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The Impact of Oil Shocks on the Housing Market: Evidence from Canada and U.S.

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Abstract

The recent volatility in oil energy markets invites us to re-assess the impact of oil prices changes on the macroeconomic environment. The Great Recession of 2007-2009 led to closer monitoring of global housing markets by regulators and market participants. Employing a structural vector autoregressive model, we find that the reaction of housing markets to oil price shocks varies significantly depending on whether the change in oil prices is prompted by demand or supply shocks in the oil market and on country oil trading status (i.e. net importer or net exporter). Our results are robust to the inclusion of different macroeconomic channels through which oil shocks may influence housing prices and control for restricted dynamic feedback effects. We also study the role of the phases of the housing cycle.

JEL classification F30, G15

Key words: Oil prices, housing markets, structural vector autoregression (SVAR)

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1. Introduction

The booming U.S. real estate market during the early to mid-2000's lured many investors (and their funding sources) in the financial markets to partake in unwarranted amounts of financial leverage and risk that inflated housing prices around the globe. The inflated asset values were not unique to the housing markets, commodities (including oil) and equity markets also reached all-time highs. The 2007-2009 financial crisis that emerged from various factors including the housing boom, aggressive mortgage lending activity, financial innovation, historically low interest rates, and increased access to money and capital markets culminated with unprecedented U.S. government intervention in the financial sector. Some scholars (e.g. Luciani, 2015) claim that from the financial market, the contagion spread to the real economy and the remainder of the world leading to a severe global recession.

When contrasted to the U.S housing market, the Canadian housing market seems unaffected by the 2007-2009 financial crisis; it remains on the rise and hence has received renewed attention from a variety of interested parties both in Canada and from abroad (refer to Figure 1). The *Economist's* analysis of housing prices conducted in 2014 suggests that Canadian property values in 2012 were reported at roughly 75% above their long-run fair value while current property values continue to hold close to these metrics. Khiabani (2015) points out that in the last decade, many oil exporting countries have experienced an unusually sharp increase in housing prices which is accompanied by a period of high oil inflows in these countries. Interestingly, the direct relationship between world oil supply and housing prices is much stronger in Canadian (a net oil exporter) compared to the U.S. (a net oil importer) in our sample data as seen in Figure 1.

[Figure 1, about here]

An interesting area of recent research examines the impact of energy prices on real estate markets (e.g. Antonakakis et al., 2016; Breitenfellner et al., 2015; and Khiabani, 2015). The current literature generally suggests that increases in oil prices negatively impact the real estate market. While this literature sheds new light on the impact of oil prices on housing, it fails to distinguish the impact caused by supply side versus demand side oil shocks. This study explores the following research questions: 1) Does housing price behavior differ in response to the nature of the oil price shock?; 2) Do oil shock effects on the housing market vary based on the country oil trading status (i.e. net importer or net exporter)?; and 3) Does the response to oil shocks depend on the phase of the housing cycle? Examining the impact of oil shocks is particularly relevant since according to the International Monetary Fund (IMF) real estate accounts for roughly a third of the total assets held by the nonfinancial private sector in the U.S. Figures from Statistics Canada suggests that in 2015 approximately 13% of GDP was associated with real estate. Understanding real estate markets is, therefore, imperative for market participants, regulators, and consumers. The increasing significance that energy prices have on economies and asset prices is also of great importance not only to academics but to policy makers around the globe as well (e.g. 9.5% of Canada's GDP was associated with the oil/energy sector). According to Hamilton (2011), ten of eleven post-war U.S. recessions were preceded by oil price shocks. In addition, nine of those eleven recessions followed shocks in the housing market.

We focus our attention on two similar but distinct markets: Canada and the U.S. Although the two countries share one of the longest land borders in the world, their economic structures are quite different. Canada is generally referred to as a small open economy whereas the U.S. is generally accepted as a large and relatively closed economy. The two economies exhibit strong interdependencies through the financial sector as suggested by Ambler

(1989) and Schmitt-Grohé (1998), which creates an interesting scenario for our research. As mentioned previously, the respective economies have weathered the past decade of global market fluctuations in very different fashions. Additionally, and of great importance to this study, Canada is a net oil exporter whereas the U.S. is historically a net oil importer. According to the U.S. Energy Information Administration (EIAA), the U.S. was the largest importer of oil in 2012 at 7.39 million barrel of oil per day.[1] Historically, Canada has been a net exporter and figures in 2012 show that Canada's net exports for the year were 2.47 million barrel of oil per day.[2] Over 70% of Canadian oil extracted is exported to the U.S.

This paper contributes to the literature in several ways. First, we empirically investigate the impact of oil shocks on housing markets employing SVAR construction introduced by Kilian (2009) who disentangles demand and supply oil shocks to explore their impact on the U.S. macro economy. Secondly, we apply the methodology to two developed countries (Canada and the U.S.), to investigate how oil shocks impact oil-exporting countries differently than oil-importing countries. Existing literature (e.g. Wang et al., 2013; and Filis and Chatziantoniou, 2014) focus on equity and inflation measures, respectively, among oil exporting and oil importing countries. Finally, we test the relationship between oil and housing over an updated time frame to 2015 using data from S&P Case-Shiller index and the National Bank House Price index. The time of this study captures substantial housing and oil price fluctuations.

Our findings indicate that the nature of the oil shock (supply vs. demand) matters when determining how the housing market reacts to shifts in oil prices. Further, this finding is much more relevant to our oil-exporting country (Canada) as opposed to the oil-importing country (U.S.). Specifically, oil shocks that originate from world aggregate demand shocks account for

[1] https://www.eia.gov/tools/faqs/faq.cfm?id=709&t=6
[2] https://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/stt/crdlsmmr/2013/smmry2013-eng.html

approximately 5% (1.5%) of the variance in the Canadian (U.S.) housing sector 12 months after the shock. Oil-specific shocks account for approximately 18% (7%) of the variance in housing prices in Canada (U.S.) after 12 months. The results remain robust to inclusion of different macroeconomic channels (i.e., interest rates, unemployment, industrial production, and the U.S./CAD exchange rate) through which oil shocks may influence housing prices. We also control for dynamic feedback effects and account for the phases of the housing cycle.

The remainder of the paper is organized as follows. Section 2 outlines relevant literature related to oil and housing markets. Section 3 describes the variables, data and sources, and presents data descriptive statistics, while Section 4 introduces the methodology employed. The empirical results are presented and discussed in Section 5. Finally, in Section 6 we present our conclusion.

2. Literature Review

2.1 Oil Prices

There is extensive literature documenting the impact oil shocks have on macroeconomic variables and equity markets. The seminal work of Hamilton (1983) indicates that oil price shocks have an impact on the U.S. macro economy (i.e., unemployment, real GNP, implicit price deflator for non-farm business income, wages, import prices, and money supply). Since then, Sadorsky (1999) investigates the U.S. equity markets and finds that positive shocks to oil prices depress real stock returns. Park and Ratti (2009) find that oil price shocks account for a statistically significant 6% of the volatility in real stock returns for their sample of 13 European countries and the U.S. Further, and contrary to the other countries, they find that Norway (an oil exporting country) shows a positive response of real stock returns to oil price increases.

Kilian (2009) brought new methodological insight by disentangling supply and demand factors within oil shocks. Using this new methodological approach, Kilian and Park (2009) conclude that demand and supply shocks driving the global crude oil market jointly account for 22% of the long-run variation in U.S. real stock returns. They also find that the response of aggregate stock returns differs greatly depending on the cause of the oil price shock.

Other studies examine various industry and regional responses to oil price shocks. Nandha and Faff (2008) find that increases in oil price-have a negative impact on equity returns for all sectors except mining and oil and gas industries. Elyasiani et al. (2011) investigate the effects of changes in oil futures returns and volatility on excess stock returns and volatility of thirteen U.S. industries employing a multi-index asset pricing model with Fama-French factors and GARCH methodology. They conclude that oil price fluctuations constitute a systematic asset price risk at the industry level on nine of the thirteen industries included in their sample. Elyasiani et al. (2013) re-examine their 2011 research by applying double-threshold FIGARCH approach to their multi-index asset pricing model. Their data rejects the more restricted GARCH, IGARCH, and Fama-French models in favor of FIGARCH modeling. They explain that their FIGARCH model captures not only short-run dynamics but also long-run persistent patterns of oil shocks effects that may decay at a slower hyperbolic pace. Wang et al. (2013) find that the response of stock market returns to oil price shocks in a country greatly depend on the country's net position in the crude oil market and on the driving forces of oil price shocks. They also find that the total contribution of oil price shocks to variations in stock market returns depend on the relative importance of oil to the country's national economy. Filis and Chatziantoniou (2014) also distinguish between net oil-importing and net oil-exporting countries and their results indicate that the level of inflation and equity markets in both net oil-exporting and net oil-importing countries is significantly affected by oil price innovations. They show that in response to oil shocks, inflation increases for oil exporting and oil importing countries. Also, stock markets exhibit a negative response to oil shocks with the exception of Norway (oil exporting country).

2.2 Housing Market

The research on the housing market has gained significant interest in the past decade as new data sources such as the Case-Shiller Housing indices have become available. Further, increased attention has been given to the housing markets around the globe as a result of the real estate market turmoil that evolved during the 2007-2009 financial crisis. Schembri (2015) outlines some of the factors that may influence housing price trends. He explains that many real estate assets serve as consumption goods and as financial assets that accumulate wealth; therefore, several different factors can play a role in demand and supply for homes. Academic literature documents the relationship between the housing market and the macro economy. Case (2000) and Catte et al. (2004), among others, have investigated macroeconomic shocks (i.e., money supply, industrial production, or interest rates) on U.S. house prices. Mishkin (2007), Goodhart and Hofmann (2008), and Vargas-Silva (2008), amongst others, focus on the relationship between monetary policy and the housing markets.

2.3 Link between Oil and Real Estate Markets

Chan et al. (2011) examine the relationships between three different asset classes: financial assets (U.S. stocks and Treasury bonds), commodities (oil and gold) and real estate (U.S. housing) assets. Using a Markov switching model they find that investors shift their capital between these three different asset classes depending on the state of the economy (e.g. tranquil versus crisis). Recently, some attention has focused on the impact of energy prices on real estate markets. Antonakakis, et al. (2016) reveal that comovements between U.S. housing and oil market returns are consistently negative over time. Breitenfellner, et al. (2015) examine 18 OCED economies and suggest that increases in energy price inflation raise the probability of housing price corrections. They argue that their findings could potentially be attributed to five theoretical linkages. First, they suggest adverse direct and indirect effects of energy price increases on personal income and expenditures of households resulting in reduced demand for housing (income effect). Second, the impact increased energy prices have on construction and building costs which lead to quantity and supply adjustments on the supply side. Third, the tightening reaction of monetary policy on the pressure induced by increased energy prices have on inflation which first withdraws liquidity from the housing market and then reduces aggregate demand, including housing demand (Luciani, 2015). Fourth, as in Chan et al. (2011) the attractiveness of the energy sector in terms of investment returns compared to housing sector may alter the flow of funds into either asset category and thus influence prices. Finally, lagging impacts of common factors on both variables such as economic growth or monetary policy.

Hamilton (2009) argues that the adverse effects of oil shocks on income and unemployment depress housing demand significantly and Kilian (2008) concludes that energy price shocks make themselves felt primarily via demand for cars and new homes. Others have also provided evidence of linkages between the energy and real estate markets in different fashions. Kaufmann, et al. (2011) suggests that rising energy prices constrain consumer budgets and thereby raise mortgage delinquency rates. This increase in mortgage delinquency is associated with falling home prices, an increase in household expenditures on energy, and rising unemployment. Khiabani (2015) focuses on identifying the channels for the transmission of oil price and credit shocks to the housing sector in the Iranian market. The findings indicate that oil price shocks explain a substantial part of housing market fluctuations in Iran.

The main advantage of our SVAR approach over previous work (e.g., Chan et al., 2011; Antonakakis et al., 2016; Breitenfellner et al., 2015; Khiabani, 2015) is that the identification structure allows us to assess the impact of higher crude oil prices differentiating the demand and supply shocks, along with the relative importance of these shocks over time. In addition, previous studies treat oil as exogenous with respect to the real estate market.

3. Data and descriptive statistics

The data used in this study consists of monthly observations during the period from January 1994 to November 2015. We use the Canadian real estate data obtained via the National Bank House Price Index.[3] For the U.S. we use the National S&P/Case Shiller index as our measure for aggregate housing prices.[4] These indices are then divided by the Consumer Price Index (CPI) of each respective country to get the inflation-adjusted real values. The Canadian CPI data is extracted from Statistics Canada's (CANSIM) website http://www.statcan.gc.ca/start-debut-eng.html (last accessed on 4/30/16), while the U.S. CPI data is collected from the Federal Reserve Economic Data (FRED) database available through the Federal Reserve Bank of Saint Louis https://research.stlouisfed.org/fred2/ (last accessed on 4/30/16).

As a proxy for world oil price level, we use monthly price data of West Texas Intermediate (WTI). We choose WTI over Brent and Dubai oil prices due to the fact that this

[3] The Teranet – National Bank House Price Index™ is an independent representation of the rate of change of Canadian single-family home prices. http://www.housepriceindex.ca/default.aspx last accessed on 01/15/2016. Limited to 02/1999 to 11/2015.

[4] The S&P/Case-Shiller Home Price Indices are the leading measures of U.S. residential real estate prices, tracking changes in the value of residential real estate both nationally as well as in 20 metropolitan regions. http://ca.spindices.com/index-family/real-estate/sp-case-shiller last accessed 01/15/2016.

study focuses two countries in North America. Also alternative proxies for oil prices such as Brent and Dubai oil have shown to have extremely high correlations with WTI suggesting that the results of this study would not be altered by using alterative oil proxies. WTI price data are collected from the Federal Reserve Economic Data (FRED) database and then divided by the U.S. CPI to get the inflation-adjusted real oil prices.

We use monthly global oil production data collected from the U.S. Energy Information Administrate (EIA) website as our measure for world oil supply. Data for global real economic activity is proxied through the global index of dry cargo single voyage freight rates, created by Kilian (2009).[5] This data source has been used extensively throughout the existing research as an estimate for the scale of global economic activity created to capture across-the-board shifts in the global demand for industrial commodities including oil.[6]

To capture macroeconomic factors of each respective country we collect data on interest rates, unemployment, U.S. industrial production and the U.S./CAD exchange. For the Canadian sample, we use the Bank Rate as a proxy for monetary policy changes. We retrieved these data from Statistics Canada table 176-0043. The unemployment rate and the US/CAD foreign exchange rate is also obtained via Statistic Canada, tables 282-0087 and 176-0064 respectively. For the U.S. sample, the federal funds rate, the unemployment rate, and industrial production were retrieved from the U.S. Federal Reserve Economic Database hosted by the St. Louis Federal Reserve Bank.

[Table 1, about here]

[5] Index data from http://www-personal.umich.edu/~lkilian/ last accessed on 01/26/2016.
[6] See for example, Jung and Park (2011), Basher et al. (2012), Wang and Yang (2013), among others.

Panels A and B from Table 1 report the descriptive statistics for our Canadian and U.S. housing variables as well as on our additional model variables. Some of the series are moderately skewed and tests on the shapes of the distributions indicate that the series are leptokurtic (i.e. implying that they exhibit higher peaks, higher kurtosis, compared to a normal distribution). Results from the Jarque-Bera tests reject the null of an underlying normal distributions for all of the series. With a sample size of 263 observations for the U.S. and 201 for the Canadian sample, the implication of the central limit theorem, non-normality is not a concern for the validity of the results.[7] Panels C and D on Table 1 show the unit root tests of included variables. We include the augmented Dickey and Fuller (1979) test along with the modified augmented Dickey Fuller test proposed by Elliott et al. (1996). The results indicate that all the series included are consistent with an I(1) process (i.e. the series have a unit root in levels but are stationary when first-differenced).

[Table 2, about here]

Table 2 reports the correlation matrix for the series of interest to this study. The U.S. housing market price index (U.S.) shows a moderately weaker yet positive relationship with crude oil prices (OIL) and world supply of oil (W-S) with correlations of 0.461 and 0.532 (see Panel B), accordingly compared to correlations of 0.757 and 0.964 between OIL and W-S, respectively, with the Canadian housing price index (CAN), refer to Panel A. Of interest is the moderate and negative correlation of -0.104 between the Canadian housing price index and global real economic activity W-D which may suggest that housing markets thrive under different economic conditions compared to other asset classes. Another interesting relationship is reflected between OIL and Unemployment which reflects a positive correlation of 0.512 for

[7] See Woolridge (1994).

the U.S. sample (see Panel B) versus negative -0.215 for the Canadian sample (see Panel A). This result is intuitive given the major differences in the country's dependence on oil markets.

4. Methodology

Drawing from the framework established by Kilian (2009) and Kilian and Park (2009), we investigate how Canadian and U.S. housing price indices respond to demand and supply shocks in the global crude oil market. Their research suggests that the impact of demand and supply shocks in the crude oil market on U.S. macroeconomic aggregates are qualitatively different, depending on whether oil price increases are triggered by oil production shortfalls, a booming world economy, or shifts in precautionary demand for crude oil that reflect heightened concerns about future oil supply shortfalls. It is plausible that the effect of these shocks on housing prices may, to some extent, vary based on the role of the housing market in the macroeconomy. Researchers have found that global business expansion tends to raise the price of crude oil. Economic shocks that power macroeconomic aggregates (and conceivably housing markets) may also influence crude oil prices which makes it challenging to isolate cause and effect when examining the relationship between oil and housing prices. Building on a structural vector autoregression (SVAR) model introduced by Killian (2010) we propose an SVAR model that connects U.S. and Canadian housing price indices (under separate estimations) to measures of demand and oil supply shocks in the global crude oil market.

The structural VAR model is expressed as follows:

$$A_0 z_t = a_0 + \sum_{i=1}^{j} A_i z_{t-i} + \varepsilon_t \quad (1)$$

where z_t represents a time series vector of the following variables: 1) global oil production (W-S_t) expressed in logarithm form, 2) the Kilian (2009) index measuring global real economic activity (W-D_t,), 3) real price of crude oil (OIL_t,) introduced in logarithmic form, and 4) the logarithm of inflation adjusted housing price indices for the Canadian and U.S. markets (CAN_t and $U.S._t$, respectively). The variables in the z_t vector enter the model in first difference. A_0, a_0, and A_i are vectors of intercept terms and coefficients while ε_t represents a vector of serially and mutually uncorrelated structural innovations. We allow e_t to represent our reduced-form VAR innovations so that $e_t = A_o^{-1}\varepsilon_t$. By imposing exclusion restrictions consistent with those introduced by Kilian and Park (2009) on the A_o^{-1} matrix of coefficients, we are able to derive structural innovations from reduced-form innovations. The lag length *j* in equation (1) is chosen to be two as determined by the Schwarz Bayesian information criterion (BIC).[8]

Our model imposes a block-recursive structure on the contemporaneous relationship between reduced-form and underlying structural disturbances. The initial block establishes a model for the global crude oil market while the second block consists of the macroeconomic channel and our housing price indices. In the initial block ε_{1t} symbolizes shocks to the global supply of crude oil ("oil supply shock"), ε_{2t} expresses shocks to the global demand for all industrial commodities (including oil) that are powered by global real economic activity ("aggregate demand shock"), and ε_{3t} represents an oil-market specific demand shock. This third shock is intended to capture shifts in precautionary demand for crude oil in reaction to increase uncertainty regarding future oil supply shortages ("oil-specific demand shock"). For our fourth shock, ε_{4t}, we will use different macroeconomic variables potentially affected by oil and that at the same time can influence housing prices. Finally, in the housing price indices block, we have

[8] Using alternative lag lengths (4 or 6) does not significantly alter our findings.

only one structural innovation for each index ε_{5t}. In this second block, we refer to the shocks as innovations to housing price indices not driven by global crude oil demand or supply shocks. We do not attempt to unravel further structural shocks driving housing prices since our work focuses on the impact of structural shocks in the crude oil market on two housing markets.

Our model imposes identifying assumptions resulting in a recursively identified structural model of the following form:

$$e_t = \begin{pmatrix} e_{1,t}^{\Delta global\ oil\ production} \\ e_{2,t}^{global\ real\ activity} \\ e_{3,t}^{real\ oil\ price} \\ e_{4,t}^{macroeconomic\ chann} \\ e_{5,t}^{\Delta real\ housi\quad price} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{pmatrix} \varepsilon_{1,t}^{oil\ supply\ shock} \\ \varepsilon_{2,t}^{aggregate\ demand\ shock} \\ \varepsilon_{3,t}^{oil-specif\quad demand\ shock} \\ \varepsilon_{4.t}^{macroeconomic\ chann\quad shock} \\ \varepsilon_{5.t}^{other\ housing-specific\ shock} \end{pmatrix} \tag{2}$$

The three exclusion restrictions in the initial block of equation (2) are consistent with a vertical short-run global supply curve of crude oil and a downward sloping demand curve as suggested by Kilian (2009). Shifts of the demand curve driven by either of the two demand shocks yield a contemporaneous change in the real price of oil as do unanticipated oil supply shocks that would shift the vertical supply curve. These restrictions were motivated by Kilian (2009) and Kilian (2010) as follows: 1) crude oil supply will not respond to oil demand shocks within the month due to the costs of adjusting oil production and the uncertainty regarding the state of the crude oil market, 2) increases in the real price of oil powered by oil-market specific shocks will not reduce concurrent global real economic activity given the sluggish nature of global real activity, and 3) shocks to the real price of oil that are not explained by oil supply or aggregate demand shocks to industrial commodities must be oil market specific demand shocks. Moreover, in the second block we have that, 4) other-housing specific shocks do not affect the macroeconomic channel within the same month. Finally, 5) shocks to the macroeconomic channel may affect housing prices within the same month.

For the macroeconomic channel, we will use the Federal Funds Fate (U.S.), the Bank Rate (Canada), unemployment, U.S. industrial production, and the U.S./CAN exchange rate. The idea is that the transmission of oil shocks to the housing market might work through these channels. Modeling the channel is important for the interpretation of the oil shocks as structural shocks as potential macroeconomic factors that affect housing prices can be contemporaneously correlated with oil shocks. Note than rather than including various channel in the same estimation, we pursue a parsimonious model and provide various robustness checks with different channels including them one by one.

The block-recursive structure of our model implies that global crude oil production, global real economic activity, and the real price of oil are treated as predetermined with respect to the macroeconomic channel and our housing prices indices. Therefore, while the housing price indices are allowed to respond to oil demand and supply shocks on impact, our assumption is that ε_{5t} does not impact global crude oil production, global real economic activity, the real price of oil, and the macroeconomic channel within a given month, but only with a delay of at least one month. It is plausible to accept that oil producers would not be immediately influenced by fluctuations in housing prices given the existence of a monopoly in the oil market (OPEC) in which oil supply is mostly exogenously managed by several large producers. The sluggish nature of global real economic activity would support our conjecture that changes in housing prices in Canada or the U.S. would not produce an immediate impact on global economic activity. While housing price changes could conceivably yield wealth effects that conceivably impact consumption, housing construction (labor and material inputs) and home sales would seem to be the elements that would generate more palpable economic activity. Since "precautionary demand" arises from the uncertainty about future shortfalls of expected oil supply relative to expected oil demand it is conceivable that oil prices do not immediately respond to housing price innovations. Finally, shocks classified as 'other housing-specific shocks' may be caused by many factors related to housing which cannot be explained by the macroeconomic channel or the previous three oil related shocks. Depending on the macroeconomic channel, these may include credit conditions, demographic changes, and regulatory changes in each respective country.

5. Results

5.1. Responses of Canadian housing market to world oil price shocks

Figure 2 reports the response of Canadian housing prices to oil supply shocks, aggregate demand shocks, and other oil-specific demand shocks. The reduced form VAR specification was estimated with two lags, as obtained by the Bayesian Information Criteria. Moreover, this initial benchmark model does not include any macroeconomic channel. These impulse response functions (IRFs) show that oil supply shock and aggregate demand shocks do not have any statistically significant effect on the path of prices. However, other oil-specific demand shocks have a positive and statistically significant effect on prices starting on the second month up until about month eight. This shock appears to elicit a peak housing price increase of approximately two percent by the third month and then gradually fades away. The direct effect of the other oil-specific demand shock on housing prices initially appears at odds with Kilian and Park (2009) who document negative impact of the shock on equity markets. However, with Canada being an oil exporting economy, our response aligns with their interpretation that industry-level stock return response patterns are consistent with the view that oil shocks are predominantly shocks to the demand for industries' products as opposed to industry production cost shocks. These authors suggest that oil shocks are viewed as adverse aggregate demand shocks for an oil importing economy such as the U.S.[9]

[Figure 2, about here]

One limitation from the IRF in Figure 2 is that there can be macroeconomic factors that affect housing prices and that are correlated with the oil shocks. Then we might mistakenly assign the effect on prices on a particular oil shock when in fact it is coming from an omitted variable. Following the structure in Equation (2), we report in Figure 3 three specifications of macroeconomic channels. We have the Bank Rate, the unemployment rate and the exchange rate. The results across all three specifications are quantitatively the same as the ones reported in Figure 2; oil supply and aggregate demand shocks have no effect on prices.[10] In addition, oil-specific demand shocks have a positive effect on prices between the second and about the 6th or 7th month after the shock.

[Figure 3, about here]

Kilian (2009) suggests that positive shocks in economic activity boost oil demand and ultimately generate oil price shocks. Carr and Beese (2008) claim that the rising price of oil between 2004 and 2007 (period of U.S. economic expansion) led the Federal Reserve to raise interest rates which increased payments for those with adjustable mortgages and spurred an increase in foreclosures placing downward pressure on housing prices. Hamilton (1983) employs VAR methodology and determine that increases in real oil prices "Granger-cause" a series of

[9] Elyasiani et al. (2011) and Elyasiani et al. (2013) who examine the impact of oil returns and volatility on industry sector stocks returns in the U.S. applying GARCH and FIGARCH methods to multi-index asset pricing models, find that the level of oil-futures return exerts a greater positive impact on oil-related (Oil and Gas Extraction and Petroleum Refinery) industries.
[10] We additionally used building permits as a macroeconomic channel and found quantitatively similar results.

variables related to the business cycle (including unemployment and output) in the U.S. In the case of oil exporting countries, Jung and Park (2011) suggest that in the short run to medium run, oil-specific demand shocks may exert positive effects (increase in wealth due to increase in oil price) although the effect may dampen quickly as the shock reduces global economic activity. They also claim that aggregate demand shocks further increases aggregate wealth, consumption, and investment for oil-exporting economies which implies lower unemployment. It is conceivable that higher unemployment reduces the pool of qualified home buyers which in turn places downward pressure on housing demand and prices. The impact of the oil shock on Industrial Production depends on the underlying nature of the industry i.e. oil-substitute, oil-related, and oil-user (refer to Kilian and Park, 2009; Elyasiani et al., 2011; and Elyasiani et al., 2013). These authors find that the level oil-futures return do not statistically impact oil user industries returns (includes building construction) while oil return volatility risk does. The implication is that the oil user sector benefits from increased oil price volatility once the oil price level is accounted for. Khiabani (2015) posits that oil windfalls to oil-exporting countries commonly leads to the accumulation of foreign reserves. A non-sterilization of these reserves potentially expands the country's monetary base which may prompt an increase in the price of non-tradable goods (including housing) and an appreciation of real exchange rates.[11]

5.2. Dynamic feedback and the housing cycle

Note that the nature of the reduce form VAR of Equation (1) means that all variables are treated symmetrically. When moving to the structural VAR we impose identification restrictions

[11] For modelling purposes we include industrial production as a macroeconomic channel in the U.S. sample since U.S. is considered an oil-importing country. We use U.S./CAN exchange rate as a macroeconomic channel in the Canadian model since Canada is a net oil-exporting country, a small open economy, and oil prices are in U.S. dollars. Our application of these two channels is consistent with the literature (see Hamilton, 1983; Kilian and Park, 2009; and Khiabani, 2015).

that eliminates a potential contemporaneous effect from housing prices to oil markets. However, the estimation still allows for a dynamic feedback from lagged housing prices to the oil markets. While this flexibility might be important for the U.S housing market, we might not need it for the Canadian real estate as this one is smaller and less likely to affect the oil markets. The trade-off we face is having a more flexible model at the expense of having to estimate more coefficients. To assess whether restricting the dynamic feedback changes our results, Figure 4 presents the IRFs of the unrestricted dynamic feedback model (same as in Figure 2) and the restricted dynamic feedback model.[12] The IRFs show that the shocks of the restricted model follow nearly the same path as the shocks of the unrestricted model.

[Figure 4, about here]

A major feature in real estate markets and in price dynamics is the existence of cycles and price bubbles (see, e.g., Damianov and Escobari, 2016). A potential question that arises when studying the role of oil markets on real estate price dynamics is whether the phase of the housing cycle plays a role. In particular, we are interested in assessing whether the response to oil shocks depend on the phase of the housing cycle. One challenge we face is the identification of the housing cycle, as there is no unique approach to empirically identify and label the phases. We follow the methods in Harding and Pagan (2002) to obtain the dates of local maxima and local minima in the pricing series to then identify the periods from troughs to peaks (recovery and expansion) and from peaks to troughs (hypersupply and recession).

[Figure 5, about here]

[12] The restricted model is obtained by setting all the lags of the real housing prices in the first three equations (i.e., global oil production, global real activity, and real oil price) to be equal to zero. Simple Granger causality tests on the unrestricted model fail to reject the null hypothesis of no Granger causality in all three cases. That is, real housing prices do not Granger cause any of the three components that characterize the oil market.

After identifying the troughs to peaks and the peaks to troughs periods, we create dummies for each and interact them one at the time with the Canadian pricing index. The resulting series allow us to estimate two additional structural VAR specifications that will capture the potentially differentiated effects during troughs to peaks versus peaks to troughs. Figure 5 presents the estimated IRFs. The shocks from oil supply still have no statistically significant effect on housing prices. However, unlike the previous estimates, shocks from the aggregate demand have a statistically significant positive effect on prices during peaks to troughs; however, the effect is economically negligible. For the oil-specific demand shocks the previous results hold, but the positive effect on prices is about twice as large during recoveries and expansions. The estimates presented in Figure 5 can also be interpreted as asymmetric pricing, in which the asymmetry is a function of the phase of the housing cycle.[13]

[Table 3, about here]

Table 3 presents the forecast-error variance decompositions for our housing price time series variable using unemployment as the macroeconomic channel. We can observe that oil supply and aggregate demand shocks have little to no influence on aggregate housing prices in Canada. However, when focusing on other oil-specific shocks, we find that 'precautionary demand' explains about 10% of the variation in Canadian housing prices at 3 months and about 18% of the variation in the long run.

5.3. Responses of U.S. housing market to world oil price shocks

Figure 6 shows the response of U.S. housing market prices to shocks in oil supply, aggregate demand, and other oil-specific demand factors. In this first specification we do not

[13] Peltzman (2000) shows that asymmetric pricing (or asymmetric price adjustments), a phenomenon where prices respond more quickly to cost increases than to cost decreases, exists in a large number of markets.

include the macroeconomic channel yet. Of the three impulse response functions reported in Figure 6, oil-specific demand shocks appear to exhibit the most influence on the path of prices. Neither unanticipated disruptions of crude oil production nor an unexpected increase in the global demand for industrial commodities, driven by a rise in global economic activity, have a statistically significant effect on the short term path of housing prices. Other oil-specific shocks (also referred to as "precautionary demand" shocks) exert short-term positive and statistically significant effect on U.S. housing prices that lasts about eight months. The effects are however weaker when compared to the Canadian results. This may lend support to the findings of Wing (2008) who suggests the declining susceptibility to oil price shocks is associated with the declining energy intensity of the U.S. economy.

[Figure 6, about here]

Following the same sequence of robustness checks as in the Canadian market, Figure 7 presents three additional specifications of Equation (2) using different macroeconomic channels. The estimates show that even after controlling for the Federal Funds rate, unemployment, and industrial production, the main results hold. Oil supply and aggregate demand shocks have no statistically significant effect, while oil-specific demand shocks have nearly the same effect in terms of magnitude and persistence as found before. The same is true when restricting the dynamic feedback, as can be observed from the IRFs reported in Figure 8.

[Figure 7, about here]

[Figure 8, about here]

Figure 9 separates the U.S. housing pricing dynamics into dynamics during recovery and expansion and dynamics during hypersupply and recession. While the results for oil supply found earlier hold, for aggregate demand we find a significant different result. Aggregate demand shocks have a positive effect during hypersupply and recessions, while they have a negative effect during recoveries and expansions. A plausible explanation is that during economic expansions, monetary policy may react by imposing interest rate increase which places downward pressure on asset values including housing. Opposite effects would materialize during economic contraction. Note that the previous non-significant effect in previous figures make sense as is the aggregation of both positive and negative effects that cancel each other out. For oil-specific demand shocks we observe a positive effect only during recoveries and expansions.

[Figure 9, about here]

[Table 4, about here]

Table 4 details the forecast-error variance decompositions for our housing price time series variable using unemployment as the macroeconomic channel. The results are consistent with what we find in our impulse response functions in that most of the forecast error variance is explained by oil-specific demand shocks. Similar to the Canadian results, oil supply and aggregate demand shocks have modest effects. Oil-specific shocks account for only 3% of the variation in U.S. housing prices at 3 months and about 7% of the variation after 12 months.

6. Conclusion

The volatility in energy markets over the recent decades encourage a reassessment of the impact of oil price shocks on the various components of macro-economy (including housing). The U.S. real estate boom during the early to mid-2000's created unjustified levels of financial leverage and risk taken on by many investors and their funding sources that lead to inflated housing prices around the globe. Unlike the U.S. housing market which collapsed in 2007, the

Canadian housing market seems unaffected by the 2007-2009 financial crisis as it remains on the rise.

We employ SVAR methodology to relate U.S. and Canadian housing price indices (under separate estimations) to measures of demand and oil supply shocks in the global crude oil market. We expand our benchmark model to control for macro-economic channels, dynamic feedback effects, and the housing cycle. This research yields empirical evidence that suggests the following results. First, evidence from the SVAR model in the U.S. and Canadian samples suggest that oil supply shocks along with aggregate demand shocks have little impact on housing prices in both markets. Second, other oil-specific shocks (precautionary demand), on the other hand, exhibit a more pronounced impact on housing prices in Canada compared to the U.S. housing market suggesting that the country's oil trading status (net importer or net exporter) matters. The importance of other oil-specific shocks in our results suggests that a rise in uncertainty regarding future oil supply shortfalls, which induces increase oil price volatility, is captured through rising housing prices. Elyasiani et al. (2011) explain that in the case of the building industry, it is plausible that when oil prices become more volatile, demand for new homes strengthens because newer buildings are more energy efficient. Third, we determine that our results capture asymmetric pricing when we account the phase of the housing cycle. Oil-specific demand shocks have a positive effect on prices that is about twice as large during recovering and expansions than during episodes of hypersupply and recessions.

The findings in our paper have important implications for academics, investor, and policy makers since the volatility in the energy and housing markets seem to impact each other. Based on the expanding popularity of real estate investment opportunities (e.g. REITs, ETFs), investment managers should be aware of the root causes of oil shocks (i.e. supply vs. demand driven) and how these shocks may influence their investment decisions while acknowledging the country's oil trading status where the investments are being made.

Central banks must focus on the underlying determinants of the price of oil when formulating monetary policy in response to energy market shocks. Specifically, precautionary demand shocks should be closely monitored during energy market cycles and economic policy makers from oil-exporting country may consider tightening monetary policy if precautionary demand is the underlying cause of the energy cycle. From a fiscal policy perspective, governments from oil-exporting countries may consider using a portion of the tax revenue generated from the energy industry to fund a housing stability reserve to be used in times of energy market volatility. The reserve fund could potentially be used during negative energy cycles by providing funds to homeowners via energy tax credits or down payment assistance programs to stabilize housing markets in specific oil-exporting regions.

It will be important to monitor the changing energy market landscape in the U.S. and abroad to investigate how the development in shale oil markets and alternative energy markets will impact the effect crude oil markets have on real estate and other financial markets. The Canadian housing upward price trends over the last two decades attracts attention especially when we look back to the housing boom and subsequent bust experienced in the U.S. housing market. Given it role in the economy, housing markets are of key concern to monetary policy makers. Expectations of future tightening of monetary policy, for example, could lower the expected real rate of housing price appreciation and raise current users cost of capital which would exert a decline in housing demand and residential construction.

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Table 1 – Descriptive Statistics Model Variables – Inflation adjusted (Real) Values

Panel A: Canadian Sample

	N	Mean	Std. Dev.	Skewness	Kurtosis	J-B (P-Value)
HP-C	201	103.03	20.83	-0.080	1.624	0.00
OIL	201	54.03	23.03	0.233	2.074	0.00
W-S	201	83873	5392.62	-0.139	1.891	0.00
W-D	201	6.452	29.51	0.006	2.076	0.01
BR	201	2.70	1.63	0.393	1.909	0.00
UE-C	201	7.14	0.81	0.147	2.606	0.00
FX	201	1.22	0.20	0.469	1.783	0.00

Panel B: U.S. Sample

	N	Mean	Std. Dev.	Skewness	Kurtosis	J-B (P-Value)
HP-US	263	120.83	20.57	0.586	2.425	0.00
OIL	263	44.92	22.95	0.522	2.122	0.00
W-S	263	81212	6985.17	-0.085	1.891	0.00
W-D	263	2.561	27.66	0.244	2.342	0.04
FF	263	2.80	2.34	0.077	1.316	0.00
UE-US	263	5.98	1.64	1.016	2.968	0.00
FX	263	1.26	0.19	-0.001	1.652	0.00

Panel C: Canadian Sample (Unit Root Tests)

Series	Trend	ADF(k)	DF-GLS (k)	Determination
HP-C	Yes	-1.918(4)	-1.910(4)	I(1)
W-S	Yes	-2.783(3)	-2.769(3)	I(1)
W-D	No	-2.423(3)	-1.895(3)	I(1)
OIL	No	-2.381(3)	-1.389(3)	I(1)
BR	No	-1.756(4)	-2.832(4)	I(1)
UE-C	No	-4.670(1)**	-3.646(1)**	I(1)
FX	No	-1.397 (2)	-1.001(2)	I(1)
ΔHP-C	No	-6.519(3)***	-4.099(3)***	I(0)
ΔW-S	No	-9.431(2)***	-7.481(3)***	I(0)
ΔW-D	No	-8.363(2)***	-6.974(3)***	I(0)
ΔOIL	No	-7.208(2)***	-4.468(3)***	I(0)
ΔBR	No	-4.598(3)***	-3.769(3)***	I(0)
ΔUE-C	No	-15.961(0)***	-15.927(0)***	I(0)
ΔFX	No	-8.600(1)***	-7.319(1)***	I(0)

Panel D: U.S. Sample (Unit Root Tests)

Series	Trend	ADF(k)	DF-GLS (k)	Determination
HP-US	Yes	-1.039(3)	-0.975(3)	I(1)
W-S	Yes	-3.446(2)**	-2.818(3)*	I(1)
W-D	No	-2.398(3)	-2.325(3)	I(1)
OIL	No	-2.011(2)	-2.424(2)	I(1)
FF	No	-1.588(4)	-2.111(4)	I(1)
UE-US	No	-1.559(4)	-1.512(4)	I(1)
IP	No	-0.809(4)	-1.140 (4)	I(1)
ΔHP-US	No	-5.964(2)***	-5.718(2)***	I(0)
ΔW-S	No	-10.632(2)***	-8.877(2)***	I(0)
ΔW-D	No	-9.351(2)***	-8.006(2)***	I(0)
ΔOIL	No	-9.285(1)***	-9.000(1)***	I(0)
ΔFF	No	-4.923(3)***	-4.016(3)***	I(0)
ΔUE-US	No	-4.973(3)***	-4.995(3)***	I(0)
ΔIP	No	-4.327(4)***	-4.136(4)***	I(0)

Notes: HP-C represents an aggregate housing price index for Canada known as the Teranet National Bank House Price Index. OIL denotes the price (dollars per barrel) of West Texas Intermediate (WTI) oil. W-S consists of world oil supply measured by global oil production expressed in millions of barrels pumped per day and averaged by month collected from the U.S. Energy Information Administrate (EIA) website. W-D represents global real economic activity (aggregate demand) and is obtained through the global index of dry cargo single voyage freight rates created by Kilian (2009). Kilian's index is constructed from an equally-weighted index of percentage change growth rates of a panel of single voyage freight rates measured in dollars per metric ton. BR denotes the bank overnight-discount rate set by the Bank of Canada. UE-C represents unemployment rate in Canada. FX represents the USD/CAD exchange rate. HP-US is an aggregate housing price index for U.S. known as the S&P/Case Shiller Index. FF represents the federal funds rate set by the U.S. Federal Reserve. UE-US is the unemployment rate in the U.S. All variables are on a monthly frequency; U.S. sample covers from 1994M1 to 2015M11 and CAN sample from 1999M2 to 2015M11. Canadian and U.S. CPI indices were used to convert housing indices and oil nominal prices to real values.
Δ denotes first-difference of each respective variable. ADF (k) refers to the 3Augmented Dickey-Fuller t-tests for unit roots and DF-GLS (K) refers to the modified ADF test proposed by Elliott, et al. (1996). Both have a null hypothesis that propose the series have a unit root and (k) refers to the lag length and is selected by the Schwarz Bayesian information criterion (BIC). *, **, *** denotes significance at the 10%, 5% and 1% level respectively.

Table 2 – Correlation Matrices Model Variables

Panel A: Canadian Sample

	HP-C	OIL	W-S	W-D	BR	UE-C	FX
HP-C	1.000						
OIL	0.757	1.000					
W-S	0.964	0.712	1.000				
W-D	-0.104	0.247	-0.138	1.000			
BR	-0.725	-0.427	-0.686	0.238	1.000		
UE-C	-0.103	-0.215	-0.139	-0.263	-0.396	1.000	
FX	-0.834	-0.901-	-0.787	-0.266	0.528	0.147	1.000

Panel B: U.S. Sample

	HP-US	OIL	W-S	W-D	FF	UE-US	IP
HP-US	1.000						
OIL	0.461	1.000					
W-S	0.532	0.781	1.000				
W-D	0.582	0.350	0.040	1.000			
FF	-0.223	-0.561	-0.710	0.073	1.000		
UE-US	-0.096	0.512	0.441	0.025	-0.748	1.000	
IP	-0.427	-0.642	-0.654	0.038	0.772	-0.849	1.000

Note: All variables are in levels. Refer to Table 1 for a detailed description of the variables and their source. The correlations are computed for the entire sample period: Canadian Sample from 1999M2 to 2015M11 and U.S. Sample from 1994M1 to 2015M11

Table 3 – Canadian Forecast-error Variance Decomposition

Months	Impulse Variable			
	Oil Supply Shock	Aggregate Demand Shock	Other Oil-Specific Shock	Real Estate Specific Shock
1	0.013	0.000	0.029	0.954
2	0.010	0.011	0.033	0.910
3	0.010	0.029	0.097	0.809
6	0.009	0.050	0.175	0.720
12	0.009	0.052	0.184	0.710
∞	0.009	0.052	0.184	0.710

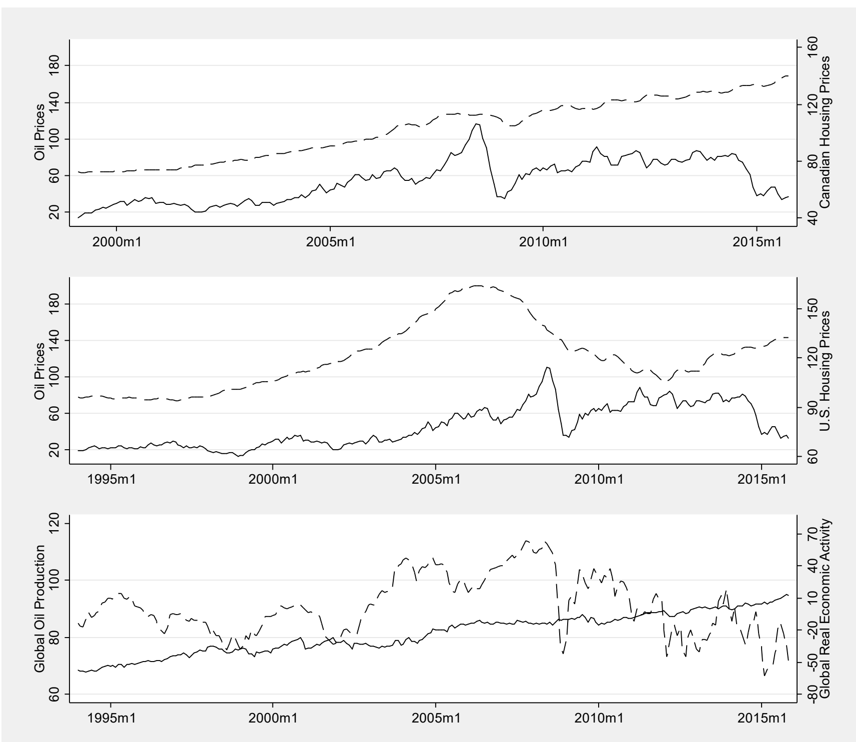
The response variable is the real value National Bank House Price Index as a proxy for aggregate housing prices in the Canada. Oil supply shock refers to the oil supply measured by global oil production data collected from the U.S. Energy Information Administrate (EIA). Aggregate demand shock is tied to the global real economic activity variable and is obtained through the global index of dry cargo single voyage freight rates, created by Kilian (2009). Other oil-specific shock is associated with the real price of West Texas Intermediate (WTI) oil. Real estate specific shock is a shock in the National Bank House Price Index.

Table 4 – U.S. Forecast-error Variance Decomposition

Months	Impulse Variable			
	Oil Supply Shock	Aggregate Demand Shock	Other Oil-Specific Shock	Real Estate Specific Shock
1	0.000	0.014	0.043	0.941
2	0.000	0.013	0.030	0.954
3	0.003	0.012	0.027	0.952
6	0.009	0.014	0.060	0.903
12	0.010	0.015	0.071	0.886
∞	0.010	0.015	0.071	0.885

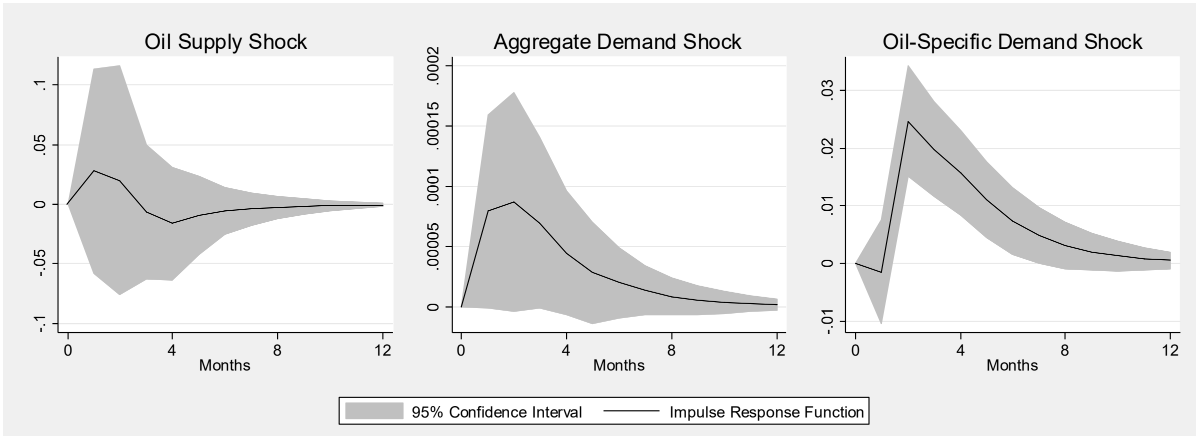
The response variable is the real value of the National S&P/Case Shiller index as a proxy for aggregate housing prices in the U.S. Oil supply shock refers to the oil supply measured by global oil production data collected from the U.S. Energy Information Administrate (EIA). Aggregate demand shock is tied to the global real economic activity variable obtained through the global index of dry cargo single voyage freight rates, created by Kilian (2009). Other oil-specific shock is associated with the real price of West Texas Intermediate (WTI) oil. Real estate specific shock is a shock in the National S&P/Case Shiller index.

Figure 1 – Canada and U.S. Housing Prices with oil related variables



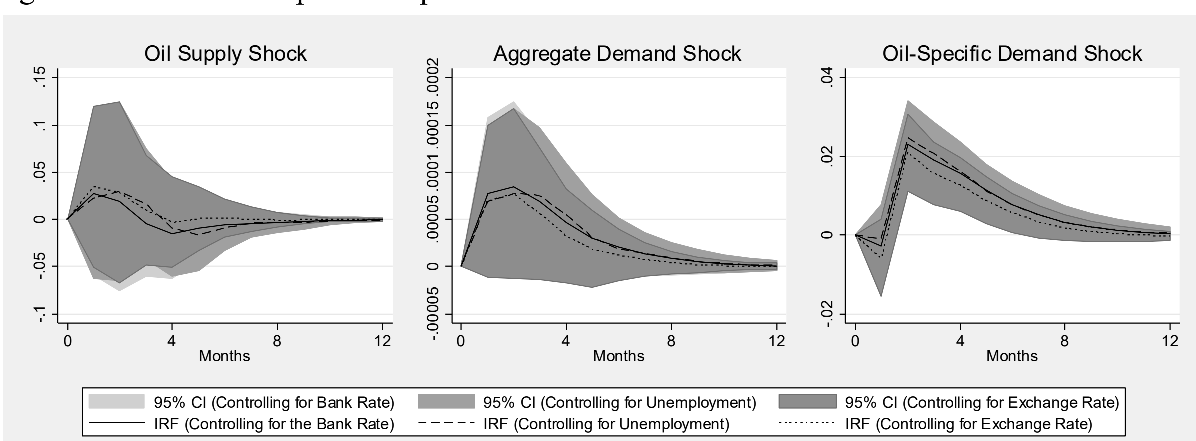
Notes: The Canadian Housing Prices is the Teranet National Bank House Price Index. U.S. Housing Prices captured by the S&P/Case Shiller Index. Oil Prices are the West Texas Intermediate (WTI) in U.S. dollars per barrel. Global Oil Production is the world oil supply expressed in billions of barrels pumped per day and averaged by month collected from the U.S. Energy Information Administrate (EIA) website. Global Real Economic Activity is obtained through the global index of dry cargo single voyage freight rates created by Kilian (2009). Kilian's index is constructed from an equally-weighted index of percentage change growth rates of a panel of single voyage freight rates measured in dollars per metric ton. All variables are on a monthly frequency; U.S. sample covers from 1994M1 to 2015M11 and Canada sample from 1999M2 to 2015M11. Canadian and U.S. CPI indices were used to convert housing indices and oil nominal prices to real values.

Figure 2 – Canadian Impulse Response Functions



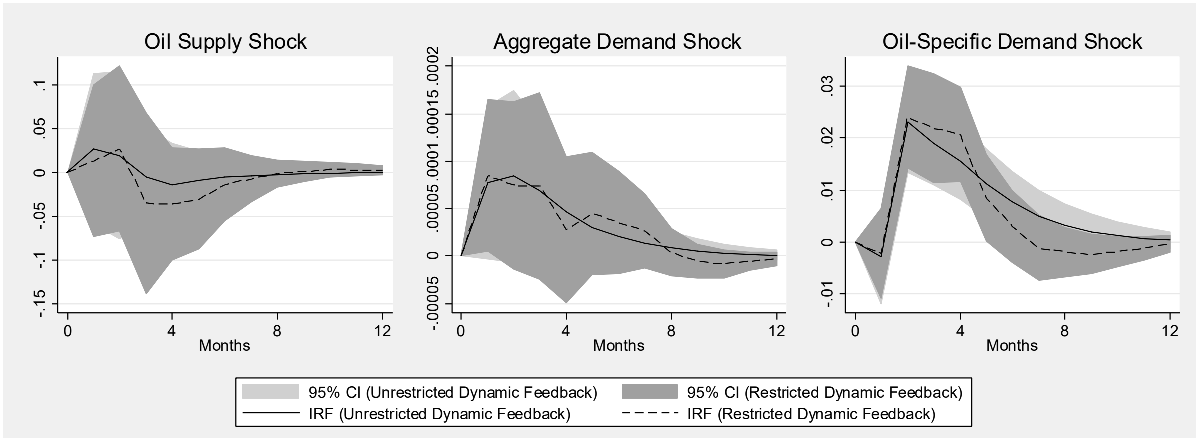
Notes: The response variable is the real value National Bank House Price Index as a proxy for aggregate housing prices in the Canada. Oil supply shock is the oil supply measured by global oil production data collected from the U.S. Energy Information Administrate (EIA). Aggregate demand shock is tied to global real economic activity and is obtained through the global index of dry cargo single voyage freight rates, created by Kilian (2009). Other oil-specific shock is tied to the real price of West Texas Intermediate (WTI) oil. Real estate specific shock is a shock in the National Bank House Price Index.

Figure 3 – Canadian Impulse Response Functions with Different Controls



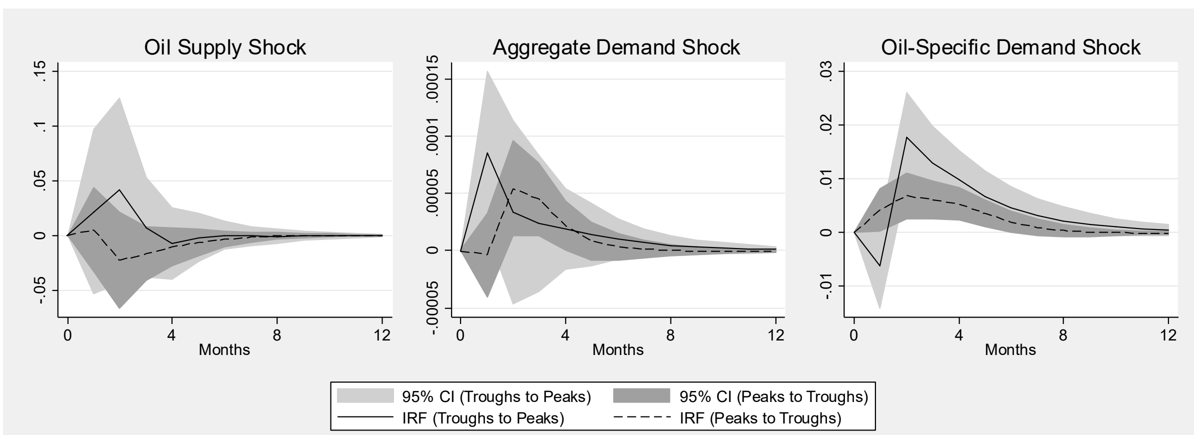
Notes: See Figure 2.

Figure 4 – Canadian Impulse Response Functions with Restricted Dynamic Feedback



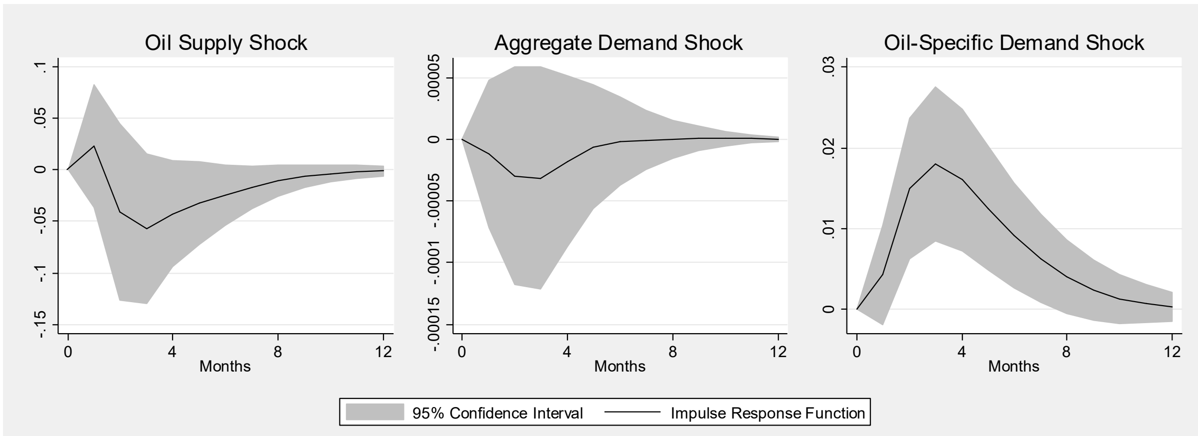
Notes: See Figure 2.

Figure 5 – Canadian Impulse Response Functions and Phases of the Housing Cycle



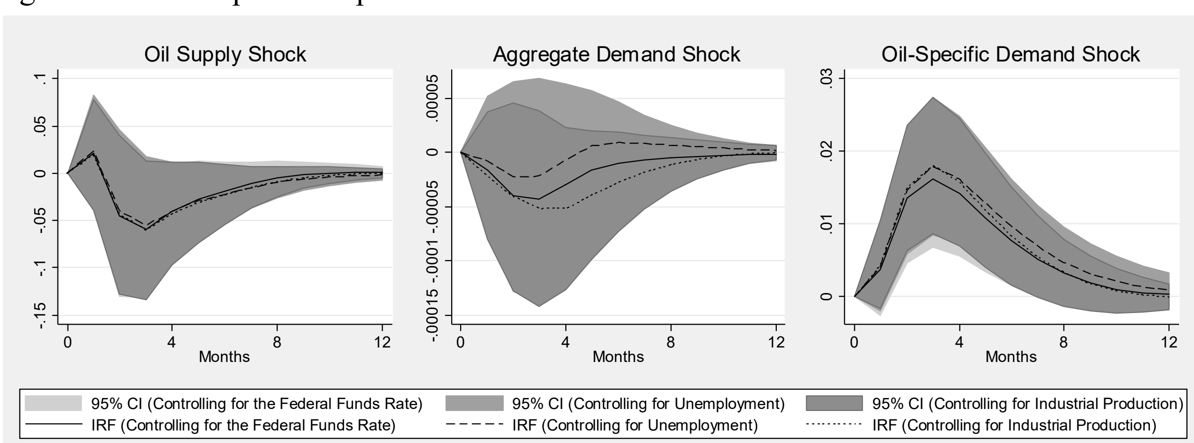
Notes: See Figure 2.

Figure 6 – U.S. Impulse Response Functions



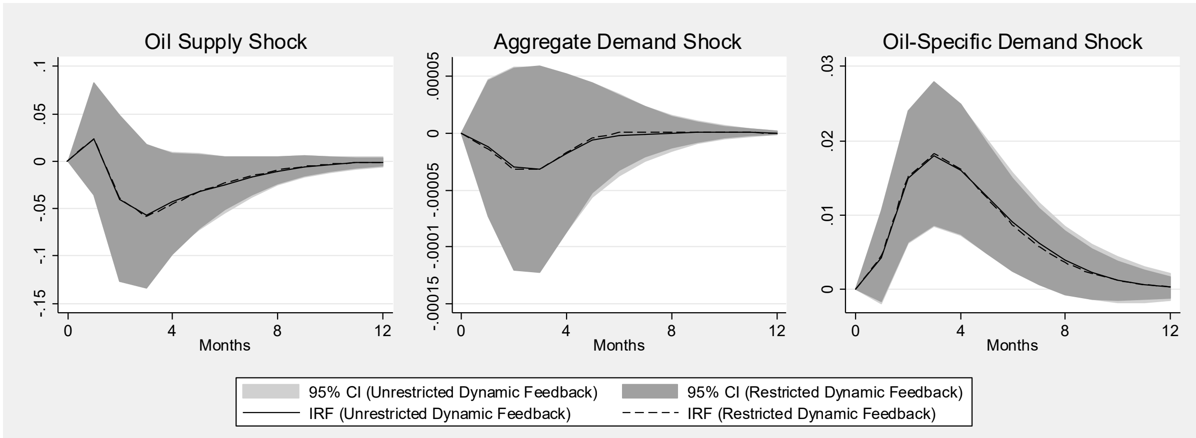
Notes: The response variable is the real value of the National S&P/Case Shiller index as a proxy for aggregate housing prices in the U.S. Oil supply shock is the oil supply measured by global oil production data collected from the U.S. Energy Information Administrate (EIA). Aggregate demand shock is tied to global real economic activity and is obtained through the global index of dry cargo single voyage freight rates, created by Kilian (2009). Other oil-specific shock is tied to the real price of West Texas Intermediate (WTI) oil. Real estate specific shock is a shock in the National S&P/Case Shiller index.

Figure 7 – U.S. Impulse Response Functions with Different Controls



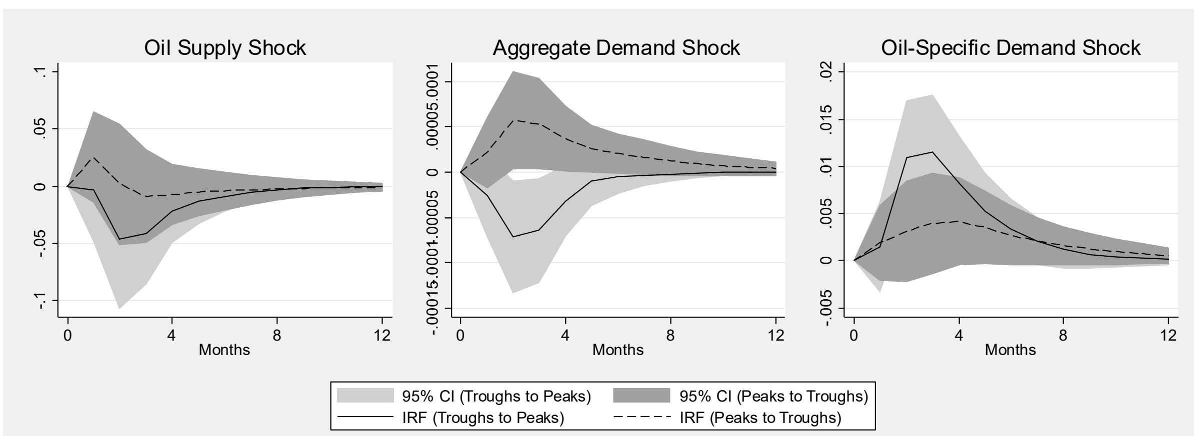
Notes: See Figure 6.

Figure 8 – U.S. Impulse Response Functions with Restricted Dynamic Feedback



Notes: See Figure 6.

Figure 9 – U.S. Impulse Response Functions and Phases of the Housing Cycle



Notes: See Figure 6.