

Household Debt, Housing Prices and the Monetary Transmission Mechanism in Canada:
A Provincial Analysis

Benjamin Tobin

5267891

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Supervisor: Professor Francesca Rondina

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ABSTRACT

Following the recent financial crisis in 2008 the topics of household debt and house prices have been brought to the forefront of economic research. Several papers have been directed towards identifying the implications of these variables as they pertain to the vulnerability of the macroeconomy. However, the available literature, as it pertains to the Canadian economy, is limited. This paper utilizes a Global Vector Autoregressive (GVAR) framework to investigate the monetary transmission mechanism in Canada, and in nine individual provinces. The conclusions drawn from the paper indicate that there exist asymmetries in the transmission of monetary policy across provinces. Furthermore, the level of household debt held by a province is found to be proportional to the magnitude of the responses following a monetary policy shock. This result identifies consequences of increasing levels of household debt and over-priced real estate as they pertain to the overall stability of the macroeconomy.

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Section 1

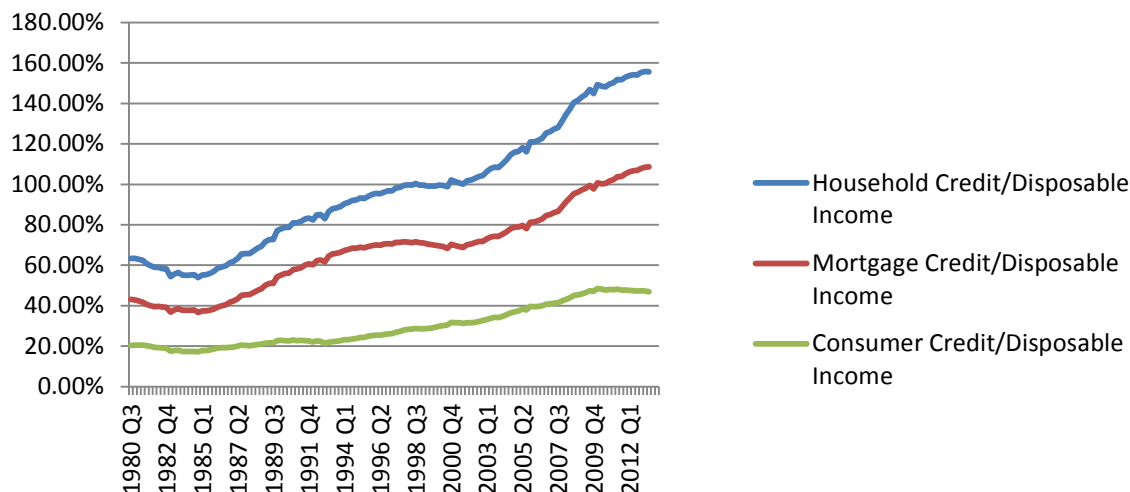
1.1 Introduction

Over the past few decades, the Canadian economy has experienced two distinct trends involving the rapid increase in the levels of house prices and household debt. The increasing proportion of household balance sheets owed to debt has led to a wealth of research into the sustainability of increasingly leveraged households. As outlined by Stephen Poloz, Governor of the Bank of Canada “household imbalances remain the most important vulnerability and could amplify the impact of external shocks” (Isfeld, 2014). Over the past few years the Bank of Canada has implemented fairly drastic manoeuvres regarding monetary policy and its approach to setting the overnight rate; the Bank’s main policy instrument. By setting the interest rate at the effective lower bound, the effects of a shock to the economy may result in greater consequences for real variables in the current Canadian economy. Thus, the consequences of such high levels of household debt and over priced real estate markets have resulted in greater uncertainty pertaining to the overall stability of the macroeconomy.

Within the framework of the monetary transmission mechanism in the Canadian economy, the Bank of Canada is able to meet its functional requirements through the adjustment of interest rates; within the channel system in which it operates. However, as the Bank of Canada targets the overnight rate, the rate at which funds can be borrowed by financial institutions, they are forced to make changes based on the Canadian economy as a whole. However, within Canada there are 10 provinces and three territories, each with distinct identities and needs. The economies of the provinces also vary to a great extent across Canada, resulting in large differences in demographics, employment rates, population growth and investment. Several of these factors have direct implications for the variables of concern within this paper, as they drive real estate markets, and as a result, household debt. In order for the Bank of Canada to successfully implement monetary policies, they must be able to accurately assess the impact of these policies across provinces.

Currently, within the Canadian economy mounting levels of household debt continue to threaten the long term health and stability of the macroeconomy. As Figure 1 shows, the level of household debt as a proportion of disposable income has increased from 62% at the beginning of 1981 to 155% as of 2012. The composition of household debt is also displayed within the figure, in which we observe the components driving the rising levels of household debt. With such a vast increase in the levels of mortgage debt, the role of housing on household debt is clearly integral to understanding the implications

(Figure1) Composition of Canadian Debt



of what a shock to housing prices or interest rates would mean for the Canadian economy. An interesting result that may be taken from the figure is that in light of the financial crisis in 2008, the total level of household debt appears to accelerate (figure 2). This however is to be expected, as a drop in interest rates will reduce the cost of borrowing and act as a catalyst for households to incur cheap debt. It is the importance of the interest rate in the operation of the macroeconomy, combined with increasingly high levels of household debt which has provided this interesting topic for investigation.

Having identified the enormous proportion of household debt attributable to mortgage debt, the role of fluctuations in house prices is clearly critical to understanding how to manage leveraged households. As seen in the levels of house prices (figure 3), we observe a slight decrease following the financial crisis, followed by a quick rebound. As the Bank of Canada implemented accommodative monetary policies, thereby cheapening the cost of borrowing, the real estate markets across Canada as a whole rebounded fairly well. However, an important characteristic of housing prices across Canada is the heterogeneous conditions specific to different regions; impacting how they operate. Several regions are dependent on commodities, such as Alberta's dependence on oil. A supply shock in oil would result in plummeting oil prices, decreasing incomes and employment, and inevitably a drop in the level of home prices as the market declines. Furthermore, important regional characteristics such as employment and population growth which may be driven by immigration or other external factors have resulted in disparities across regional real estate markets. As such, modeling of the Canadian provinces individually will allow for a more robust and realistic analysis of the effects of specific shocks on each region.

Economic theory would suggest that a robust economy, such as Alberta, with low unemployment, young demographics and a high degree of population growth would have higher home prices due to increasing demand. Alternatively, Newfoundland and Labrador has historically been a province of high unemployment, negative population growth and has continued to experience changes in demographics involving an aging population. As would be expected, these factors have resulted in low demand for homes resulting in stagnant real estate markets. However, the differences between these provinces become magnified when approached within the scope of a unified Canadian monetary policy.

The main goal of this paper is to identify key differences in the impact of monetary policy across provinces and to analyze how these differences may contribute to changes in the macroeconomy. It can also be seen that heterogeneous responses across regions could be a critical underlying source of instability in the Canadian economy and a source for shifts in policy formulation. First, I will examine the process of the monetary transmission mechanism within the Canadian economy and its effects on both household debt and the housing market. I will proceed by examining the relationship that exists at the aggregate Canadian level, creating a benchmark for the investigation into the regional distribution of responses across the provinces. The main analysis will be devoted to the regional disparities that exist across Canada with respect to a monetary policy shock. The vastly different levels of household debt and regional dependencies will allow for an interesting investigation into the effects of a monetary policy shock in each region. By accounting for the unique characteristics of each region, these responses will be analyzed for a more coherent understanding of what these differences across Canada mean for the monetary policy of the Bank of Canada.

The analysis will begin with how changes in monetary policy affect household debt, residential investment, housing prices and gross domestic product (GDP) within Canada through the use of a Structural Vector Autoregressive (SVAR) model. The results may provide a powerful insight into how the monetary transmission mechanism may affect these variables in the Canadian economy. Alternatively, the goal is to investigate what the effects of a shock to housing prices will mean for residential investment, household debt and GDP within the context of the Canadian economy. Due to the tight relationship that persists between household debt and housing prices, the result of a shock to the latter at a point where the Canadian economy is carrying vast levels of debt may amplify the effects of such a shock on the aggregate economy.

Next, the main analysis will involve the examination of monetary policy shocks on each of the provincial economies. Within a GVAR framework, each province will be modelled individually using a SVAR; in which provincial specific variables are included along with variables representing the rest of Canada and a set of global variables. By including variables for the rest of Canada, we are able to see what the spillover effects of a provincial shock will be. The results of these developments will have powerful implications for the current Canadian economy, and will provide insight into the relationship between housing prices and household debt within each of the Canadian provinces. As Ontario, Quebec, Alberta and British Columbia account for 87% of Canadian GDP (as of 2007) the analysis will focus on the effects on these four major economies. Alternatively, an investigation into how the smaller provinces in Canada fare will be done as the majority of monetary policy is most likely geared towards the more robust provinces listed above.

This paper provides empirical evidence on the monetary transmission mechanism in Canada, and across the nine provinces included within the analysis. The first contribution of this paper is derived from the analysis of the monetary transmission mechanism within Canada. By allowing the analysis to continue until the last quarter of 2007, we are able to capture more recent estimates of the contemporaneous relationship amongst the variables within the Canadian economy. Extending upon a Canadian level analysis, the paper further contributes to the existing literature by using updated provincial data in the estimation of housing and monetary policy shocks. Through the identification procedure used, we are able to explicitly state that the same monetary policy shock is being identified in all provinces under scrutiny.

The paper will proceed as follows. Section 1.2 will include a literature review, identifying the relationships identified by previous authors. Section 2 will include the methodology and approach utilized within the analysis conducted. Section 3 will discuss the selection of data. Section 4 will present first, an analysis of the benchmark model of the Canadian economy, followed by the regional analysis of the provincial models. In conclusion, the implications and contributions of the results will be discussed in Section 5.

1.2 Literature Review

In the Canadian economy household debt reached an all time high of 155 times disposable income as of 2012. Due to the consistent increases experienced in household debt and house prices across the globe, numerous papers have been directed at the question of how an economy will be affected by the circumstances that currently persist. More precisely, an analysis of how the determinants of household debt affect the vulnerability of households and the greater economy as a whole when the economy is subjected to shocks arising from the Central Bank's primary policy tool; the overnight interest rate. A better understanding of household debt, including its determinants, relationship with house prices and its transmission throughout the economy will provide a basis for the analysis of the metric within the Canadian economy.

Macroeconomic theories of debt provide an economic platform for the analysis of how household debt may impact the Canadian economy. Alternatively, an analysis of these theories will provide insight into the credit channel through which changes in housing prices are transmitted throughout the economy. Within a finite horizon consumption savings model, the variable of debt is entered as negative savings. Based on the consumers preferences associated with present and future consumption, consumers are able to borrow, or lend in order to optimize their lifetime consumption. This concept, a cornerstone in consumption theories of macroeconomics, describes the transmission mechanism of monetary policy through debt to the economy. A shock due to monetary policy or the main asset in the economy, house prices, would work to decrease transitory income. As in Kajuth (2010), we see that the wealth effect can be derived from the assumption that homeowners face liquidity constraints, and have high permanent income relative to current income. The degree to which homeowners are able to extract the added value in real estate, following increase in house prices, determines their ability to increase consumption towards the optimal level, implied by the permanent income hypothesis. Therefore, the increase in home prices acts not only to increase household debt, but also consumption as it acts to stimulate the economy. Hurst and Stafford (2004) show that in the event of a negative unemployment shock, households are in fact able to use their home equity in smoothing consumption. These results further indicate the importance of household debt and home prices in the macroeconomy through the credit channel in impacting consumption and the economy on a broader basis. In relation to these two frameworks, this paper aims to capture the relationship that exists between increasing house prices, household debt and GDP. As a result, we will be able to investigate the extent to which housing markets are able to impact the Canadian macroeconomy.

When interpreting the levels of household debt in Canada, an analysis of the determinants of the metric yield valuable insight into its rapid growth. The levels of household debt observed in other countries over the past decade share the uncharacteristically high growth observed in Canada, allowing for a number of empirical studies of the key indicators in other nations. In regards to household debt in Australia, Meng, Hoang and Siriwardana (2011) utilise a VAR model in arriving at the conclusion that the effect of GDP and housing prices are positively related to household debt; while interest rates, unemployment and inflation show a negative correlation. This study also suggests that the increasing levels of household debt are due to robust economic growth, a result which may not be useful in the current Canadian economic conditions. However, Goodhart and Hofmann (2008) also find that a significant multidirectional link persists between house prices, monetary variables and the macro economy within their VAR model. The role of housing prices in propelling changes in household debt appears to be a widespread trend across empirical studies, as was the case for Jacobson and Vatne (2011) and Anundsen and Jansen (2011). This result is found to be reinforced within this paper. Furthermore, the addition of the global analysis allows us to further investigate whether this is a uniform phenomenon, or region specific. However, the results found by Jacobson and Vatne also attribute the rising levels of household debt in Norway to other factors, including new loan products, increased liquidity, and easier access of home owners to financing.

As a result of the rapid growth of household debt in Canada for such a prolonged period of time, the importance of house prices, increasing debt levels and consumption has been magnified. The inevitable question of how these metrics can be sustained, while maintaining economic growth, remains to be seen in the event of a monetary policy shock. The effects of a monetary policy shock on the housing market using a Bayesian VAR, conducted by Jarocinski and Smets (2008) finds evidence that monetary policy has a significant negative effect on housing investment and house prices in the United States. The results of the monetary policy shock on real variables also appear to be consistent with other findings, such as McCarthy and Peach (2002) and Vargas-Silva (2008), who utilize a VAR model in their findings. Both of these papers attribute the fluctuations in housing prices to policy tools. However, McCarthy and Peach (2002) fail to recognize that rising home prices prior to the housing crash were due to an inflationary price bubble; as indicated by Greenspan (2009). This paper provides an extended analysis of house prices, through the use of a VAR framework and the inclusion of household debt. The evidence found by Musso, Neri and Stracca (2010), reinforces the findings that a monetary policy shock in the United States economy has large negative effects on housing market variables, including real house prices and residential investment. The importance of these findings in the Canadian economy is magnified when

we analyze the makeup of household debt, 69% of which was attributable to mortgage debt in Canada as of 2013.

The macroeconomic implications of rising household debt and home prices appear to be unsustainable based on literature within this realm. However, within the scope of interest rate changes in the economy, the implications of these metrics appear magnified. Cynamon and Fazzari (2008) conducted an analysis of the United States economy leading up to the financial crisis. Their findings indicated that the consumption boom experienced from the early 80's until 2006 had undoubtedly increased the level of financial instability, which inevitably cumulated with the financial crisis. A study by Debelle (2004), concludes that the increased indebtedness of households has heightened the sensitivity of the household sector to changes in interest rates, income and asset prices. These studies, conducted prior to the financial crisis in the United States shed insight onto the consequences of the growth of household debt within the Canadian economy. The findings of Assenmacher-Wesche and Gerlach (2008) are based on a VAR model which induces shocks to interest rates. The results indicate that interest rate shocks account for a large proportion of fluctuations in credit and GDP, but a much smaller proportion of the fluctuations in property and equity prices. Another VAR analysis of the United States economy by Kim (2011) indicates a negative long run relationship between household debt and output. This finding of Kim outlines the fact that as household debt encourages consumers to increase their consumption, the negative effects caused from accumulating excessive debt will result in credit driven cyclical periods of output. This will result in a manufactured economic boost, as the foundation for the increase in economic activity is based on debt and thus not sustainable. The issue with this kind of economic boost is that it will lead to increased financial fragility and increase households vulnerability to shocks. As outlined by Greenwood-Nimmo (2009), an additional effect of an interest rate shock on the economy will be an increase in the debt burden on households, which will again increase the vulnerability of households. As households deal with increasing debt burdens they must inevitably reduce their consumption as disposable income shrinks, leading to further drops in output.

All of these studies illustrate the intricate composition of household debt in various countries around the world. A common theme amongst this literature which spans household debt is the importance of housing prices, and increasing vulnerability to monetary policy shocks. Within the context of the Canadian economy it is important to outline distinct characteristics of the Canadian real estate market. As of May 2014, TD Economics reports that the average resale home price growth rate reached 7.1% year over year. This rate surpassed income growth and pushed up the home price-to-income ratio to

a new high. (TD Economics, 2014, p.1). Continued increases in house prices highlight the continued leveraging of households, likely a response to the low interest rates which continue to persist. However, as indicated in an IMF report; of the nearly 50 systematic banking crises in recent decades, more than two thirds were preceded by boom-bust patterns in house prices. (Zhu, 2014, June 5). As the Canadian real estate market continues to boom, the raising concern and hope for a 'soft landing' in home prices increase. In an assessment of the Canadian financial sector conducted by the IMF in 2014, government support of residential mortgage markets was indicated as a crucial factor in the sustainability of Canadian real estate markets. As noted in the report, the Canadian Mortgage and Housing Corporation (CMHC) maintains a loan insurance program which involves 100% government-backed insurance (IMF, 2014). This feature of the Canadian housing market clearly indicates a large role for this crown corporation, should the housing market crash in the Canadian economy, easing the impact on financial institutions, should housing prices collapse. This insurance program will mitigate against the risk that a severely negative housing market scenario will occur in Canada. However, the risk of continuous increases in home prices has become apparent following the real estate crash in the United States.

The divergent circumstances and environments that persist between the Canadian provinces have created a challenge to the implementation of a non-partisan monetary policy regarding the provinces. As the provinces within Canada display distinct characteristic differences in their economic conditions, the necessary policy required for each province's economy to thrive results in a divergence of interests amongst the provinces. In a study of the United States, Mian and Sufi (2014) find a direct correlation between the level of debt in a state and the degree to which they were affected by the housing crash. They conclude that the combination of higher debt loads and the crash in house prices is what decimated household spending in the states with the highest levels of household spending. When looking at the Canadian economy, a Bank of Montreal survey shows that Albertans hold the highest debt levels in the country; nearly \$50000 more than the national average (McIntosh, J, Perkins, T. 2007). This finding is further highlighted by the findings of a TD Economics special report, which finds that households in British Columbia, Alberta and Ontario are the most vulnerable to an adverse economic shock (TD Economics, 2011). These findings indicate that these three provinces, which account for a large portion of GDP, are the most susceptible to an adverse economic shock. Furthermore, Jud and Winkler (2002) find that changes in house prices are strongly influenced by population growth, changes in income and changes in interest rates. Within this paper, the investigation into discrepancies across provinces may yield a powerful insight into the response of provincial housing markets and debt to monetary policy shocks induced upon the system.

In recent works, the observed trends in household debt and housing prices have led to a greater financial instability across the United States. Since the formation of the European Monetary Union (EMU), several papers have been directed towards the European Central Bank's ability to control the dynamic environment, in which they operate (see Peersman (2004), Clausen, Volker; Hayo, Bernd (2002), Dees, Di Mauro, Pesaran and Smith (2007), to name a few). As indicated in Peersman (2004), due to the diversity in economic and financial structures across the economies in the EMU, common monetary policy shocks can be expected to have a different impact in terms of timing, magnitude and distributional effects. Within the literature pertaining to the EMU, several methodologies have been utilized in trying to capture the degree to which the effects of monetary policy vary across the countries. The findings of Dees, Di Mauro, Pesaran and Smith (2007) are based on a Global VAR (GVAR), in which international linkages in monetary policy are examined between the United States and the Euro region. The results indicate that no real spillover effect between the two regions is experienced from monetary policy shocks. However, this analysis most likely suffers from the issue of trying to separate the impact of changes in interest rates and exchange rates in analyzing the responses to a policy shock. The analysis of Clausen, Volker, Hayo, and Bernd (2002) focuses on the economies of France, Germany and Italy; as these economies account for almost three quarters of European output. Utilizing a semi-structural dynamic modelling approach, the impulse responses indicate a homogeneous response is observed across the three countries examined in response to a monetary policy shock. Consistent with these findings, Peersman (2004) finds, through the use of a SVAR model, that the monetary policy effects on output across countries are relatively similar. However, within the GVAR literature, the model presented in this paper holds a unique position. The analysis conducted focuses solely on one country, Canada. As such, we are able to estimate over a larger period than the previous literature as the data collection method across the Canadian provinces is uniform. Similarly, we are able to dismiss any issues that may exist within the data or methodology, that are attributable to exchange rates or other international differences between countries.

The majority of the studies, which have been conducted in the realm of a common monetary union, restrict their attention to the relationships that exist between monetary policy shocks and output responses across the European region. However, the implication of household debt and housing markets within the framework of a common monetary policy across a body of countries has received much less attention. Christidou and Konstantinou (2013) examine the housing markets response to a monetary policy shock across the United States using a VAR model. The estimates produced for each state indicate that there is in fact a heterogeneous response across regional housing markets in response to a common

monetary policy shock. The present paper works to extend on this research through the inclusion of global variables and the analysis of regional differences within a global framework. However, in a study of the UK, Norway and Sweden, Bjornland and Jacobsen (2010) find a homogeneous response across the economies. Using a SVAR, the results indicate that a monetary policy shock induces a large and prolonged effect on housing markets in all three regions examined. The model presented within extends upon the literature pertaining to household debt and housing prices by providing a framework that allows for global interdependencies. As such, the model extends on the literature in this realm by providing a platform for the analysis of regional interactions. However, the conclusions derived from other countries do not indicate any consistent consequence for a common monetary policy, a finding which is found to be reinforced for the Canadian economy within this paper.

2. Methodology

2.1 Specification of the Benchmark Model: A Canadian SVAR

The approach taken to model the relationship between the variables within this paper is done using a Structural Vector Autoregressive Model (SVAR), as developed by Bernanke (1986) and Sims (1986). From economic theory we are able to impose contemporaneous structural restrictions, providing a platform for the analysis. Based on the model's ability to impose such restrictions, the SVAR model is used extensively within the literature spanning monetary policy and housing market shocks. For the purpose of the baseline framework, the SVAR is estimated for the Canadian economy as a whole.

The SVAR model is estimated in the form written as :

$$A_0 Y_t = c + A(L)Y_{t-1} + \epsilon_t$$

In this equation, A_0 represents an $n \times n$ lower triangular matrix describing the contemporaneous relationship between endogenous variables (where $n=6$), c represents the vector of constants, ϵ_t represents the vector of orthogonal structural shocks, while $A(L)$ is the matrix polynomial in the lag operator. The vector of structural shocks on the system, ϵ_t , are assumed to be normally distributed with a zero mean.

Within the benchmark analysis, the variable Y_t represents is a (6x1) vector of endogenous variables. These variables contained within Y_t include gross domestic product (gdp_t), the consumer price index (cpi_t), the house price index (hpi_t), residential investment ($hiqg_t$) (taken as annual growth per quarter), household debt (hd_t), and the bank rate (i_t), as set by the Central Bank. For each of the variables included, the values are denoted by time t , in the following order.

$$Y_t = \{gdp_t, cpi_t, hpi_t, hiqg_t, hd_t, i_t\}'$$

The order of the variables in the system leads to the desire to examine the effects on household debt and housing prices in the monetary policy transmission process. The economic intuition for the ordering of the endogenous variables is further discussed in the identification section. The two structural shocks of primary interest are shocks to monetary policy and house prices.

2.2 Specification of the GVAR Model

Within the main analysis, the model is estimated utilizing a Global Vector Autoregressive Model (GVAR). The GVAR model, as recently developed by Pesaran et al. (2004), provides a macroeconomic framework for the analysis of interactions amongst economies. By enabling the modeling of regional linkages, the GVAR approach provides a coherent means of identifying the regions involved in global imbalances. Furthermore, the special attention devoted to the spillover effects of the variables within the model allows us to disentangle the geographic linkages following an economic shock. These features are made possible through the inclusion of a series of global variables common to all regions, as well as a series of economy specific and foreign specific variables. The GVAR model presented is composed of nine Canadian provinces each modelled separately as a SVAR. Each provincial model is linked to the others through the inclusion of variables representing the rest of Canada and core global variables representing the global economy. This framework allows for the modelling of each of the provinces separately while ensuring that financial linkages are included within the model.

Each SVAR model is then estimated in the form,

$$A_0 Y_t = c + A(L)Y_{t-1} + \epsilon_t$$

where each of the nine provincial models Y_t is as,

$$Y_t = \{gdp_t, cpi_t, Z_{i,t}, i_t\}'$$

As in the benchmark analysis, the vector of structural shocks on the system, ϵ_t , are again assumed to be normally distributed with a zero mean. The core variables, such as gross domestic product (gdp_t), the consumer price index (cpi_t) and the bank rate (i_t), are included in all provincial models.

However, for each province i the set of provincial specific and residual Canadian values are grouped as,

$$Z_{i,t} = \{X_{i,t}, X_{i,t}^*\}'$$

The set of provincial variables, $X_{i,t}$, includes three variables specific to each province i : the house price index ($hpi_{i,t}$), residential investment ($hiqg_{i,t}$) (taken as annual growth per quarter) and household debt ($hd_{i,t}$). The provincial variables are included for province i at time t in the following order.

$$X_{i,t} = \{hpi_{i,t}, hiqg_{i,t}, hd_{i,t}\}'$$

The set $X_{i,t}^*$ contains variables which represent the values for the rest of Canada. Within $X_{i,t}^*$, a variable for the house price index ($hpi_{i,t}^*$), residential investment ($hiqg_{i,t}^*$) (taken as annual growth per quarter) and household debt ($hd_{i,t}^*$) are included. These variables are unique to each province i and are calculated as the sum of all provinces j , where $i \neq j$.

$$X_{i,t}^* = \{hpi_{i,t}^*, hiqg_{i,t}^*, hd_{i,t}^*\}'$$

The inclusion of these variables is done to show the impact of the rest of Canada on each provincial economy i . Alternatively, the inclusion of these variables allows for the analysis of spillover effects into the rest of Canada following an adverse economic shock in a given province.

Thus, each provincial model is estimated for the vector Y_t expressed as,

$$Y_t = \{gdp_t, cpi_t, hpi_{i,t}, hiqg_{i,t}, hd_{i,t}, hpi_{i,t}^*, hiqg_{i,t}^*, hd_{i,t}^*, i_t\}'$$

The ordering of the sets $X_{i,t}, X_{i,t}^*$ is done based on economic intuition which lends to the analysis of the primary provinces of concern: Ontario, Quebec, Alberta and British Columbia. The ordering of the bank rate last in the vector follows the assumption that the bank rate contemporaneously responds to all other variables within the model. A monetary policy shock is orthogonal to all global, provincial and out of province variables. The ordering of other variables in the system was determined based on the optimal identification strategy which will be discussed in more detail in the next section. Each of the nine provincial models is estimated individually as a SVAR.

2.3 Identification of the SVAR

In order to identify the shocks a Choleski decomposition was utilized, in which the variables were ordered as above. Through the Choleski decomposition, the lower triangular identification structure enables us to impose short run restrictions based on the ordering of the variables of interests within the model. The variables included within the model are ordered based on the sequence in which their effects are determined in the economy, relative to the other variables in the system. The bank rate is placed last

in the ordering, as this implies that all of the remaining variables respond to a monetary policy shock with a lag. The placement of housing prices before residential housing investment implies that a shock to house prices will immediately affect residential investment, household debt and the bank rate. This result implies that within the scope of the Canadian economy, a shock to housing prices will result in a credit driven response in household debt, as the value of homes is directly proportional to this metric. However, the immediate response of residential investment results due to a direct response in the future value of home production, as determined by the underlying value in home prices. This assertion relies on the assumption that investors are able to rapidly react to changes in house prices. Thus, a change in house prices, which reflects the future value of an investment in housing, will result in a rapid change in the level of residential investment. Alternatively, as a shock to residential investment will affect the supply of housing with a lag, we assume that the effect on housing prices will occur with a lag. Compared to the alternative, this ordering provides a more plausible interpretation of the real world, and thus was selected for the purpose of the analysis. Alternatively, the consumer price index and gross domestic product will respond to this shock with a lag; a result, which would appear to be intuitive as employment and production do not adjust instantaneously to changes in the economy. When choosing the ordering restriction within the model, a reverse ordering in housing prices and residential investment was also tested. However, the chosen ordering provided a superior economic interpretation with respect to the transmission of a housing shock to the economy. Also, following several authors from the previous literature (Christidou and Konstantinou (2013) and Christiano, Eichenbaum and Evans (1999)) the backward looking aspect of the model will include 4 lags.

For the main analysis, the ordering of the variables was done as in the benchmark analysis, as this framework provides an intuitive economic interpretation. With the addition of the province specific and residual Canadian values, further intuition must be provided in justifying the ordering of the variables. Within the sets X_t and $X_{i,t}^*$ the ordering of the variables remains as in the benchmark analysis. However, the ordering of these sets within the vector $Z_{i,t}$ requires an economic interpretation. The vector of province variables is placed before the vector representing the sum of all provinces j , where $i \neq j$. The use of a GVAR model allows us to look at the spillovers effects of a regional specific shock into the rest of Canada. The model is constructed with the goal of capturing these interactions that persist within the Canadian economy. It is true that housing markets are geographically isolated, and real estate is immobile. However, when looking at the spill over effects following a shock to a provincial housing market, we are concerned with providing an ordering which allows us to capture the ‘most realistic’ relationship. Within Canada there is a high degree of labour mobility and financial integration,

characteristics that may lead to spill over effects within Canada. In the selected scenario, where the provincial specific variables are ordered before the out of province variables, a shock to a provincial housing market would affect the rest of Canada immediately. Following this intuition, a shock to Ontario, Quebec, British Columbia or Alberta will result in spillover effects outside of the province immediately. This ordering lends a more logical argument concerning the larger Canadian provinces, which collectively account for 87% of Canadian GDP. In the scenario where the out of province variables are ordered before the variables for the province, a shock to a provincial housing market would affect the rest of Canada with a lag. Thus, a shock to the rest of Canada will affect each province immediately. Following this scenarios logic, a shock to the rest of Canada will affect the individual provinces immediately. This result lends to a more logical argument for these smaller provinces. The choice of ordering represents a trade-off. However, as we are interested in the largest provinces which account for 87% of Canadian GDP, the chosen ordering provides the most realistic interpretation possible as it is a more logical argument to claim that a shock to Ontario will immediately affect the rest of Canada than the opposite. Due to the specification of the model we are not able to say that the same provincial shocks are being identified across the different provinces. As such, the analysis of housing shocks must be made under the discretion that inconsistencies exist in the identification procedure. Therefore, when analyzing the provincial level shocks the results are not directly comparable across the provinces. Moreover, the ordering implies that each province will respond to a shock in the rest of Canada with a lag; a result which again lends to the focal provinces of the analysis. Within the model, we are also able to say that across each province we are identifying a monetary policy shock that is orthogonal to all global, provincial and out of province variables. However, as the provincial and out of provinces variables differ across models, the shocks identified across the provinces are not the same. For each province identified, the variable lists also remain the same for consistency. This enables the impulse responses in each province to be analyzed on the basis that differences are solely based on differences in the provincial data, with respect to a monetary policy shock.

The models displayed within this paper were estimated using EViews software (Version 8). Both the GVAR and SVAR models were estimated using the method of equation-by-equation OLS. Based on the residuals produced for each model that was estimated, we were able to compute the reduced form covariance matrix. From the residual values of each model estimated, we are able to compute the reduced form covariance matrix as follows,

$$\hat{\Sigma} = \frac{1}{T - kp - 1} \sum_{t=1}^T \hat{\epsilon}_t \hat{\epsilon}_t'$$

Within EViews, the error bands are computed using the asymptotic distribution of the coefficients of the MA representation obtained by inverting the estimated VAR model. Therefore, the error bands produced represent uncertainty about the estimated coefficients of the model. Using the impulse response functions produced from the models, the effects of various effects on the economy will be analyzed over a period of 20 quarters. Starting from the baseline scenario, the analysis of two orthogonal, one standard deviation shocks to the system will be investigated. The first shock induced on the system is that of a monetary policy shock. Next, a shock to the housing price index will be evaluated.

Finally, the lag length selected was 2 quarters as suggested by the Schwarz Criterion for all nine provinces (Tables 4-12). Several lag lengths were selected in the robustness analysis. However, the responses generated with longer lag lengths were insignificant and failed to display any mean tendency due to increased volatility. Following authors such as Galesi and Lombardi (2009), the lag length of 2 was chosen.

3. The Data

3.1 The Benchmark Model : The Canadian Economy

The sample of data used in the benchmark analysis will include six variables taken on a quarterly basis for the period of 1981Q1 to 2007Q4 for the Canadian economy. The analysis will stop immediately prior to the deep recession experienced in 2008 in order to obtain a better view of the impact of a monetary policy shock during a stable policy regime. The variables used will include gross domestic product, the consumer price index (The Bank of Canada's measure of CPI excluding the 8 most volatile components), the housing price index (referred to as NHPI hereafter), residential housing investment, household debt and the bank rate (see Table 13). The data used in the analysis was obtained from the Statistics Canada Cansim database. In order to adjust the level of residential investment for the seasonality of the Canadian economy, the difference in the annual growth per quarter was used. All other series with the exception of the bank rate are seasonally adjusted series from Statistics Canada and enter into the model in the form of their log difference (figure 5).

3.2 The Main Analysis: Provincial Economies

In the main analysis, the data are taken for nine provinces (Newfoundland and Labrador, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia) on a quarterly frequency, for the period spanning 1986Q1 to 2007Q4. The analysis will again stop immediately prior to the deep recession experienced in 2008 in order to better identify the relationship between the variables during a stable policy regime. Due to a limited availability of data, Prince Edward Island was not included in the analysis. The variables included at the aggregate Canadian level include gross domestic product, the consumer price index and the bank rate; all of which remain as in our benchmark model. Two variables are included for each the NHPI, residential housing investment and household debt. The first variable included represents the individual province, and the second provides the residual value for each respective variable in the rest of Canada. All variables were obtained as seasonally adjusted series with the exception of residential investment, which was manually adjusted to reflect the difference in the annual growth per quarter. All variables have been transformed and enter the model in there log difference representation (figures 6- 14).

Due to the various limiting constraints on available quarterly data for Canadian provinces, the provincial specific variables were constructed based on the data available. Regarding household debt, the provincial data is only available at annual intervals; therefore, quarterly values were imputed. Using the annual data, the weights representing each province's share of household debt was computed. Using these weights, the household debt attributable to each province was imputed based on the aggregate Canadian level of household debt for each quarter. In this approach we must assume that the same percentage of Canadian debt applies to each province for all four quarters in a year. However, based on available data this approach provides the most coherent means of obtaining the quarterly data necessary. Residential housing investment is included as in the benchmark analysis, with each provincial value being represented as the difference in annual growth per quarter. Due to the methodology used by Statistics Canada in computing the NHPI, it was necessary to construct a series which allowed for the modelling of each individual province. First, a time-varying weight was computed for each quarter based on the percentage of new home sales in each province (Table 1). The choice of weights based on house sales in each province was undertaken with the rationale that higher quantities of home sales should correspond to a greater contribution to the national change in the NHPI. As the weights for each province are fairly consistent over time, an average is taken for the computation of the provincial variables. A drawback to this approach is that the measure of housing prices used within the analysis represents an approximation. However, by fixing the weights and thus making it time-invariant, we are able to ensure we are identifying the effect of monetary policy on house prices and not simply changes in the weights over time. In computing the provincial variables, the log difference in the NHPI for each province is taken and multiplied by the provinces respective weight. This variable is included for each province, as well as a variable representing the sum of all other variables computed for provinces. The later variable allows us to interpret changes in the rest of Canada, which must again be interpreted as an approximation due to the time-invariant weight attached to the variable. However, as displayed in figure 4, the sum of provincial variables is consistent with the evolution of the NHPI at an aggregate Canadian level. As a result, the time-invariant weight provides a reliable means of generating the necessary variables. The manipulation of the data was not preferential. However, in order to compute the analysis at a provincial level, covering the span of years required, the data used provided the most efficient means of obtaining the necessary data.

The choice to use a nominal measure of the NHPI, residential investment and household debt was based on the methodology used in previous literature in this area. The use of nominal measure of data are consistent with authors including Antipin (2008), Vargas-Silva (2008), Clausen and Hayo (2006) and

Meng, Hoang and Siriwardana (2011). When the model is estimated using real variables, similar results are observed following a monetary policy shock (figure 43). However, in the presence of real variables, a housing price shock results in a marginally negative response in household debt (figure 44). Therefore, as a result of the inclusion of real variables, a counter-intuitive response is observed in household debt. Within the scope of a housing price shock, the responses of all other variables remain as in the main analysis.

The variables in the model are included in their log-difference form due to issues of model stability. When estimating the model using variables in their log-level form, the impulse responses generated by the SVAR were exhibiting explosive behaviors, and the model was non-stationary. To verify that the models are stationary when the variables are defined in log-differences, a unit root test was conducted for each estimated model. In all models, the results indicate that no root lies outside the unit circle, and we reject the null hypothesis of a unit root at the 99% level of significance for all variables.

4. The Analysis

4.1. The Benchmark Analysis: A Canadian SVAR

Using the impulse response functions produced from the SVAR, the effects of various effects on the economy will be analyzed over a period of 20 quarters. Starting from the baseline scenario, the analysis of two orthogonal shocks to the system will be investigated. The first shock will involve the resulting effect of a monetary policy shock. Second, a shock to the housing price index will be evaluated.

4.1.1 Monetary Policy Shock

Using the impulse response functions produced from the SVAR, the first shock analyzed represents an increase to the bank rate. The resulting effects on the Canadian economy involve a negative impact on GDP and a positive impact on the CPI; as shown in Figure 15. Starting with the effect on GDP, an intuitive explanation of this result can be obtained. Within the impulse responses generated we are able to observe an average negative behaviour in the value of housing prices, residential investment and to a lesser extent household debt. The impact seen when looking at the value of residential investment follows the traditional intuition that an increase in interest rates will lead to a reduction in investment, however the decrease is not significant. It may also be the case that the increasing debt burden to households associated with the increase in interest rates will lead to defaults on mortgages, fueling the negative response in house prices. As households reduce the amount they are willing to borrow or default on their mortgages, there is a reduction in economic activity as households experience a decrease in their transitory income. As a result of this negative impact, we then observe a large reduction in GDP. When looking at the applicability of these results, a shock to the interest rate leads to an intuitive result with respect to the variables within the system. The results obtained from the analysis of the monetary policy shock appear to be consistent with authors including Jaobsen and Bjornland (2010), and Meng, Hoang and Siriwardana (2011). The resulting impact of the interest rate shock on the price level is positive, consistent with Goodhart and Hofmann (2008). However, the response seen in the price level following a monetary policy shock results in a counterintuitive response from an economic perspective. The economic theory would suggest that in the case of monetary tightening, a decrease to the price level should occur. When estimating the model in which CPI is ordered first in the vector of variables again results in the existence of the price puzzle (Figure 42). As Christians, Eidenbaum and Evans (2008)

indicate, the phenomenon of the price puzzle is attributed to forward-looking monetary policy as the impulse responses capture in part the anticipated reaction of monetary policy to expected future inflation. However, overall the resulting response of the monetary policy shock on the Canadian economy is consistent with previous literature on other countries.

4.1.2 Housing Price Shock

The next shock analyzed using the impulse responses is a housing price shock on the Canadian economy. This shock is interpreted as an increase to the growth rate of house prices in the economy, resulting in the various responses as follows (Figure 25). The largest response to housing prices appears to be household debt, which displays a large increase following the shock. An interesting note is that after 6 quarters when the rise in housing prices appears to taper off, the increase experienced in the growth of household debt is also reversed. This can be seen as a boom in household borrowing, which is only sustainable as long as housing prices continue to rise. The response of household debt appears to accelerate after two quarters, before beginning to decline towards its pre-shock level. These responses are consistent with the findings of the previous authors, such as Musso, Neri, and Stracca (2010), who find the same relationship persists within a model including mortgage debt in place of household debt in the European region. With respect to the interest rate, no significant response is seen in the short or long run. The impact on the consumer price index of a house price shock again involves a response which is not statistically significant. Alternatively, the resulting increase in GDP stemming from a shock to house prices is again not found to be significant. The link between the response of household debt and the shock in house prices displays the interdependence between the variables. This result also appears to be consistent with the previous literature (Jacobson and Vatne (2011), Goodhart and Hofmann (2008)) and the consensus view regarding the effects of a housing price shock on household debt in the economy.

4.2. The Main Analysis: The Provincial Economies

Using the impulse response functions produced from the GVAR, the effects of shocks to each of the 9 provincial models will be analyzed over a period of 20 quarters. Starting from the baseline scenario, the analysis of 2 orthogonal shocks to each of the provincial models will be investigated. The first shock induced on the system is that of a monetary policy shock. Next, a shock to the housing price index will

be evaluated. The analysis will focus on the provinces of British Columbia, Alberta and Ontario as they compose the highest proportion of household debt; Quebec will also be included due to its large contribution to GDP.

4.2.1 Monetary Policy Shock

Using the impulse response functions produced from the GVAR analysis, the first shock represents an increase to the bank rate across each of the provinces. Examination of the largest provinces, Ontario, Quebec, Alberta and British Columbia unveils several interesting results; as shown in figures 16, 18, 20, and 21. Firstly, a somewhat homogeneous response to the monetary policy shock is observed across the global variables included within the system. This involves a marginally positive impact on the CPI and an average negative response in GDP across all four of the major provinces. Amongst the responses to the global variables, the largest reduction to Canadian GDP is seen to occur in Ontario after 4 quarters, an intuitive response due to the size of Ontario's economy. When analyzing the impact on provincial specific variables, British Columbia is seen to have the largest impact on household debt while Ontario experiences the largest impact in housing prices. However, neither impact is seen to be significant. This result appears to have an intuitive explanation, as British Columbia and Ontario's economies are cited to have the highest value on the household financial vulnerability index (TD Economics, 2011). However, within the other two provinces included in the main analysis, a homogeneous response is observed in response to the increase in interest rates involving no significant response.

Next, the response to the monetary policy shock is investigated across the remaining provinces: Saskatchewan, Manitoba, Nova Scotia, Newfoundland and Labrador, and New Brunswick; as shown in figures 17, 19, 22, 23 and 24. Across each of the provinces a homogeneous response is observed in the global variables and across all 5 provinces a homogeneous response is found in the provincial specific variables. Following the increase to interest rates, an increase in the CPI is observed. Across the provinces we observe a negative mean tendency in household debt, house prices and residential investment. However, this response is not significant in any of the provinces. The exception to the lack of significance is seen in the negative impact on household debt experienced in Saskatchewan, and the negative impact on housing investment in the province of Manitoba. However, the results indicate, as

would be expected, that the smaller economies within Canada are far less responsive to changes in monetary policy.

4.2.2 Housing Price Shock

The next shock analyzed involves the impulse responses generated by the GVAR following a housing price shock on each of the provincial economies. This shock can be interpreted as an increase to the growth rate of house prices in the economy, resulting in the following responses. However, a discussion regarding the interpretation of the provincial housing shocks is necessary. As indicated in the identification section, the shocks generated across each respective province cannot be generalized to be the same shock. Instead, each shock produced represents a structural housing price shock induced on each provincial economy, in which the magnitude and responses to said shock differ across provinces.

Once again the analysis will begin with an examination of the largest provinces, Ontario, Quebec, Alberta and British Columbia. Across each of the provinces, a homogeneous response is observed across the global variables, GDP and CPI; as shown in figures 26, 28, 30 and 31. This response involves a negative mean tendency in GDP in all four provinces. However this response is significant in Ontario, which shows a decrease following 10 periods. This result is accompanied by a significant increase in the CPI in Ontario and Quebec. An interesting result is the opposite impact experienced in British Columbia, where a negative response is observed in the CPI. With respect to the provincial specific variables a heterogeneous response is observed in each of the provincial models. Within Alberta and British Columbia no significant response is observed across the provincial specific variables in response to their respective housing shocks. However, a positive mean tendency is observed in the level of household debt. The largest response to a housing price shock appears to be in Quebec and Ontario, representing an interesting result. This involves an immediate increase in residential investment, which appears to taper off rapidly. The impact on household debt experienced in Quebec and Ontario also results in a significant increase following four quarters. When observing the impact of a house price shock on the rest of Canada, a heterogeneous response is once again observed. Across all four provinces, the provincial housing shock results in a significant increase in the interest rate solely in Ontario. The largest influence on the rest of the country is seen following a real estate shock in the economies of Quebec and Ontario. The responses generated indicate that a regional house disturbance in these provinces results in a large spillover effects in the rest of the country. This impact involves an increase to housing prices across Canada, accompanied by a large increase in household debt. However, the spillover

effects generated are again not directly comparable due to the inconsistency across provinces in the identification procedure utilized. As such, the results indicate only the spillover effect present for the shock identified in each province.

Next, the response to the house price shock is observed across the remaining provinces: Saskatchewan, Manitoba, Nova Scotia, Newfoundland and Labrador, and New Brunswick; as shown in figures 27, 29, 32, 33 and 34. Across each of the provinces a homogeneous response is observed in the global variables involving a negative impact on GDP on average, resulting in a significant response in Manitoba and Newfoundland and Labrador. Across all 5 provinces a homogeneous response is also found in the provincial specific variables with respect to the provincial specific shocks. Following the increase to the growth rate of house prices no significant increase in household debt is observed. The responses generated show a positive mean tendency with respect to household debt; excluding Newfoundland and Labrador, which shows a decrease following four quarters. Within all provinces the response of residential investment appears to be insignificant. When analyzing the responses generated across the rest of Canada, the only significant response is observed in household debt stemming from a shock to New Brunswick. In response to the provincial specific shocks in all five remaining provinces, no change in the interest rate is observed. The results indicate that the smaller economies within Canada are less responsive to adverse shocks to house prices, generating a smaller impact regarding the Canadian economy.

4.3 Robustness Analysis

Throughout the estimation process several robustness checks were conducted in order to justify the benchmark model. The first set of robustness checks involved the estimation of the benchmark model using different variables. The baseline model was estimated using the disposable income of households in place of GDP. This analysis was done to determine if disposable income may provide a better proxy for the impact of the impulse responses of interest. However, as seen in Figure 35 the model containing disposable income resulted in statistically insignificant results for disposable income in the majority of orthogonal shocks imposed on the system. As a result, the use of GDP provides a superior approach for examining the economy wide responses to each shock in addition to providing a better indication of the health of the economy. From an economic perspective, using GDP within the model provides a proxy for factors such as the level of production and enables inferences that we would be unable to make had disposable income been selected. The second set of robustness checks involved the identification of the optimal number of lags to be included within the system. Using the optimal lag criterion generated from the baseline model (Figure 36) the optimal lag lengths indicated by the Akaike and Schwarz information criterion were tested. As seen in Figure 36, the model estimated using the optimal lag length of the AIC (eight) generated insignificant responses and failed to display any mean tendency due to increased volatility. Also, the lag length suggested by the SC of three resulted in far less robust estimates from an economic perspective than that of the baseline model.

The estimation of the GVAR model, for each of the nine provinces, the same set of variables was included in the system as in the benchmark model. Once again robustness checks were completed accounting for different lag lengths within the model. The suggested lag length from the Akaike information criterion was tested against the chosen lag length of two. The robustness check completed for British Columbia is included in figure 37. It can be seen that the suggested lag length of the AIC of eight again generates insignificant and far less consistent results pertaining to the monetary policy shock. Alternatively, the suggested lag length of two as suggested by the Schwarz Criterion results in a far more robust response functions. Within the selection of data used within the model, several robustness checks were conducted in the selection of the series selected for housing prices. In the GVAR framework employed in this paper, the choice of adopting fixed weights is a better alternative to the use of time-varying weights. Indeed, by fixing the weight of each province in the computation of the provincial and “out of the province” HPI, we are able to ensure that we are actually identifying the effect of monetary policy on house prices rather than changes in the weights over time. Across the provincial models, the

response of housing prices following a monetary policy shock become far more consistent when examined within a time-invariant scope. This choice was made on the basis that the chosen specification eliminates the changes present in the analysis due to changes in the weights. Each of the provincial models was also estimated with varying orderings within the vector $Z_{i,t}$. However, the identification in which the ordering of provincial specific variables were placed second in the ordering provided less intuitive results. The interpretation of the chosen model lends to the identification of shocks in larger provinces, as the ordering suggests that a shock to a variable in each province will immediately impact the rest of Canada; a sentiment that would prove to be more relevant for the five provinces under the main analysis.

The final series of robustness checks completed with respect to the GVAR model estimated for the nine provinces revolves around the identification of provincial shocks. Due to the procedure used, the identified shocks across each provincial economy cannot be considered the same. As such, this inconsistency in the shocks identified was approached through the analysis of several alternative specifications. The first alternative tested against the baseline framework involved the estimations of each provincial model with varying orderings within the vector $Z_{i,t}$. However, the identification in which the provincial specific variables were placed second in the ordering provided insignificant responses across all provinces. The superior interpretation of the chosen model again lends to the identification of shocks in larger provinces. This ordering suggests that a shock to housing prices in Ontario, or British Columbia will immediately impact the rest of Canada, providing a more intuitive economic assertion (See Figure 38 and 39 respectively).

When identifying housing price shocks in the baseline framework, the shock identified may be larger than the actual housing shock present in each respective province. This is due to the assertion that a change in the housing price index may in part be caused by a spillover effect of a shock in another province. However, the alternative specification in which the provincial level variables are ordered second lends to a different interpretation. In this scenario, the identified housing price shocks are identified as changes in the provincial housing price index that are orthogonal to changes in the rest of Canada. As such, the identified shocks may be smaller than the actual shocks present in each respective province; as part of the change seen in housing prices for the rest of Canada may now be caused by spillover effects originating in a province. It is in part due to this assertion that the shocks identified are smaller in the alternative framework, resulting in the insignificant responses observed. Further, due to the

identification procedure used, we are able to make the assumption that the actual provincial shocks present within each province lie somewhere in between the shocks identified by these two alternative orderings. The shocks as identified by the alternative framework are however most likely closer to the actual shocks present within the smaller provinces; as the shocks originating in the smaller provinces are less likely to have an impact on the other provinces. Alternatively, the shocks identified in the chosen specification of the model are most likely closer to the actual housing price shocks present within the larger provinces. This is due to the fact that the larger housing markets of these provinces are less susceptible to housing shocks in other provinces. Therefore, the selected framework lends to the main analysis of the paper, in which the largest provinces are the focal point of the investigation.

The next specification regarding the identification of provincial shocks involves the estimation of each provincial model in which the three provincial specific variables are estimated in the benchmark SVAR; such that the vector of variables is represented as:

$$Y_t = \{gdp_t, cpi_t, hpi_t, hiqg_t, hd_t, X_t, br_t\}'$$

The responses generated from this specification of the model for Ontario and British Columbia can be seen in Figure 40 and 41 respectively. The resulting estimates produced using this specification require a significant departure from the interpretation of the chosen results. Firstly, the changes in the national level variables included within the model include the effects generated within the province, in which the shock has been induced. An issue with this specification is that a shock to housing prices implies that Canada as a whole is affected with a lag when a provincial specific shock occurs. This result implies that each province is again affected with a lag from its own shock. The results however produce counter-intuitive responses as all variables remain around zero and the only significant responses result from the national variables. However, the provincial variables again result in insignificant responses across all provinces. The interpretation of a shock to Ontario's house prices in this specification implies that Canada as a whole responds with a lag. Alternatively, a shock to Nova Scotia also results in a lagged response at the national level and so on. Therefore, the specification was chosen on the basis that the interpretation of shocks lends to an intuitive economic assertion with respect to the transmission of shocks from the largest provinces.

5. Conclusions

5.1 Interpreting the Results: The Benchmark Model

The results of the impulse response analysis indicate that a relationship persists between household debt, house prices and monetary policy in the Canadian economy. As discussed in the introduction, the implications of a shock to one of these variables may have a rippling effect on the economy. When looking at the effect of monetary policy we saw that a positive shock to the interest rate induced a large negative response in GDP. The implications of these results imply that an increase to the interest rates will have detrimental effects for the economy, a result which enables the Bank of Canada to mitigate these effects through their policy decisions.

With respect to a shock in the growth rate of house prices, the impulse responses generate a large positive response in household debt. The corresponding neutrality observed in the consumer price index and GDP also provides insight into the implications of the house price shock. Within the current economic conditions in the Canadian economy, pertaining to over-priced real estate markets, the role of house prices and their ability to hinder economic growth appear apparent. In the case of a house price shock, the effects on the stability of the economy appear to be mixed. The results found within the paper imply that a shock to house prices will positively influence households' levels of household debt. As a result, households become more susceptible to any negative external shocks. As household debt is so closely tied to the level of house prices, this dependence will result in an increase in financial fragility. This issue is in line with the conventional idea that the housing market plays a large role in the macroeconomy, and is the case for the Canadian economy as well.

5.2 Interpreting the Results: The Main Analysis

The results of the GVAR analysis indicate that discrepancies exist between the responses to adverse economic shocks across the nine provincial economies. Across the provinces analyzed, the impulse responses indicate again that a relationship persists between household debt and house prices. This can be seen as the magnitude of the response to one of these variables is accompanied by an equivalent reaction to the other. When analyzing a monetary policy shock, the importance in which

province the shock was induced on resulted in varying responses to the global variables within the system. This result indicates that the goal of policy decisions should perhaps be skewed towards the provinces most susceptible to impacting the Canadian economy. Generally, the results indicated that the severity of a monetary policy shock was proportional to both the size of a province, and the level of household debt held in each respective province. The province ranked the highest in financial vulnerability by TD Economics (British Columbia) produced the largest response in household debt following an increase to interest rates. There are several implications for the Bank of Canada stemming from the detrimental effects of an interest rate shock, for both the national and regional economies. In general, an increase in the interest rate resulted in a negative impact on GDP and a negative mean tendency in household debt. This result reiterates the traditional policy implications stemming from monetary policy; as these results would imply an eventual slowdown in output as households re-optimize their consumption choices. As such, the role of transparency and moderation would appear to be crucial aspects of the Bank of Canada's policy decisions as they attempt to mitigate the adverse effects associated with a positive monetary policy shock.

The next shock induced on the GVAR model involved a positive shock in the growth rate of house prices. The impulse response generated again indicated that a homogeneous response is not observed across the regional economies of Canada. A crucial aspect of the response to provincial level shocks was again the size of the province in which the shock was induced. Due to the identification procedure utilized, it must also be noted that for the housing shocks in each economy we are not able to say that a shock of the same magnitude is being identified within each provincial model. As such, the magnitude of the responses shed light solely on the impact of the housing shock identified without an association to the other provincial shocks. In Ontario and Newfoundland and Labrador, the results indicate that a provincial specific housing price shock lead to an increase in household debt in the rest of Canada. Also, in Ontario, a housing shock leads to a significant increase in the interest rate, a result which appears as an intuitive response to counteract rising home prices. Based on the size of Ontario's economy, the resulting impact on interest rates provides a glimpse of the importance of this province. The responses also indicate that heterogeneous responses are observed across the regional economies following the regional specific shocks. This result has direct implications for the stability of the Canadian macroeconomy, as a shock to a regional economy has spillover effects for the rest of the Canada. As discussed in the introduction, the Canadian housing market has continued to experience rapid gains in the value of real estate. In the case that the market should crash, the resulting implications for each province are not uniform. As such, the Bank of Canada's role in mitigating the effect of a negative housing shock

is limited based on the varying degree of regional factors. However, the housing market within the Canadian economy is of high importance for the sustainable health of the Canadian economy.

5.3 Conclusions

The empirical GVAR model utilized in the analysis of household debt, house prices and monetary policy in the individual provinces and the Canadian economy revealed several implications for policy decisions. The analysis conducted provided an examination of the dynamic responses of the housing market, household debt and monetary policy shocks within the Canadian economy. Our results indicate that the level of household debt increases in times of economic and housing market growth. However, within the context of real-estate markets, the results imply that household debt can lead to further instability of the economy. The increase of household debt and housing prices within the Canadian economy shed light on the implications of various shocks. Therefore, the analysis conducted indicates the presence of serious implications arising from the rapid increase of both household debt and housing prices in the Canadian economy. With respect to the regional economies of Canada, the analysis indicated that a heterogeneous response exists with respect to adverse economic disturbances. The impulse response analysis revealed that the level of household debt held by a province is in fact proportional to the magnitude of the responses following a monetary policy shock. This result implies that the rising levels of household debt do in fact have significant implications regarding the overall stability of the macroeconomy. When examining the regional differences in provincial housing markets, the analysis again revealed a heterogeneous response across provinces. Within the provincial analysis, a shock induced upon Ontario and Quebec resulted in the greatest responses. This result highlights the regional discrepancies that exist within Canadian housing markets and the importance of the largest provinces regarding the health of the Canadian economy.

Also, the period of data utilized allowed for a more complete analysis up to the period of the most recent recession. The selection of variables also enabled the identification of spillover effects following a shock to different regions of the Canadian economy. The identification of provincial level models through the GVAR analysis provided a platform to disentangle the regional differences in responses to economic shocks. Thus, as outlined in this paper, the growth in household debt and house prices has generated a great source of vulnerability for households. As such, the diverging circumstances that

persist across provincial borders may create a barrier to the transmission of effective monetary policy in Canada, creating a unique challenge for policymakers in the years to come.

Appendix

Appendix A List of Figures

Figure 2 Aggregate household, mortgage and consumer debt

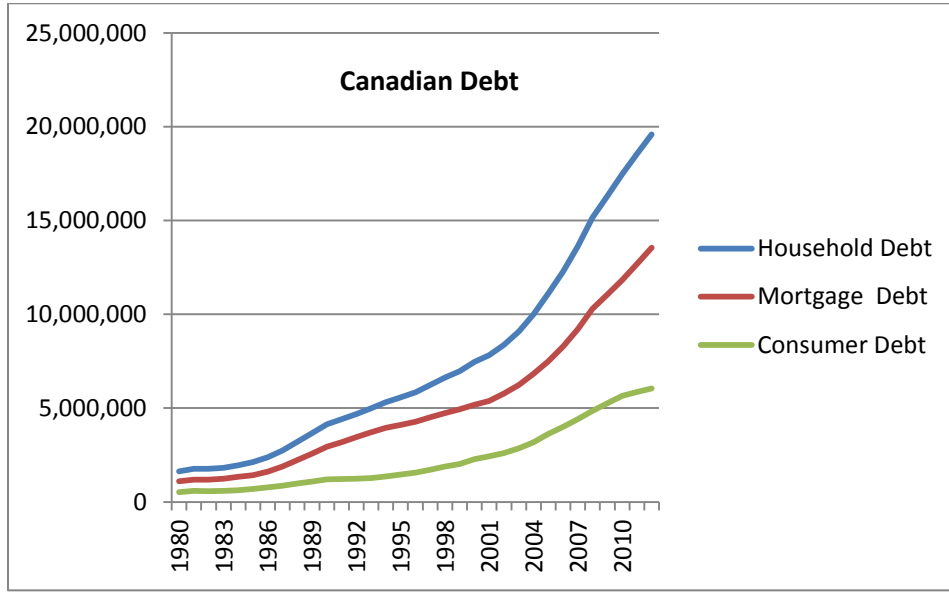


Figure 3 Aggregate House Prices

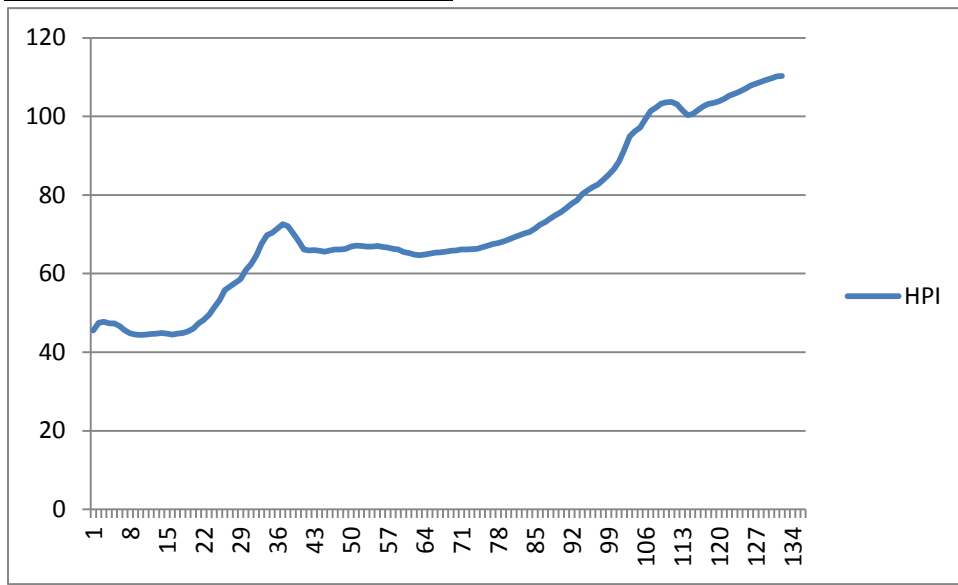
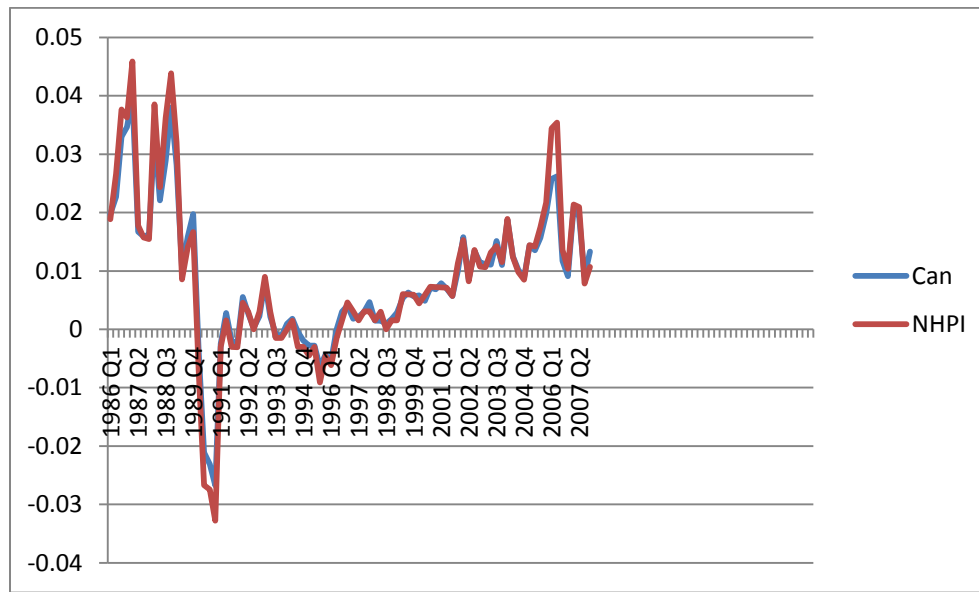


Figure 4 Aggregate NHPI and the sum of weighted variables generated



Graphs of Data

Figure 5 Canadian Data in log differences

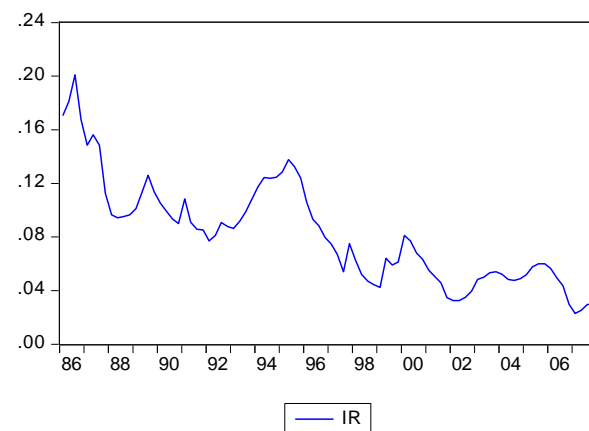
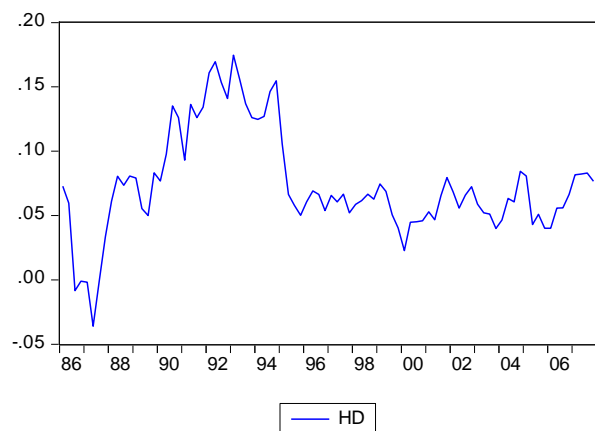
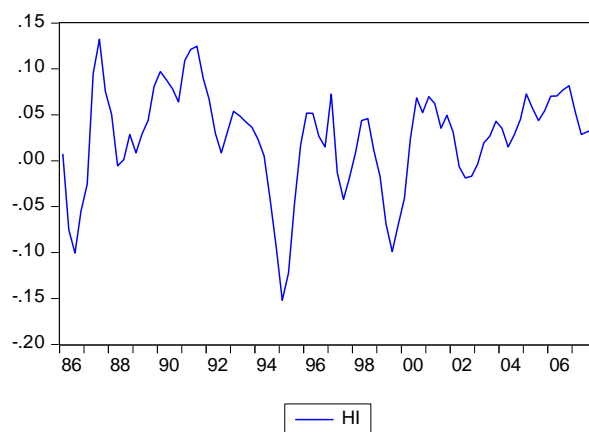
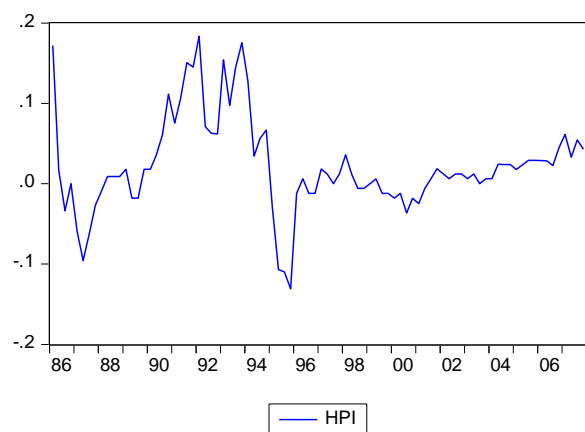
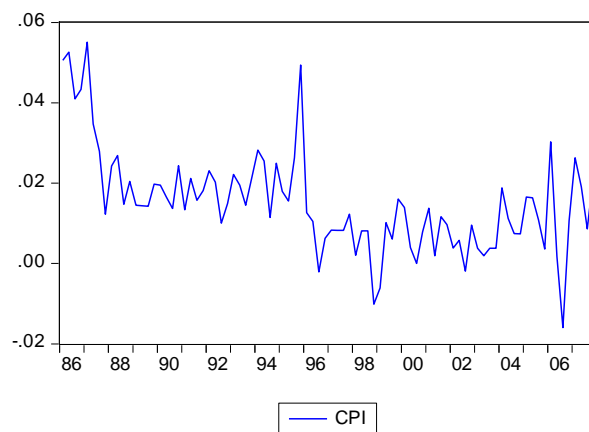
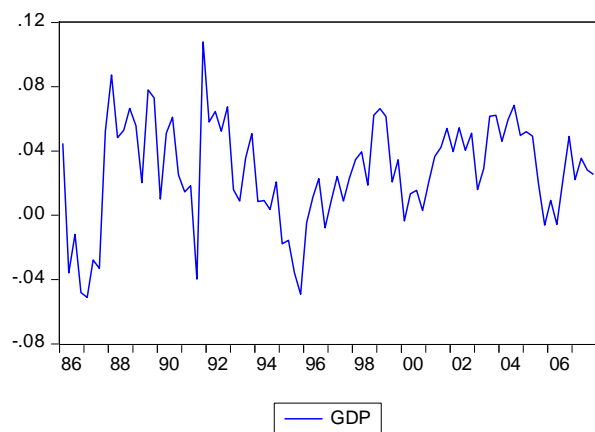
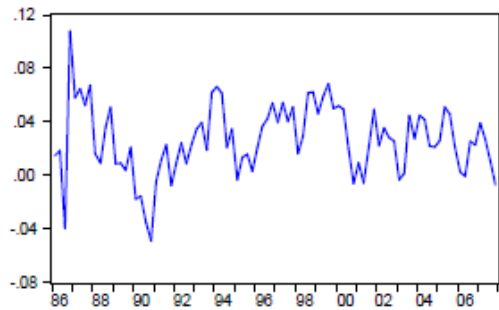
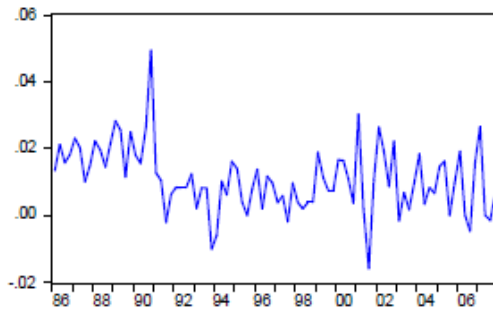


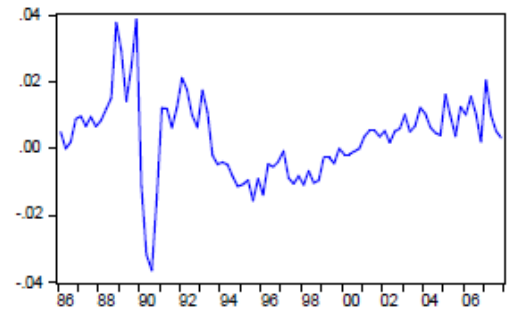
Figure 6 British Columbia data in log differences



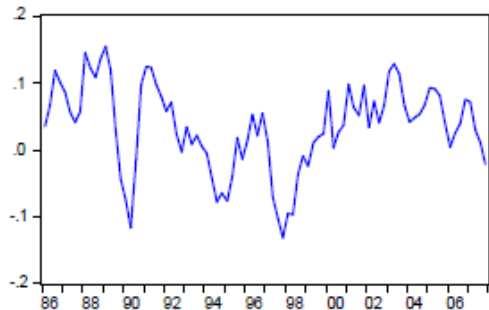
GDP



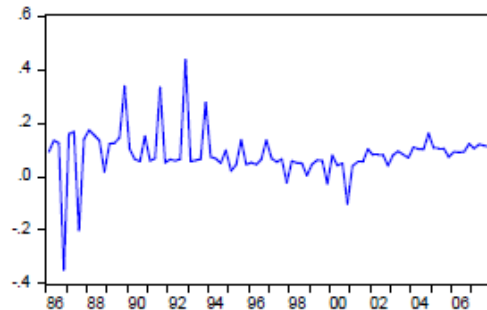
CPI



HPI



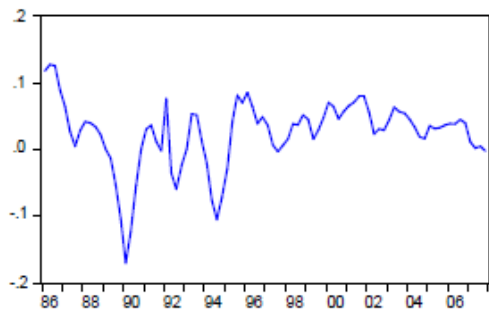
HI



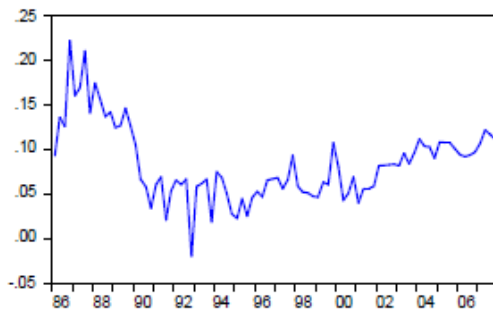
HD



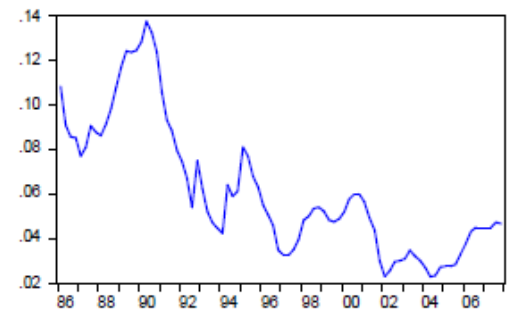
HPIR



HIR



HDR



IR

Figure 7 Saskatchewan data in log differences

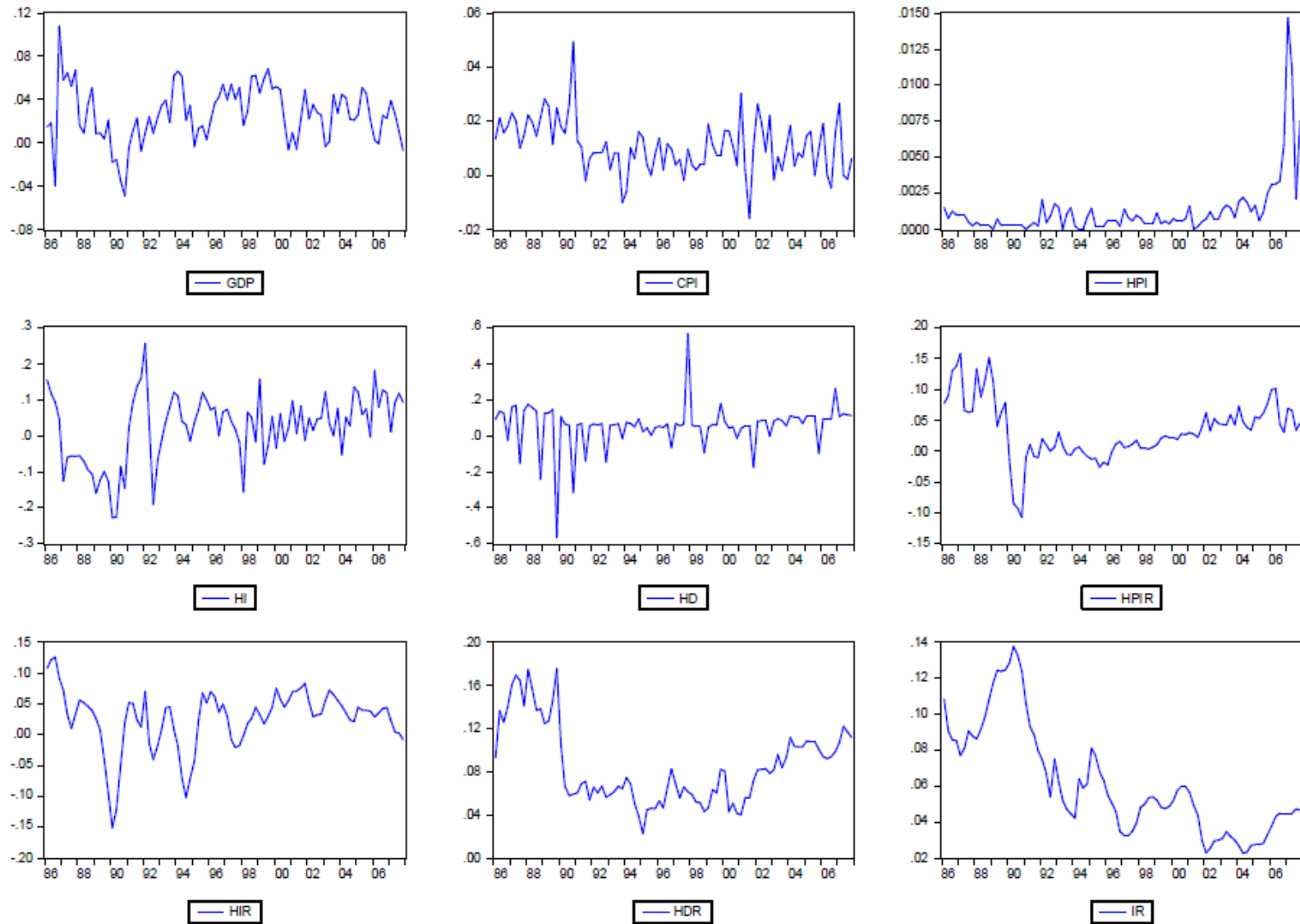
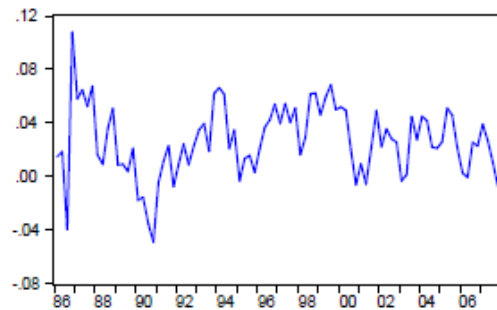
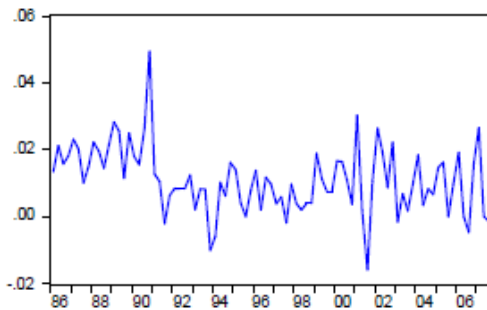


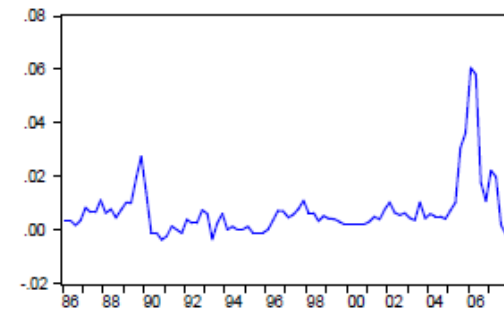
Figure 8 Alberta data in log differences



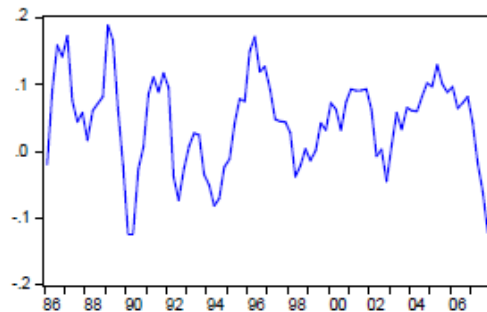
GDP



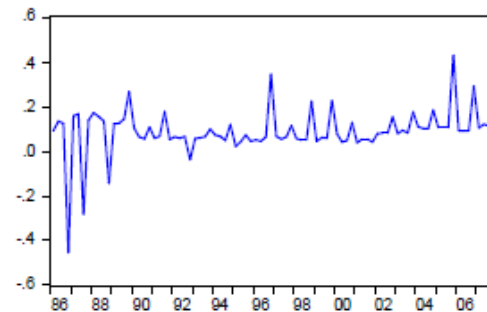
CPI



HPI



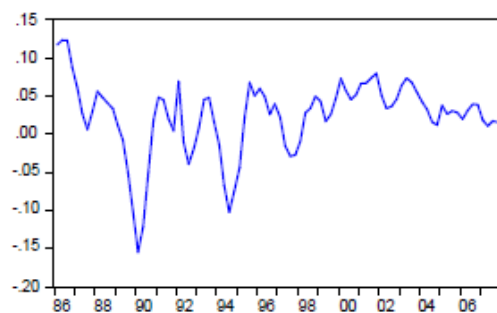
HI



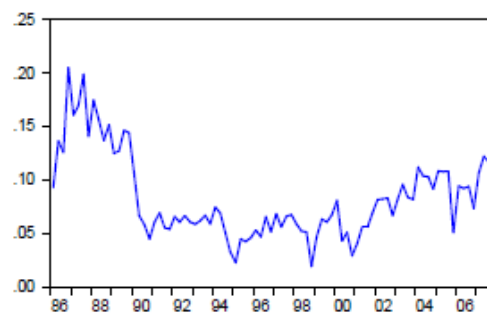
HD



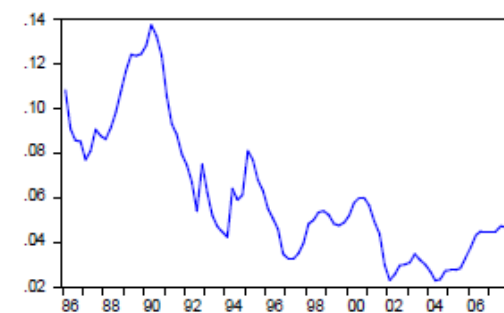
HPIR



HIR



HDR



IR

Figure 9 Manitoba data in log differences

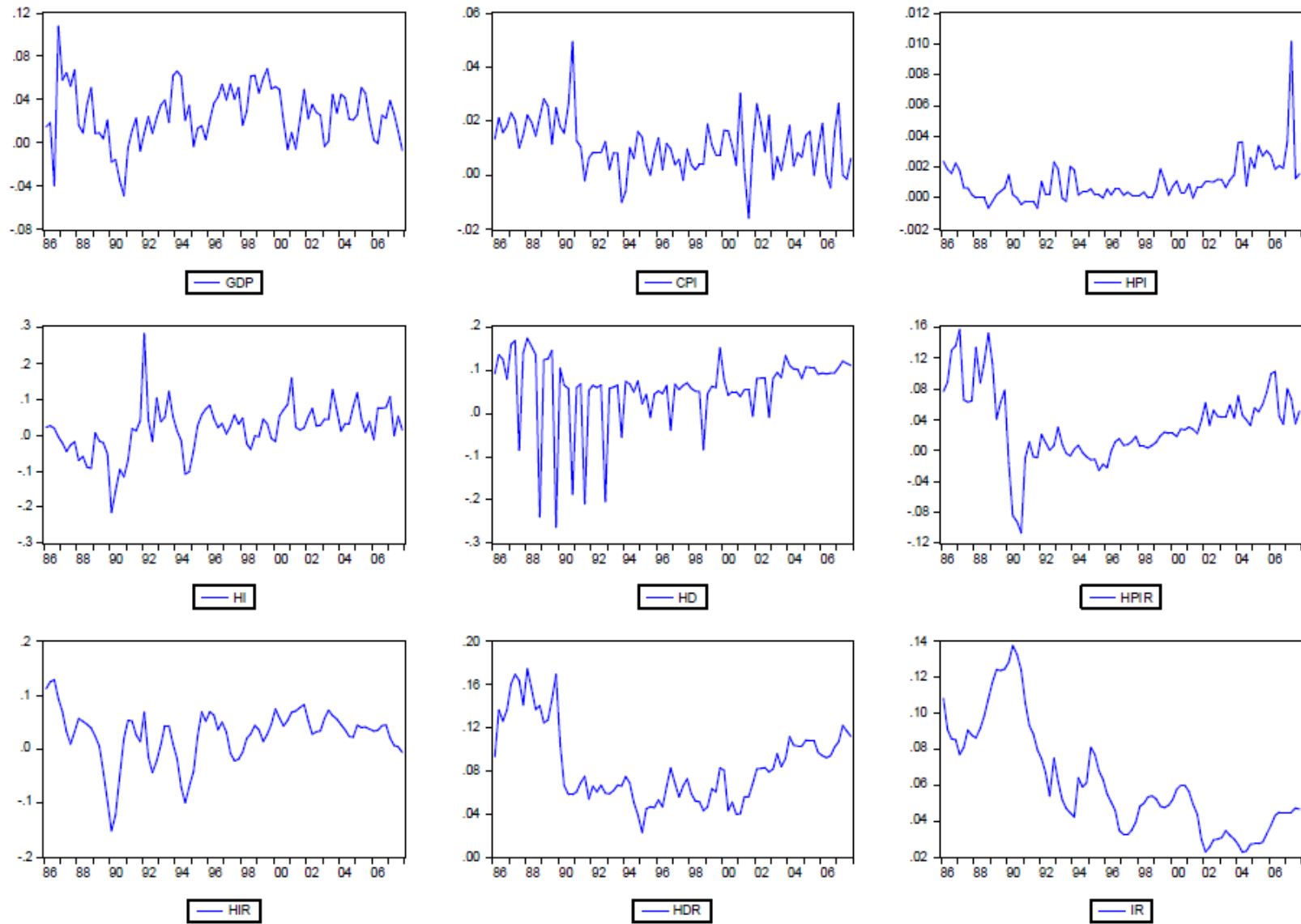


Figure 10 Ontario data in log differences

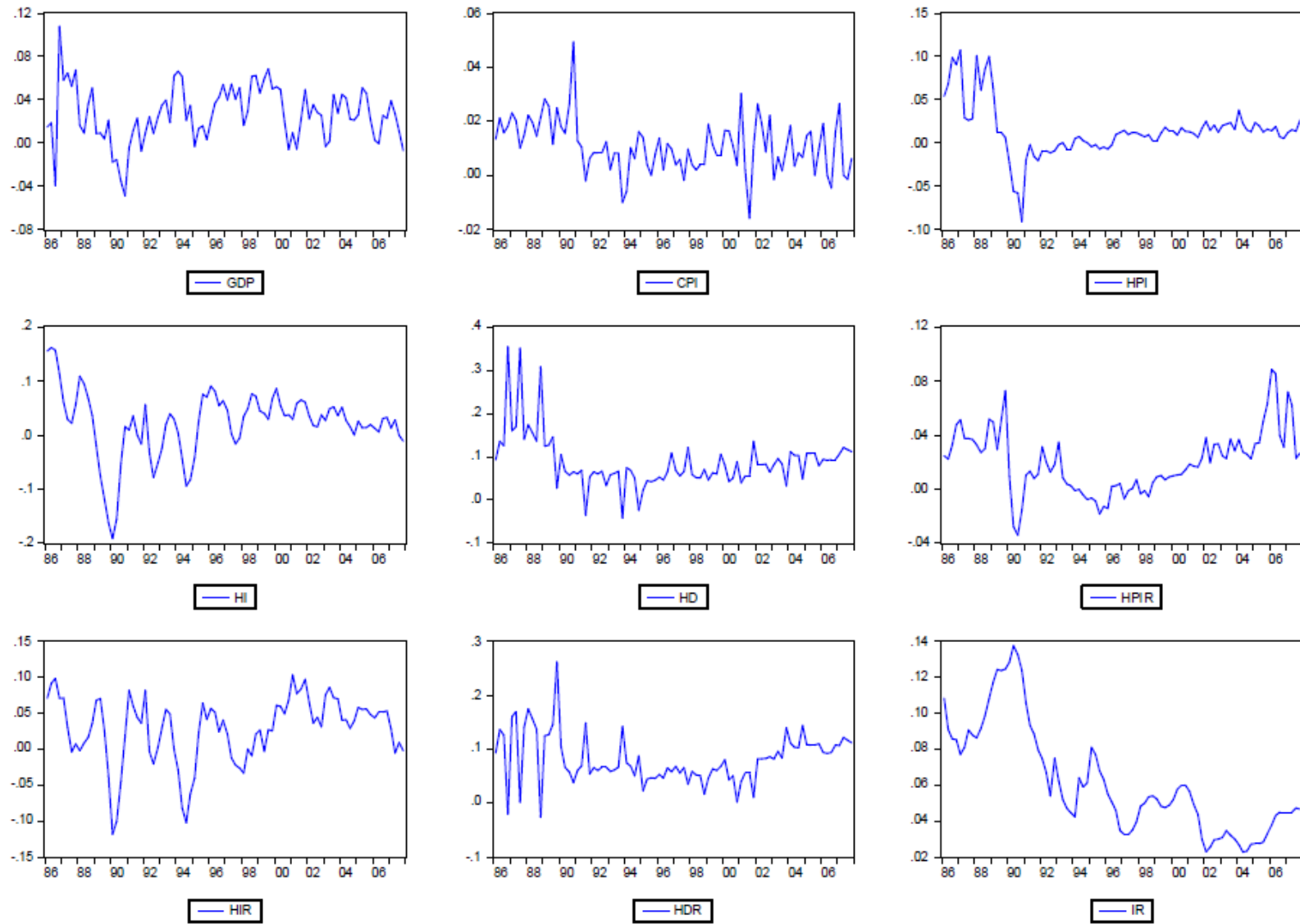


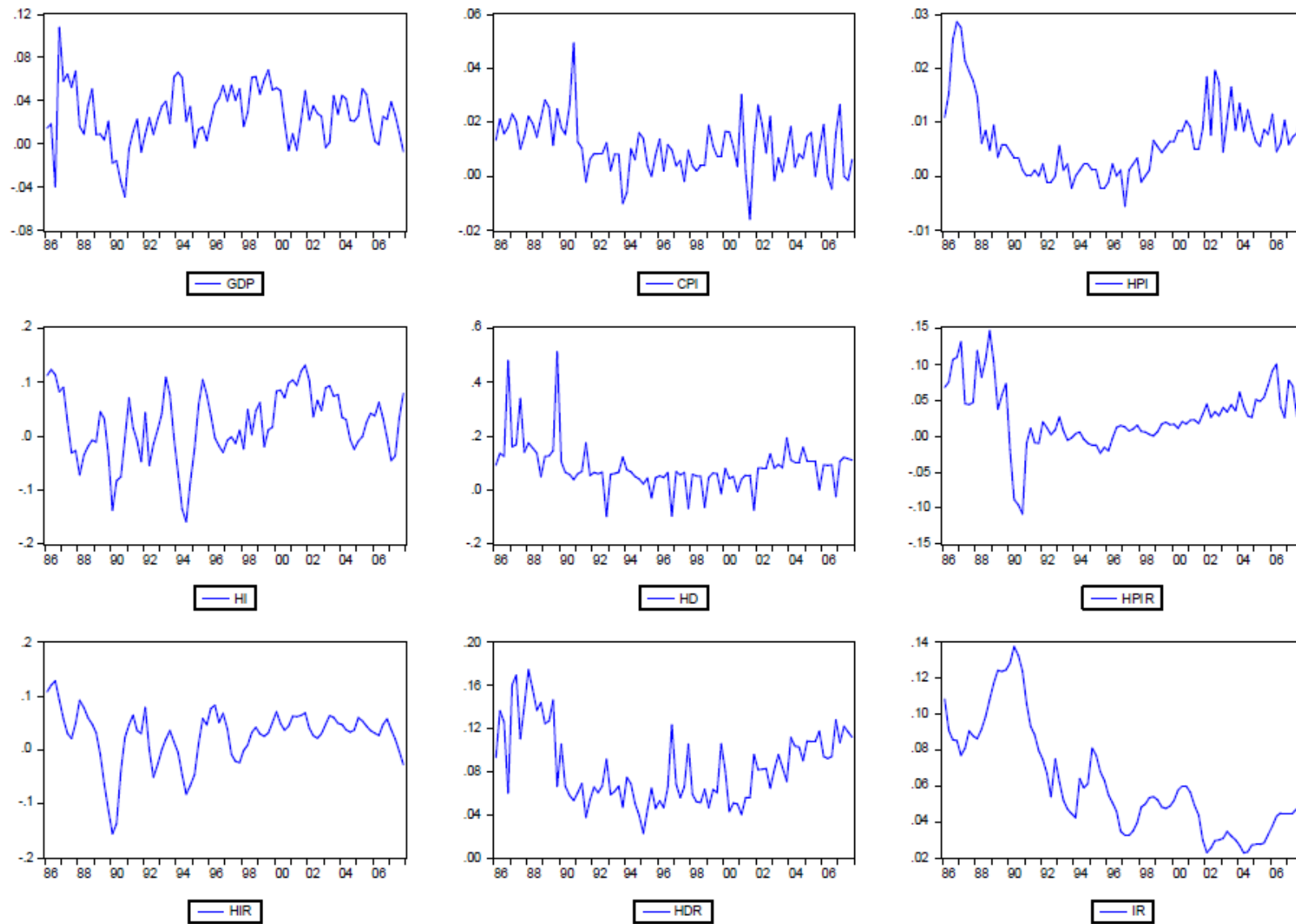
Figure 11 Quebec data in log differences

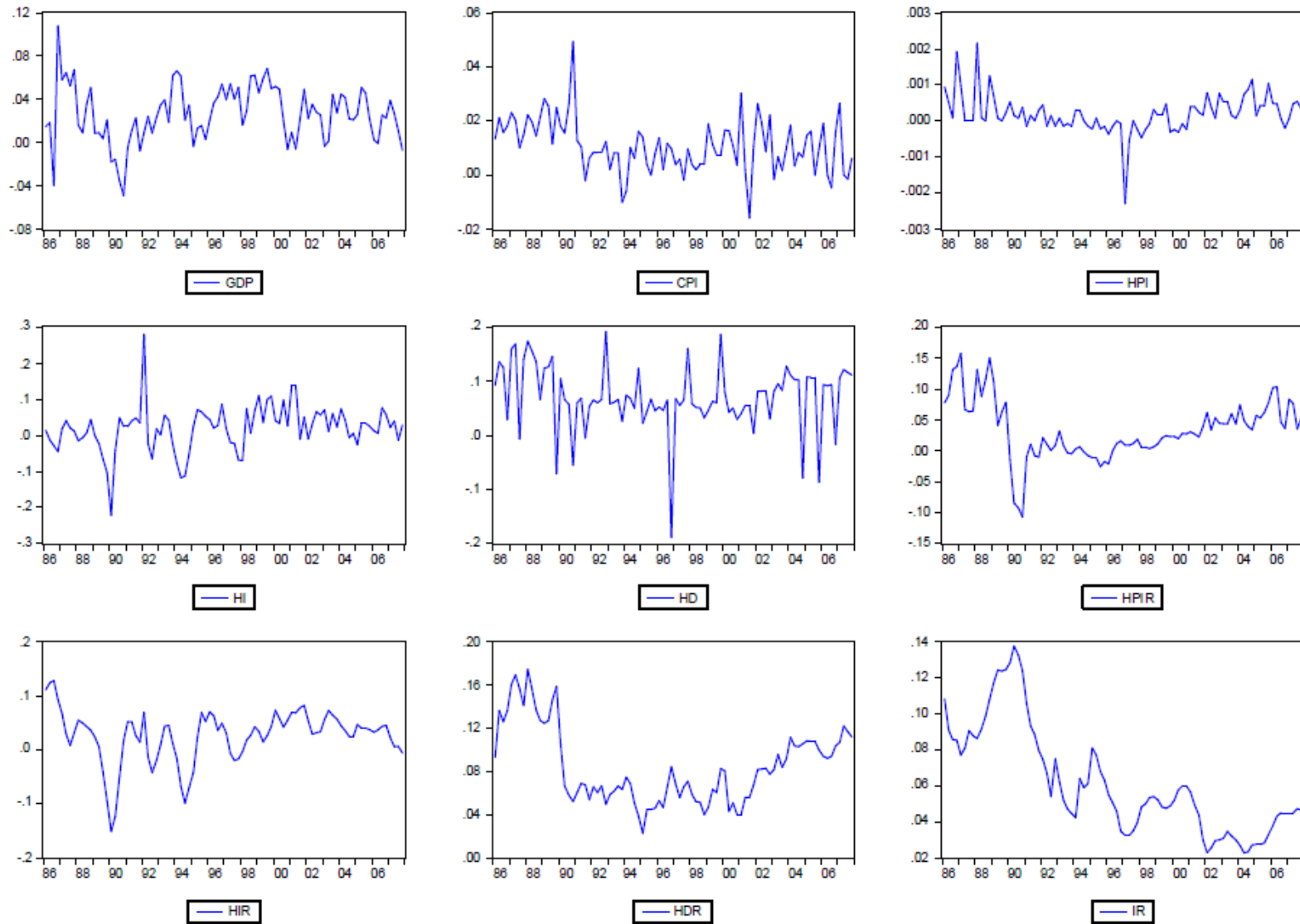
Figure 12 New Brunswick data in log differences

Figure 13 Nova Scotia data in log differences

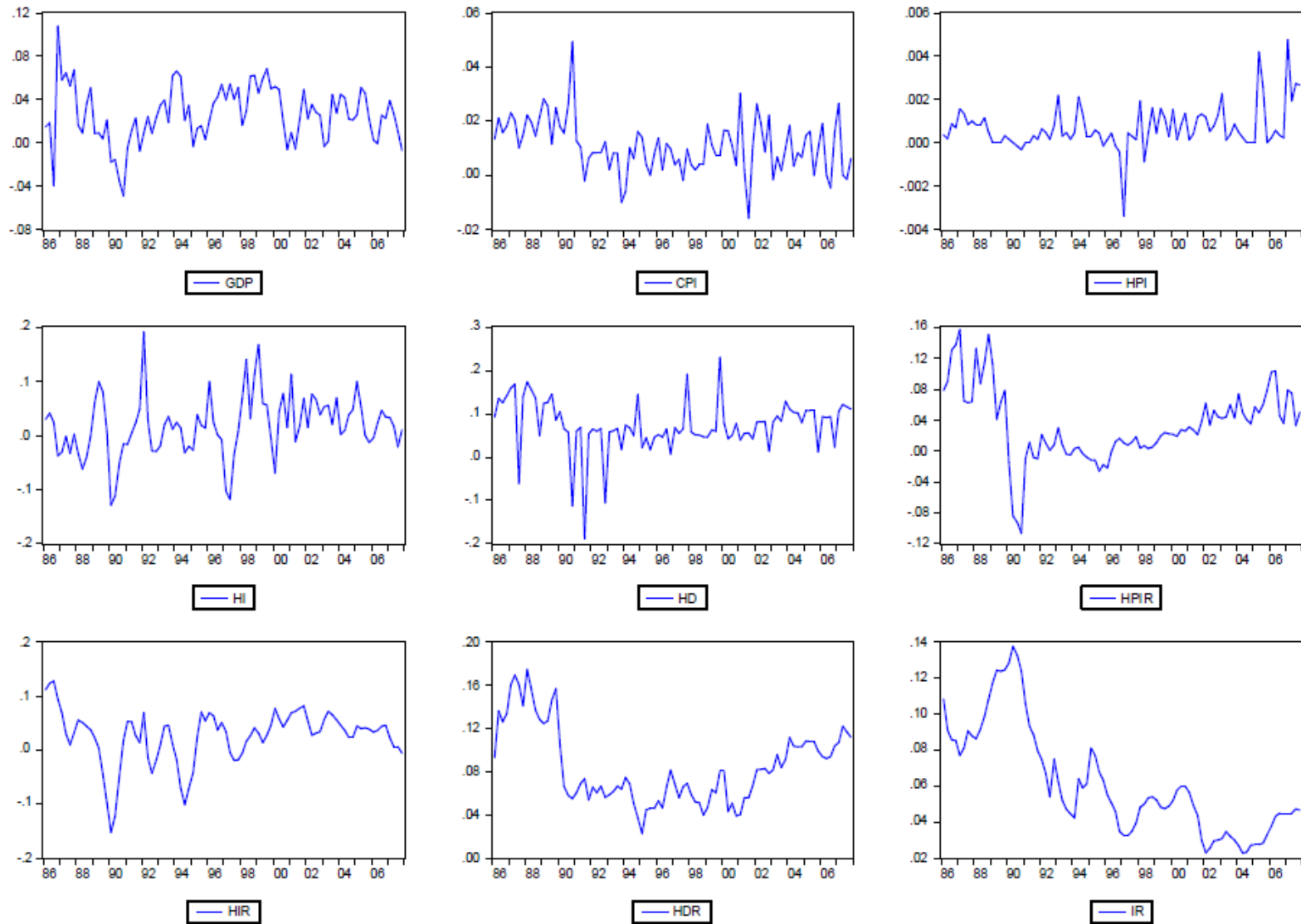
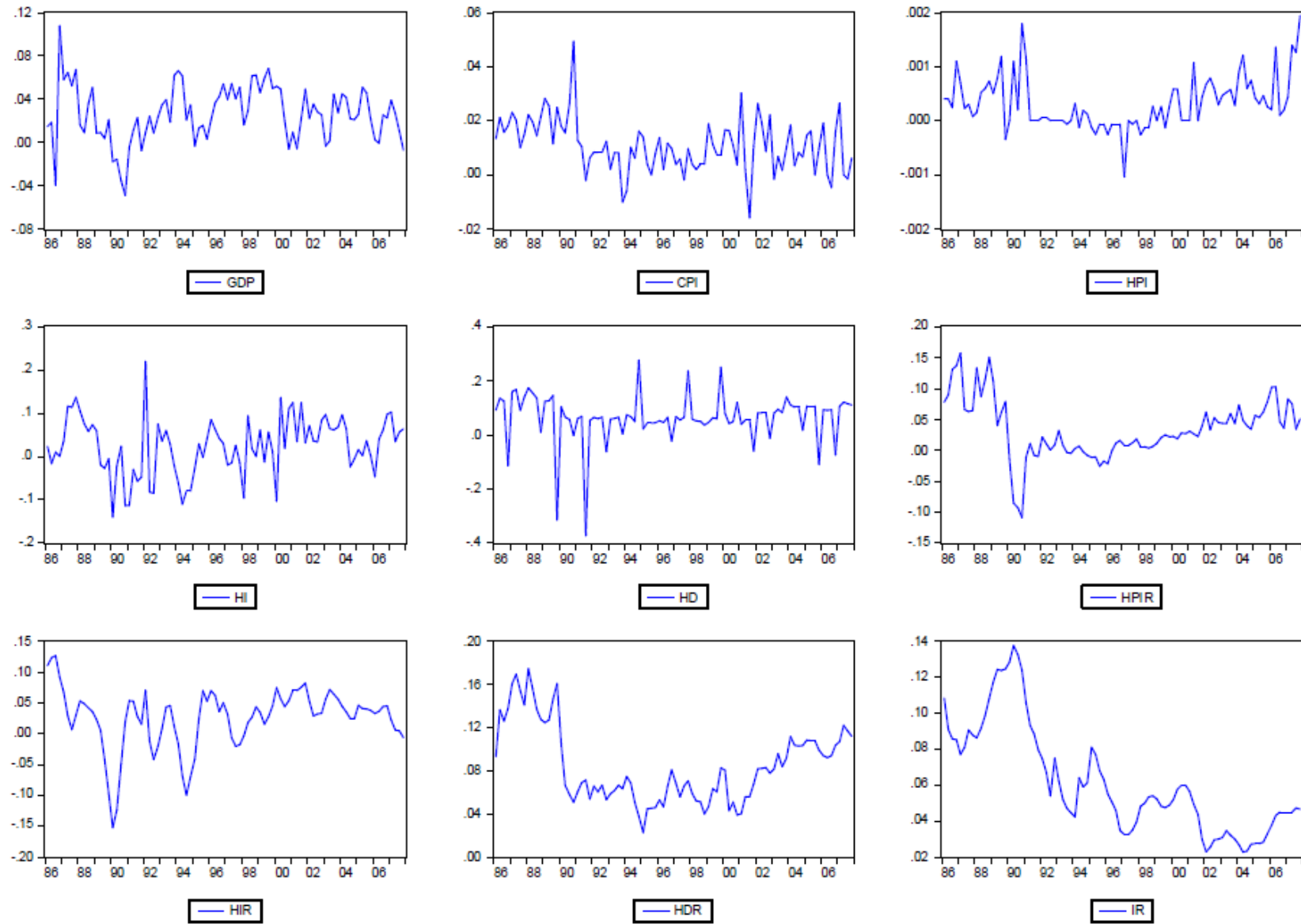


Figure 14 Newfoundland and Labrador data in log differences



Impulse Responses

Figure 15 Monetary Policy Shock: Canada

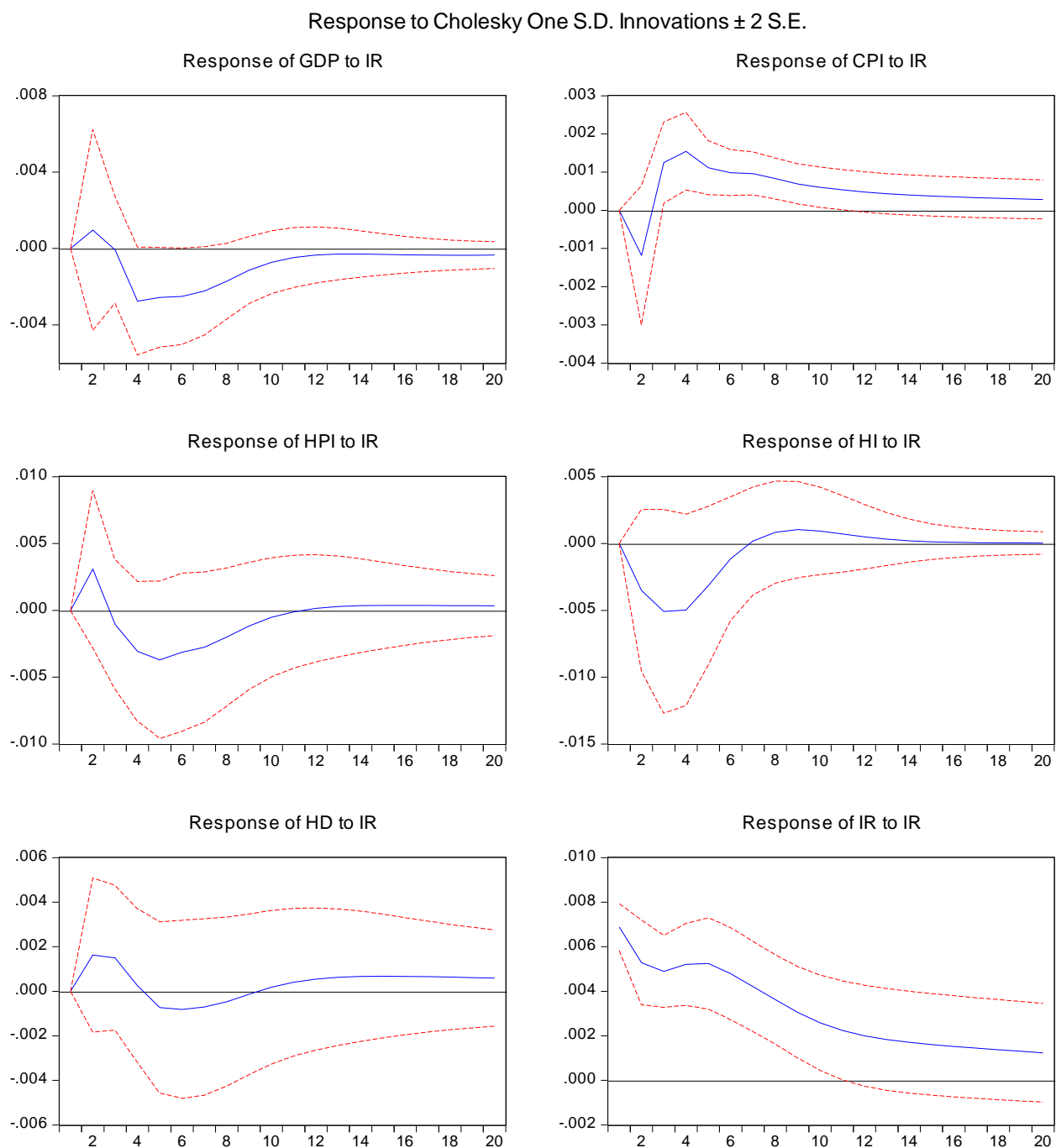


Figure 16 Monetary Policy Shock: British Columbia

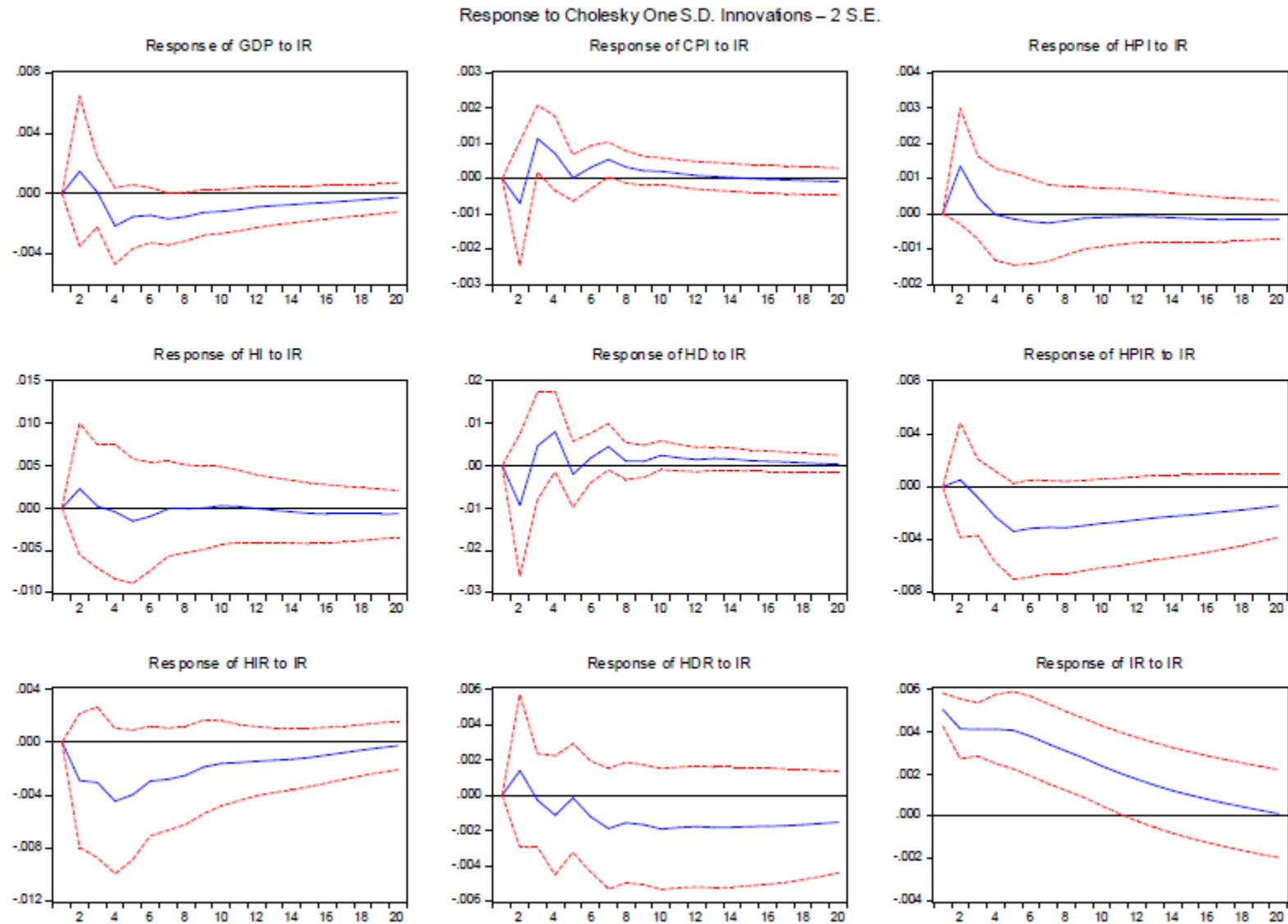


Figure 17 Monetary Policy Shock: Saskatchewan

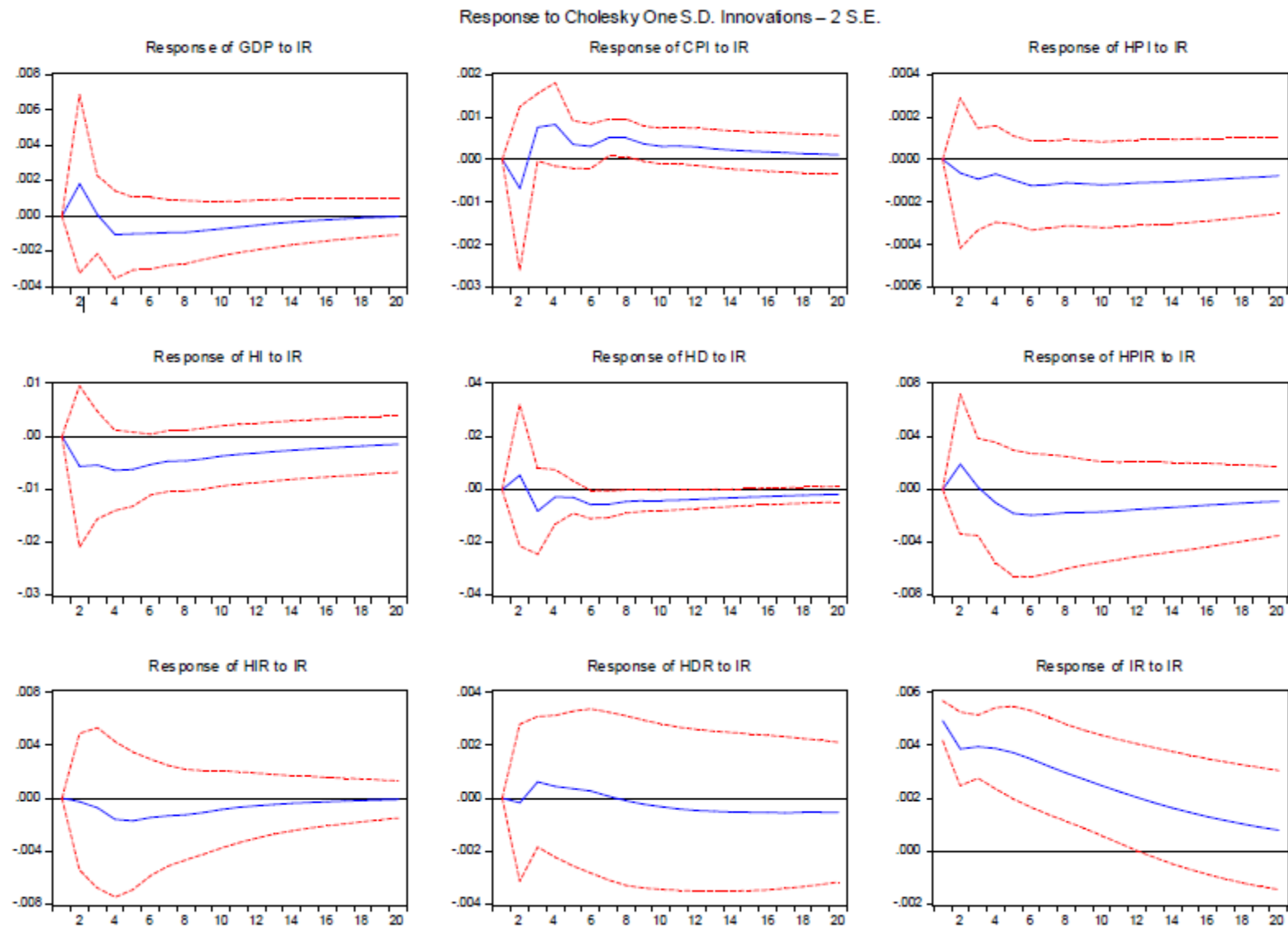


Figure 18 Monetary Policy Shock: Alberta

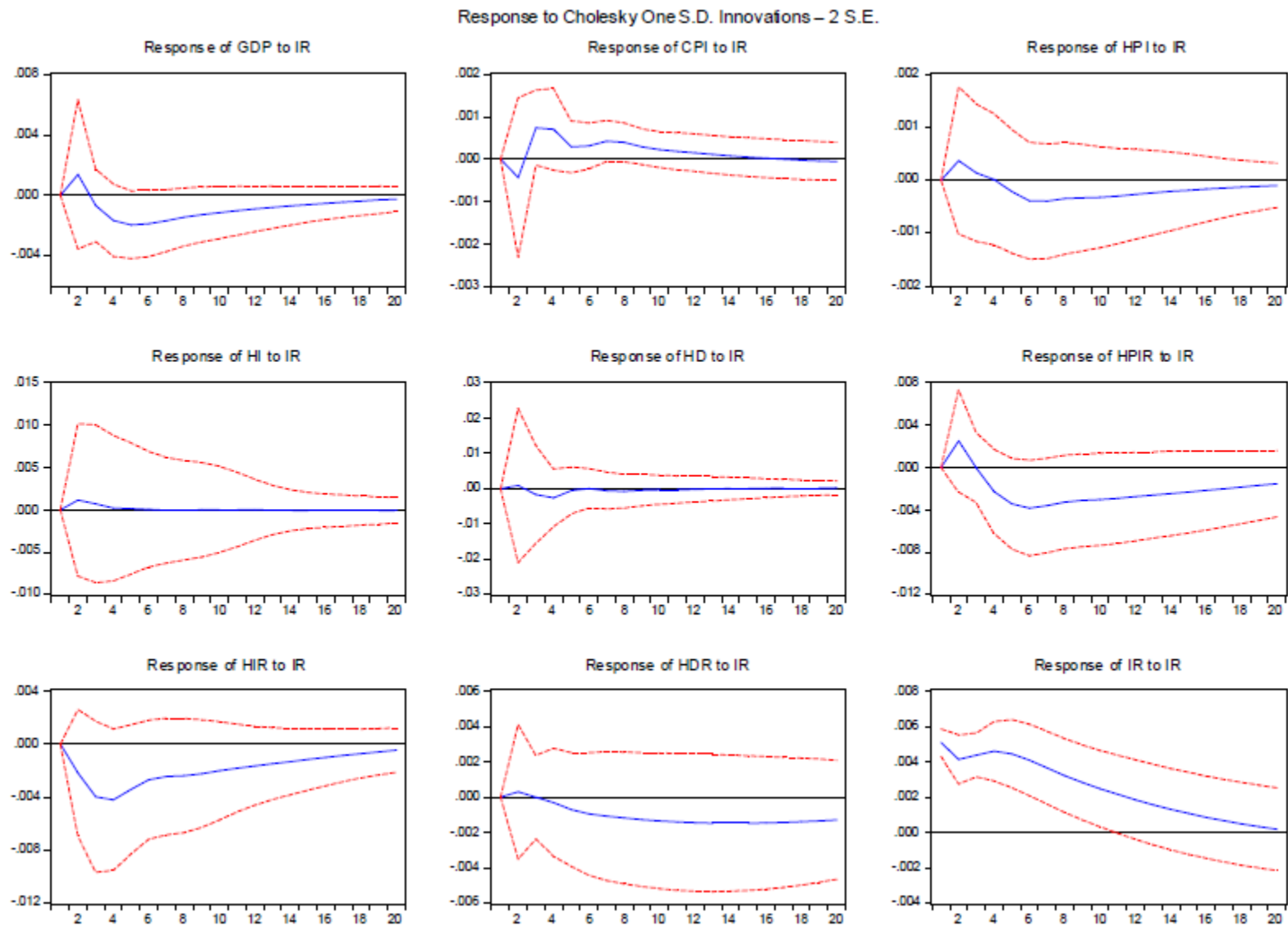


Figure 19 Monetary Policy Shock: Manitoba

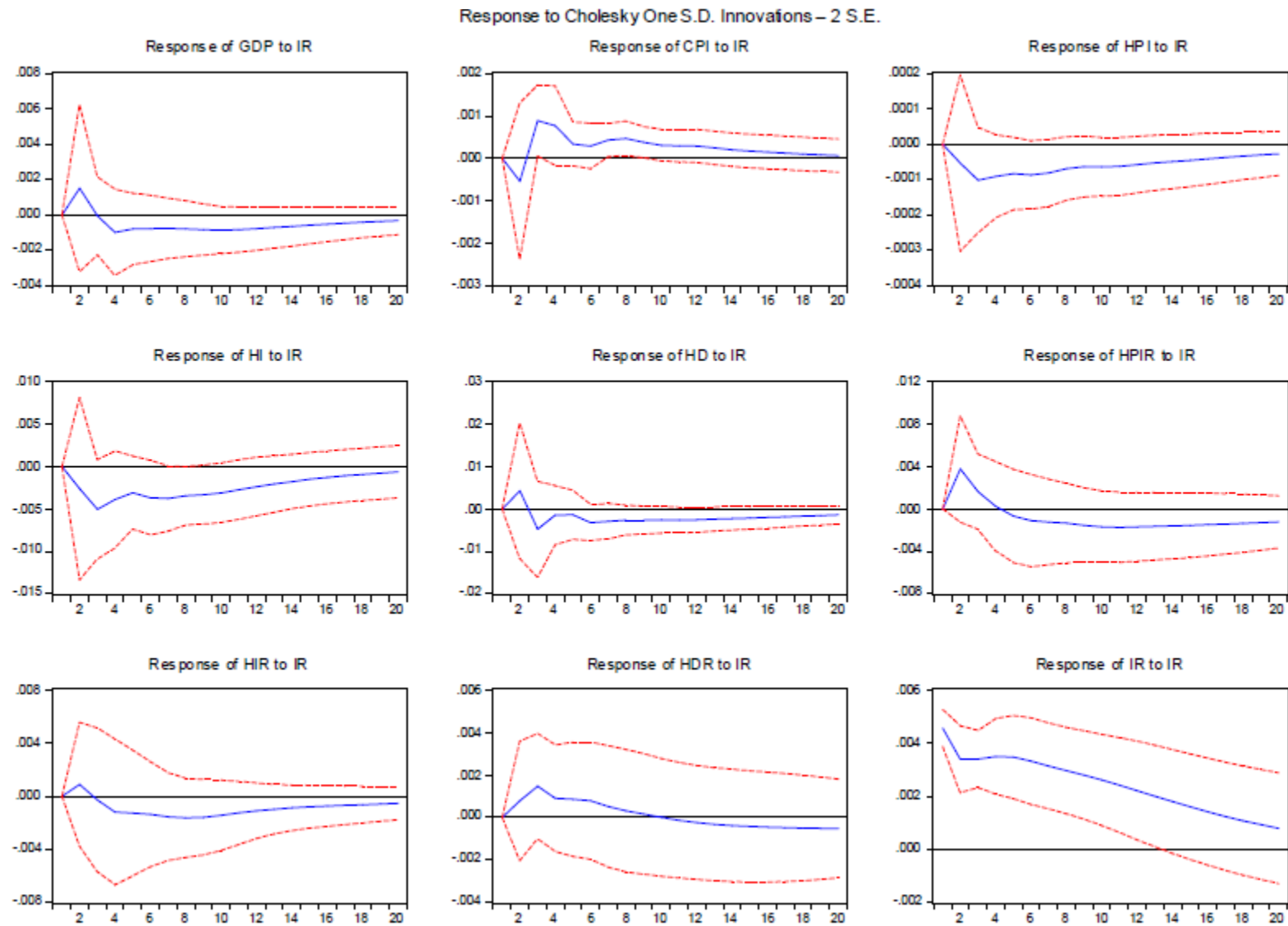


Figure 20 Monetary Policy Shock: Ontario

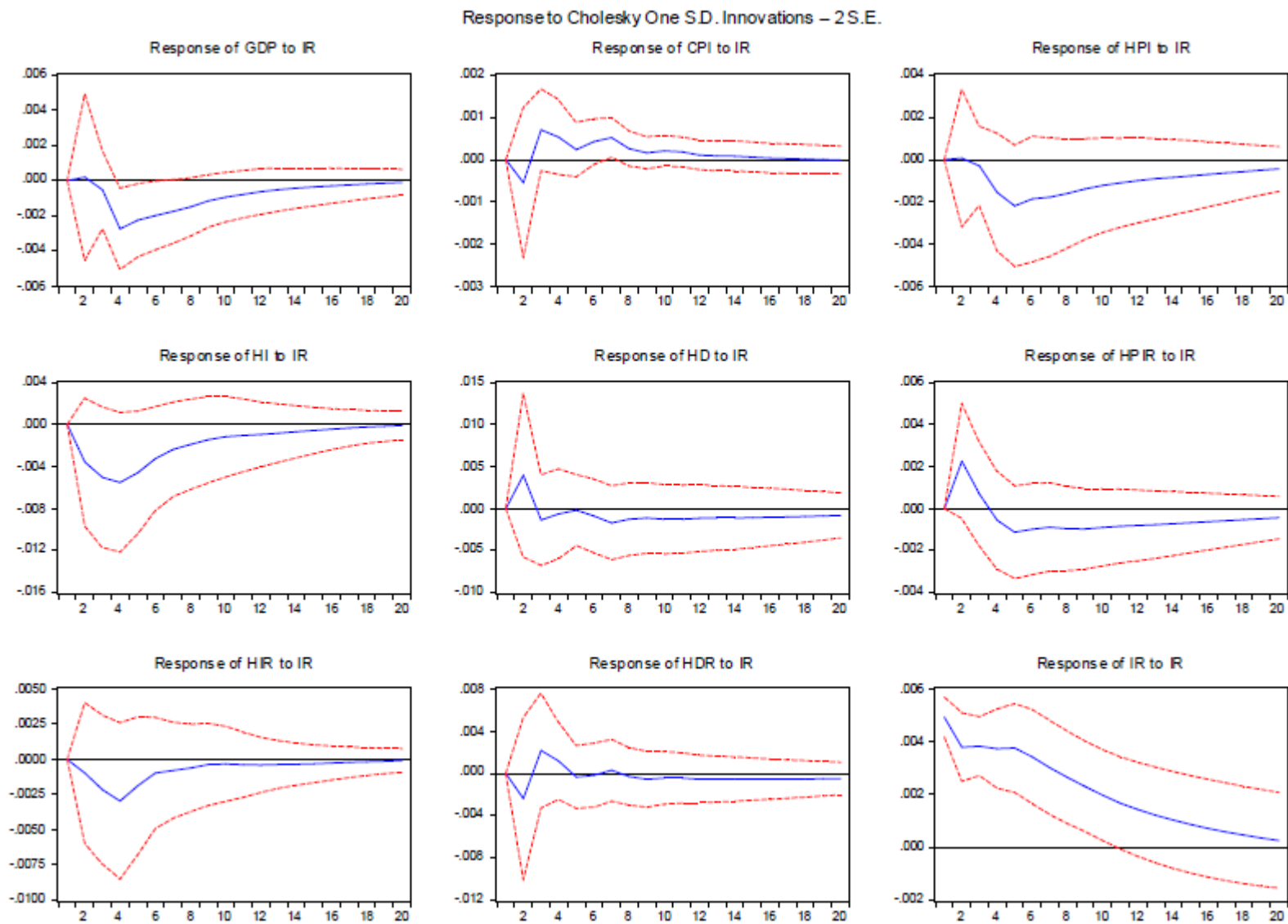


Figure 21 Monetary Policy Shock: Quebec

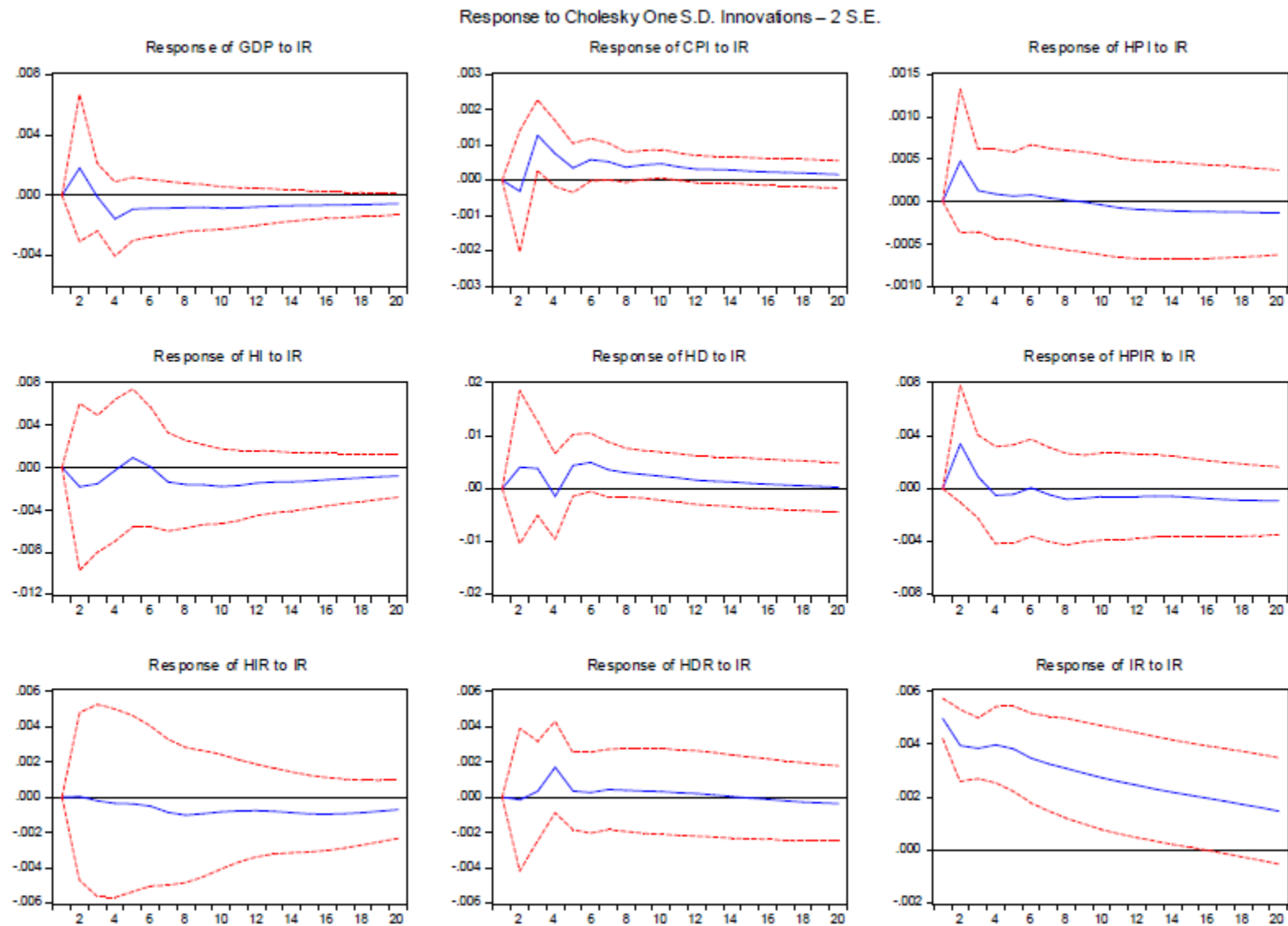


Figure 22 Monetary Policy Shock: New Brunswick

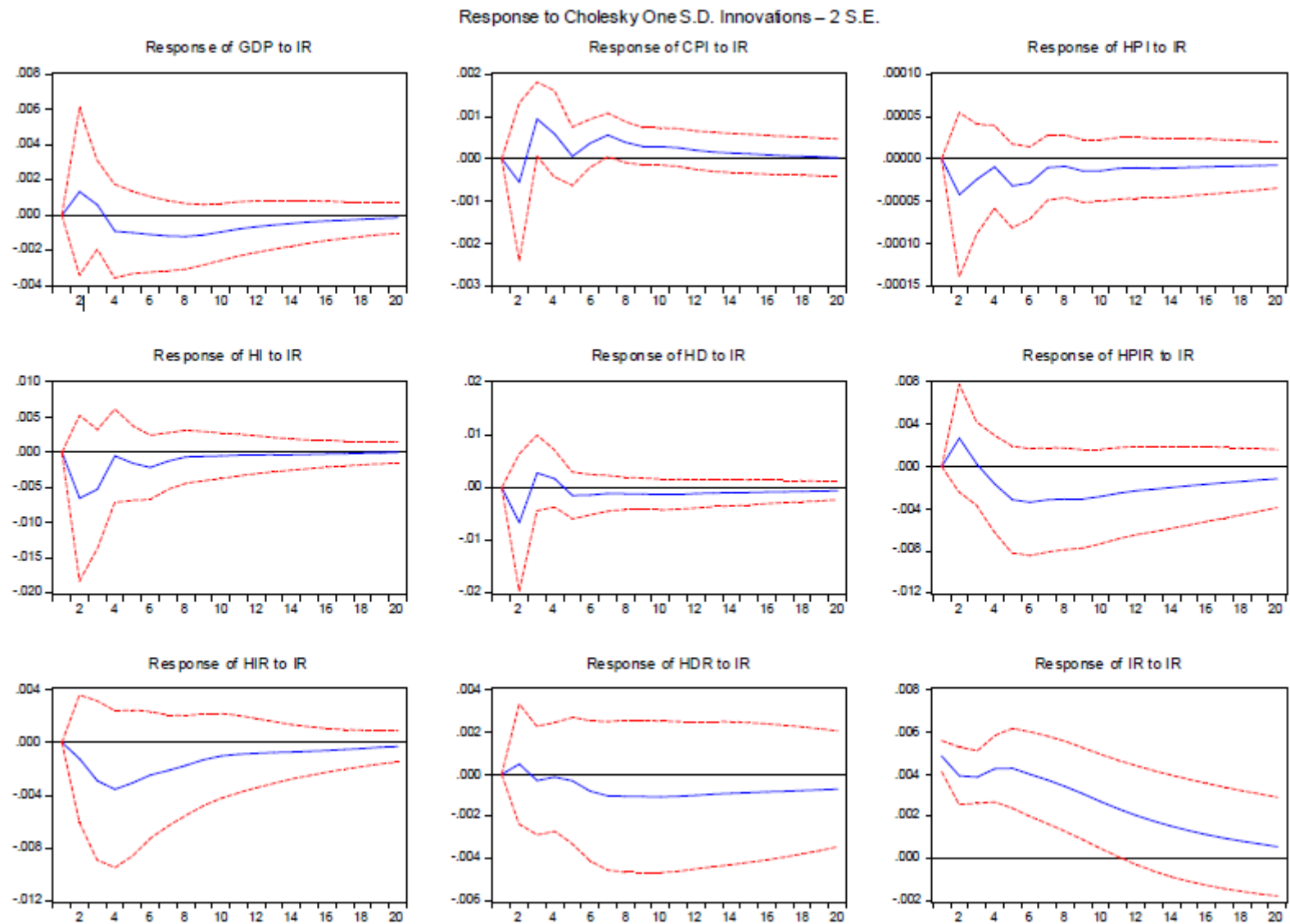


Figure 23 Monetary Policy Shock: Nova Scotia

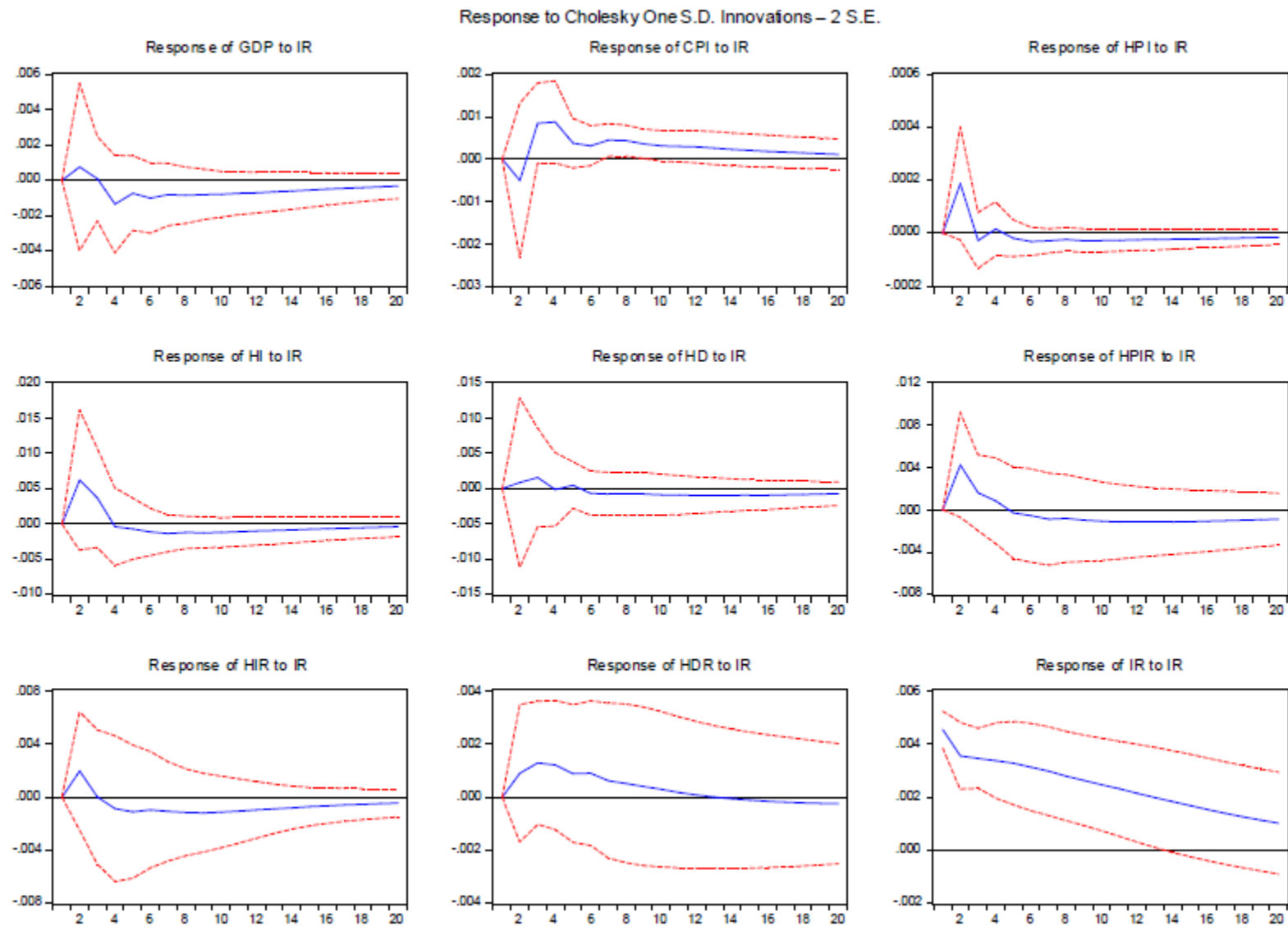


Figure 24 Monetary Policy Shock: Newfoundland and Labrador

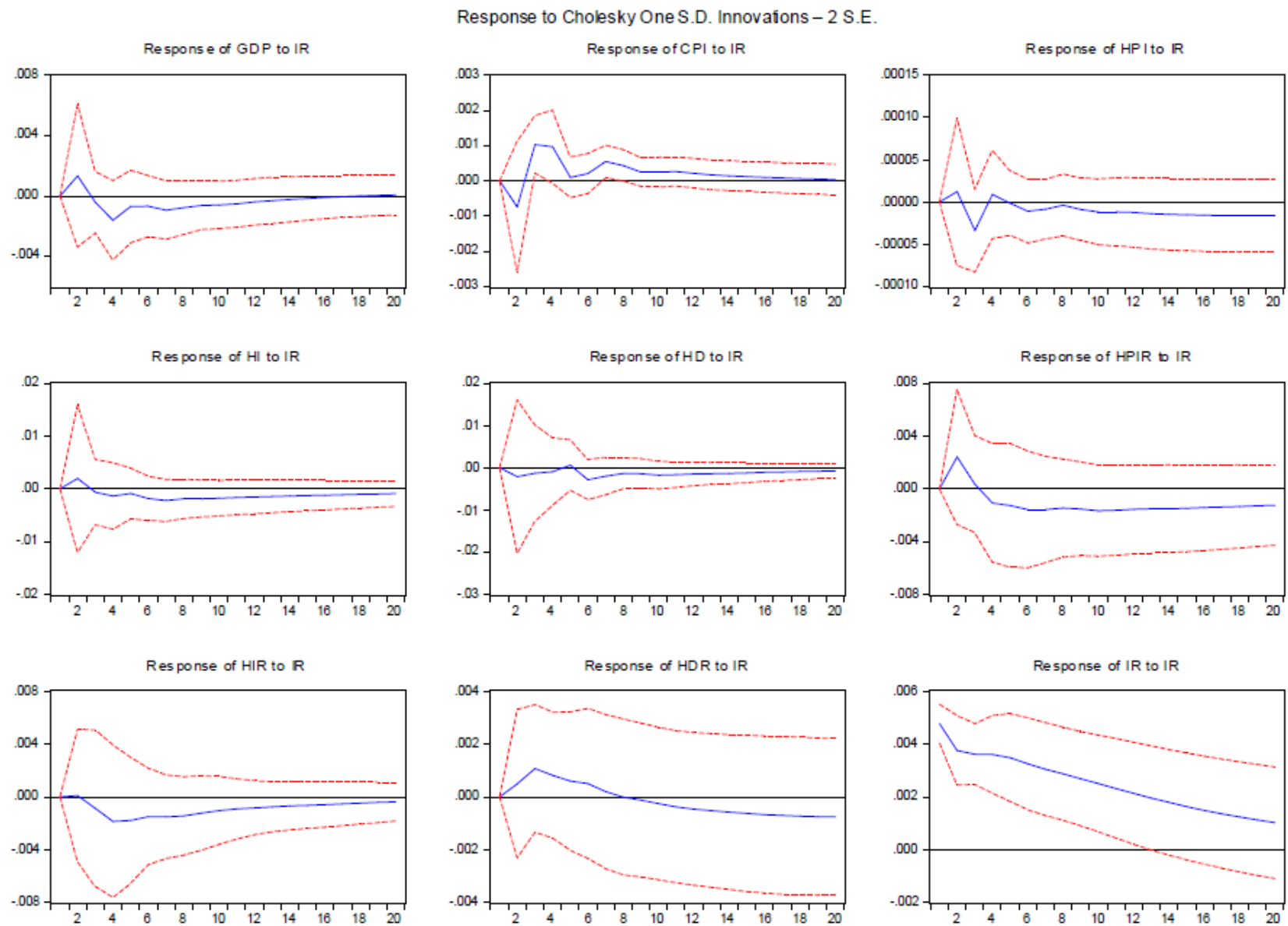


Figure 25 Growth Rate of Housing Price Shock

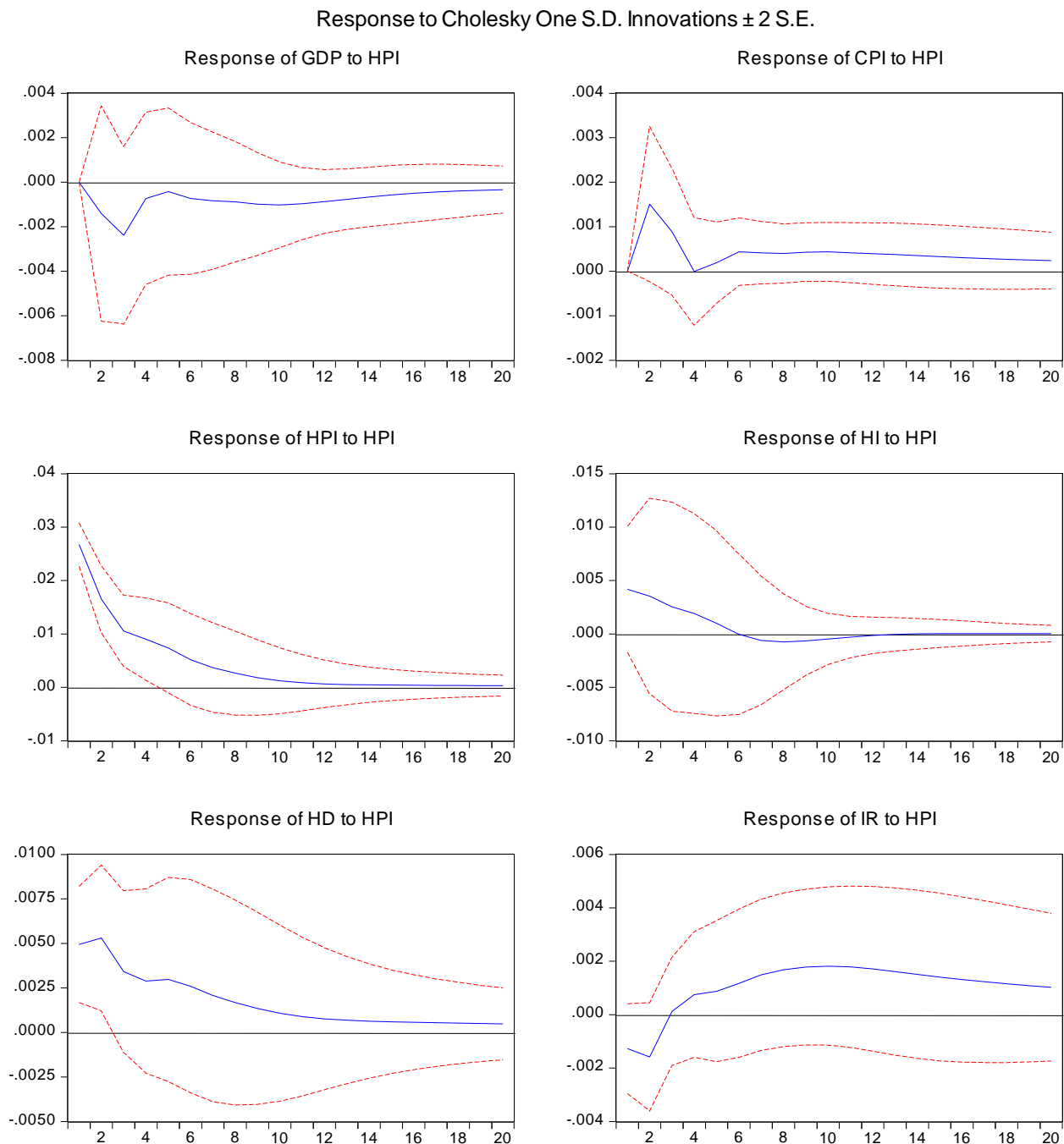


Figure 26 House Price Shock: British Columbia

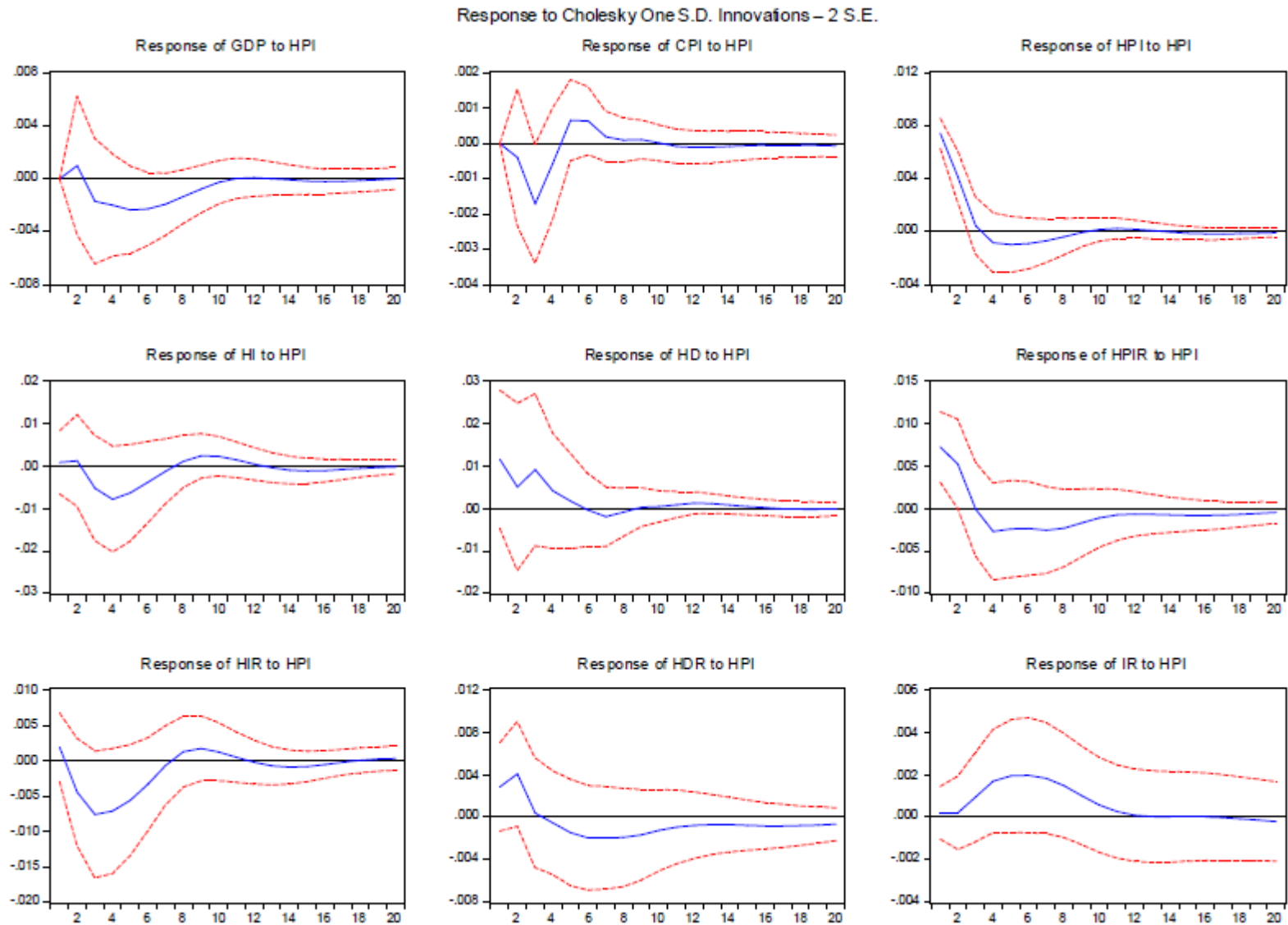


Figure 27 House Price Shock: Saskatchewan

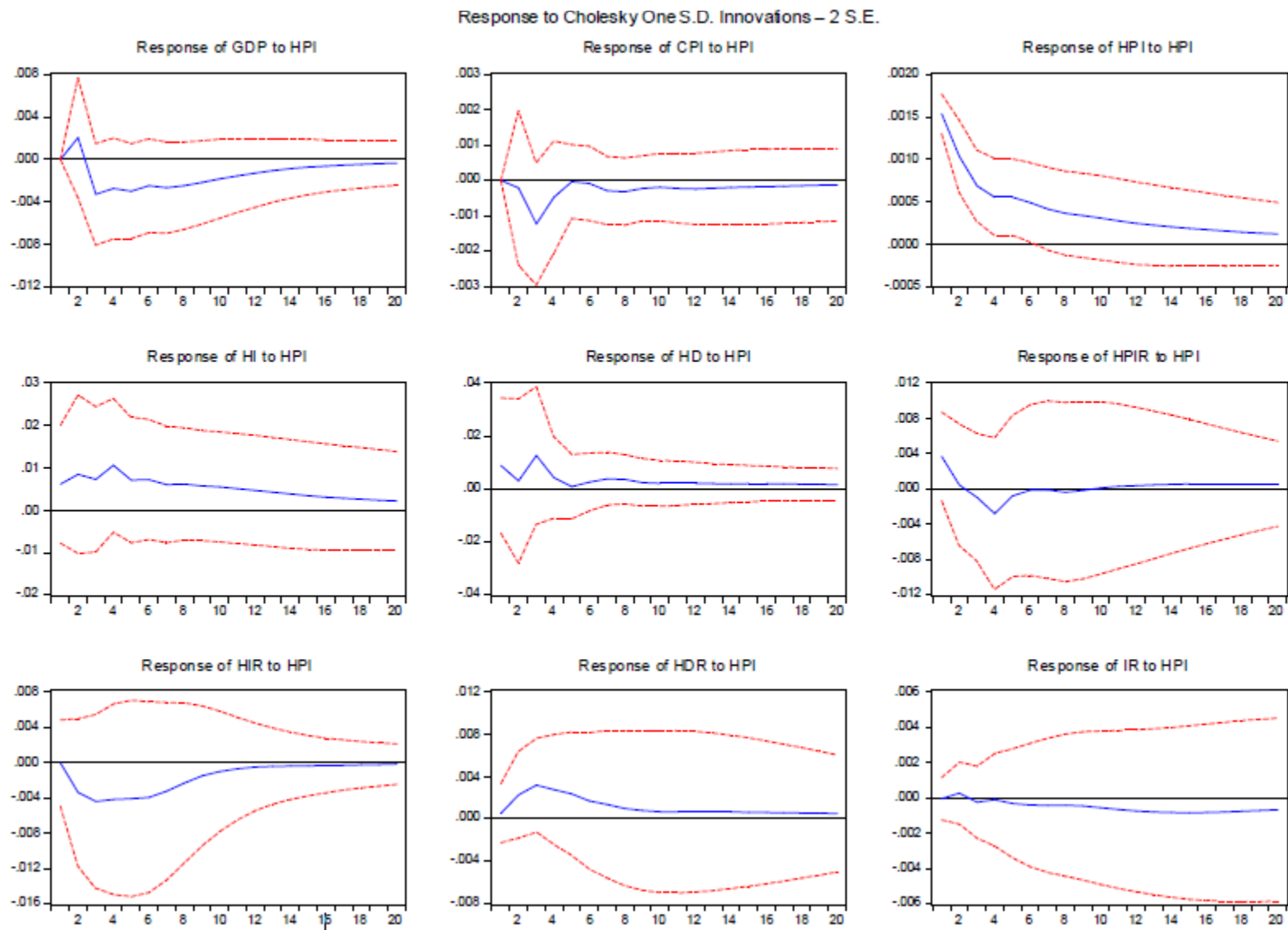


Figure 28 House Price Shock: Alberta

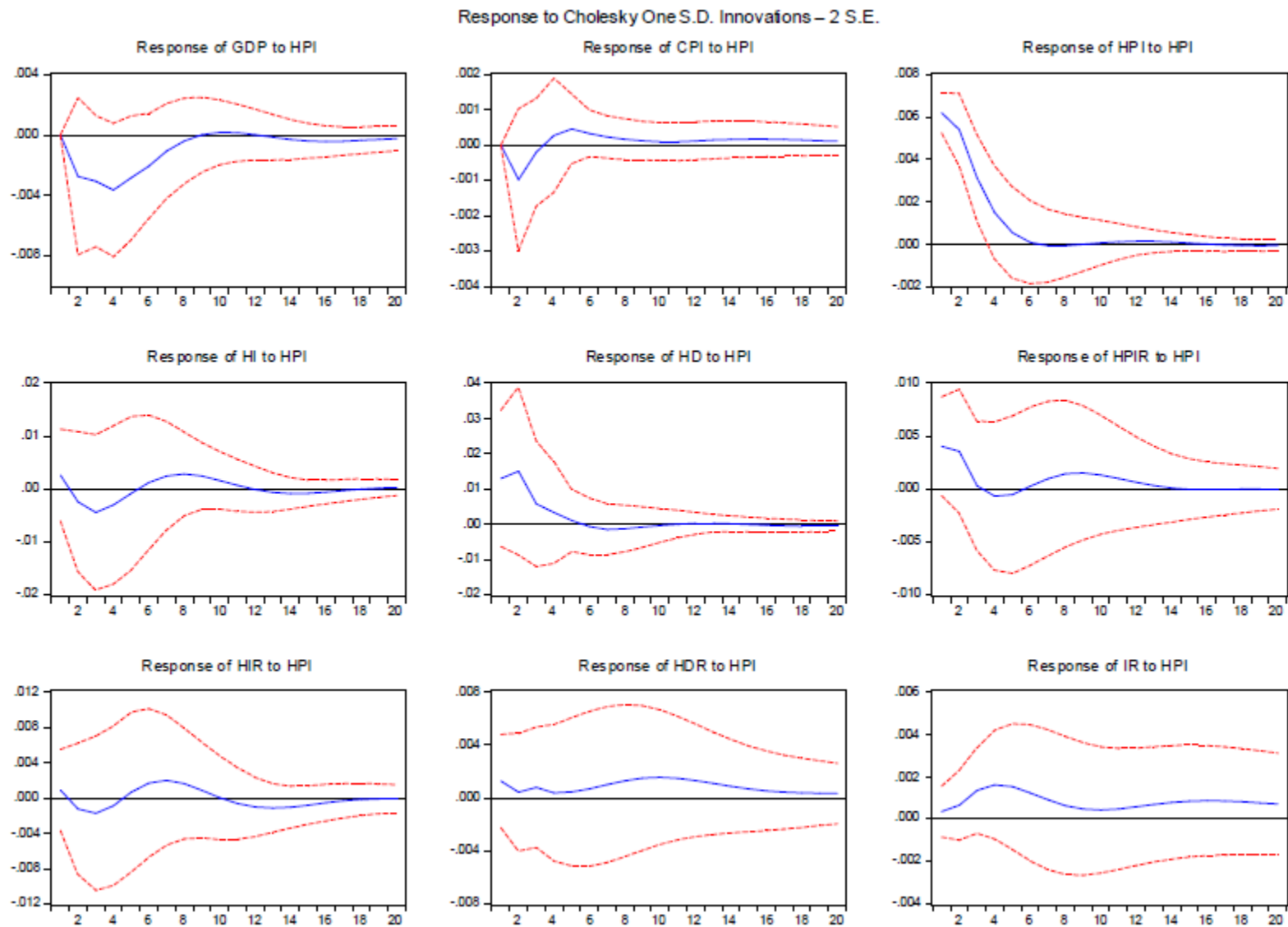


Figure 29 House Price Shock: Manitoba

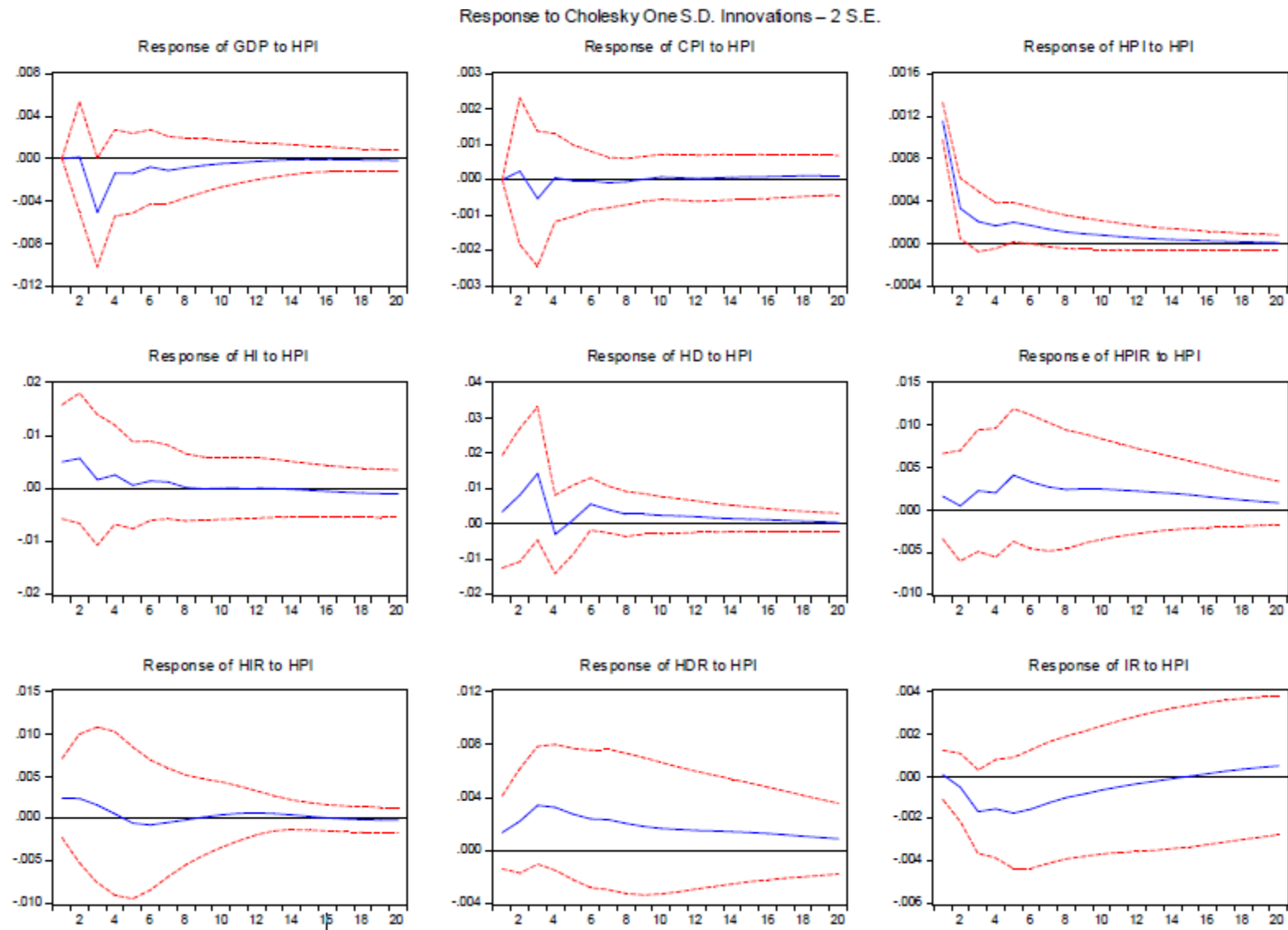


Figure 30 House Price Shock: Ontario

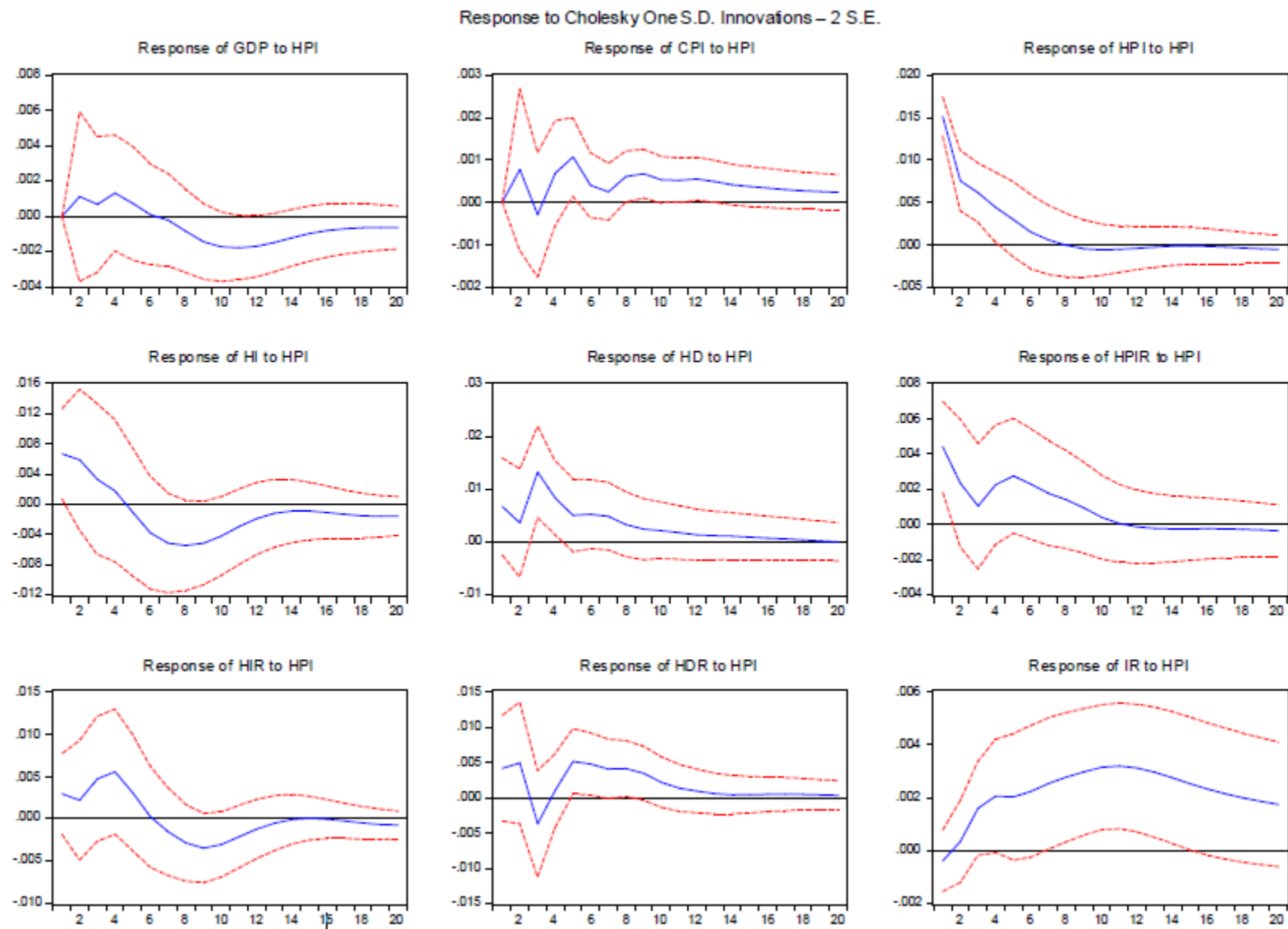


Figure 31 House Price Shock: Quebec

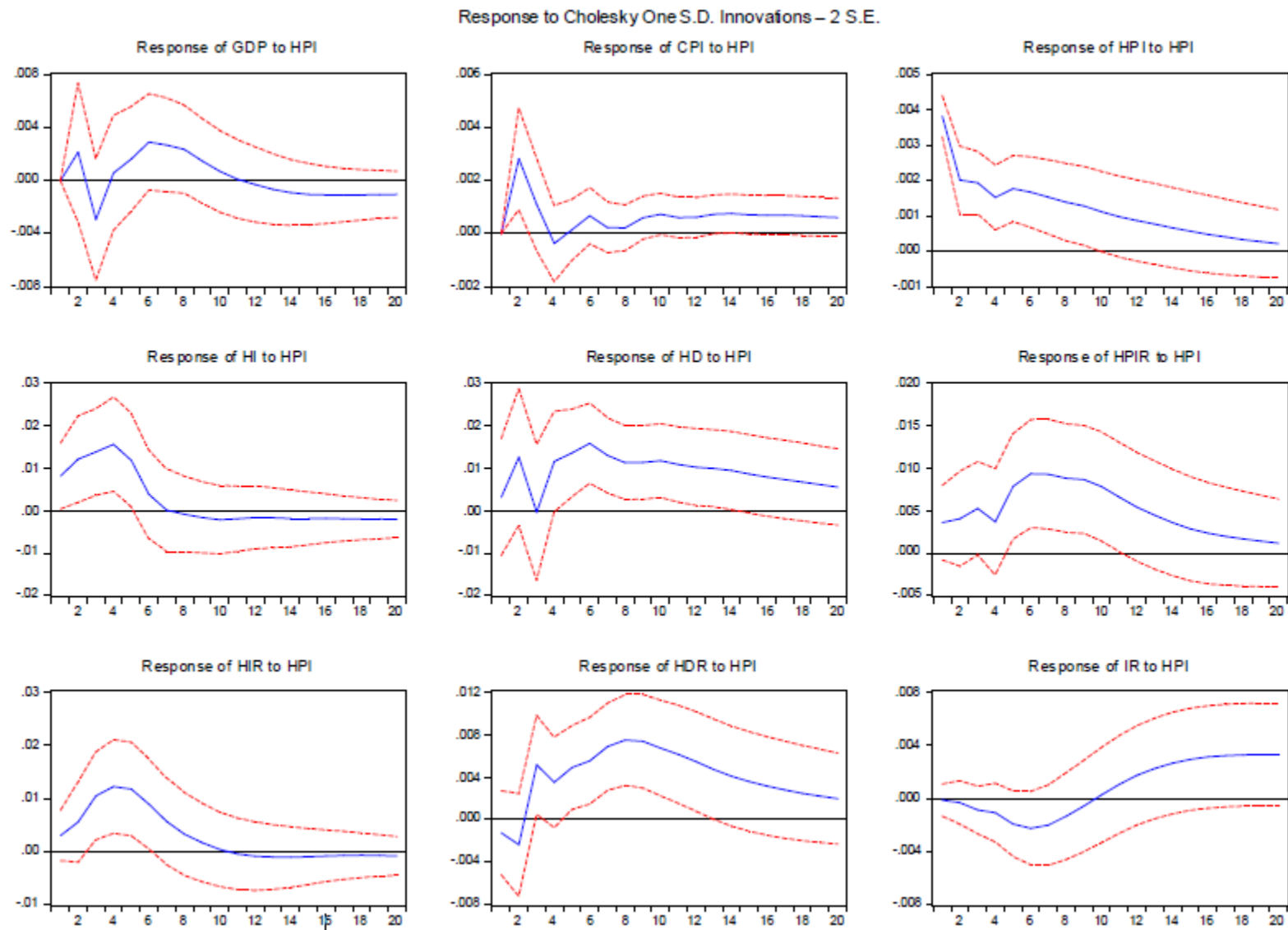


Figure 32 House Price Shock: New Brunswick

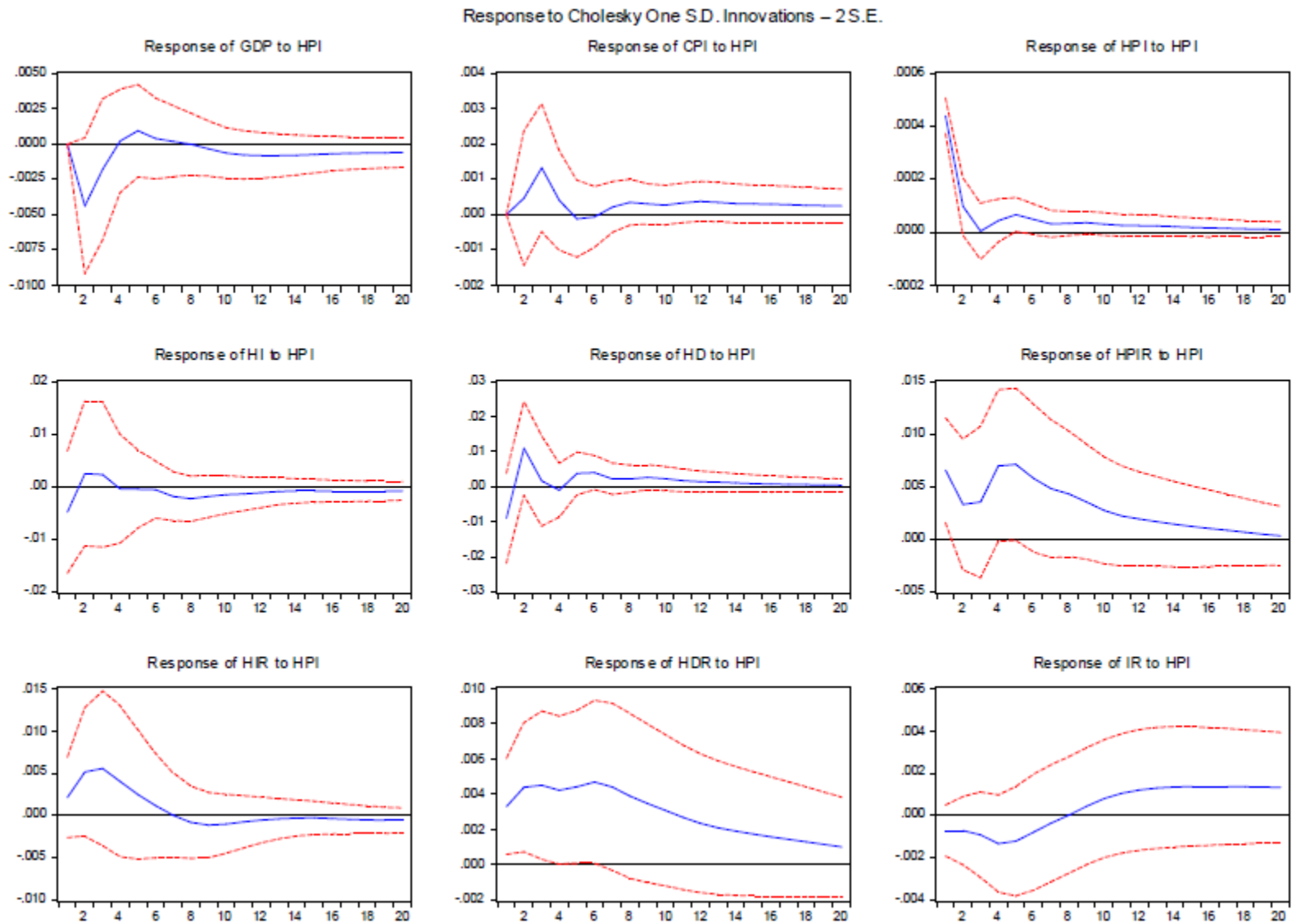


Figure 33 House Price Shock: Nova Scotia

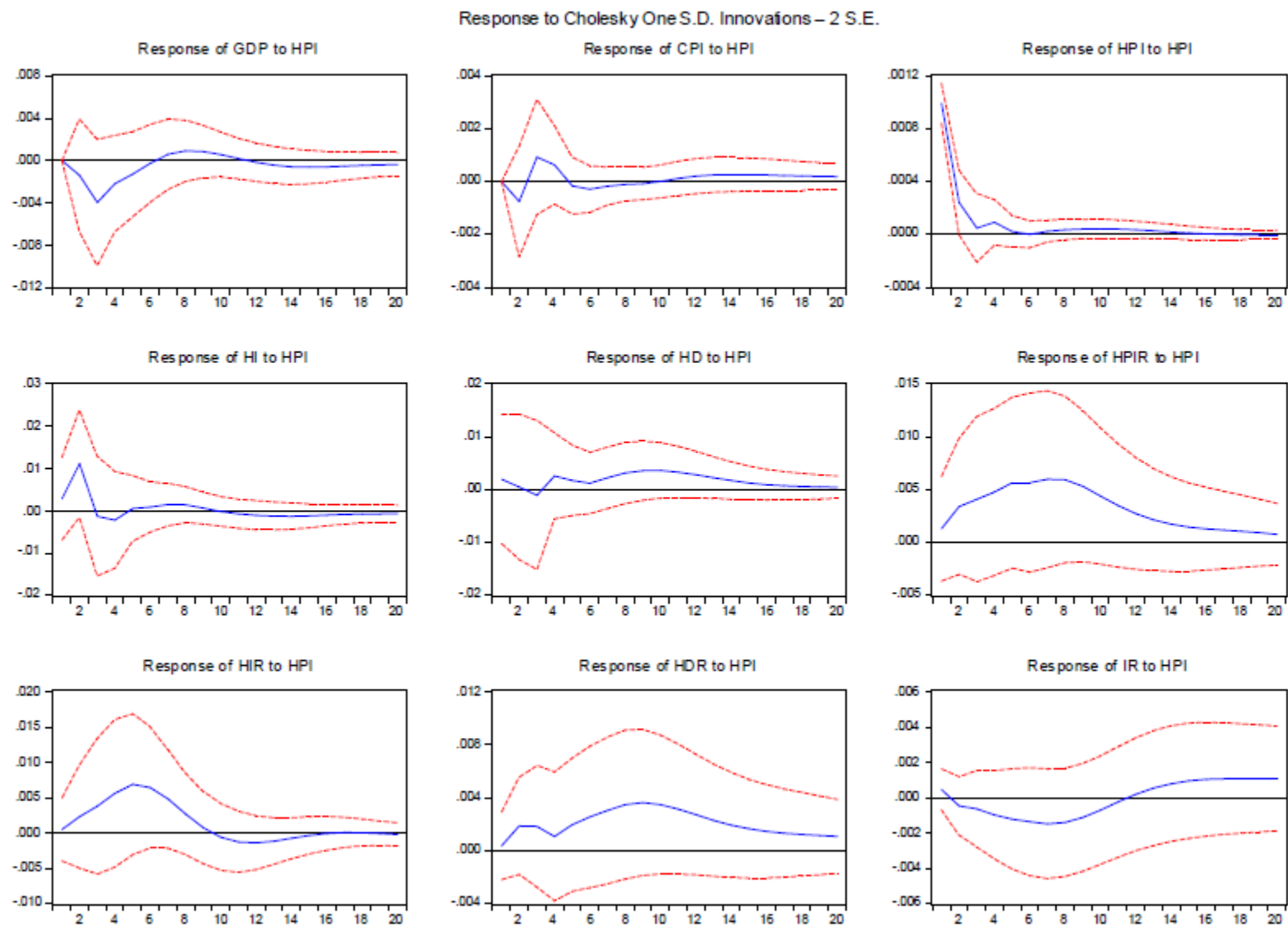
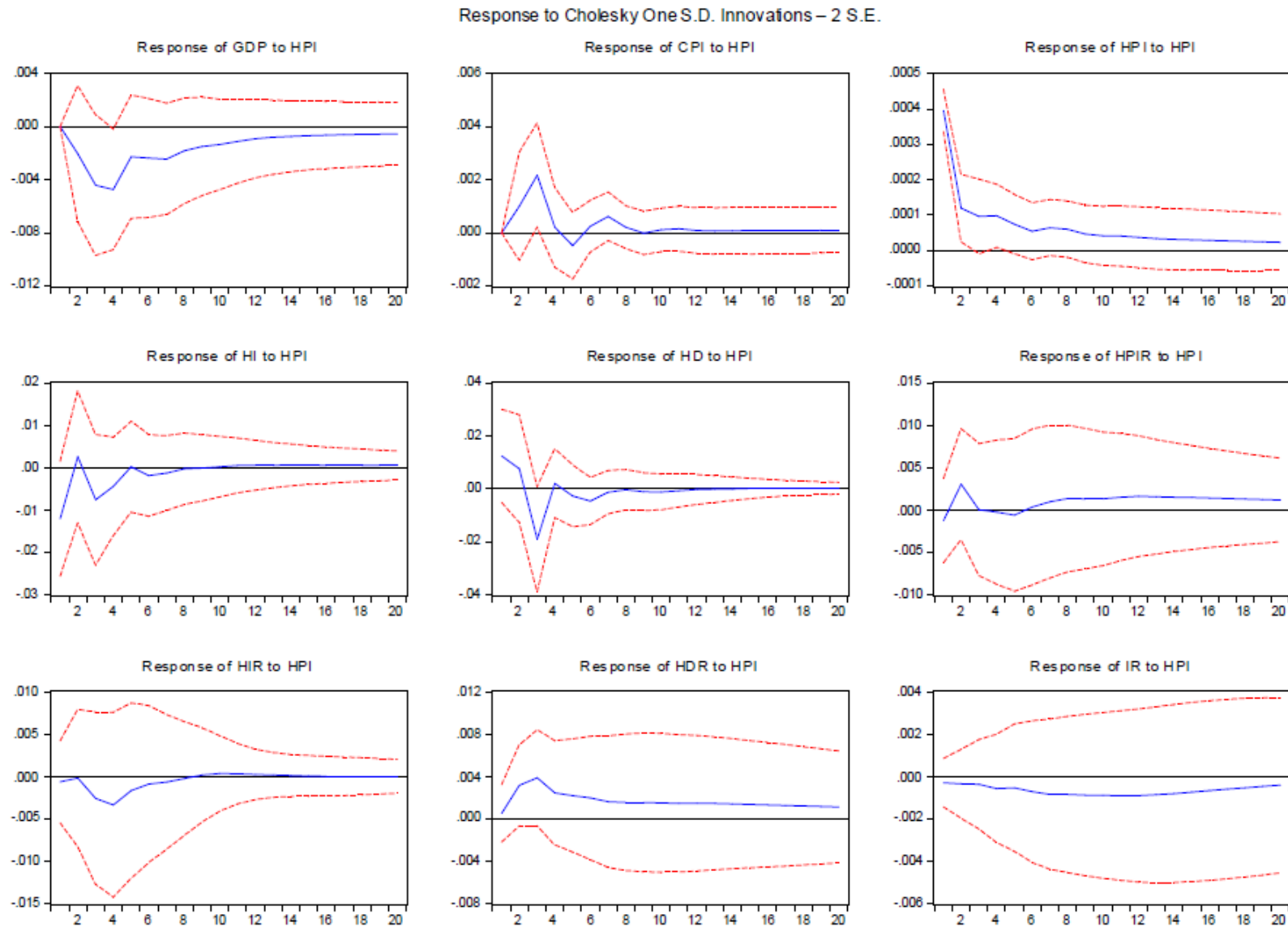


Figure 34 House Price Shock: Newfoundland and Labrador



Robustness Analysis

Figure 35 Impulse Responses with Disposable Income

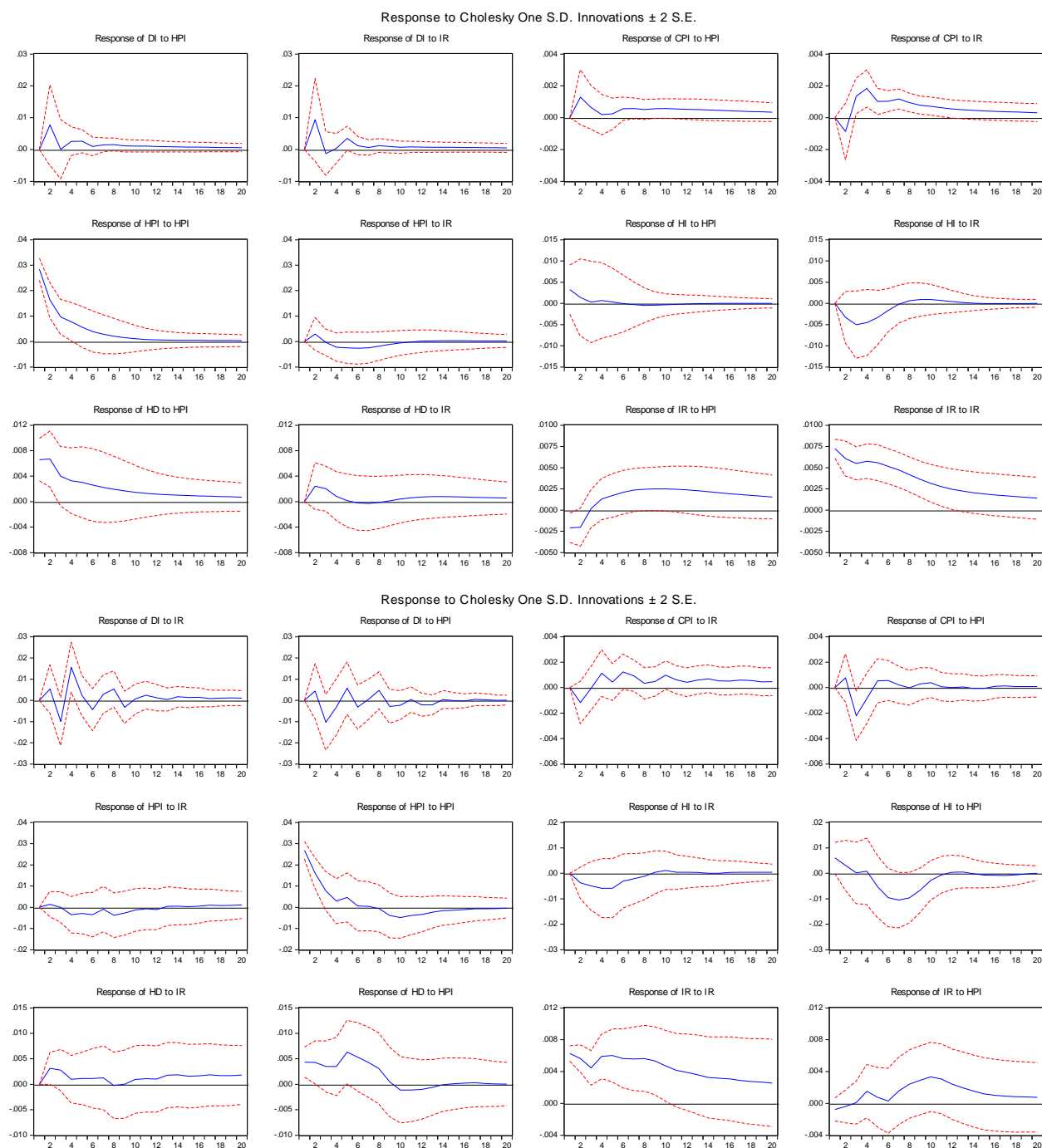


Figure 36 Impulse Responses with lag length of 8

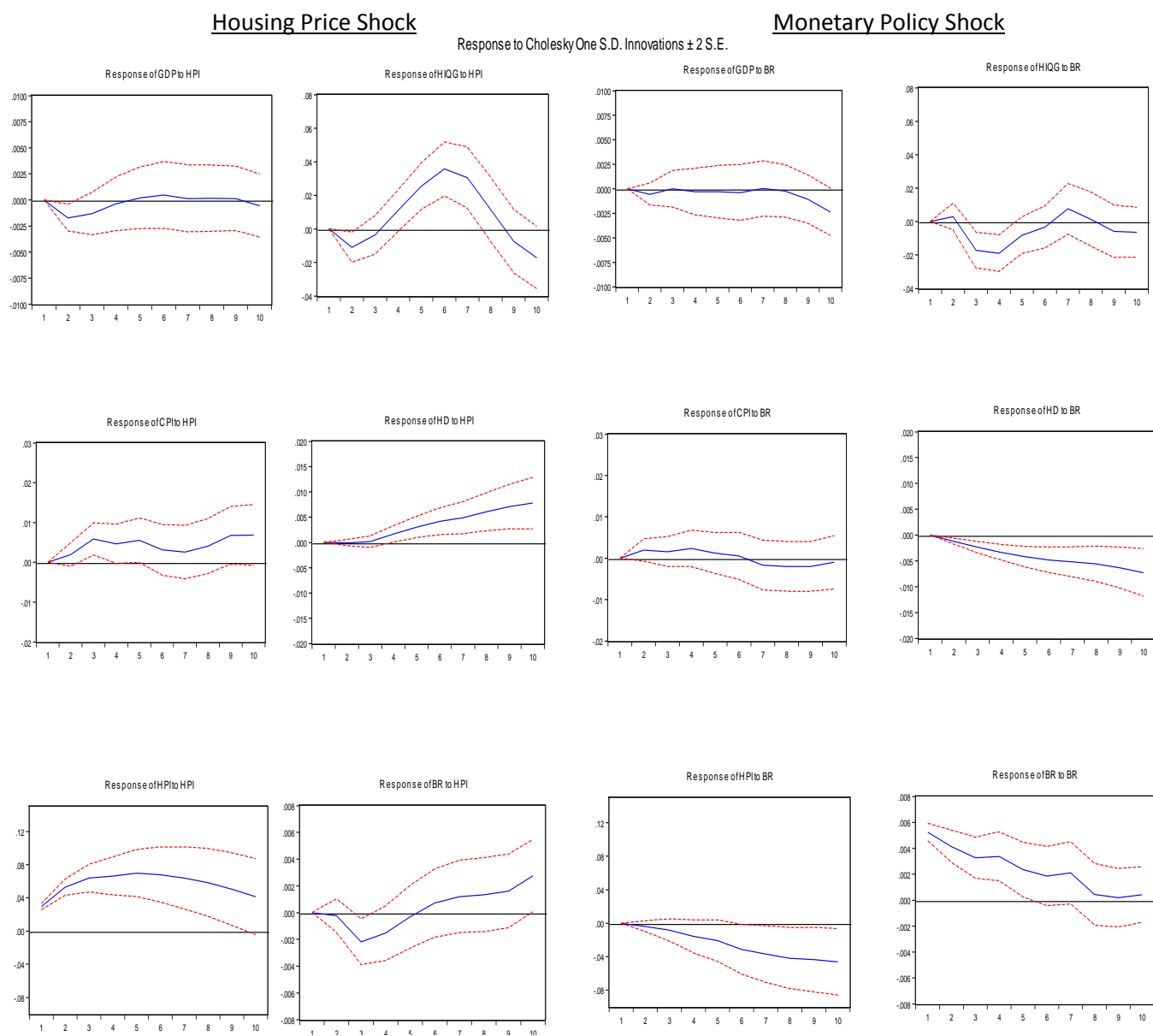


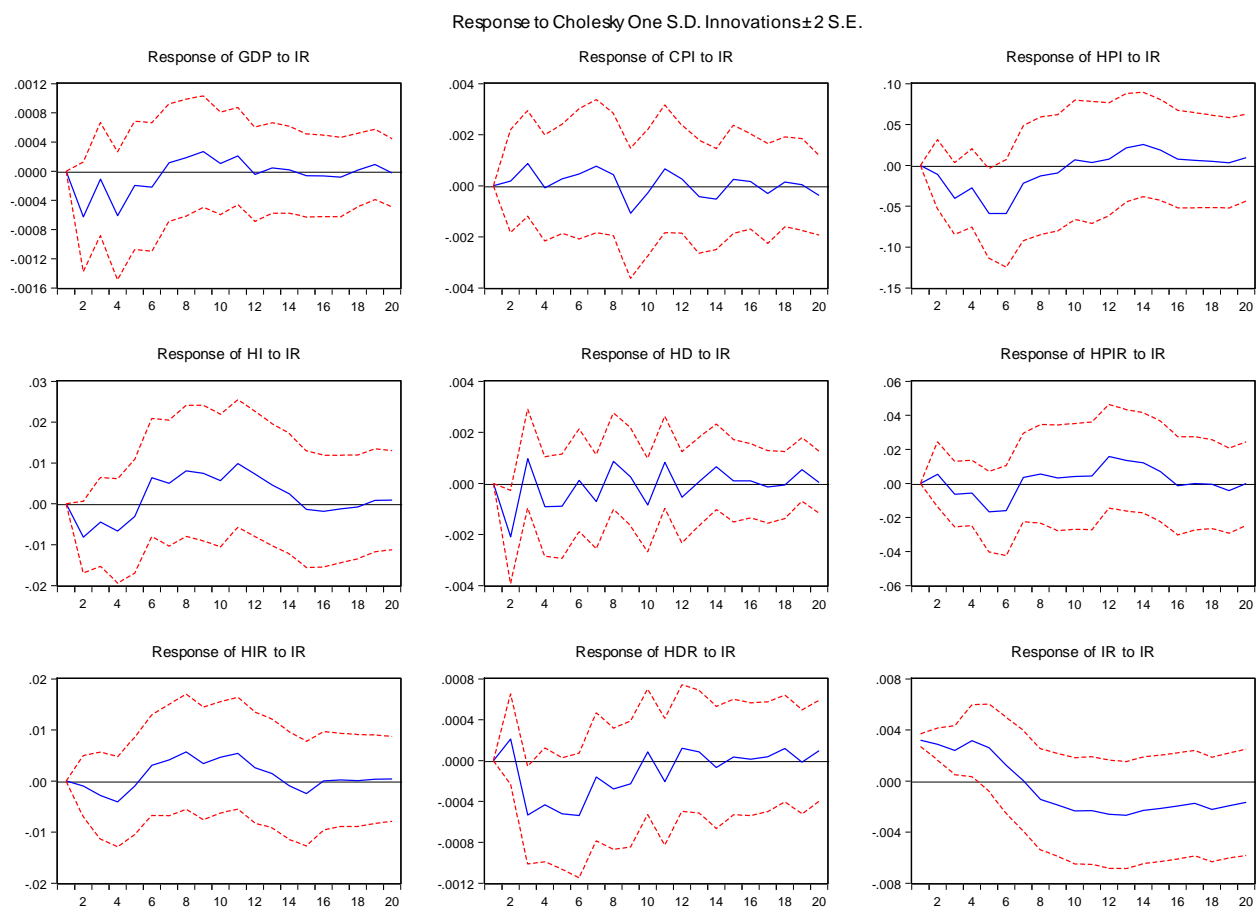
Figure 37 Impulse Responses with lag length of 8: British Columbia

Figure 38 Impulse Responses with alternative provincial identification:

Reverse Ordering in the Vector Z_t , Ontario

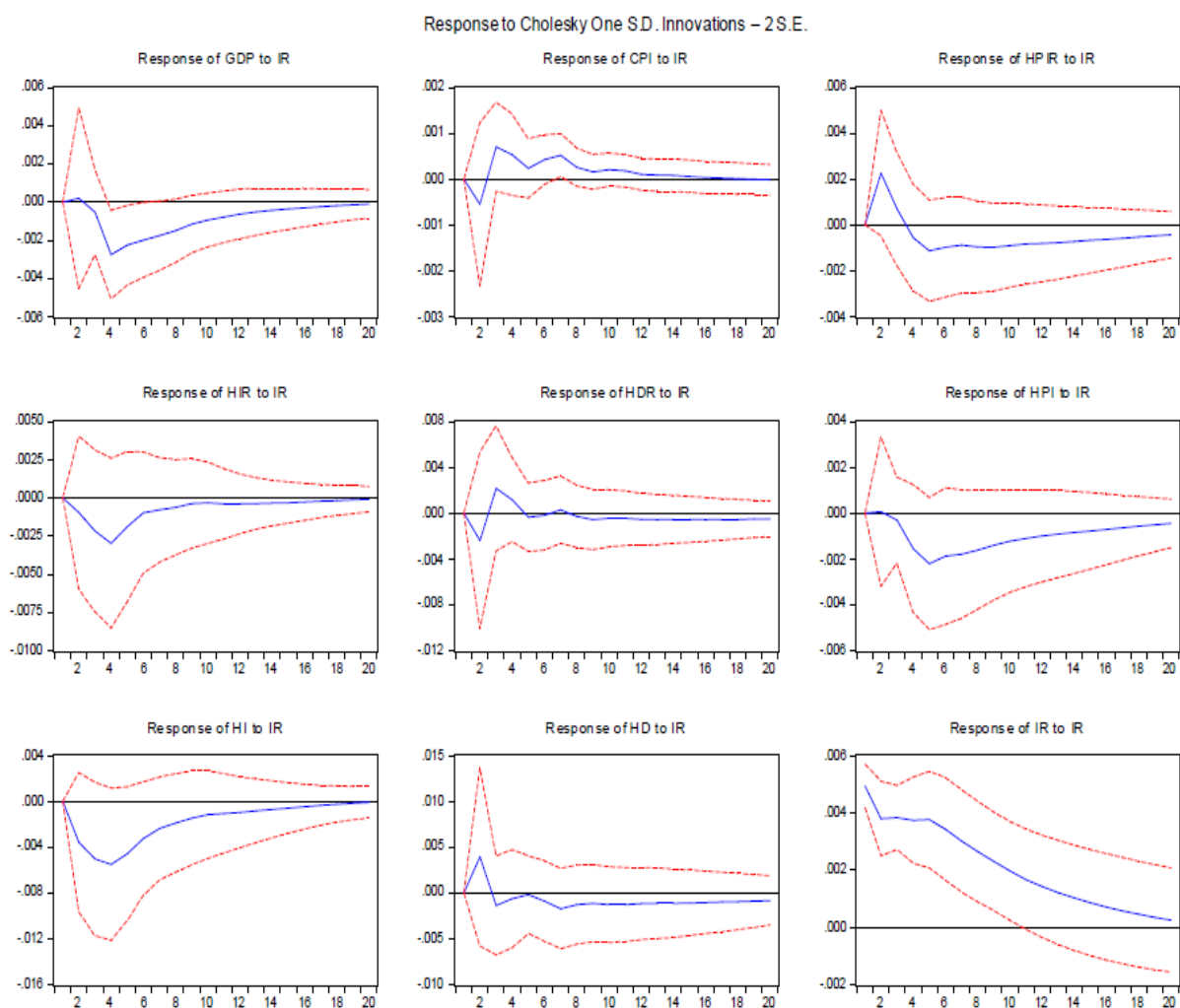


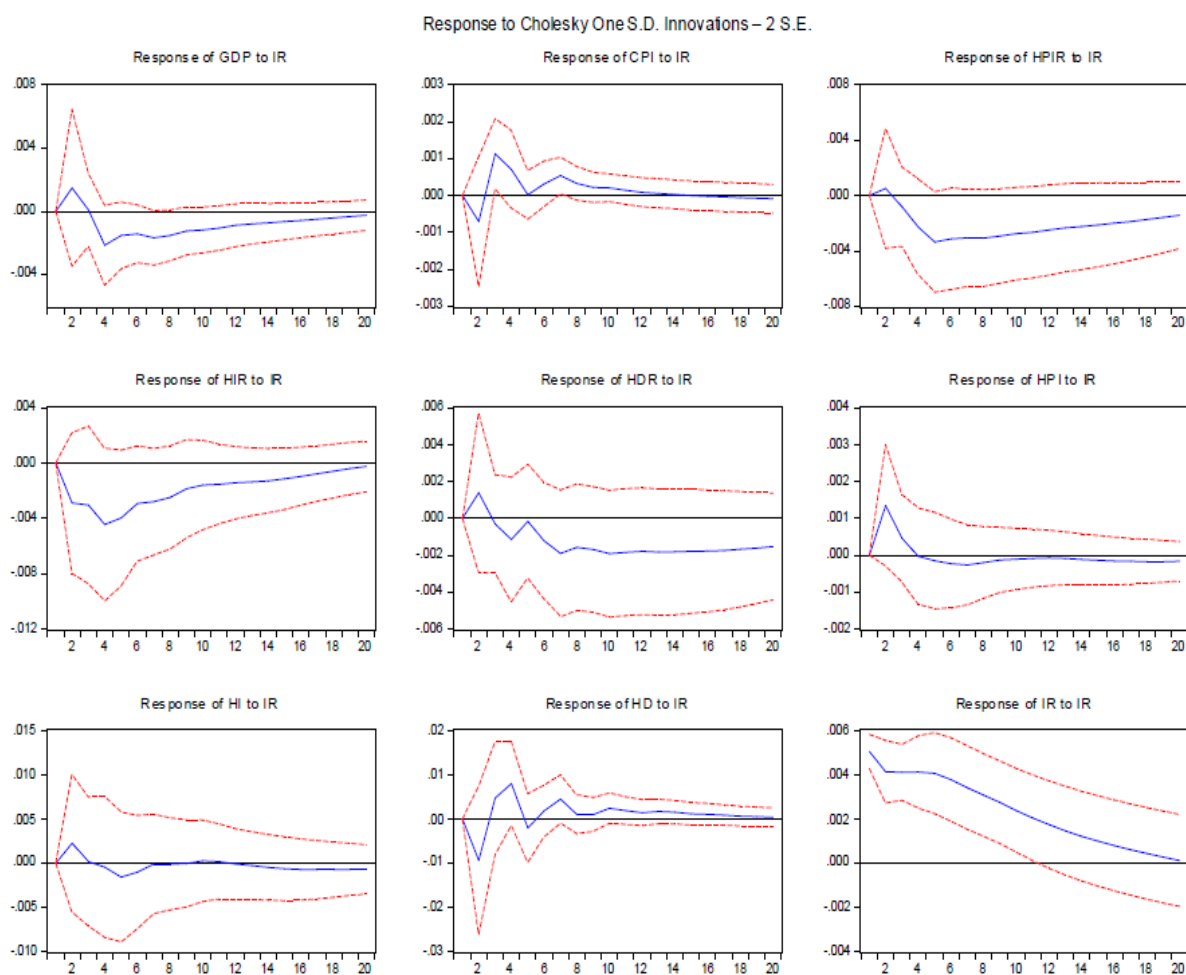
Figure 39 Impulse Responses with alternative provincial identification:**Reverse Ordering in the Vector Z, British Columbia**

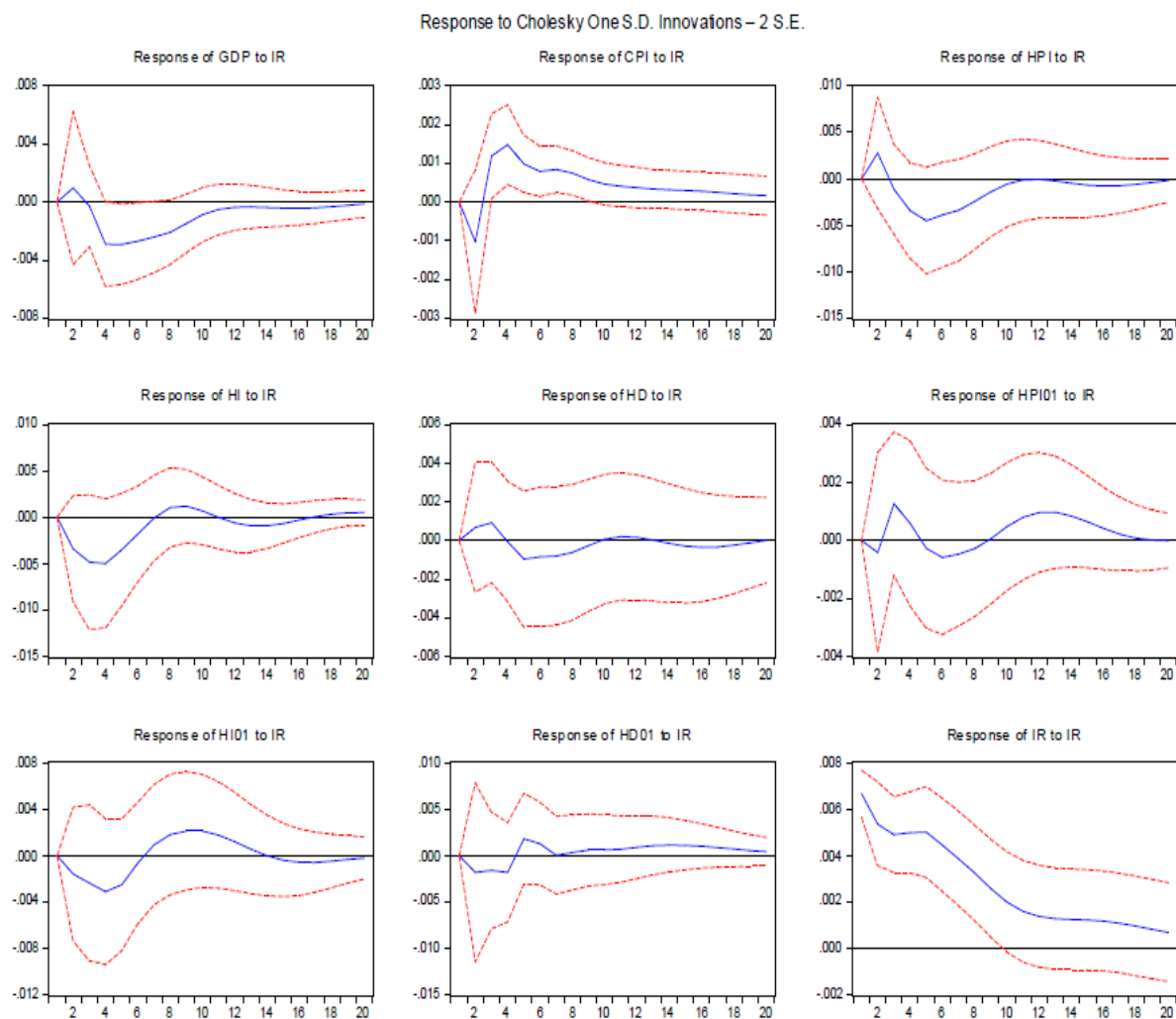
Figure 40 Impulse Responses with alternative provincial identification:**Provincial Specific Variable in the National SVAR: Ontario**

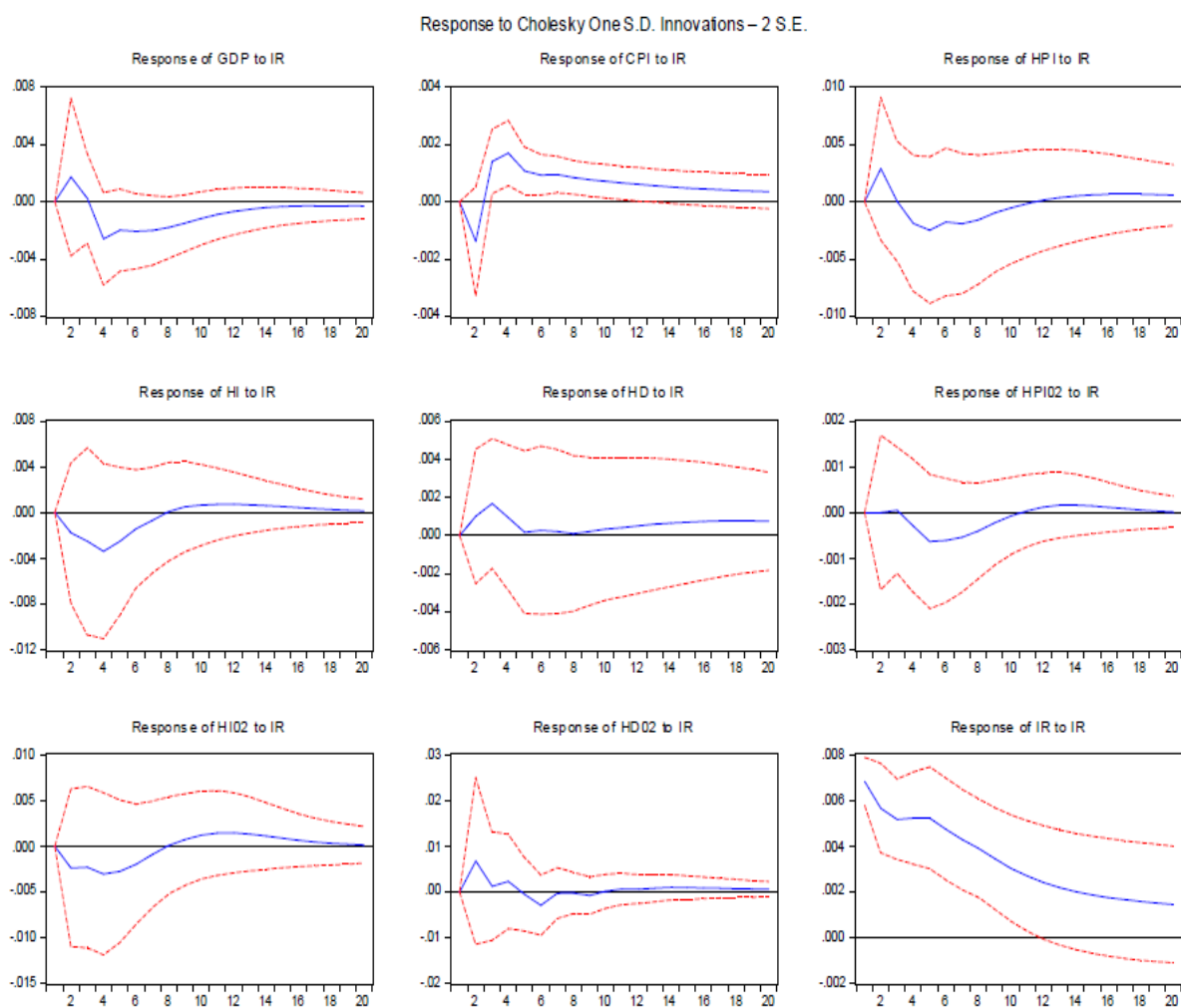
Figure 41 Impulse Responses with alternative provincial identification:**Provincial Specific Variable in the National SVAR: British Columbia**

Figure 42 Impulse Responses with alternative ordering:

Canada

Response to Cholesky One S.D. Innovations ± 2 S.E.

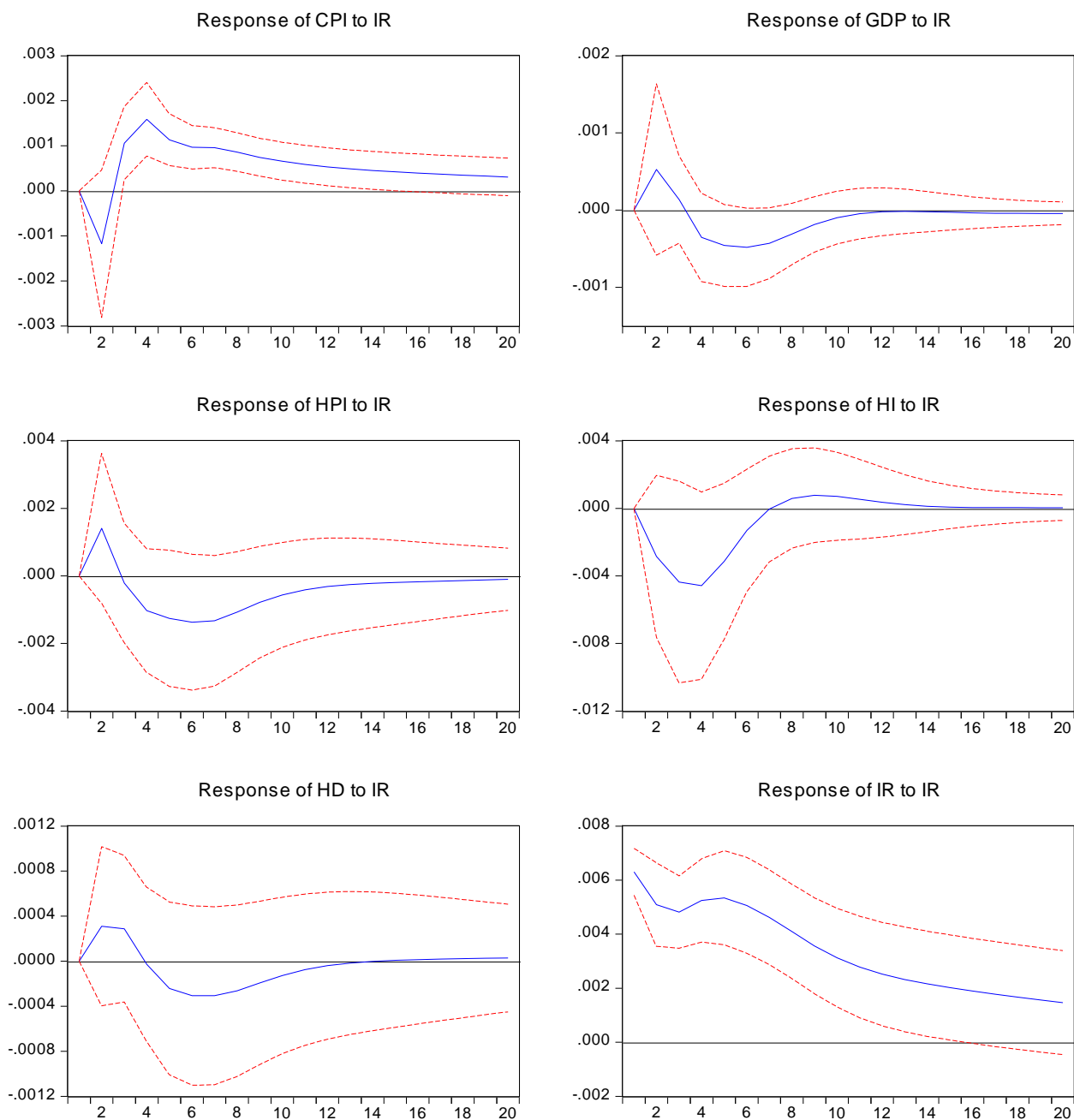


Figure 43 Impulse Responses with Real Variables:

Monetary Policy Shock to Canada

Response to Cholesky One S.D. Innovations ± 2 S.E.

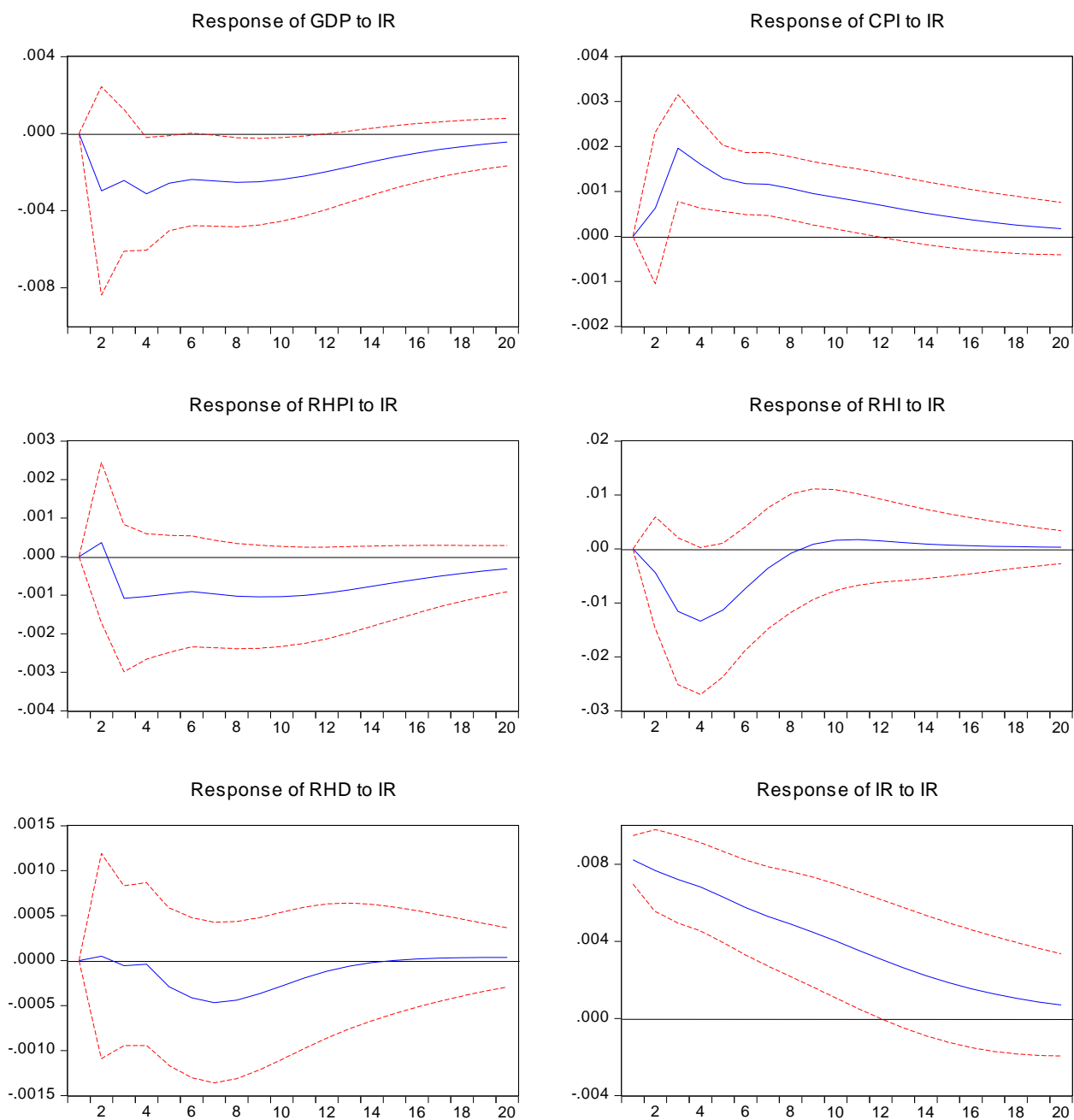
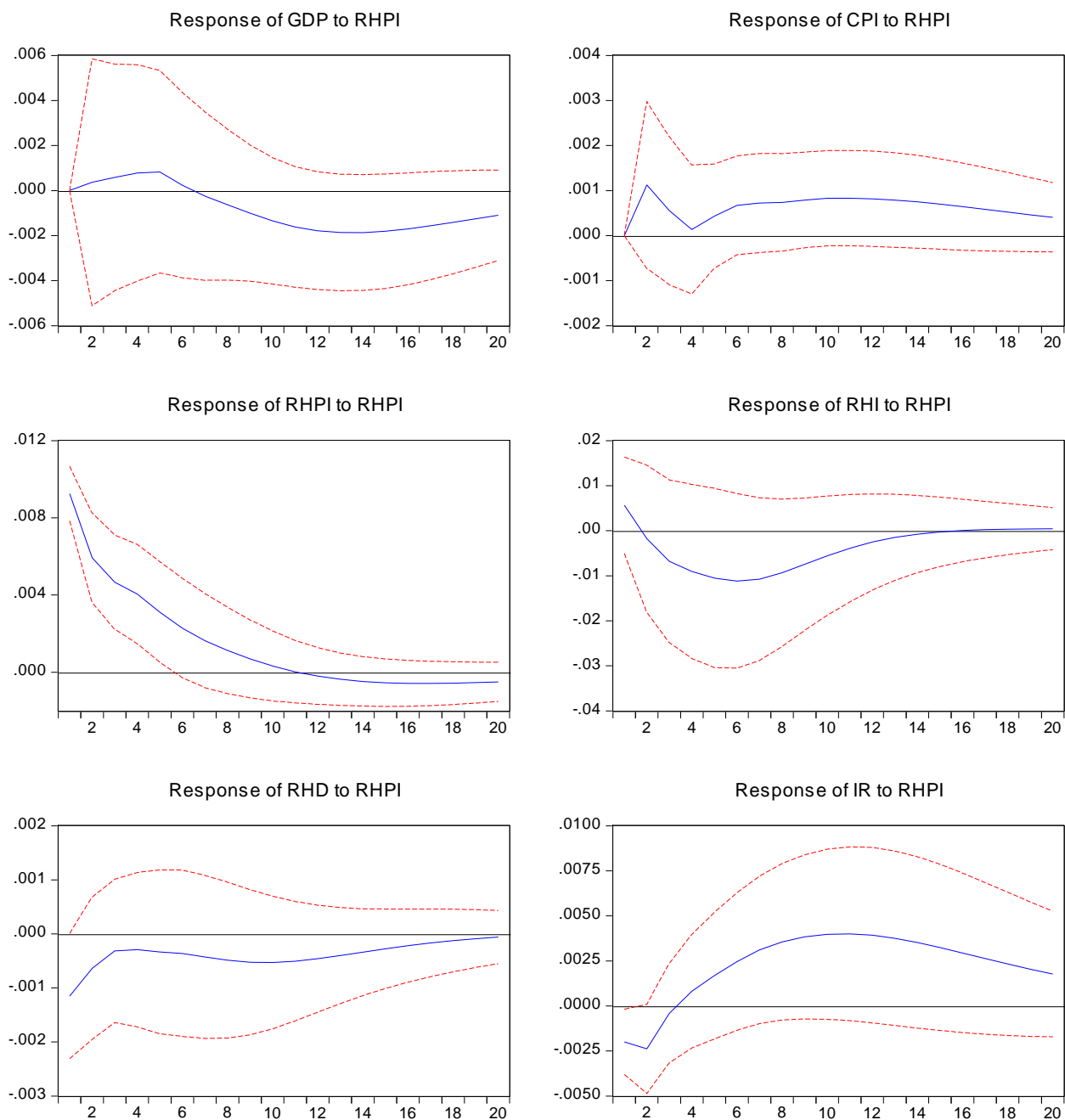


Figure 44 Impulse Responses with Real Variables:

House Price Shock to Canada

Response to Cholesky One S.D. Innovations ± 2 S.E.



Appendix B List of Tables**Housing Price Index Weights****Table 1 Time Varying Weights**

	NFL	PE	NS	NB	QC	ON	MB	SK	AL	BC
1981	1.7%	0.3%	2.8%	2.0%	17.5%	36.2%	4.0%	3.4%	15.3%	16.7%
1982	1.6%	0.3%	2.6%	1.9%	17.1%	35.9%	4.0%	3.4%	15.5%	17.4%
1983	1.5%	0.3%	2.7%	1.9%	16.3%	35.4%	3.9%	3.6%	14.7%	19.5%
1984	1.5%	0.3%	2.8%	2.0%	16.3%	36.4%	4.1%	3.7%	13.5%	19.2%
1985	1.5%	0.3%	3.0%	2.0%	16.7%	37.4%	4.2%	3.8%	12.8%	18.2%
1986	1.5%	0.3%	3.2%	2.0%	16.8%	39.9%	4.3%	3.8%	11.5%	16.4%
1987	1.4%	0.3%	3.2%	2.0%	18.3%	42.2%	4.2%	3.6%	10.0%	14.6%
1988	1.4%	0.3%	3.1%	1.9%	19.2%	44.3%	4.0%	3.4%	8.9%	13.3%
1989	1.3%	0.3%	3.0%	1.9%	18.8%	46.4%	3.6%	3.1%	8.4%	13.0%
1990	1.2%	0.3%	2.9%	1.8%	20.6%	45.0%	3.3%	2.6%	8.6%	13.6%
1991	1.2%	0.3%	2.8%	1.7%	20.5%	45.1%	3.1%	2.3%	8.7%	13.9%
1992	1.1%	0.3%	2.6%	1.7%	21.1%	44.0%	2.9%	2.2%	9.0%	14.9%
1993	1.0%	0.3%	2.5%	1.8%	20.3%	43.8%	2.7%	2.1%	8.8%	16.4%
1994	1.0%	0.3%	2.5%	1.7%	20.6%	42.6%	2.6%	2.1%	8.9%	17.3%
1995	1.1%	0.3%	2.6%	1.8%	20.6%	42.0%	2.6%	2.1%	9.0%	17.6%
1996	1.1%	0.3%	2.6%	1.8%	20.3%	41.9%	2.6%	2.1%	9.1%	18.0%
1997	1.0%	0.3%	2.5%	1.7%	19.4%	42.2%	2.5%	2.0%	9.7%	18.3%
1998	1.1%	0.4%	2.6%	1.7%	18.7%	42.8%	2.5%	2.3%	9.9%	17.8%
1999	1.1%	0.4%	2.6%	1.7%	18.2%	43.1%	2.4%	2.2%	10.3%	17.7%
2000	1.1%	0.4%	2.7%	1.8%	17.8%	43.3%	2.5%	2.3%	10.7%	17.2%
2001	1.2%	0.4%	2.7%	1.8%	17.6%	43.9%	2.5%	2.2%	10.9%	16.6%
2002	1.1%	0.4%	2.7%	1.7%	17.0%	44.6%	2.5%	2.1%	10.9%	16.8%
2003	1.1%	0.4%	2.7%	1.7%	17.2%	44.5%	2.4%	2.1%	11.1%	16.6%
2004	1.1%	0.4%	2.7%	1.7%	17.7%	43.8%	2.4%	2.0%	11.3%	16.5%
2005	1.1%	0.4%	2.7%	1.6%	17.9%	43.2%	2.4%	2.0%	11.6%	16.8%
2006	1.0%	0.3%	2.6%	1.6%	17.5%	43.1%	2.4%	1.9%	12.6%	16.7%
2007	1.0%	0.3%	2.6%	1.5%	17.0%	43.0%	2.4%	2.0%	13.2%	16.8%
2008	1.0%	0.3%	2.5%	1.5%	17.0%	42.0%	2.5%	2.2%	13.9%	16.9%
2009	1.0%	0.3%	2.5%	1.5%	17.2%	40.8%	2.6%	2.3%	14.1%	17.6%
2010	1.1%	0.3%	2.4%	1.5%	17.2%	40.9%	2.6%	2.3%	14.0%	17.5%
2011	1.0%	0.3%	2.4%	1.5%	16.8%	41.7%	2.6%	2.3%	13.8%	17.3%
2012	1.1%	0.3%	2.4%	1.5%	18.1%	40.9%	2.7%	2.4%	13.4%	17.0%

Table 2 Time Invariant Weight

NFL	PE	NS	NB	QC	ON	MB	SK	AL	BC
1.2%	0.3%	2.7%	1.7%	18.2%	41.9%	3.0%	2.6%	11.4%	16.7%

Lag Selection Criteria**Table 3 Canada**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	591.7303	NA	2.32E-12	-9.762171	-9.622797	-9.705571
1	2156.932	2947.796	1.98E-23	-35.24886	-34.27324	-34.85266
2	2274.48	209.6283	5.11E-24	-36.608	34.79613*	35.87219*
3	2320.358	77.22823	4.39E-24	-36.77264	-34.12452	-35.69723
4	2353.982	53.23815	4.66E-24	-36.73304	-33.24868	-35.31802
5	2394.701	60.3992	4.46E-24	-36.81168	-32.49107	-35.05706
6	2435.592	56.56632	4.33e-24*	-36.89321	-31.73635	-34.79898
7	2464.202	36.71618	5.28E-24	-36.77004	-30.77693	-34.33621
8	2512.851	57.56728*	4.75E-24	36.98085*	-30.15149	-34.20741

Table 4 British Columbia

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1598.897	NA	7.22E-29	-39.2567	-38.9907	-39.15
1	1978.059	664.7035	4.64E-32	-46.6188	43.95825*	-45.5513
2	2053.528	115.532	5.70E-32	-46.4822	-41.4272	-44.4541
3	2127.231	96.45103	8.22E-32	-46.302	-38.8526	-43.3132
4	2236.28	118.4736	6.07E-32	-46.9946	-37.1507	-43.0451
5	2363.976	110.3546	3.94E-32	-48.1476	-35.9093	-43.2374
6	2520.505	100.4876	2.22E-32	-50.0125	-35.3797	-44.1416
7	2766.269	103.1603*	4.19e-33*	54.08073*	-37.0535	47.24919*

Table 5 Saskatchewan

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1633.375	NA	3.08E-29	-40.108	-39.842	-40.0013

1	1993.312	631.0011	3.18E-32	-46.9954	-	-	44.33487*	45.92794*
2	2057.071	97.6055	5.22E-32	-46.5697	-41.5147	-44.5415		
3	2140.827	109.6073	5.88E-32	-46.6377	-39.1883	-43.6489		
4	2256.858	126.0581*	3.65E-32	-47.5027	-37.6588	-43.5532		
5	2342.35	73.88234	6.72E-32	-47.6136	-35.3753	-42.7034		
6	2488.927	94.09849	4.84E-32	-49.2328	-34.6	-43.3619		
7	2691.951	85.21993	2.63e-32*	-	52.24570*	-35.2185	-45.4142	

Table 6 Alberta

Lag	LogL	LR	FPE	AIC	SC	HQ		
0	1576.673	NA	1.25E-28	-38.708	-38.4419	-38.6012		
1	1965.556	681.7457*	6.32e-32*	-46.31	-	-	43.64952*	45.24259*
2	2030.416	99.29239	1.01E-31	-45.9115	-40.8566	-43.8834		
3	2100.346	91.51259	1.60E-31	-45.6382	-38.1888	-42.6494		
4	2187.686	94.8878	2.02E-31	-45.7947	-35.9509	-41.8452		
5	2298.495	95.76153	1.99E-31	-46.5308	-34.2925	-41.6206		
6	2440.243	90.9987	1.61E-31	-48.0307	-33.398	-42.1599		
7	2638.837	83.36042	9.75E-32	-	50.93425*	-33.9071	-44.1027	

Table 7 Manitoba

Lag	LogL	LR	FPE	AIC	SC	HQ		
0	1729.225	NA	2.89E-30	-42.4747	-42.2086	-42.3679		
1	2081.532	617.6251	3.60E-33	-49.1736	-	-	46.51313*	-48.1062
2	2158.012	117.0806	4.32E-33	-49.062	-44.0071	-47.0339		
3	2248.799	118.808	4.09E-33	-49.3037	-41.8543	-46.3149		
4	2377.592	139.9226*	1.85E-33	-50.4837	-40.6399	-46.5343		
5	2484.02	91.97533	2.03E-33	-51.1116	-38.8733	-46.2014		
6	2600.092	74.51523	3.11E-33	-51.9776	-37.3448	-46.1067		
7	2843.54	102.188	6.22e-34*	-	55.98864*	-38.9614	-	49.15711*

Table 8 Ontario

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1607.099	NA	5.90E-29	-39.4592	-39.1932	-39.3525

1	1999.328	687.6105	2.74E-32	-47.1439	-	44.48339*	-46.0765
2	2076.28	117.8036	3.25E-32	-47.044	-41.989	-41.989	-45.0158
3	2148.477	94.48042	4.87E-32	-46.8266	-39.3772	-39.3772	-43.8378
4	2251.194	111.5939	4.20E-32	-47.3628	-37.519	-37.519	-43.4133
5	2398.654	127.4346*	1.67E-32	-49.0038	-36.7655	-36.7655	-44.0937
6	2533.527	86.58461	1.61E-32	-50.334	-35.7013	-35.7013	-44.4631
7	2742.416	87.68211	7.55e-33*	-	53.49176*	-36.4646	46.66023*

Table 9 Quebec

Lag	LogL	LR	FPE	AIC	SC	HQ	
0	1650.031	NA	2.04E-29	-40.5193	-40.2532	-40.4125	
1	2026.399	659.8049	1.41E-32	-47.8123	-	45.15181*	-46.7449
2	2117.545	139.5322	1.17E-32	-48.0628	-43.0079	-43.0079	-46.0347
3	2188.294	92.5854	1.82E-32	-47.8097	-40.3603	-40.3603	-44.8209
4	2276.432	95.7545	2.25E-32	-47.986	-38.1421	-38.1421	-44.0365
5	2402.494	108.9427	1.52E-32	-49.0986	-36.8603	-36.8603	-44.1885
6	2574.489	110.4169*	5.86E-33	-51.3454	-36.7127	-36.7127	-45.4746
7	2765.682	80.25371	4.25e-33*	-	54.06622*	-37.039	47.23469*

Table 10 New Brunswick

Lag	LogL	LR	FPE	AIC	SC	HQ	
0	1853.437	NA	1.35E-31	-45.5417	-45.2756	-45.4349	
1	2185.593	582.2989	2.76E-34	-51.743	-	49.08254*	50.67561*
2	2255.905	107.6382*	3.85E-34	-51.4791	-46.4242	-46.4242	-49.451
3	2328.677	95.23277	5.69E-34	-51.276	-43.8266	-43.8266	-48.2872
4	2419.699	98.88815	6.55E-34	-51.5234	-41.6796	-41.6796	-47.574
5	2517.463	84.48699	8.91E-34	-51.9374	-39.6991	-39.6991	-47.0272
6	2664.603	94.46019	6.33E-34	-53.5704	-38.9377	-38.9377	-47.6996
7	2878.536	89.79915	2.62e-34*	-	56.85274*	-39.8256	-50.0212

Table 11 Nova Scotia

Lag	LogL	LR	FPE	AIC	SC	HQ

0	1782.489	NA	7.76E-31	-43.7899	-43.5238	-43.6831
1	2130.463	610.0288	1.08E-33	-50.3818	47.72131*	49.31438*
2	2205.793	115.3198	1.33E-33	-50.2418	-45.1869	-48.2137
3	2283.394	101.5515	1.74E-33	-50.1579	-42.7085	-47.1691
4	2388.636	114.3372*	1.41E-33	-50.7565	-40.9126	-46.807
5	2488.195	86.0389	1.83E-33	-51.2147	-38.9764	-46.3045
6	2624.79	87.6906	1.69E-33	-52.5874	-37.9547	-46.7166
7	2834.176	87.89017	7.84e-34*	-55.75743*	-38.7302	-48.9259

Table 12 Newfoundland and Labrador

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1798.999	NA	5.16E-31	-44.1975	-43.9315	-44.0908
1	2143.236	603.4776	7.86E-34	-50.6972	48.03670*	-49.6298
2	2226.059	126.7902	8.04E-34	-50.7422	-45.6873	-48.7141
3	2314.589	115.8542	8.05E-34	-50.9281	-43.4787	-47.9393
4	2395.514	87.91853	1.19E-33	-50.9263	-41.0824	-46.9768
5	2495.43	86.34737	1.53E-33	-51.3933	-39.1551	-46.4832
6	2663.711	108.0323*	6.47E-34	-53.5484	-38.9157	-47.6776
7	2886.348	93.45246	2.16e-34*	-57.04563*	-40.0184	50.21410*

Table 13 Variable Descriptions

Abbreviation	Variable Name	Description	Source
GDP	Gross Domestic Product	Gross domestic product at 2007 constant prices, expenditure-based, quarterly (dollars)(Seasonally Adjusted)	Statistics Canada. <i>Table 380-0084</i>
CPI	Consumer Price Index	Consumer Price Index (CPI),(Core) 2011 basket, quarterly (2002=100 unless otherwise noted)(Seasonally Adjusted)	Statistics Canada. <i>Table 326-0020</i>
NHPI	New Housing Price Index(NHPI)	New housing price indexes, quarterly (index, 2007=100)(Seasonally Adjusted)	Statistics Canada. <i>Table 327-0046</i>
HI	Residential Housing Investment	Residential values, by type of investment, quarterly (dollars)	Statistics Canada. <i>Table 026-0013</i>

HD	Household Debt	Household Credit: Credit measures, quarterly (dollars)(Seasonally Adjusted)	Non-Statistics Canada Information. <i>Table 176-0032</i>
IR	Interest Rate	Bank Rate, last Wednesday unless otherwise stated, quarterly (percent unless otherwise noted)	Non-Statistics Canada information. <i>Table 176-0043</i>

Provincial Analysis Variables : Transformations

HPI	New Housing Price Index	Generated as a weighted approximation of the NHPI using the time-invariant weight proposed in A.4	Imputed From: Statistics Canada. <i>Table 327-0046, Table 026-0013</i>
HI	Residential Housing Investment	Residential values by province, quarterly (dollars)	Statistics Canada. <i>Table 026-0013</i>
HD	Household Debt	Generated as a weighted approximation of the level of household debt based on the annual proportion of debt out of the national value.	Imputed From: Statistics Canada. <i>Table 026-0013, Table 380-0084, Table 380-0038</i>
HPIR	New Housing Price Index	Generated as the sum of HPI across all provinces j , where $j \neq i$.	Generated from HPI
HIR	Residential Housing Investment	Generated as the sum of residential housing investment across all provinces j , where $j \neq i$.	Generated from HI
HDR	Household Debt	Generated as the sum of household debt across all provinces j , where $j \neq i$.	Generated from HD

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