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Cross-Border Transmission: Analyzing Oil Shocks Pass-Through in U.S. and Canada

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ABSTRACT

This paper investigates the degree of oil prices pass-through to import, producer, and consumer prices in Canada and the United States from 1980 to 2017 using a Structural Vector Auto-Regression (SVAR) model. The results indicate a positive long-run correlation between oil prices and aggregate price levels. The impulse response function reveals a persistent and incomplete pass-through for oil prices, i.e., 0.04 for Canada and 0.25 for the U.S. Greater pass-through exists in an economy with more oil import share. Consistent with the impulse response function, variance decomposition reveals that oil price shocks in the United States are the primary cause of the variation in import and producer prices. However, in Canada, oil price shocks explain the variation in producer and consumer prices.

Keywords: Oil Shocks, Pass-Through, Import Price Index, Producer Price Index, Consumer Price Index, Structural Vector Autoregression
JEL Classifications: C32, E31, Q41, Q43

1. INTRODUCTION

Oil is considered the primary strategic product worldwide and the second-largest contributor to global, immediate energy consumption. Most countries worldwide are dependent on foreign oil and pay trillions of dollars annually to acquire it. During crisis times, the world often sees an oil shock, which causes oil prices to surge. Sometimes oil producers deliberately create the shock, as with the oil embargo of 1973, and sometimes the culprit is soaring demand. This crude oil demand-supply dynamics usually influence the general price level as oil is a crucial input in almost all industries. History presents numerous instances of crude oil price fluctuations, where both oil rich and oil deficit countries suffered the consequences of increasing prices.

Oil price shocks can significantly impact prices in an open economy like Canada and the United States. This is particularly important in the current context, with the depreciation of the Canadian dollar vis-à-vis the U.S. Dollar, and the recent fluctuations in the oil prices, due to various global incidents and confrontations.

This study investigates the impact of oil price fluctuation on three different types of prices - oil shocks pass through - in the U.S. and Canada: Import, Producer, and Consumer prices. The paper applies a Structural Vector Auto-Regression model (SVAR). The methodology was first proposed by Sims (1980) to determine the proportion of the price level variance that can be explained by the changes in oil prices in Canada and the United States.

The rest of the paper will be divided as follows. Section two presents a literature review, Data, their properties, and preliminary tests are presented in section three, the empirical model is presented in section four, results and discussion are provided in section five, and section six concludes.

2. LITERATURE REVIEW

The oil price is one of the most familiar economic indicators that measure, impact and predict economic activities worldwide. The cause and effect of oil price fluctuations and volatility have been a considerable concern for most economists and policymakers.

Bauch (2011) highlights the importance of examining "Oil Shocks," an instance in which crude prices rise significantly, particularly in the short run.

Few of the previous studies examining oil price shocks comprise Rasche and Tatom (1977), Mork and Hall (1980), and Hamilton (1983). As noted in surveys conducted by Balke et al. (2002), Jones et al. (2004), and Kilian (2008), the literature finds implications such as higher oil prices, slower GDP growth, a potential recession, and a higher unemployment rate, as well as higher the price levels.

Contributions include Huntington (2003), Stock and Watson (2003), Congressional Budget Office (2006), Blanchard and Gali (2008), Edelstein and Kilian (2007), Segal (2007), and Herrera and Pesavento (2009). They primarily deal with the oil price shocks, such as exogenous. Conversely, developing literature examines the consequences of treating oil price shocks as endogenous with the sources that might include demand and supply, among them Barsky and Kilian (2002; 2004), Bodenstein et al. (2007), Nakov and Pescatori (2007; 2010) and Kilian (2007; 2008; 2009). Various oil price shocks could explain the evident uncertainty of the link between oil prices and overall economic activity. Kilian (2008) claims that most of the oil price increases after 1970 have resulted from demand shocks; Only the recession of 1980-1982 was due to exogenous oil supply shocks; as well as the exogenous supply shocks clarify only a fraction of the rise in oil prices over 1973-1974, 1990-1991. and 2002-2003 episodes. Kilian (2009) identifies oil price shocks as variously arising from shocks to crude oil supply, global demand, and precautionary demand and then uses a vector autoregressive model to show that the different sources of shocks have substantially differential effects on U.S. GDP and consumer prices.

How does the domestic price of goods and services react to the world prices for crude oil changes? Several authors have documented declines in the "pass-through rate" of oil prices – defined as percentage responses of domestic prices to a percentage increase in oil prices – both for the U.S. and elsewhere. This finding is considered essential to a subject's importance per se because this is thought to considerably affect how we recognize our nation's economies (Shioji and Uchino, 2010).

Early works generally used production functions to investigate the effects of changes occurring in oil prices in an aggregated economy, e.g., Hamilton (1983; 1985) and Gisser and Goodwin (1986). Each study shows the negative link between energy prices and output. Hooker (1996) discovered that, in the United States, the negative relationship between oil prices and GDP weakened after 1973 by studying the period 1984:1-1994:2. In addition, Hooker (1999) pointed out that oil price changes would not appear to impact the U.S. core inflation after 1980 strongly.

The primary constraint of these ex-works is that they assumed the exogeneity of oil price variation: the likelihood of reverse causality from the world economy through oil demand fluctuations has not been examined. To address the exogeneity problem, Kilian (2009) has created the structural VAR model of the global oil market to determine three underlying shocks in the global oil market. (1) Oil supply shocks; shocks to physical ability to produce oil. (2) Aggregate demand shocks; shocks to the current demand for all industrial commodities determined by global macroeconomic conditions. And (3) Oil-specific demand shocks; shocks that can't be explained based on oil supply shocks or aggregate demand shocks. Afterward, he concludes that each oil price shock affects GDP growth and CPI in the United States differently.

Following that contribution, the structural VAR model was widely used in subsequent studies examining oil-related economic issues. For example, Kilian and Park (2009) constructed a two-block structural VAR model that included the global oil market block and the U.S. stock market block to explore the differences in the responses of industry-level stock returns to changes in oil price. Furthermore, Fukunaga et al. (2010) examined the implications of oil price shocks on the industry-level production in the United States and Japan. They found that each shock would affect industry-level output differently based on oil intensiveness, and transmission mechanisms would differ between countries.

By looking at the country coverage of the previous work, most empirical literature focuses on the impacts of changes occurring in the oil price on the developed economy. The influence of changes in oil prices on developing countries has been largely unknown. Though, Sakashita and Yoshizaki (2016) studied the effects of oil price shocks on production and price level in five emerging countries compared with the United States, utilizing a two-block structural VAR model of the global crude oil market suggested by Kilian and Park (2009). Their main conclusions are that the influence of oil price shocks on the index of production (IIP) and consumer price index (CPI) in emerging countries is also depending on where changes primarily are coming from (it is also true for the United States). They also find that certain emerging countries demonstrate exceptional impulse response patterns, the shapes of which differ from those of the United States. Differences exist in impulse response patterns amongst emerging countries.

Recent research continues to deepen the understanding of oil price shocks and their transmission to domestic price levels, particularly in the context of evolving global energy markets, supplychain disruptions, and postpandemic macroeconomic adjustments. Several studies since 2020 emphasize that the magnitude and persistence of oil price passthrough depend not only on the nature of the shock—supply, demand, or precautionary—but also on structural features of the economy, including energy dependence, exchangerate regimes, and production linkages.

Baumeister and Hamilton (2021) show that the pass-through from oil prices to inflation has become increasingly state-dependent, with weaker effects during periods of stable inflation expectations. Their findings highlight the growing role of monetary policy credibility in moderating the inflationary impact of oil shocks. Caldara et al. (2022) similarly document that oil supply disruptions continue to exert significant upward pressure on inflation in advanced economies, but the magnitude varies substantially across countries depending on energy intensity and exchange-rate flexibility.

Table 1: Data sources and Description

Variable	Description	Source
Oil price	Global price of Brent crude, U.S. Dollars per barrel, quarterly, not seasonally adjusted.	International monetary fund (IMF)
Exchange rate	Real effective exchange rates based on manufacturing consumer price index, Index 2010=1, quarterly, not seasonally adjusted.	Organization for economic co-operation and development (OECD)
Consumer prices index	Consumer price index of all items, index 2010=100, quarterly, not seasonally adjusted	Organization for economic co-operation and development (OECD)
Interest rate	3-Month or 90-day rates and yields: Interbank rates, percent, quarterly, not seasonally adjusted	Organization for economic co-operation and development (OECD)
Import price index	Import price index: All commodities, index 2000=100, quarterly, not seasonally adjusted	U. S. Bureau of labor statistics
Producer prices index	Producer prices index: Index 2010=1, quarterly, not seasonally adjusted	Organization for economic co-operation and development (OECD)
GDP	Gross domestic product, quarterly, seasonally adjusted	U. S. Bureau of labor statistics
Output gap	Calculate as follows: Output gap=Actual GDP – Potential GDP.	
Foreign consumer prices index	FCPI for Canada=(90% CPI USA+4% CPI China+3% CPI UK+2% CPI Japan+1% CPI Mexico). FCPI for USA=(30% CPI China+26% CPI Mexico+27% CPI Canada+9% CPI Japan+8% CPI Germany)	

Crosscountry analyses also highlight important heterogeneity. Kang et al. (2021) find that G7 economies exhibit markedly different responses to oil shocks, with oilimporting countries experiencing stronger and more persistent passthrough to import and producer prices. Their results align with the patterns observed in our study, where the United States—being more oilimport dependent—shows a larger immediate response in import prices relative to Canada. Chen and Hsu (2023) further show that commodityexporting economies experience asymmetric passthrough, with positive oil shocks generating stronger inflationary pressures than negative shocks, reflecting nonlinearities in production costs and exchangerate adjustments.

The COVID19 pandemic and subsequent supplychain disruptions have also reshaped the literature. Narayan and Gupta (2021) analyze the unprecedented collapse and rebound of oil prices in 2020 and find that passthrough to producer and consumer prices became more volatile due to bottlenecks in transportation, logistics, and global manufacturing networks. Conflitti et al. (2024) show that global supplychain pressures amplify the inflationary effects of oil shocks, particularly in manufacturingintensive economies, underscoring the importance of considering supplychain frictions in modern passthrough models.

Methodological advances have also emerged. Kilian and Zhou (2023) propose refined identification schemes for SVAR models that better distinguish between precautionary demand shocks and supply shocks, improving the interpretation of impulse responses. Aastveit and Bjørnland (2022) employ time-varying parameter VARs and find that the sensitivity of inflation to oil shocks increased again after 2021 due to geopolitical tensions and structural changes in global energy markets.

Together, these recent contributions reinforce the relevance of examining oil price pass-through in open economies such as Canada and the United States. They highlight that the transmission of oil shocks remains dynamic and context-dependent, shaped by global demand conditions, exchange-rate movements, and evolving energy market structures. These findings complement and strengthen the motivation for our analysis and support the empirical patterns observed in our SVAR results.

Table 2: Unit root test

Variables	Test statistic			
	Canada		United States	
	Level	1st difference	Level	1st difference
Oil prices	−1.542	−8.220	−1.542	−8.220
REER	−2.228	−9.781	−1.754	−9.659
Inflation	−4.627		−11.145	
Interest rate	−1.756	−9.834	−2.008	−10.014
IMP	−1.316	−7.208	−1.216	−8.156
PPI	−0.918	−7.604	−0.337	−8.101
Output gap	−2.104	−6.257	4.372	−6.749
GDP				

Critical values for the test statistics are: –3.5 at 1%, –2.9 at 5%, and –2.6 at 10%

3. THE DATA AND THEIR PROPERTIES

The choice and order of the variables used in the SVAR are based on the various consideration. Since the study aims to capture the effects of oil price variations on import, producer, and consumer prices, the three prices and oil prices will be included in the model.

The paper adopts quarterly data covering the period 1980: Q1 to 2017: Q3. A detailed account of the data used and the data sources are given in Table 1. The oil price level is represented by a global price of Brent crude denominated in U.S. Dollars per barrel. The output gap is calculated by subtracting the potential GDP from the actual GDP. Furthermore, import prices, producer prices in manufacturing, and consumer prices are considered. Finally, the 3-Month or 90-day rates and yields; Interbank Rates are used to model monetary policy instruments and real exchange rates to control foreign and domestic price changes.

3.1. The Data Properties

Unit root tests are performed to assess the data's time-series properties. The Augmented Dickey-Fuller (ADF) test results are summarized in Table 2. The test indicates that Exchange Rates

($reer_t$), Oil Prices (oil_t), Interest Rates (i_t), Import Prices Index (imp_t), Producer Prices Index (ppi_t), Gross Domestic Product (GDP_t), and Output Gap (gap_t) are integrated of order one, I(1), while the inflation (π_t) is a stationary series.

Estimating the Structural Vector Autoregressions (SVAR) requires establishing the order of the integration of the series involved and then selecting the optimal lag length of the SVAR model. The lag length should be high enough to ensure that the errors are approximately white noise and small enough to allow estimation. The leg lengths are chosen by minimizing the Akaike Information Criterion (AIC). One lag of the first differenced series is used to estimate the SVAR model for Canada. At the same time, four lags are used to estimate the model for the United States. These lag lengths minimize the AIC of the SVAR (Table 3).

4. THE EMPIRICAL ANALYSIS

One of the main shortcomings of the unrestricted VAR (UVAR) approach is the difficulty of interpreting the impulse responses. This is because the choice of the Cholesky decomposition in the UVAR is not unique, given the number of alternative sets of orthogonalized impulse responses that can be obtained from any estimated VAR model. If we are going to perform impulse–response analyses, we ask, "What is the impact of a shock on one equation, keeping all the other shocks steady?" To analyze that impulse, we have to keep other shocks fixed. If error terms are associated, then a shock to one equation is related to shocks to other equations; a thought experiment of keeping all other shocks constant cannot be performed. The resolution is to write the errors as a linear combination of "structural" shocks.

Sim's (1980) own the approach of circumventing this problem by choosing an orthogonalization – typically imposing a causal ordering on the VAR. In the absence of such restrictions, the orthogonalized impulse responses are challenging to interpret, and the estimated model gives few meaningful insights into the economic system that it represents. The SVAR approach builds on Sim's approach. Still, it attempts to identify the impulse responses by imposing a priori restrictions on the covariance matrix of the structural errors and/or long-run impulse responses themselves, as suggested by Bwire et al. (2013).

4.1. Methodology

The structural VAR model is conducted to analyze the interrelationships between oil prices and overall price levels in Canada and the United States. The SVAR model depends on economic theory rather than Cholesky decomposition to recover structural innovations from residuals of reduced-form VAR. One likely drawback of the Cholesky approach is that in cases where the covariance between innovations is empirically non-zero, the disturbances' common component will be arbitrarily attributed to the first variable in the recursive VAR. This renders the reported impulse response functions (IRFs) and variance decompositions (VDs) susceptible to the ordering of the variable in the VAR. Such a VAR model has been criticized as devoid of economic content (Helmy et al., 2018).

Table 3: AIC for different lag estimation of SVAR model

Lags	Canada	USA
0	14.15	26.40
1	12.61*	25.80
2	12.96	25.85
3	13.08	26.04
4	12.88	25.62*

The standard VAR model is specified as follows:

$$X_t = \theta + \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \ldots + \Pi_k X_{t-k} + \mathcal{E}_t \tag{1}$$

And, in matrix form following Hamilton, the SVAR model can be written as:

$$B_0 X_t = \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + \beta_p X_{t-p} + \mu_t \tag{2}$$

Where X_t is a vector of n endogenous variables, θ is a vector of constants, Π_i are matrices of coefficients to be estimated, $\mathcal{E}_t$ is a white noise error term, the matrix β_0 is of order n*n and describes the contemporary relationships between the variables, and μ_t is the (unobserved) vector of structural shocks of order n*1. The white noise errors mean that the structural disturbances are serially uncorrelated such that $E|\mu_t \mu_t^`| = D$, where D is a diagonal matrix.

By multiplying equation (2) by an inverse matrix Σ_0^{-1}, we obtained the reduced form of the VAR model of the dynamic structural model as in equation (3). It is noted that this adjustment is needed because the model given in equation (2) is not immediately observable, and structural shocks cannot be adequately identified.

$$X_t = \sum\nolimits_0^{-1} \left(\beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + \beta_p X_{t-p} + \mu_t \right) \tag{3}$$

Where μ_t is a n*1 vector of serially uncorrelated structural disturbances of the model and is obtained as follows:

$$X_t = \Sigma_0^{-1} \tag{4}$$

To estimate an SVAR model and get the impulse response functions (IRFs) and variance decompositions (VDs), you need to use structural shocks, μ_t, and not the forecast errors, $\mathcal{E}_t$. These innovations include a linear combination of serially independent structural shocks, μ_t. So, the whole idea of structural decomposition is to take the observed values of $\mathcal{E}_t$ from an empirical VAR and restrict the system to recover μ_t (Helmy et al., 2018).

The variance-covariance matrix is given by:

$$E \,|\, \varepsilon_t \varepsilon_t^` \,| = \beta_0^{-1} \; E|\mu_t \mu_t^`| \, (\beta_0^{-1})^` = \beta_0^{-1} \; D(\beta_0^{-1})^` = \Omega \tag{5}$$

Cholesky decomposition of the variance-covariance matrix of the reduced form VAR residuals `Ω is used to create structural shocks. Because the inference of the SVAR model has K^2 more parameters than the VAR, to come up with a unique solution, both the order condition and the rank condition are needed to be satisfied. The order condition requires that several matrices β0 and D parameters are less than the number of free parameters in the matrix Ω. Since Ω is a symmetric matrix, the number of free parameters of the matrix

Ω is defined by the k(k+1)/2, where k represents the number of endogenous variables incorporated into the system.

If D is a diagonal matrix, then β_0 can have no more free parameters than k(k-1)/2. Two different restrictions on matrix β_0 can be imposed. The first is the normalization restriction that aims to assign the value of 1 to variables $X_{t,j}$ in each of the i^{th} equation. And the second is the exclusion restriction, which aims to assign zero to some variables in the equation. These restrictions are defined by the theoretical model (Bwire et al., 2013).

4.2. The Baseline Model

The data used in the SVAR model consists of quarterly observations, covering the period from 1980: Q1 to 2017: Q3. Referring to the variable of interest for our analysis and taking into account their unit root properties, the variables included in the model are the first difference of the log of oil prices (Δoil_t) that is used to capture supply shocks, interest rate (Δi_t) is included to allow for potential effects of monetary policy, output gap (Δgap_t) or gross domestic product (ΔGDP_t) is used to capture demand shocks, exchange rate ($\Delta reer_t$), import prices index (Δimp_t), producer prices index (Δppi_t), and the level of the Inflation (π_t).

The ordering of the variables is indicated by the vector of endogenous variables $X_t = (\Delta oil_t, \Delta i_t, \Delta gap_t, \Delta reer_t, \Delta imp_t, \Delta ppi_t, \pi_t)$. Imposing the restrictions suggested by the theoretical model and using this ordering in the Cholesky decomposition, the relationship between the error terms of the reduced-formed VAR, ε_t, and the structural disturbances (shocks), μ_t, of the model can be specified as follows.

$$\varepsilon_t^{oil} = 1\, \mu_t^{oil}$$

$$\varepsilon_t^{i} = \alpha_{21}\mu_t^{oil} + 1\, \mu_t^{i}$$

$$\varepsilon_t^{gap} = \alpha_{31}\mu_t^{oil} + \alpha_{32}\mu_t^{i} + 1\, \mu_t^{gap}$$

$$\varepsilon_t^{reer} = \alpha_{41}\mu_t^{oil} + \alpha_{42}\mu_t^{i} + \alpha_{43}\mu_t^{gap} + 1\, \mu_t^{reer}$$

$$\varepsilon_t^{imp} = \alpha_{51}\mu_t^{oil} + \alpha_{52}\mu_t^{i} + \alpha_{53}\mu_t^{gap} + \alpha_{54}\mu_t^{reer} + 1\, \mu_t^{imp}$$

$$\varepsilon_t^{ppi} = \alpha_{61}\mu_t^{oil} + \alpha_{62}\mu_t^{i} + \alpha_{63}\mu_t^{gap} + \alpha_{64}\mu_t^{reer} + \alpha_{65}\mu_t^{imp} + 1\, \mu_t^{ppi}$$

$$\varepsilon_t^{\pi} = \alpha_{71}\mu_t^{oil} + \alpha_{72}\mu_t^{i} + \alpha_{73}\mu_t^{gap} + \alpha_{74}\mu_t^{reer} + \alpha_{75}\mu_t^{imp} + \alpha_{76}\mu_t^{ppi} + 1\, \mu_t^{\pi}$$

Identification of the structural shock (μ_t) is obtained by appropriately ordering the seven variables of interest and applying Cholesky decomposition to the variance matrix of the reduced-form residuals (ε_t). In this case, it is essential to set the order of the variables. The oil price shock is ordered first, as no factor affects the oil price except its own supply, influencing other variables (Ito and Sato, 2006). Following an oil price shock, a change in the interest rate captures monetary shocks. Ordering monetary policy shock second allows it to affect the output gap and exchange rate in a country (Saha and Zhang, 2013). Next, the exchange rate shock is set after the output gap to respond to the demand shock (output gap shock). Finally, following the literature on distribution chains, the price levels (IMP, PPI, and CPI) are put last in the order.

5. THE EMPIRICAL RESULTS

5.1. Impulse Response Function of Oil Prices Shock for Canada and United States

The impulse response functions from oil price shocks investigate the response of import prices, producer prices, and consumer prices. Figure 1 shows the impact of a one standard deviation shock, defined as exogenous and unexpected in the oil price level on the pricing chain (import prices, producer prices, and consumer prices) in Canada and the United States. The solid line is the estimated response, while the dashed lines denote a two-standard error confidence band (95 %) around the estimate.

Figure 1 conveys the immediate positive impact of an oil price shock on import prices in Canada and the United States. Based on the numbers in Table 4, this effect of a structural one standard deviation shock of oil prices shock to import prices in Canada is about 0.71 increase in the import prices level, and in the United States is about 1.86 increase in the import prices level.

Economic theory points out that an increase in oil prices might have an inflationary effect in at least four ways. First, energy prices represent a portion (sometimes considerable) of production costs. Second, it might lead to higher inflation expectations. Third, it might lead workers to demand a higher wage to compensate for the increase in energy prices (Blanchard and Gali, 2008). And fourth, it might mimic an adverse supply shock if real wages do not decrease sufficiently, thus triggering an employment adjustment. By contrast, an increase in oil prices might have a deflationary effect like an adverse demand shock because higher energy prices tend to reduce net-disposable income and thus consumption and investments (Edelstein and Kilian, 2007; Conflitti and Luciani, 2017).

The results indicate that the U.S.'s import prices response to oil shocks is more than double relative to Canada. This is not surprising since Canada is an oil-exporting country while the U.S. is among the top two importing countries. As a result, an increase (decrease) in oil price will be more reflected in the U.S. import prices, raising (lowering) the U.S. imports bill compared to Canada.

The influence of the oil shock on the pricing chain in Canada is conveyed in Figure 2. The pass-through to import prices is higher than producer and consumer prices, where the immediate effect of oil price shock on producer prices is about 0.20, and 0.08 increases consumer prices.

Although Canada is a net oil exporter, the impact of the oil shock on import prices is positive. The influence on Canada's terms of trade caused by high export prices is partially offset by lowering consumers' disposable incomes and spending power through high oil prices at the pump and higher import prices due to higher energy costs. Thus, higher oil prices will have a net negative effect. This

Figure 1: Impulse response function of oil prices shock

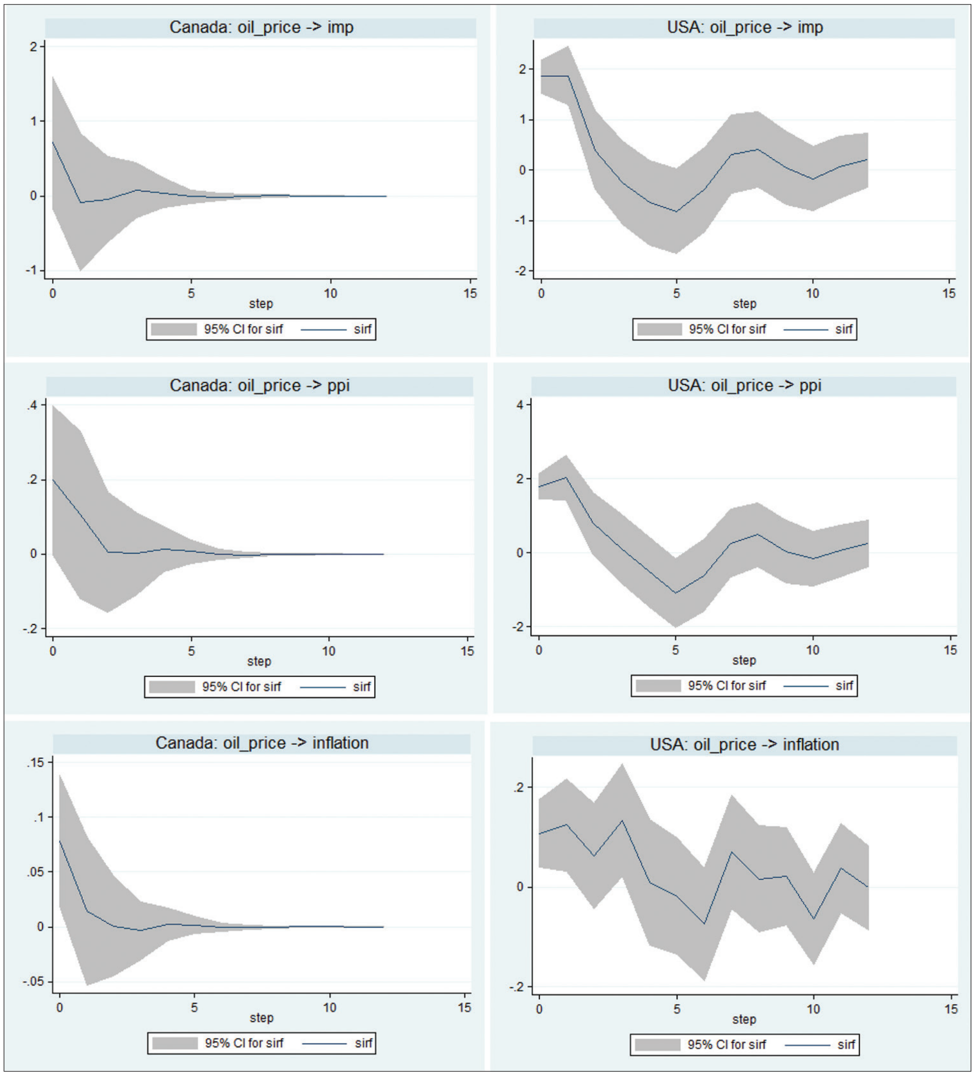


Figure 2: Canada (oil shock)

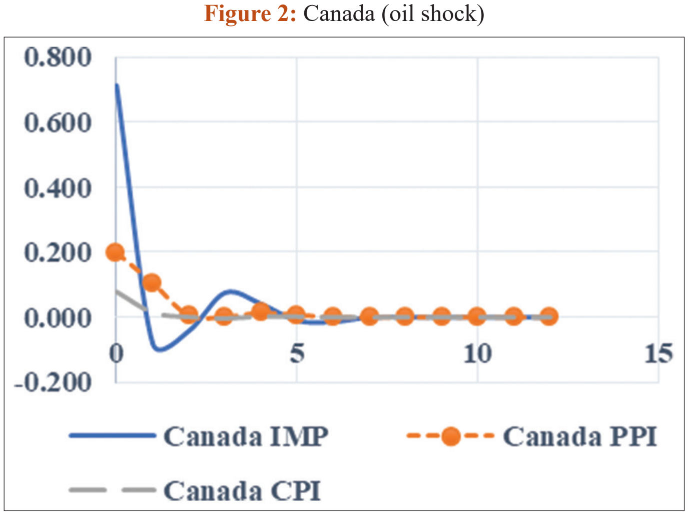


Table 4: Impulse response function of oil prices shock

Step	Canada			United states		
	IMP	PPI	CPI	IMP	PPI	CPI
0	0.713	0.198	0.079	1.860	1.798	0.108
1	−0.081	0.106	0.014	1.868	2.028	0.125
2	−0.042	0.005	0.001	0.396	0.793	0.062
3	0.075	0.001	−0.004	−0.249	0.120	0.135
4	0.041	0.013	0.002	−0.648	−0.501	0.010
5	−0.010	0.007	0.002	−0.812	−1.095	−0.018
6	−0.014	0	0	−0.385	−0.618	−0.074
7	0	0	0	0.319	0.264	0.071
8	0	0	0	0.412	0.486	0.017
9	0	0	0	0.045	0.035	0.022
10	0	0	0	−0.167	−0.164	−0.063
11	0	0	0	0.059	0.051	0.038
12	0	0	0	0.206	0.246	0

negative effect will work its way through the economy through two channels: First, it gives consumers less disposable income, and secondly, it increases input costs and discourages production in sectors other than oil, especially energy-intensive sectors (Millington, 2016).

Further, lower oil prices are typically accompanied by a weaker Canadian dollar. For example, the Canadian currency depreciated when oil prices dropped in 1985-1986. The Lonnie fell from 85 cents US in 1980 to 71 cents US in 1986, when the oil prices reached their cyclical low. So, the most significant economic change in Canada because of lower oil prices has been the

Table 5: Oil prices and canadian consumer spending based on an assumed 30% drop in oil prices

Component description	$ Billions (C$)
H1/14 Spending on motor fuel	48.5
Savings from lower oil prices	8.9
Amount saver than spent*	4.4
Increased spending	4.4
Imported content**	1.6
Net impact on GDP	2.9
Percent of GDP	0.1

*Assumes that just 50% of savings from lower gasoline prices are spent. **Import content of new consumer spending assumed to be 35%. Based on BOC review, autumn 2005. Source: Statistics Canada, RBC economics research

Table 6: Canada investment in the oil and gas extraction sector in 2013

Industry / Subsector	Percentage of private		
	$ Billions	Non-residential investment	Percentage of GDP
Oil and gas extraction	76.3	30.3	4.0
Support activities for manufacturing oil and gas	5.4	2.2	0.3
Petroleum and coal manufacturing	1.8	0.7	0.1
Pipeline transportation	6.7	2.7	0.4
Total	90.2	35.9	4.8

Source: Statistics Canada, RBC economics research

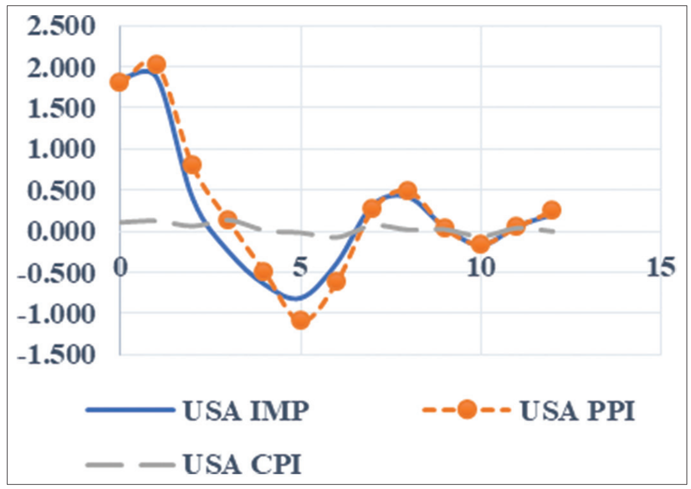
corresponding decline in the Canadian dollar. A sudden oil price drop increases uncertainty in oil sector investment and other goods-producing sectors. Capital investment is reduced or delayed throughout the economy, and overall growth is diminished.

Although oil price drop increases uncertainty in oil sector investment, Canadian consumers benefit from lower oil prices via lower fuel costs. According to Ferley et al. (2015), during the first half of 2014, Canadian consumers bought roughly $48.5 billion of motor fuel at an annual rate (Table 5). Based on its own estimates of the pass-through rate of decline in oil prices into gasoline prices, a 30% fall in oil prices usually would be reflected in about an 18% decline in gasoline prices. All else held equal, representing savings of $8.9 billion on the consumer's motor vehicle fuel bill.

Still, there exist some concerns about the impact of lower prices on the Canadian economy, such as high household debt levels and recent volatility in equity markets, which could cause households to remain more cautious than usual about spending; however, even making the very conservative assumption that households spend only half these savings on other goods implies an additional $4.4 billion in consumer spending in 2015 due to the drop-in energy costs. Assuming a 35% import content for this new consumer spending leaves a net add to GDP of about $2.9 billion, or about 0.1% points, from increased consumer spending. Ferley et al. (2015) argue that this rise in spending does not need households to have more loans. The assumptions above convey an increase in the share of disposable income saved. Note that the collapse in oil prices has led to a significant short-term drop in investment in the oil industry, with global investment in production and exploration falling from $700 billion in 2014 to $550 billion in 2015, which trickles to energy commodities. Sharp declines in investment in other commodity sectors have also contributed to overall slow global growth (Rogoff, 2016).

In short, it is most likely that the drop in business investment in Canada, notably in the oil and gas sector, would be fully offset by a rise in consumer spending and exports (Ferley et al., 2015). One may perceive the Canadian economy as just oil and gas extraction. As shown in Table 6, Although investments in the oil and closely-related industries represented greater than a third of business investment in Canada in 2013, this only accounts for <5% of GDP since business investment itself account for approximately 13% of all GDP. Furthermore, importing the existing content of Canadian investment in equipment is generally relatively high,

Figure 3: USA (oil shock)



which suggests that a portion of any drop in business investment will reflect weaker import growth rather than weaker domestic production (Ferley et al., 2015).

On the other hand, pass-through in the United States, as shown in Figure 3, is higher for PPI than IMP from the first four periods only, and then the pass-through increases for IMP relative to PPI. The immediate impact of a structural one standard deviation shock of oil price shock on producer prices is about 1.80, while it is 0.108 for the consumer prices level.

Change in oil prices is traditionally considered as cost shocks or productivity shocks to oil-importing countries such as the U.S. A rise in fuel prices means higher production and transportation cost. As many industrial chemicals are refined from oil, higher oil prices hit the manufacturing sector. The increase in oil price was primarily viewed as unfavorable because it increased the price of importing oil and increased costs for the manufacturing and transport sectors. This increase in costs could be passed on to the consumer. BEA estimates convey that energy input across all private industries in the U.S. in 2013 was worth $600 billion, which is a slightly more significant amount than the combined value-added from the four industries closely related to oil and gas extraction listed in Table 7. Lower oil prices are negative for the oil and gas extraction industry; however, they are positive for most other industries, accounting for an additional 96.7% of U.S. GDP (Ferley et al., 2015).

Rogoff (2016) noted that lower oil prices for oil-importing advanced economies are a significant incentive against capital outflows for emerging markets. However, developed economies policymakers should expect a future rise in the oil prices as much as the decline in the past.

Further, Ferley et al. (2015) explained that oil price shocks that pass through occur through both its energy and the non-energy components. Both producers and consumers are expected to suffer the consequences—consumers' bills for fuel, heating, and transportation increase. U.S. households purchased about \$400 billion worth of gasoline and other fuels, at an annualized rate, over the first half of 2014. As shown in Table 8, an average 30% drop in oil prices represents about an \$86 billion increase in household purchasing power. Some of that is saved; however, even adjusting for this, more robust consumer spending could boost U.S. GDP growth of around 0.5 PPTS (~\$82 billion). There is the possibility that more of the 1-time boost to income will be saved, but even if only half were spent, it would still add 0.2-0.3 PPTS to GDP growth.

Simultaneously high oil prices will also be hurt consumers by a decrease in savings which are likely to reduce consumption and reduce the GDP; they are also expected to benefit U.S. shale oil producers in the long term - Who, according to the estimates, oil prices must stand above the US \$60 to break even -- and bring to higher associated investment. Higher oil prices will also positively affect US energy companies such as Exxon, Chevron, etc. (Srikant, 2015).

Beattie (2018) argues that oil prices influence the U.S. economy in two opposite ways because of the diversity of industries. While higher oil prices can drive job creation and investment in oil and gas, notably in higher-cost shale oil deposits, it does harm businesses and consumers with higher transportation and manufacturing costs. Meanwhile, a drop in oil prices hurt the unusual oil activity; however, advantages in the manufacturing sector and other sectors in which fuel costs are a fundamental concern.

Table 7: U.S. Current production in oil and gas related industries: 2013

Gross value added	\$ Billions	% of GDP
Gross value added		
Oil and gas extraction	291.9	1.7
Mining support	68.7	0.4
Pipeline transportation	21.0	0.1
Petroleum and coal refining	169.7	1.0
Total	551.3	3.3

Source: U.S. Bureau of economic analysis, RBC economic research

Table 8: U.S. consumer spending implications of 30% oil price decline

Consumer spending	\$ Billions	Percentage of GDP
Consumer spending		
Gasoline purchases, annualized H1/14	409	2.44
Savings from a reduction in gasoline prices	85.8	0.51
Less amount saved rather than spent	4.3	0.03
Total	81.5	0.49

Assumes: Every 10% decline in oil prices lowers gasoline prices by 7% and a 5% saving rate. Source: U.S. Bureau of economic analysis, RBC economics research

5.2. Estimation of Pass-Through rates of Oil Prices Shocks in Canada and the United States

Several authors have documented declines in the "pass-through rate" of oil price shocks in the U.S. and elsewhere. This conclusion is essential not just for a subject's relevance per se but also because this is believed to significantly influence how we understand the working of our national economies. Literature conveys three different hypotheses on the causes of the decline in the pass-through rate. First producers' increased confidence in monetary policymakers. Since the central bank will try to suppress inflation by raising the interest rate as soon as it sees rising oil prices, producers will hesitate to pass the increased cost onto the prices of their goods. Secondly is higher wage flexibility. As oil price increases, profits are expected to decline, inducing producers to cut their production and wage payments. However, if wages start decreasing fast, firms will find less reason to raise prices. Thirdly and most importantly is the cost structure. After the bad experiences of the 1970s and the early 1980s, firms have learned the danger of being oil-dependent. Consequently, they transformed their production structure into a less oil intensive and thus have become less vulnerable to oil shocks and minor needing to change their prices in response to oil prices movements (Shioji and Uchino, 2010).

This section describes the data and the methodology used to estimate the pass-through rates of oil prices. A separate sample for each country is used from 1980 to 2017.

For each country, the following pass-through equation is estimated:

$$\Delta PPI = \delta_0 + \delta_1 \Delta PPI_{t-1} + \delta_2 \Delta(Oil + PPI) + \delta_3 \Delta(Oil_{t-1} + PPI_{t-1}) + \delta_4 \Delta(Oil_{t-2} + PPI_{t-2})$$

The variables oil and PPI are the quarterly oil prices and producer price index, respectively. The coefficients δ_2, δ_3, and δ_4 represent the immediate, one-quarter lag, and two-quarter lag impact of an oil price change on the producer price level, respectively. The equation incorporates lagged adjustment of inflation to shocks so that $(\delta_2 + \delta_3 + \delta_4)/(1-\delta_1)$ measures the long-run pass-through of oil price movements to producer prices level.

Table 9 reports each country's regression of the long-run pass-through rates of oil prices for the entire period. The pass-through estimates are incomplete (<1) for both countries, indicating that producer prices increase less than the increase in oil prices.

In theory, the first-round effects of oil price changes on CPI emerge rapidly through the prices of energy items such as motor fuels and bottled gas. On the other hand, the indirect channel of

Table 9: The long-run pass-through rates of oil price shocks

Country	Pass-through rate
Canada	0.04
USA	0.25

Source: Authors' calculations based on the outcomes of the SVAR model

Table 10: Variance decomposition for the U.S.

Impulse	Response	Variance	Response	Variance	Response	Variance
Oil prices	IMP	0.61	PPI	0.53	CPI	0.04
Interest rate	IMP	0	PPI	0	CPI	0.01
Output gap	IMP	0	PPI	0.01	CPI	0.02
REER	IMP	0	PPI	0	CPI	0.07
IMP	IMP	0.39	PPI	0.27	CPI	0.02
PPI	IMP	0	PPI	0.19	CPI	0
CPI	IMP	0	PPI	0	CPI	0.84
Total		1		1		1

Table 11: Variance decomposition for Canada

Impulse	Response	Variance	Response	Variance	Response	Variance
Oil prices	IMP	0.02	PPI	0.04	CPI	0.06
Interest rate	IMP	0	PPI	0	CPI	0.01
Output gap	IMP	0.02	PPI	0.02	CPI	0.13
REER	IMP	0.03	PPI	0.02	CPI	0.01
IMP	IMP	0.93	PPI	0	CPI	0
PPI	IMP	0	PPI	0.93	CPI	0
CPI	IMP	0	PPI	0	CPI	0.79
Total		1		1		1

the pass-through of oil price changes to consumer prices occurs relatively slower via production costs. The second round refers to the notion that the first-round price changes may cause a revision of the inflation expectations and nominal wages, leading to inflation (Akcelik and Ogunc, 2016).

The degree of oil price pass-through for Canada is less than in the U.S., where the long-run rate of oil price pass-through for Canada is 0.04, suggesting that on average, a 1% appreciation in oil prices causes producer prices to rise by 4% in the long-run, while in the U.S. The long run of oil price pass-through is 0.25, suggesting that, on average, a 1% appreciation in oil prices causes producer prices to rise by 25% in the long run. Although both countries are neighbors and industrial countries, that is not surprising since Canada is an oil-exporting country while the U.S. is an importing.

5.3. Variance Decomposition

To further analyze the transmission channels of pass-through rates for the U.S., the variance decomposition of the SVAR model is used, as shown in Table 10. The results recommend that by the 12 quarters, oil price shocks explain 61% of the variation in import prices and 53% of the variation in producer prices. On the other hand, own shock explains 39% of the variation in import prices and as low as 19% of the variation in producer prices, which is considerably lower than the oil shocks, implying that their own shock explains the significance of oil shocks.

Regarding the U.S. CPI, its own price shock explains 84% of the variation in consumer prices, implying that oil shocks do not influence consumer prices. Further, exchange rate shocks appear to be more prominent than oil and import price shocks in explaining the variation in CPI. The exchange rate shocks account for 7% of the variation in CPI, while oil prices shocks explain only 4% and 2% explained by import prices.

On the other hand, Table 11 reveals transmission channels of pass-through rates in Canada. After 12 quarters, variations in import and producer prices are explained mainly by their own shock -93%-while the rest is explained by oil, output gap, and exchange rate shocks.

Similarly, the own shock explains 79% of CPI variation while exchange rate and interest rate shocks account only for 1% of the variation in consumer prices. Oil price shocks explain 6% of the variation in consumer prices, and the output gap explains 13% of the variation in consumer prices.

In short, while the impulse response function shows the oil shock does influence prices, the impact is at best very moderate if compared with its price shock. These results should not be misinterpreted as the non-significance of oil shocks, but that there are other variables such as exchange rate and output gap that contribute along with oil in price fluctuations in Canada.

6. CONCLUSION

This paper estimates oil price pass-through to import, producer, and consumer prices for the United States and Canada using a Structural Vector Auto-Regression model. The results recommend the existence of partial or incomplete pass-through for oil shocks in both countries, where it values 0.25 for the United States and only 0.04 for Canada. The lower pass-through in Canada versus the United States is mainly explained by the difference between the two countries in oil trade and consumption direction and volume. While Canada is an oil-exporting country with average oil consumption, the U.S. is the second exporter and consumer of oil globally.

The pass-through magnitudes are broadly in line with previous literature. These low magnitudes, which have led to partial pass-through, reveal that oil is not the high cost of production in both countries. Still, maybe other factors such as wages, notably since the U.S. and Canada are considered service economies.

The oil shock pass-through rates show that it declines along the distribution chain. For Canada, the average oil price pass-through ratios of import, producer, and consumer prices are 0.713, 0.198, and 0.079, respectively, and 1.860, 1.798, and 0.108 for the United States. This result is supported by various empirical studies, such as McCarthy (2007), who concluded that the oil price shocks impact declines along different stages of the distribution process - importer, producer, and consumer - known as the "pricing chain." This allows for a contemporary impact of import price shock on producer prices and a contemporaneous producer effect price shock on consumer prices, but not vice versa.

Regardless of the degree of pass-through, there will still be winners and losers because of oil shocks. An increase in oil prices raises the revenue for oil-exporting countries such as Canada, while oil-importing countries may suffer due to higher oil prices. Consumers will find their real incomes shrink as they cannot save on transportation and home-heating costs, while producers face a higher bill for energy. However, oil companies will see their profits expand, and laborers employed by companies directly related to the oil industry will face increasing job prospects.

Lastly, the variance decomposition results convey that oil price shocks significantly impact the U.S. import prices relative to Canada. Still, oil shocks contribute to the fluctuation in producers' and consumers' prices in both countries.

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