.

Drehmann, M., & Tsatsaronis, K. (2014). *The credit-to-GDP gap and countercyclical capital buffers: Questions and answers*. https://www.bis.org/publ/qtrpdf/r_qt1403g.htm

Eichenbaum, M., & Evans, C. (1995). Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates. *The Quarterly Journal of Economics*, *110*(4), 975–1009.

*Financial System Review—2019*. (n.d.). Retrieved May 1, 2021, from https://www.bankofcanada.ca/2019/05/financial-system-review-2019/

Flodén, M., Kilström, M., Sigurdsson, J., & Vestman, R. (2019). *Household Debt and Monetary Policy: Revealing the Cash-Flow Channel* (SSRN Scholarly Paper ID 3079675). Social Science Research Network. https://doi.org/10.2139/ssrn.3079675

Hamilton, J. D. (2018). Why You Should Never Use the Hodrick-Prescott Filter. *Review of Economics and Statistics*, *100*(5), 831–843. https://doi.org/10.1162/rest_a_00706

Ho, A. T. Y., Khan, M., Mow, M., & Peterson, B. (2019, September 20). *Home Equity Extraction and Household Spending in Canada* (No. 2019–27). Bank of Canada. https://www.bankofcanada.ca/2019/09/staff-analytical-note-2019-27/

Hodrick, R. J., & Prescott, E. C. (1997). Postwar US business cycles: An empirical investigation. *Journal of Money Credit and Banking*, *29*(1), 1–16. https://doi.org/10.2307/2953682

Holm, M., Paul, P., & Tischbirek, A. (2020). The Transmission of Monetary Policy under the Microscope. In *Working Paper Series* (No. 2020–03; Working Paper Series). Federal Reserve Bank of San Francisco. https://ideas.repec.org/p/fip/fedfwp/87419.html

Iacoviello, M. (2005). House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle. *American Economic Review*, *95*(3), 739–764. https://doi.org/10.1257/0002828054201477

Ireland, P. N. (2005). The Monetary Transmission Mechanism. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.887524

Jordà, Ò. (2005). Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*, *95*(1), 161–182. https://doi.org/10.1257/0002828053828518

Kartashova, K., & Zhou, X. (2020). How Do Mortgage Rate Resets Affect Consumer Spending and Debt Repayment? Evidence from Canadian Consumers. In *Staff Working Papers* (No. 20–18; Staff Working Papers). Bank of Canada. https://ideas.repec.org/p/bca/bocawp/20-18.html

Kim, Y., & Lim, H. (2020). Transmission of monetary policy in times of high household debt. *Journal of Macroeconomics*, *63*, 103168. https://doi.org/10.1016/j.jmacro.2019.103168

Mian, A., & Sufi, A. (2014). *House Price Gains and U.S. Household Spending from 2002 to 2006* (Working Paper No. 20152; Working Paper Series). National Bureau of Economic Research. https://doi.org/10.3386/w20152

Mian, A., & Sufi, A. (2015). *House of Debt*. University of Chicago Press. https://press.uchicago.edu/ucp/books/book/chicago/H/bo20832545.html

Newey, W. K., & West, K. D. (1987). A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica*, *55*(3), 703. https://doi.org/10.2307/1913610

Ramey, V. A. (2016). Macroeconomic Shocks and Their Propagation. In *Handbook of Macroeconomics* (Vol. 2, pp. 71–162). Elsevier. https://doi.org/10.1016/bs.hesmac.2016.03.003

Ramey, V. A., & Zubairy, S. (2018). Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data. *Journal of Political Economy*, *126*(2), 850–901.

Romer, C. D., & Romer, D. H. (2004). A new measure of monetary shocks: Derivation and implications. *American Economic Review*, *94*(4), 1055–1084. https://doi.org/10.1257/0002828042002651

Witmer, J., & Yang, J. (2015, December 8). *Estimating Canada's Effective Lower Bound* (No. 2015–2). Bank of Canada. https://www.bankofcanada.ca/2015/12/staff-analytical-note-2015-2/

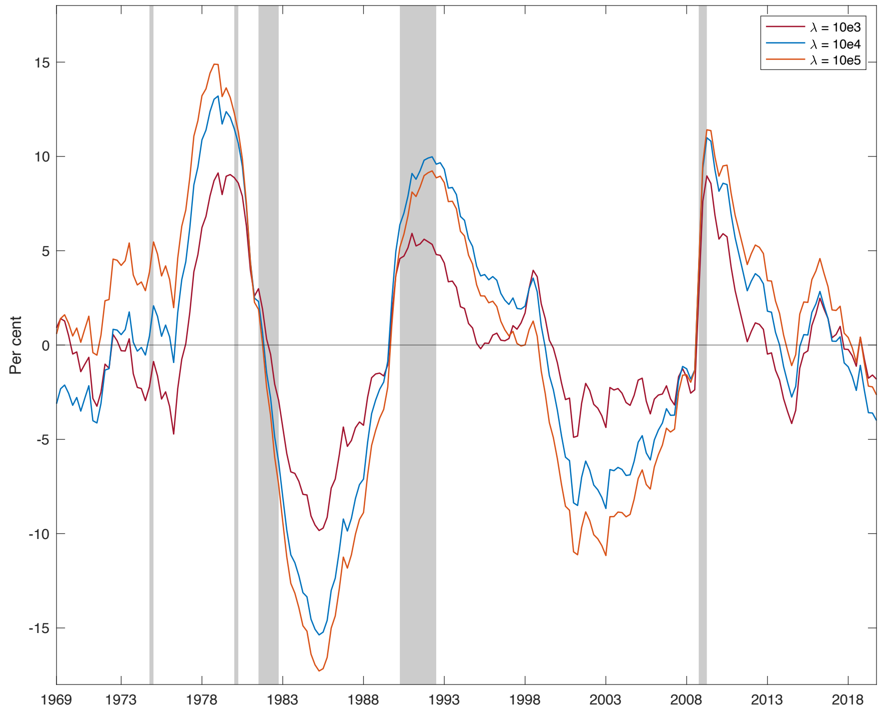
Woodford, M. (2003). Optimal interest-rate smoothing. *Review of Economic Studies*, *70*(4), 861–886. https://doi.org/10.1111/1467-937X.00270

Zabai, A. (2017). Household debt: Recent developments and challenges. *BIS Quarterly Review*. https://ideas.repec.org/a/bis/bisqtr/1712f.html

Zettelmeyer, J. (2004). The impact of monetary policy on the exchange rate: Evidence from three small open economies. *Journal of Monetary Economics*, *51*(3), 635–652. https://doi.org/10.1016/j.jmoneco.2003.06.004

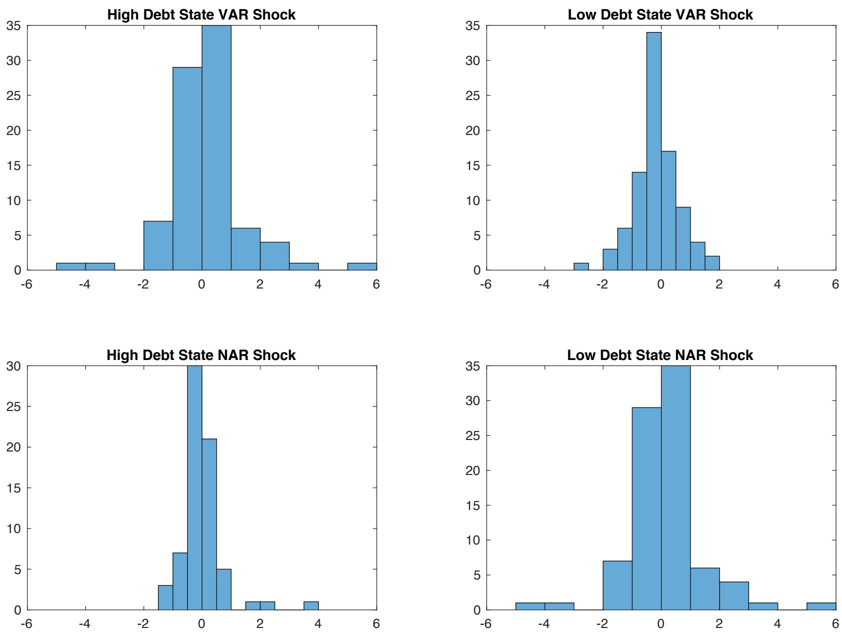
# Appendix

## A.1 Alternate specifications of lambda



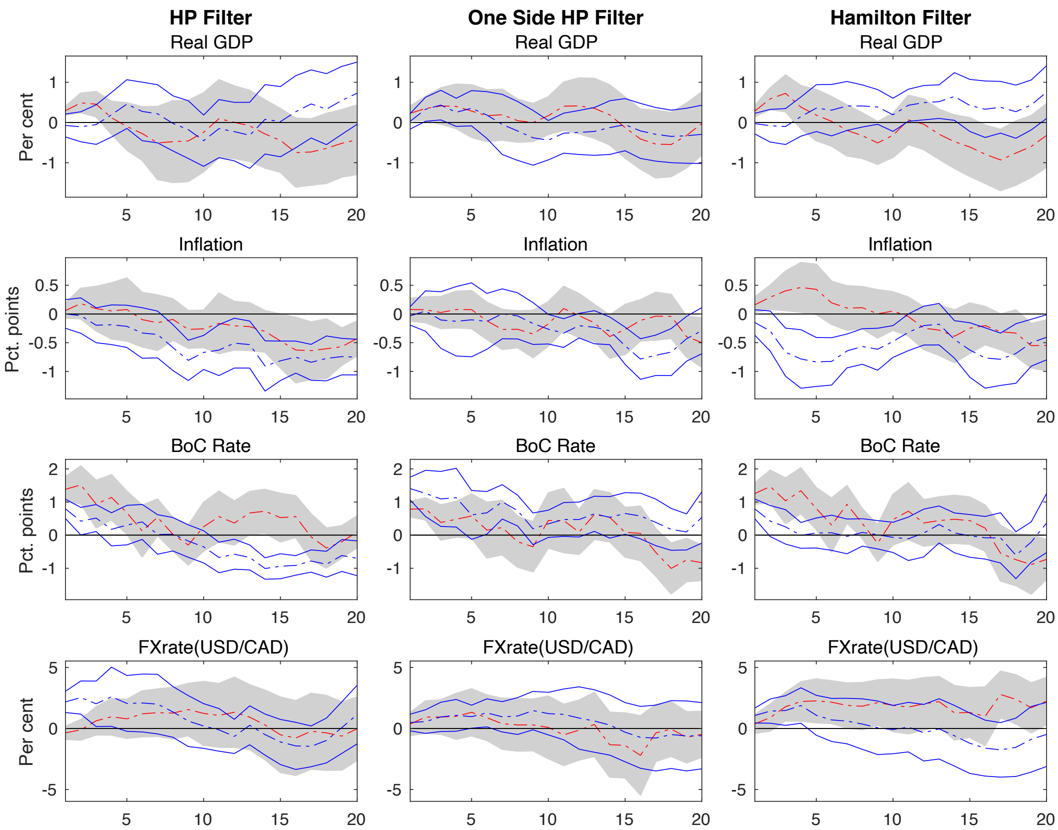

APPENDIX 1: DEBT GAP USING THE HP FILTER WITH DIFFERENT VALUES OF $\lambda$

## A.2 Histogram of VAR shocks and Narrative Shocks by State



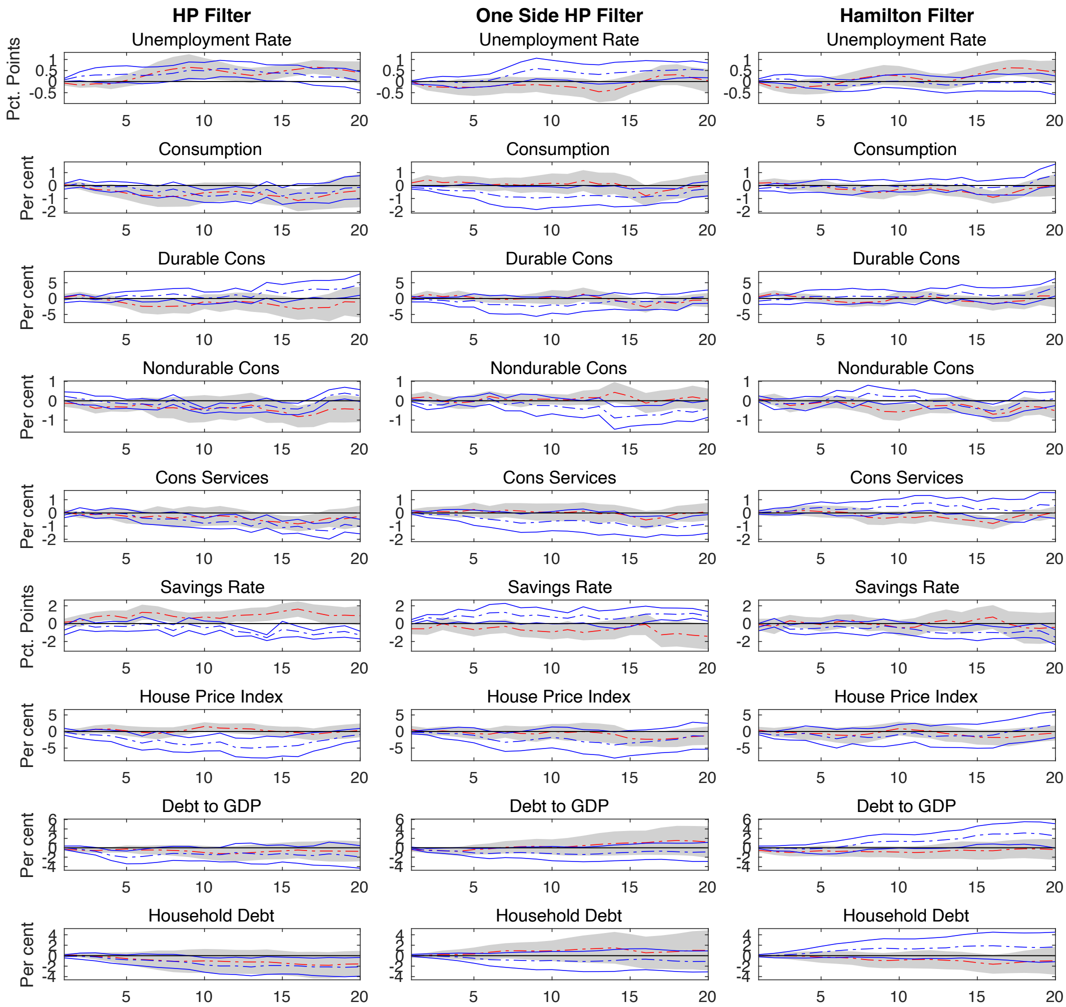

APPENDIX 2: HISTOGRAMS OF VAR SHOCKS AND NARRATIVE SHOCKS BY HOUSEHOLD DEBT STATE

## A.3 Impulse Responses for Alternate Measures of the Debt Gap and Narrative Shock Identification



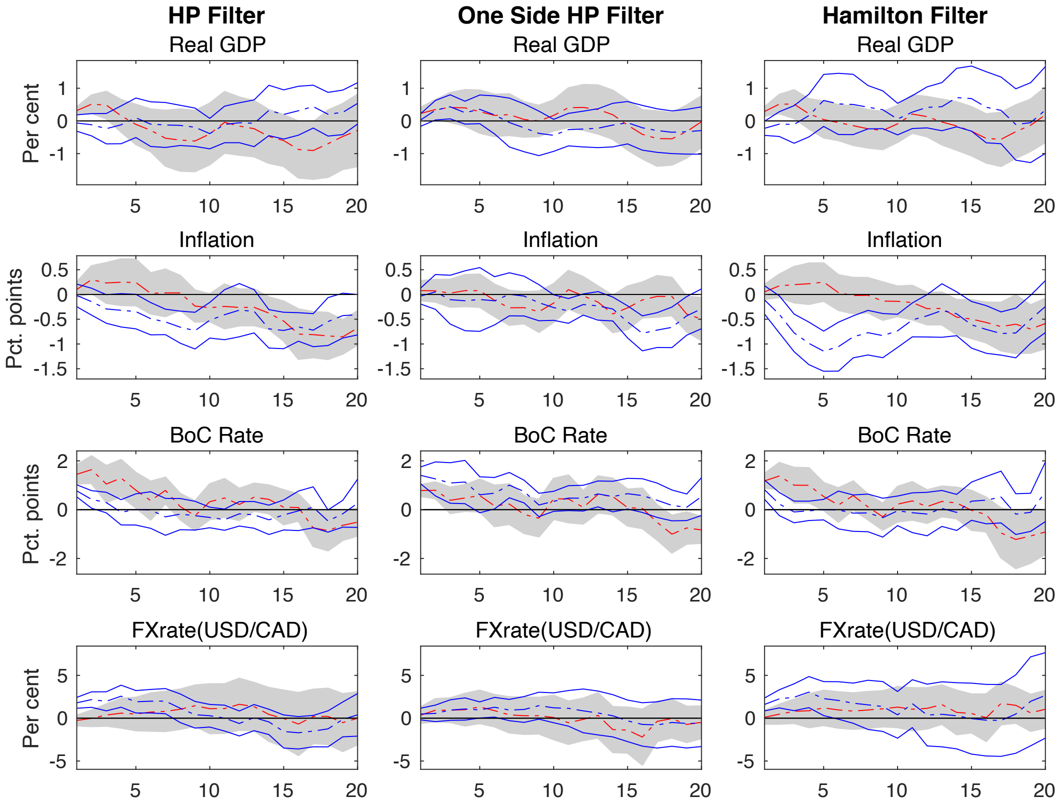

APPENDIX 3: STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY MORTGAGE DEBT TO GDP.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*



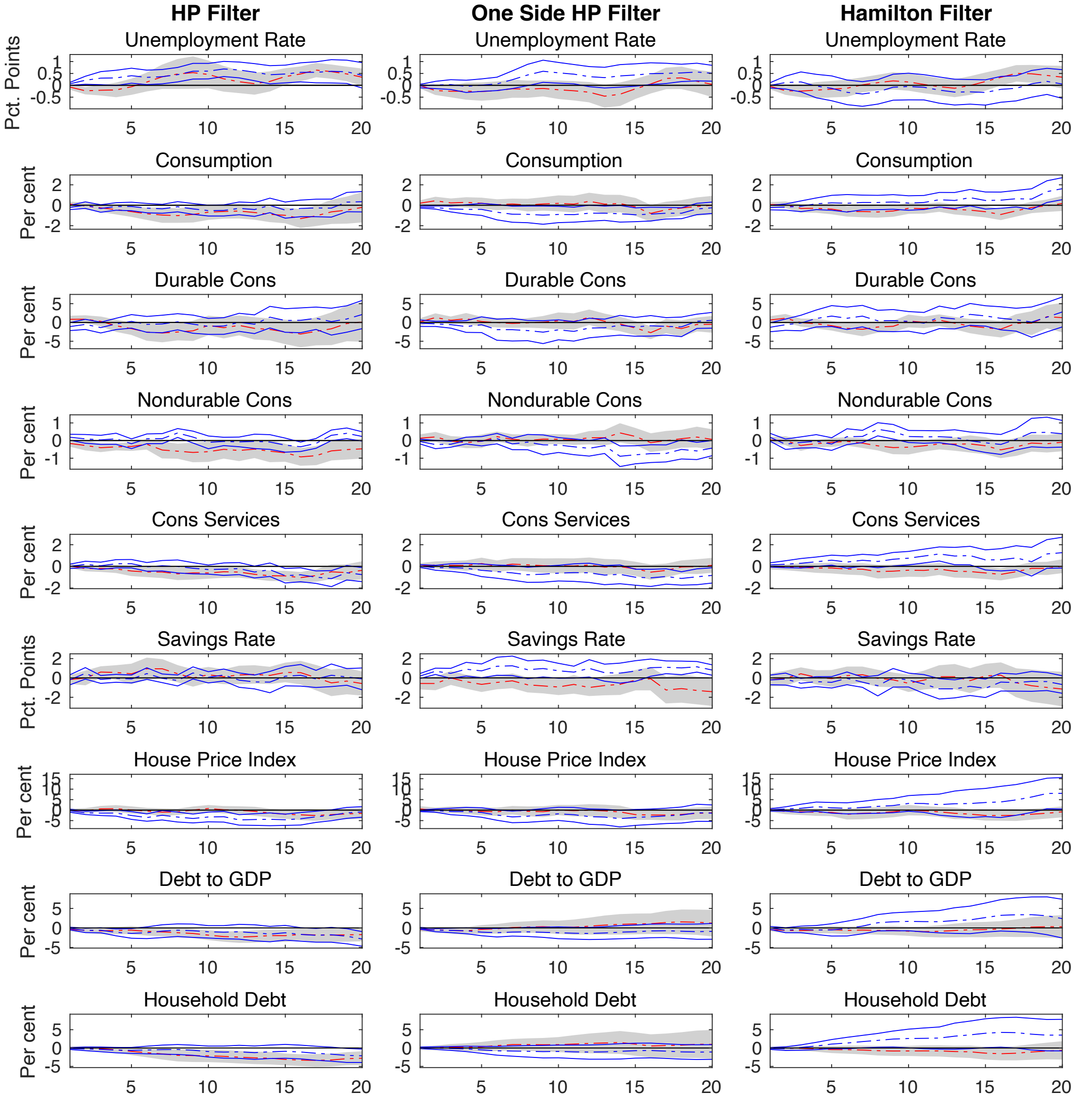

APPENDIX 3: EXTENDED STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY MORTGAGE DEBT TO GDP.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*




APPENDIX 3: STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY HOUSEHOLD DEBT TO DISPOSABLE INCOME.

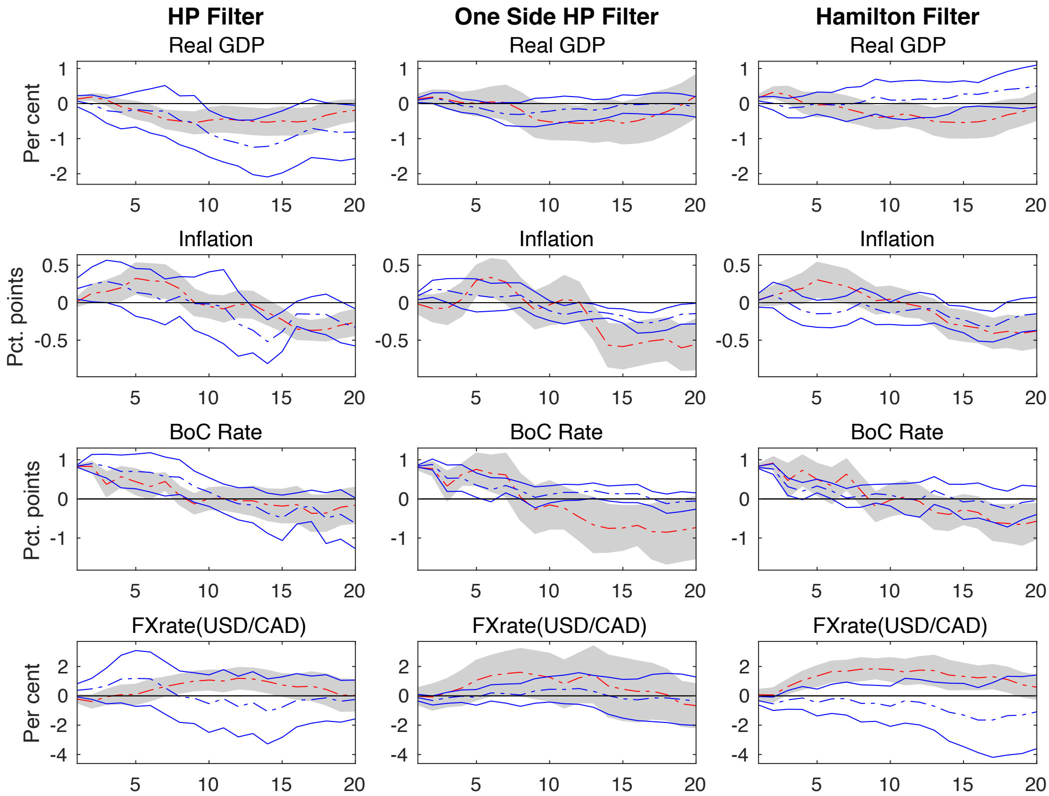
*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*




APPENDIX 3: EXTENDED STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY HOUSEHOLD DEBT TO DISPOSABLE INCOME.

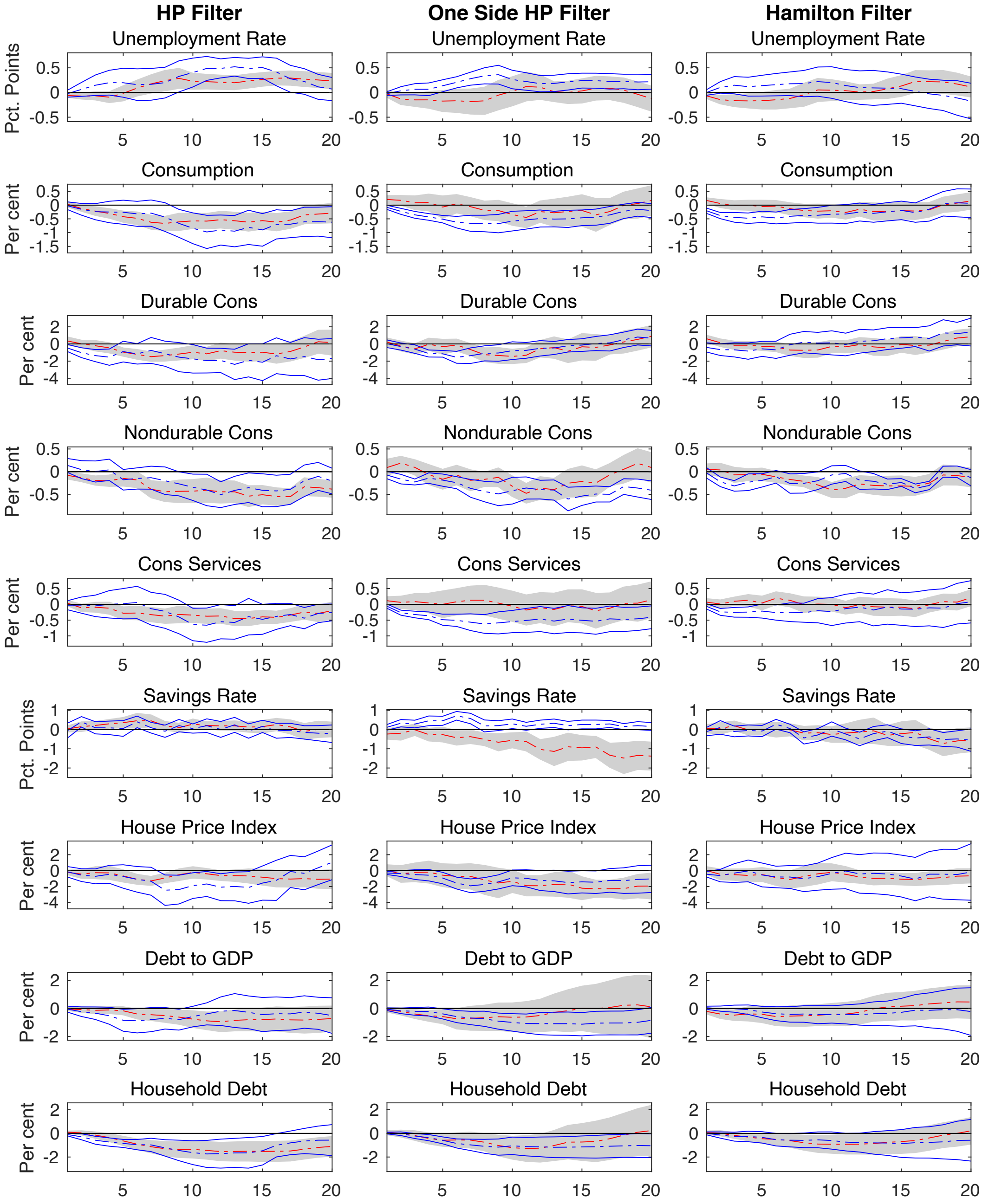
*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

## A.4 Impulse Responses for Debt Gap Defined Using Mortgage Debt to GDP and VAR Shock Identification




APPENDIX 4: STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY MORTGAGE DEBT TO GDP.

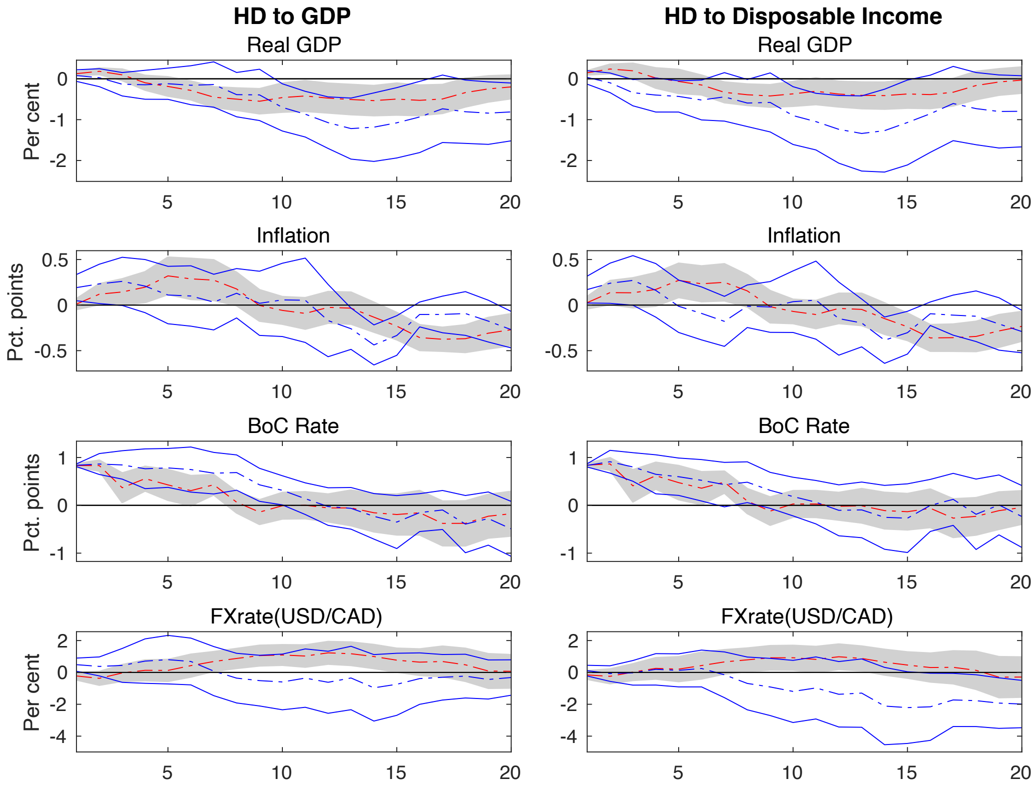
*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*




APPENDIX 4: EXTENDED STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION USING DEBT GAP DETERMINED BY MORTGAGE DEBT TO GDP.

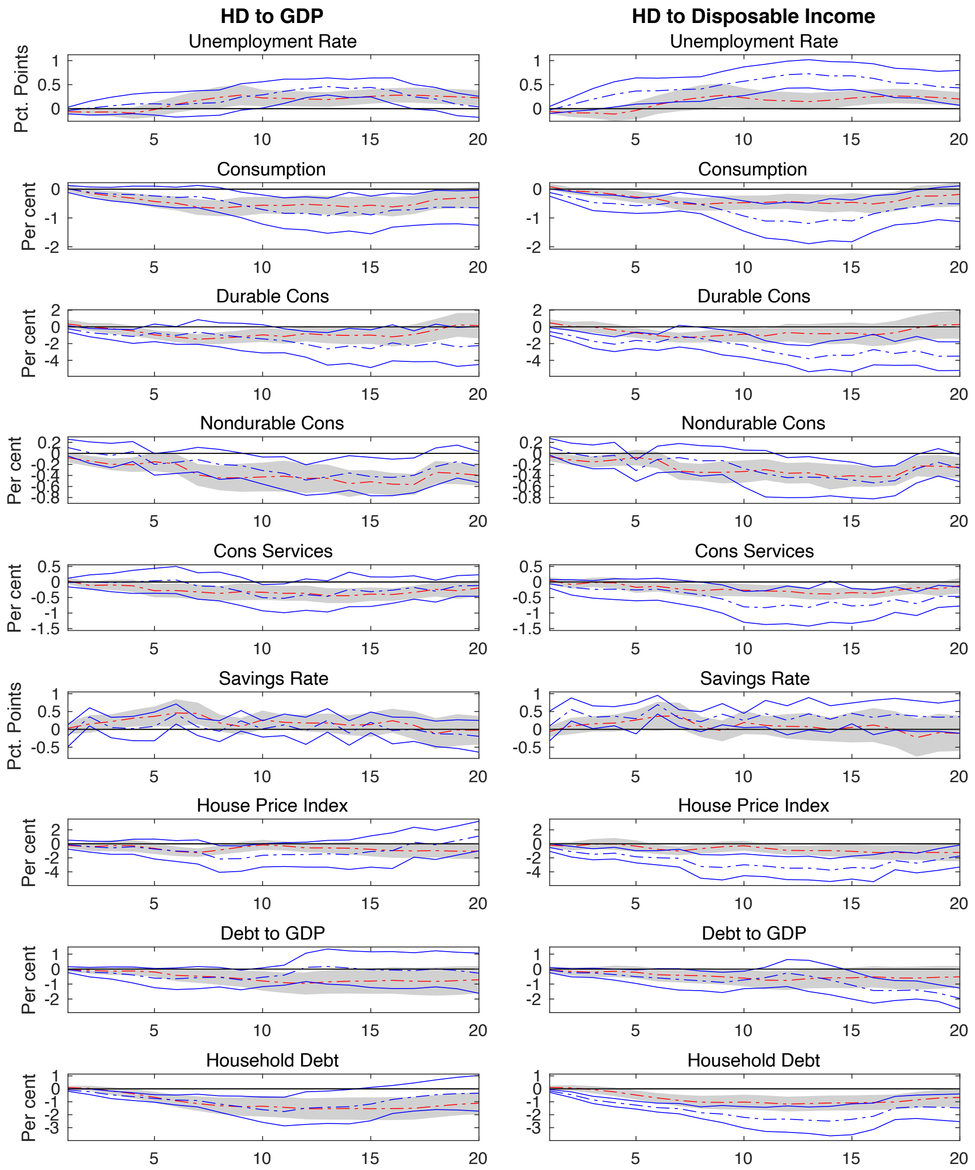
*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

## A.5 State Dependent Impulse Response Comparison for Alternate Debt Gap Specifications




APPENDIX 5: STATE DEPENDENT MODELS WITH VAR SHOCK IDENTIFICATION COMPARING RESULTS ACROSS DEBT GAP SPECIFICATIONS.

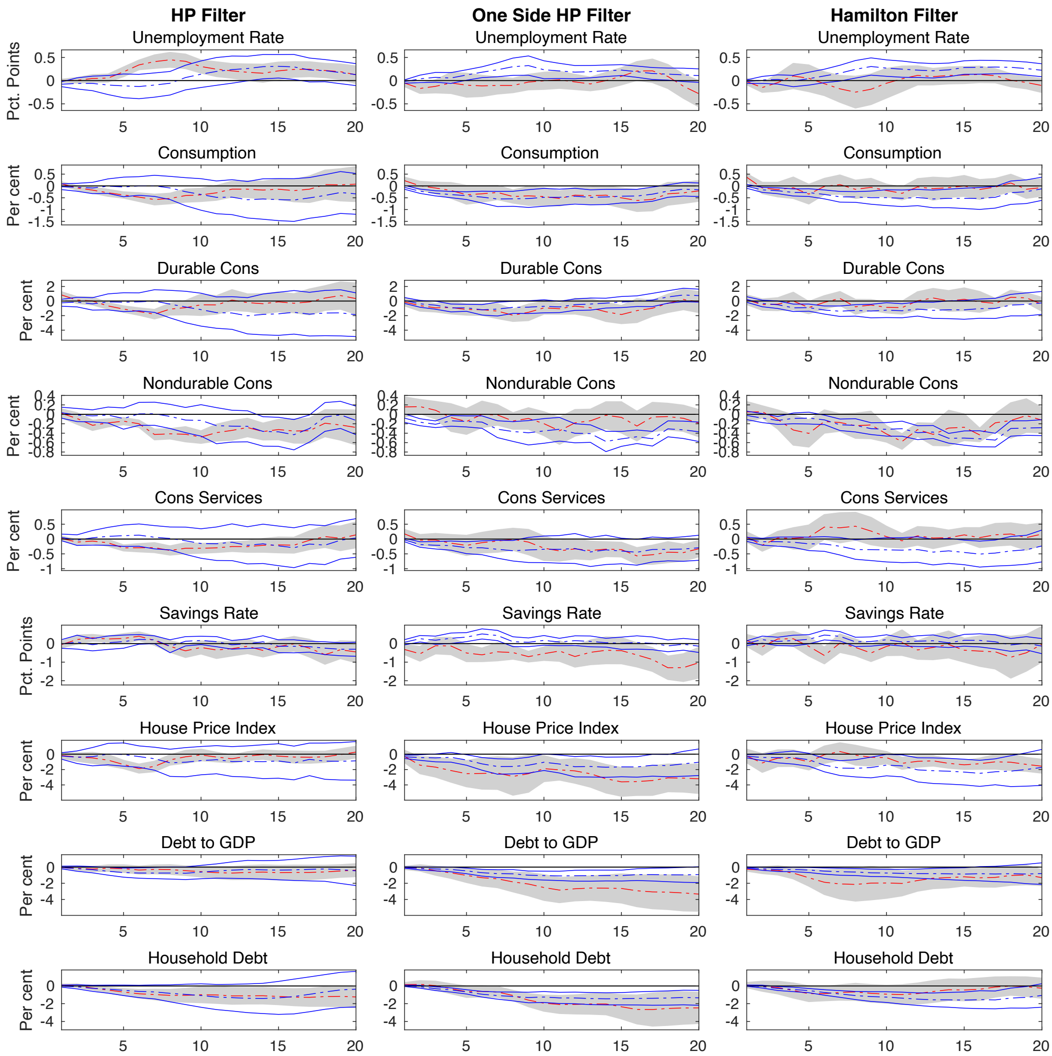
*NOTE: LEFT COLUMN PRESENTS HOUSEHOLD DEBT TO GDP. RIGHT COLUMN PRESENTS HOUSEHOLD DEBT TO DISPOSABLE INCOME RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*




APPENDIX 5: EXTENDED STATE DEPENDENT MODELS WITH VAR SHOCK IDENTIFICATION COMPARING RESULTS ACROSS DEBT GAP SPECIFICATIONS.

*NOTE: LEFT COLUMN PRESENTS HOUSEHOLD DEBT TO GDP. RIGHT COLUMN PRESENTS HOUSEHOLD DEBT TO DISPOSABLE INCOME. RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

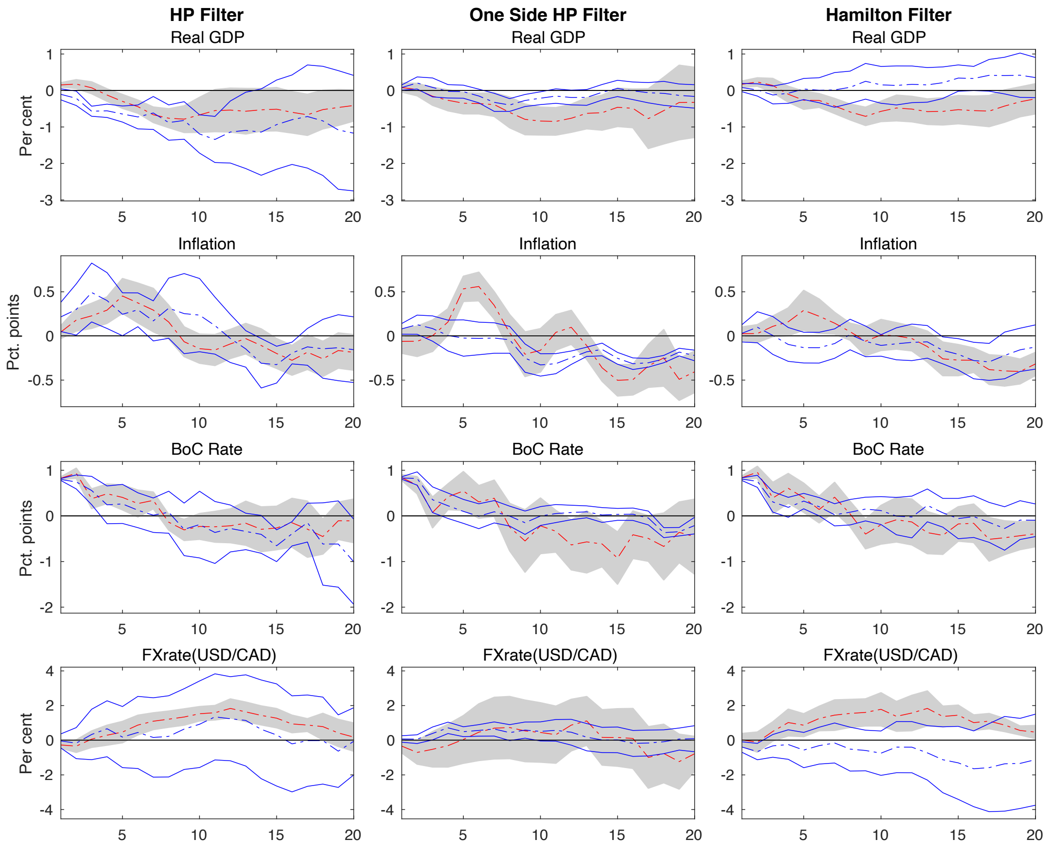
## A.6 Extended State Dependent Model with VAR Shock Identification and Debt Threshold of 3.5% Above Trend




APPENDIX 6: EXTENDED STATE DEPENDENT MODELS WITH VAR SHOCK IDENTIFICATION DEBT GAP THRESHOLD OF 3.5%

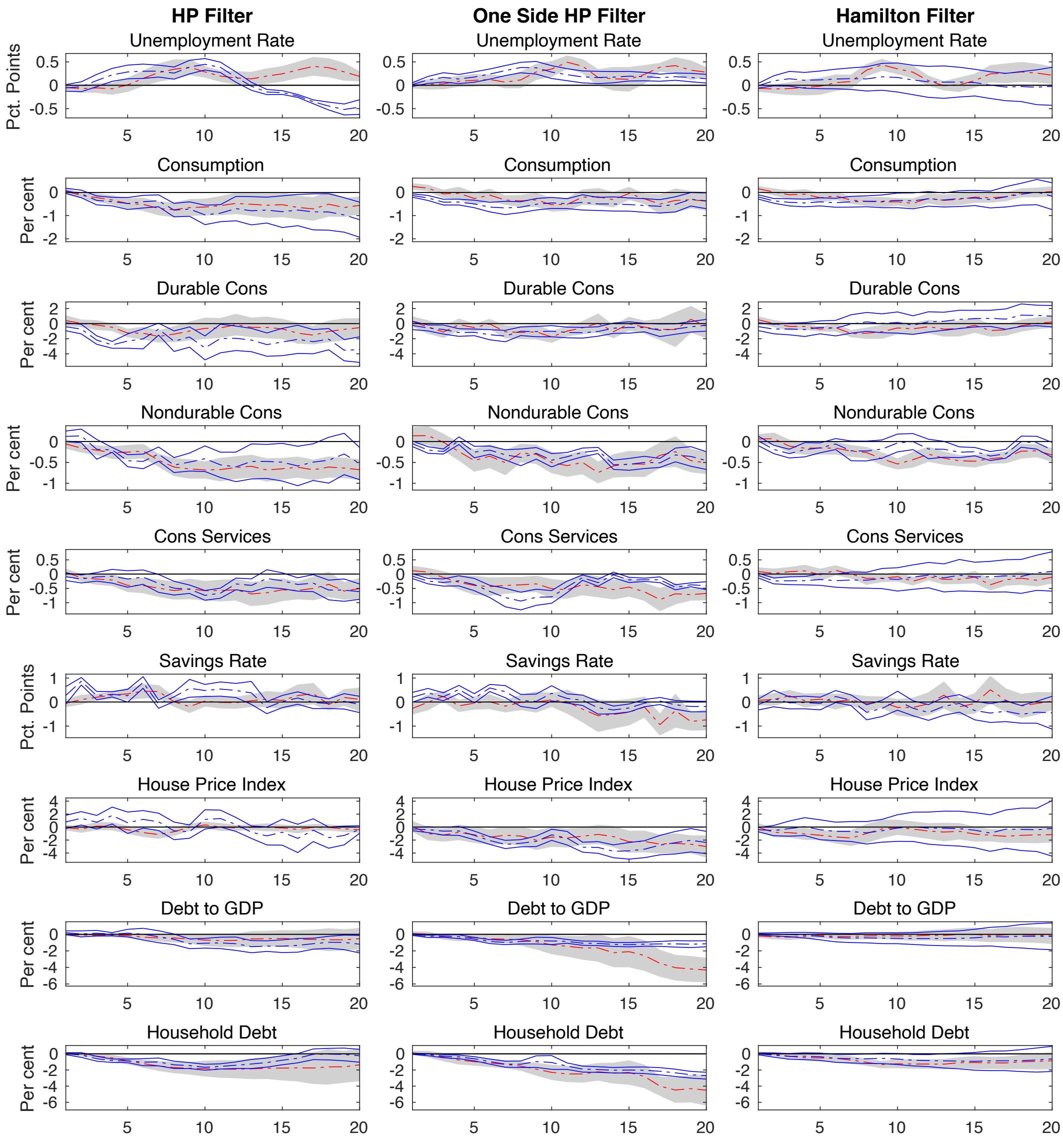
*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*

# A.7 Additional Figures for Impulse Responses Excluding the Zero Lower Bound



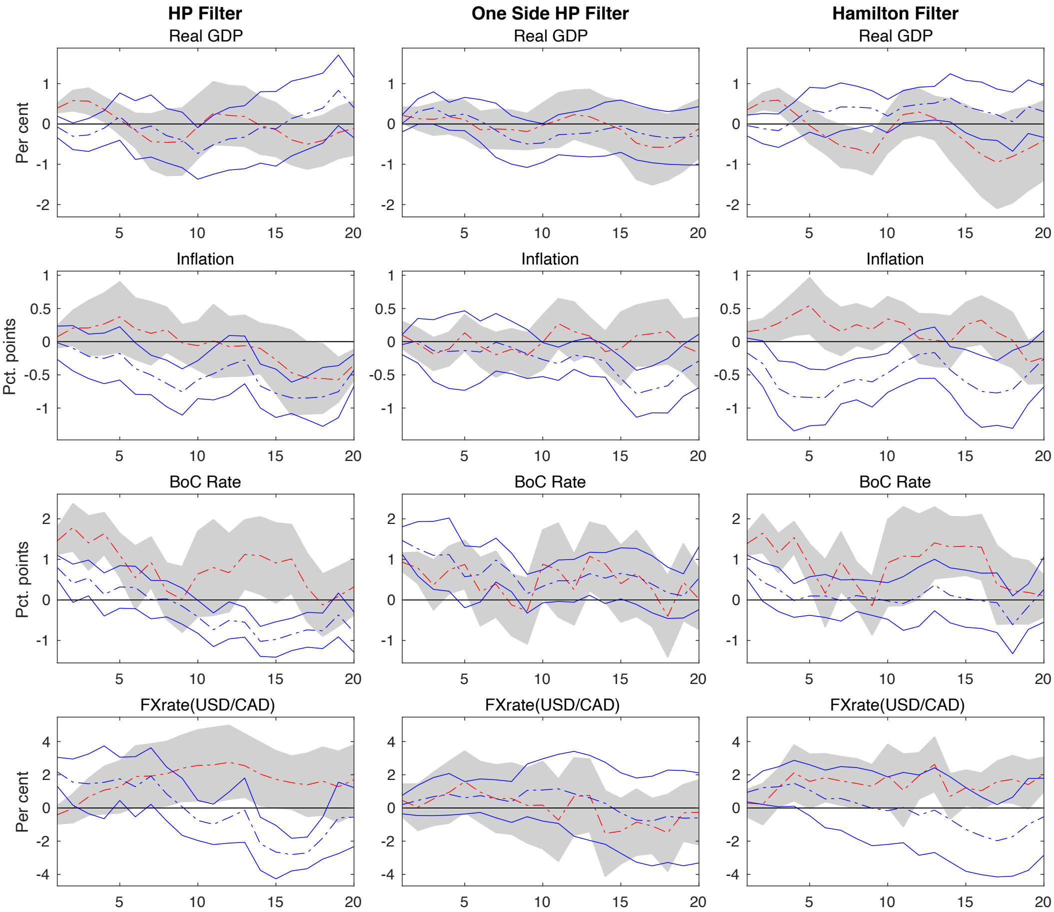

APPENDIX 7: STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION USING SAMPLE ENDING Q4 2008.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*



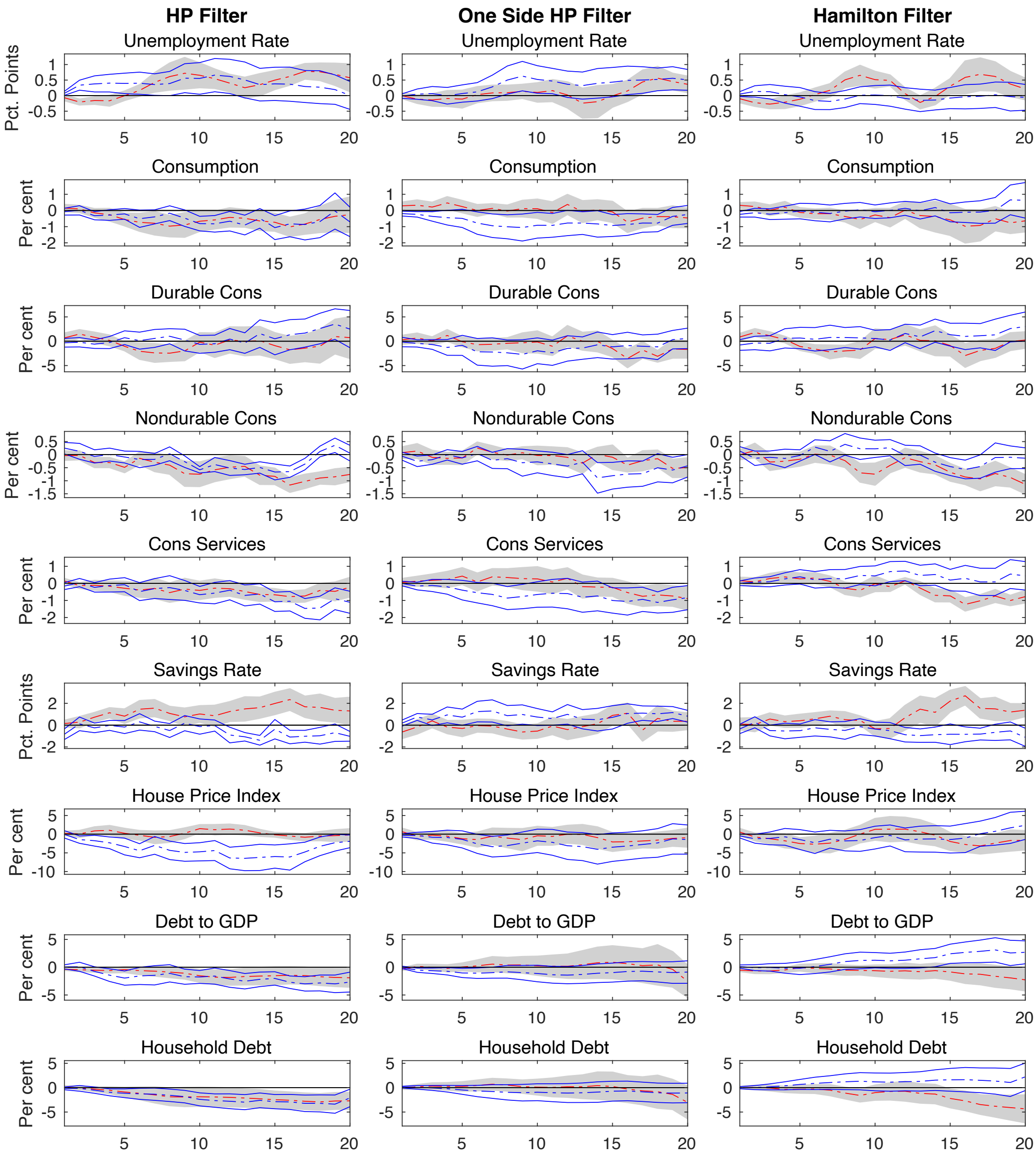

APPENDIX 7: EXTENDED STATE DEPENDENT MODEL WITH VAR SHOCK IDENTIFICATION USING SAMPLE ENDING Q4 2008.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*




APPENDIX 7: STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION USING SAMPLE ENDING Q4 2008.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*




APPENDIX 7: EXTENDED STATE DEPENDENT MODEL WITH NARRATIVE SHOCK IDENTIFICATION USING SAMPLE ENDING Q4 2008.

*NOTE: RED DASHED LINE REPRESENTS THE HIGH DEBT STATE WHILE THE BLUE DASHED LINE REPRESENTS THE LOW DEBT STATE. SHADED AREA AND SOLID BLUE LINES REPRESENT 90 PERCENT CONFIDENCE BANDS FOR EACH STATE.*