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On the link between current account and oil price fluctuation in diversified economies: The case of Canada*

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Abstract

This study revisits the important link between oil prices and current account for oil exporting countries by paying a particulary attention to the time-varying nature of this link. To this end, we rely on an innovative methodology which is the time-varying parameter vector autoregressive (TVP-VAR) model with sign restriction. We find that while an oil supply shock has a non-significant impact on the current account, an oil demand shock has a positive and significant impact which tends to increase over time. In addition, by studying the economic factors underlying the growing evolution of this relationship, we find that, although the propensity to import of oil revenues has a significant negative influence on the pass-through of oil demand shocks on the current account, deepening of the domestic financial market and accumulation of foreign exchange reserve have a significant positive effect.

JEL Classification: F32, Q43, C32.

Keywords: curent account, oil prices, time-varying parameters.

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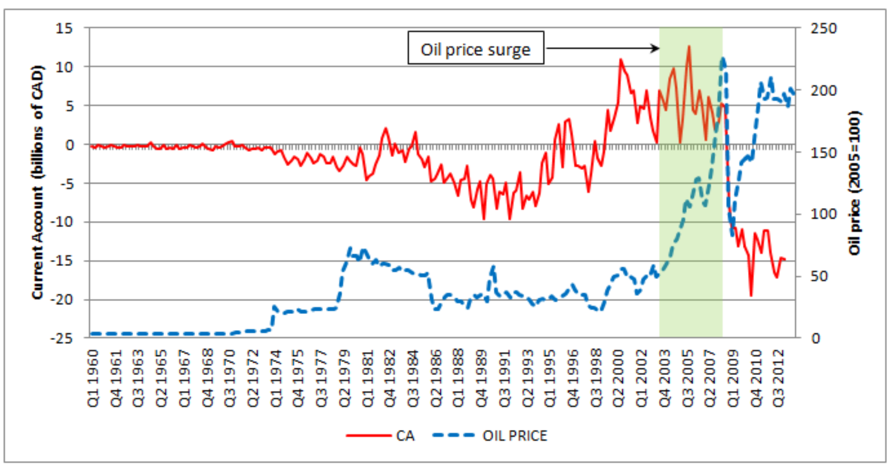
1 Introduction

The interactions between macroeconomics and fluctuations in oil prices are one of the most discussed topics of international macroeconomics. The abundance of this literature stems from the key role played by the evolution of oil prices in the formation of external imbalances (deficits for some countries and surpluses for others) and its importance to economic activity. Thus, the oil price surge in the 2000s was considered partly responsible in worsening and for persistence of global imbalances[1] observed during the same period. This view is relayed in the literature by some authors such as Rebucci and Spatafora (2006), Blanchard and Milesi-Ferretti (2010) and Arezki and Hasanov (2013). According to them, the oil price dynamics played a leading role in explaining the observed recent global imbalances. Indeed, the sharp and unprecedented increase in crude oil prices from 2003 to 2008 would have resulted in transfers of wealth from oil importers to oil exporters, thereby accelerating these imbalances. The following figure 1 illustrates the current account surplus that accompanied the sustained oil price increase for Canada.

Figure 1: Current Account of Canada and Oil Price



Despite the rising interest on current account and oil price nexus, surprisingly, much fewer theoretical (Backus and Crucini, 2000, and Bodenstein et al., 2011) and empirical (Bollino, 2007, Kilian et al., 2009, Ozlale and Pekkurnaz, 2010, and Le and Chang, 2013) studies

[1] The problem of global imbalances is one of the most worrying to which policy makers and researchers face. To reduce the extent and persistence of these imbalances during the 2000s, the International Monetary Fund (IMF) launched in 2006 a first multilateral consultation on global imbalances. The European Union adopted in 2011 two regulations on macroeconomic imbalances to detect and correct excessive imbalances. Global imbalances were also at the center of discussions at the G20 summits (since 2006) that have given rise to the adoption in 2011 of guidelines for measuring excessive imbalances.

treat directly this issue.[2] Moreover, no clearcut consensus emerges and the common finding from these studies is that the sign and the magnitude of oil price impact on current account depend crucially on the nature of the economy considered — oil-importing or oil-exporting country —, the degree of domestic financial development, the degree of international financial market integration, and the management of foreign exchange rate reserve (Buetzer et al., 2012). This point of view is shared by Morsy (2012) who argued that in the context of exhaustible resources, revenue windfalls can be allocated to both saving and investment for intergenerational equity concerns, which thus leave this important topics as an outstanding issue. The relationship between the current account and the price of oil for oil exporting countries also depends on the propensity of the economies to absorb oil shocks (positive or negative) itself depending on their level of economic diversification. A country with a low level of export diversification and a prominent oil sector will have a current account strongly linked to the oil balance, making systematic the relationship between the current account and oil price.

From this point of view, Canada appears as an interesting case for studying this relationship. Indeed, Canada has different economic features compared to both oil exporters and oil importers as pointed out by Kilian et al. (2009). Namely, this country is classified among the largest oil-exporters but its oil exports account for a relatively small share of total exports (less than 20%), thus indicating a sufficiently diversified export structure. Canada is ranked among the top ten most diversified countries in the world while being among the top ten largest oil-exporting countries. This particularity is interesting for studying the relationship between the current account and the price of oil because if that relationship is often considered as linear especially for little or no diversified countries, it can be subject to regular disruptions because of the terms of the trade in other export sectors (eg automotive industry for Canada).[3], [4]

The main objective of this paper is to assess the impact of oil price movements on the current account of Canada taking into account of the potential non-linearity of this relationship. To this end, we rely on recent innovative methodology that permits both to disentangle different sources of oil price fluctuations and to assess the time-varying extent of the relationship between current account and oil price. Namely, we use a time-varying parameters vector autoregressive (TVP-VAR) model with sign restriction in line with Primicery (2005), Cogley and Sargent (2005) and Baumeister and Peersman (2013).

Despite the country case nature of this study, our paper contributes to the literature in several ways. First, we offer a recent and updated comprehensive literature review of studies

[2] Most of the studies focused on the sustainability of the current account, the reversal of the current account and its economic cost as well as the role of the exchange rate regime (see among others Edwards, 2005; Freund, 2005; Aizenman and Sun, 2010; Christopoulos and León-Ledesma, 2010; Lane and Milesi-Ferretti, 2012; Schoder et al., 2013).

[3] When the oil balance is predominant in the current account (the case of essentially oil countries), any change in oil prices is likely to mechanically drive the current account in the same direction.

[4] Section 2 returns more broadly on the reasons that make Canada's case unique and interesting to study.

that treat directly or indirectly the current account and oil price nexus. Second, it accounts for what is well known in the literature that "not all oil price shocks are alike" (Kilian, 2009) by distinguishing the effects of oil prices due to a supply shock, and those derived from a demand shock. That is, oil price shocks may steem from different sources such as an oil supply disruption or an unexpected change in oil demand condition.[5] Indeed, an oil price increase due to oil production shortfall would not have the same impact on current account as an unexpected oil demand increase. Rise in oil price associated with a production shortfall might compensate the resulting loss in revenue whereas that associated with a rise in demand triggers an oil revenue windfall. In this vein, this paper assesses the current account and oil price fluctuations link by disentangling different sources of oil price fluctuations, namely those that come from oil supply disruption and those that follow an unexpected rise in precautionary or physical oil demand. Third, allowing the relationship between the current account and the price of oil to be time-varying, we go out the beaten track where it is often assumed a linear relationship while some authors such as Le and Chang (2013) argue the opposite. By dividing the sample of their studies into three different episodes, these authors show that the relationship between the current account and oil prices varies considerably from year to year in terms of magnitude, signs and signal of causality. The main obvious rationale for this finding is that different sources of oil price fluctuations do not necessarily occur at the same time. Therefore, the time-varying nature of oil price shocks leads to unstable relationship between oil prices and macro-economic variables as argued by Kilian (2009) and Kilian et al. (2009). Moreover, Baumeister and Peersman (2013) argue that changes in factors such as the oil intensity of economic activity, the energy market regulations, the capacity utilization rate in the crude oil production and the degree of oil market financialization are likely drivers of time-varying nature of the relationship. Therefore, we propose to estimate for the whole sample period considered in this study the extent of the oil-price elasticity of current account. Furthermore, our paper provides some explanations on the relationship between the current account and oil price fluctuations for Canada, which is not often the case in previous studies.

As is standard in the literature, we find a positive relationship between oil prices and current account indicating that an oil price increase is followed by a current account surplus for oil exporting countries. Moreover, impulse response analysis shows that an unexpected oil price increase following an unexpected oil production shortfall does not have a significant impact on the current account. In constrast, oil demand shocks have a significant positive impact on the latter. More interestingly, the time-varying specification that we adopt in this study allowed us to obtain two main results. First, we uncover that the oil price and current account nexus has increased over time and is mainly demand-driven. Second, by conducting a formal assessment of the influence of adjustment factors on the oil price and current account nexus, we find that the positive impact of oil price increase on the current account is mitigated by the propensity to spend oil revenues windfall to import. In constrast, the degree of domestic

[5] Given the increasing financialization of oil markets and the prominent role played by speculators, Kilian and Murphy (2013) made a distinction between physical demand and speculative shocks in explaining oil price fluctuations.

financial development and the exchange rate reserve accumulation have a significant positive impact on the link between oil price and current account.

The rest of the paper is organized as follows: section 2 provides a review of the recent literature; section 3 presents the empirical methodology used; section 4 discusses the results; and section 5 concludes.

2 Oil shocks and external balances

2.1 A global perspective

A large body of literature has investigated the relationship between oil price and macroeconomic in oil-importing countries by looking either (i) at the effect of oil price shock on economic activity through the supply and demand channel[6], or (ii) at the impact of global economy on the oil price movements.[7] However, little has been done to investigate the impact of oil price shocks on external balances in oil-importing and oil-exporting countries, whereas recent discussions have suggested that oil price has played a prominent role in determining global imbalances (see Rebucci and Spatafora 2006; Blanchard and Milesi-Ferretti 2010; and Arezki and Hasanov 2013).

Rather an important literature has indirectly studied this question through the so-called "Dutch disease" phenomenon.[8],[9] One can cite among other works, Corden and Neary (1982), Chen and Rogoff (2003), Cashin et al. (2004), Chen and Chen (2007), Coudert et al. (2011), and more recently Bodart et al. (2012, 2015) who suggest that there exist a positive long-run relationship between the price of oil (commodity prices in general) and the real exchange rate via the terms of trade. According to the literature, depending on various factors (such as the exchange rate regime, the degree of financial openness, the degree of trade openness, the degree of export diversification, the degree of institutional constraints, etc) an oil price increase will lead to a real exchange rate appreciation for oil-exporting countries. In turn the real exchange rate appreciation will generate a terms of trade deterioration for non-oil exporting firms ("income effect") and a resource transfert from non-oil to oil

[6] The supply channel refers to a term-of-trade shocks following an exogeneous increase of imported crude oil price, where crude oil is considered as an intermediate input influencing domestic economy through the effects on production decision (see among other, Kim and Loungani 1992; Backus and Crucini 2000). This approach has been confronted to the demand channel, where the effect of oil price shocks can be seen as the reduction in the demand for goods and services (see among others, Lee and Ni 2002; Bernanke 2006; Kilian 2008; and Hamilton 2009).

[7] See Barsky and Kilian 2002; Kilian 2009; Alquist and Kilian 2010; Kilian and Vega 2011; and Kilian and Murphy 2014 to name few.

[8] The indirect implication of this strand of literature on the oil price-external balances nexus comes from the existing relationship between the real exchange rate, the current account, and the commodity price dynamics.

[9] The "Dutch disease" literature belongs to the more general "Natural Resource Curse" literature which stresses that increases in commodity prices have negative effects on the economic growth of commodity producing countries. See Frankel (2010) for a recent survey on this topic.

sectors ("substitution effect").[10] Another indirect literature is to link the current account to the net saving (saving minus investment) in an accounting identity in order to understand the impact of the domestic oil investment-saving allocation on external balances.[11]

More directly related to our context, Bruno and Sachs (1982), Gavin (1990, 1992), and Ostry and Reinhart (1992) were among the first to study the direct impact of oil price shocks on external accounts. However, these studies appear to be limited by not considering the endogeneous and exogeneous components of oil price shocks whereas recent theoretical and empirical models suggest that not all oil shocks are alike (see Barsky and Kilian 2002, 2004; Kilian 2008c; Kilian 2009; Alquist and Kilian 2010; Kilian and Murphy 2014 to name few).[12] More recent studies of Kilian et al. (2009) and Bodenstein et al. (2011) investigate how oil revenues is recycled in the global economy by distinguishing betwen supply and demand shocks. A common finding from these studies is that oil price increase will result to positive external balance for oil exporters at the expense of oil importers. An in-depth examination of the effect of oil price shock on external accounts reveals that two channels are usually at play: (i) the trade channel, and (ii) the valuation channel. While the former channel works through the adjustment of prices and quantities of exported and imported goods reflecting the response of trade accounts[13] (see Kilian et al. 2009; and Bodenstein et al. 2011), the latter works through the adjustement of income flows and foreign liability position reflecting the international portfolio structure of oil-importing and oil-exporting countries. Focusing on the macroeconomic ajustments of the current account, we leave aside the mechanisms related to the role of the valuation effects in the external adjustment of economies.[14]

From a macroeconomic perspective, it follows that after a positive oil price shock, both oil-exporting and oil-importing countries adjust their trade accounts by running oil-trade balance surplus and deficit respectively. Recalling that the trade balance is composed by the oil-trade and non-oil trade balances and that it largely determines the evolution of the current account, it remains that the adjustments of the latter depend to an important extent to the reaction of the non-oil trade balance with respect to the oil-trade one. According to the literature, the role of the non-oil trade balance is indeed of primary importance since it can either implify the

[10] See Neary (1988) for more details.

[11] See Bems and Carvalho (2011) and Cherif and Hasanov (2013) for the saving behavior of oil-exporting countries; Chinn and Ito (2007), Van der Ploeg and Venables (2012), Bascher and Fachin (2013), Araujo et al. (2013), and Allegret et al. (2013) for the role of domestic investment.

[12] Implicit reasoning behind standard pre 1990 models are that (i) oil prices are treated as exogeneous with respect to global economy; and (ii) the effect of an exogeneous oil price will be the same, regardless the origin of the shocks (i.e. demand or supply shocks).

[13] As in Kilian et al. (2009), the *trade balance* here is equivalent to the *merchandise trade balance*, composed by *oil-trade* and *non-oil trade* balances. In turn, we assume that the response of the current account following an oil price shock is mainly reflected in the *merchandise trade balance*.

[14] Interested reader can refer to Lane and milesi-Ferreti 2007a; Gourinchas and Rey 2007a,b; Devereux and Sutherland 2010; Ghironi et al. 2015 among other.

initial effect (especially for countries that export non-oil forms of commodities which could be affected by oil disturbances[15]), or offset the oil trade deficits (Kilian et al., 2009; Buetzer et al.; 2012). As pointed out by Kilian et al. (2009), the response of the non-oil trade balance sheds also much light on the degree of the international financial market integration as well as on the management of foreign exchange reserve. In a international financial integration viewpoint, it is well known that external balances adjustment can be different depending on the market completeness, then three possible international financial market situations usually exist in the literature: (i) the complete market, (ii) the financial autarky, and (iii) the incomplete market. Under the standard framework of complete market, a positive temporary oil price shock will result for oil-exporting countries to lend oil surplus revenues and for oil-importing countries to borrow oil deficit in order to maintain a sustainable current account imbalances (a transitory flow imbalance). It follows that no internal adjustment is required and the current account reacts with respect to the oil-trade balance only.[16] Under the extreme framework of financial autarky, by definition, external current account imbalances cannot emerge in response to oil price shocks. Standard theoretical models focus on the complete or autarky design only, and little is known about the incomplete situation whereas this perspective appears to be more realistic. Thus, under the incomplete market assumption, adjustments of the non-oil trade balance are required to cushion the oil-trade balance movements. Such adjustment works through change in the terms of trade via a real exchange rate appreciation or depreciation (see, Cashin et al. 2004; Chen and Chen 2007; and Kilian et al. 2009). Looking now to the role of the foreign exchange reserve as adjustment factor, Buetzer et al. (2012) show that while the exchange rates of oil exporters do not systematically appreciate with respect to those of oil importers after shocks raising the real oil price, oil exporters experience significant appreciation pressures following an oil demand shock for which countries accumulate foreign exchange reserves in order to counter.[17],[18] It follows that the non-oil trade balance is not affected by the oil price shock and that the overall effect on the trade balance is captured in the oil-trade balance only.

2.2 Oil shocks and current account in diversified countries: The case of Canada

As discussed in the previous Section, a small literature has studied the impact of oil price shocks on external accounts. More specific country case studies are concerned with oil-importing countries, such as Bollino (2007) for the case of the United States and Ozlale and Pekkurnaz (2010) for Turkey, where both indicate a significant effect of oil price shocks

[15] See Baumeister et al. 2010.

[16] If the shock is permanent, it should be adjusted with full internal adjustment. However, because such adjustment is costly, external imbalances may arise even in the case of permanent oil price increases.

[17] This result also confirms that not all oil shocks are alike when investigating the effect on macroeconomic aggregates.

[18] The adjustment process works broadly on the opposite way for oil-importing countries.

in the short-run.[19] Other focuses on asian emerging oil-importing and -exporting countries, such as the study of Le and Chang (2013) for Malaysia, Singapore and Japan. A more general study is the one of Kilian et al. (2009) who investigate the effect of oil shocks on external balances by considering a large panel of oil-importing and exporting countries.[20] However, considered countries in the literature are preatty much the same in terms of trade balance structure and export diversification, while nothing is known about well diversified exporting countries such as Canada. As pointed by Kilian et al. (2009), Canada is likely to behave differently from both oil-importing advanced economies and from major oil exporters. Four reasons can justify the specific interest to focus on the behavior of this country when looking at the oil shocks-current account nexus.

First, Canada is the only advanced economy among the top 10 oil-exporters in 2013 with 1,643 thousand barrels per day. Furthermore, it is also one of the main oil consumer in 2013 with 2,431 thousand barrels per day against 4,074 thousand barrels per day produced conferring a leading role of the country within the world oil market organization. Second, while the configuration of main oil-exporting countries has been quite stable from 1980s, Canada switched from being net oil-importer to net oil-exporter over time.[21] Third, according to the U.S. Energy Information Administration and the *Oil & Gas Journal*, Canada controls the third-largest amount of proved reserves in the world in 2014 with 173 billion barrels, after Venezuela and Saudi Arabia (respectively 297 and 268 billion barrels).[22] This situation therefore gives to the canadian economy an important role in the future of the world oil market framework. Fourth, looking more specifically at the structure of the exports during the period 1995-2013 (Table 1) it appears that while canadian exports are large in absolute value, the fuel share is less than 20% compared to 81% in average for OPEC member countries[23] testifying the well diversified struture of the canadian trade balance.[24] The Figure 2 which reports the export diversification Theil index of considered countries following the definitions and methods used in Cadot et al. (2011) confirms this observation over the period

[19] Note that Bollino (2007) sets forth an alternative explanation of the effect of oil price on U.S. trade deficit taking in account the 'twin nature' of the overall trade definition, namely (i) the petroleum trade deficit, and (ii) the China bilateral trade deficit.

[20] The list of oil exporters includes Algeria, Angola, Azerbaijan, Barhain, Brunei, Congo (Rep. of), Ecuador, Gabon, Indonesia, Iran, Kazakhstan, Kuwait, Libya, Mexico, Nigeria, Norway, Oman, Qatar, Russia, Saudi Arabia, Syria, Trinidad and Tobago, Turkmenistan, the United Arab Emirates, Venezuela, and Yemen. The list of oil importers includes the United States, Japan, and the Euro Area (with Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain).

[21] Before 1982, Canada was indeed net importer of crude oil.

[22] The dynamic of the Canadian crude oil proved reserves has considerably changed over time, from 1980 to 2002 they were well below 10 billion barrels. In 2003, they rose to 180 billions barrels after oil sands resources were deemed to be technically and economically recoverable.

[23] OPEC members include Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Lybia, Nigeria, Qatar, Saudi Arabia, UAE, and Venezuela.

[24] Considered oil-exporting countries on the Table 1 are those of Kilian et al. (2009), where we add Canada and the UK.

1982-2010 where Canada appears to be one of the most diversified country.[25] Looking more specifically at the stucture of the fuels exports, the Table 1 also reveals that Canada exports also non-oil energy (such as gas, coal and electricity) but that the share of non-oil energy is low (around 7% of the total).[26] The remaining of the total exports is of the form of exported manufactured goods (54%) and others (26%). Another particularity of Canada crude oil exports is that it is profoundly dependent on the United States because it exports almost 97% of oil in 2013 representing one-third of the U.S. crude oil imports.[27] Overall, Canada appears to be specific compared to the behavior of oil-exporting and -importing countries. A paradox that the literature has previously ignored whereas the case is of primary interest.

Another interesting comparison that proved the specificity of Canada, is the one with the UK. Indeed, a first examination reveals that as Canada, the UK is also quite different compared to other main oil-exporting countries, especially in the structure of the exports diversification (see Table 1 and Figure 2). Based on this basic evaluation one could say that both UK and Canada are approximately the same and can be classified within the same subgroup of exporters. However, this observation is not supported by the data. Indeed, fundamental differences exist between the two exporters. First, looking at the net crude oil position of the two countries (i.e. the difference between crude oil exports and imports) over the period 1980-2013[28] (Figure 3 below) reveals that while both countries switched from being net-importer to net-exporter over time, in the beginning of 2000s the divergence between the two series has increased to the point that the UK has become net importer of crude oil since 2003, making it a net importer of all fossil fuels for the first time since at least the early 1970s. Second, unlike canadian crude oil proved reserves which continuously increased since the early 2000s, the UK crude oil proved reserves started its decline since the beginning of 1980s. Last but not least, while the UK is a net importer of non-oil energy, Canada is net exporter of both oil and non-oil energy. Thus, a thorough analysis of the data confirms the importance to distinguish Canada among the main oil-exporter, especially when looking at the effect of oil price on external balance.

[25] The codes used for the countries displayed in Figure 2 are the following: Algeria: DZA; Angola: AGO; Azerbaijan: AZE; Canada: CAN; Congo: COG; Ecuador: ECU; Gabon: GAB; Indonesia: IDN; Iran: IRN; Kazakhstan: KAZ; Kuwait: KWT; Libya: LBY; Mexico: MEX; Nigeria: NGA; Norway: NOR; Oman: OMN; Qatar: QAT; Russia: RUS; Saudi Arabia: SAU; Syria: SYR. Trinidad and Tobago: TTO; Turkmenistan: TKM; United Arab Emirates: ARE; Venezuela: VEN and Yemen: YEM.

[26] More precisely, Canada ranks the fourth-largest exporter of natural gas, behind Russia, Qatar, and Norway. It exports more than 50% of the coal produced, and is net exporter of electricity.

[27] While overall U.S. crude oil imports are declining, crude oil imports from Canada are increasing. To stressed the deep trade relationship between the two countries, Canada is also the only country to import U.S. crude oil (133,000 bb/d in 2013).

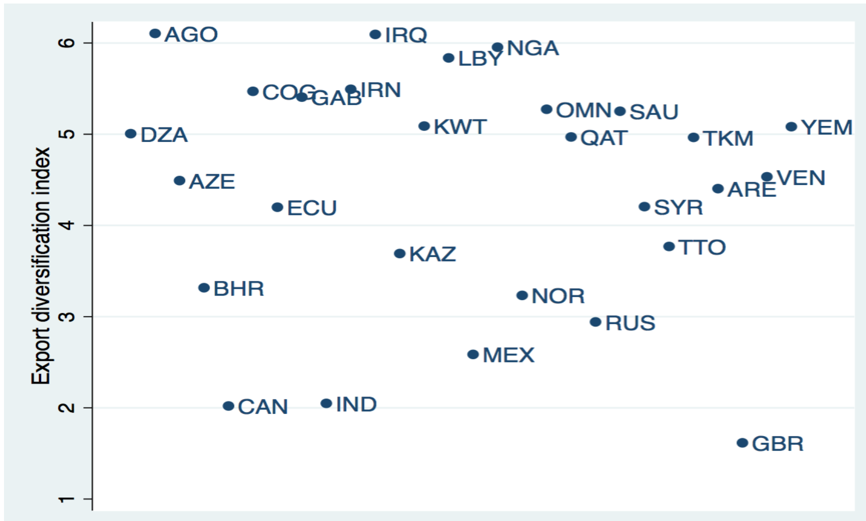
[28] Data are from the U.S. Energy Information Administration.

Table 1: Exports of main oil-exporting countries (percent of total export)

Country	Fuels					Manufact. goods	Others
	Petroleum	Gas	Coal	Electricity	Total		
Algeria	60.61	37.13	0.00	0.01	97.75	1.17	1.08
Angola	96.61	0.61	0.00	0.00	97.22	0.37	2.41
Azerbaidjan	1.35	2.08	0.04	0.72	4.20	77.02	18.79
Bahrain	14.47	0.04	0.06	0.00	14.57	63.82	21.61
Brunei	2.35	0.07	0.02	0.00	2.44	77.97	19.59
Canada	12.38	5.25	1.03	0.59	19.25	54.45	26.31
Congo	3.98	0.06	0.02	0.46	4.06	76.78	19.15
Ecuador	14.04	3.10	0.02	0.46	17.63	70.82	11.55
Gabon	3.59	0.22	0.07	0.00	3.88	76.13	19.99
Indonesia	10.42	9.79	8.34	0.00	28.55	42.25	29.21
Iran	74.46	2.51	0.03	0.04	77.05	11.33	11.62
Iraq	98.07	0.06	0.00	0.00	98.13	0.72	1.15
Kazakhstan	63.22	3.24	1.52	0.09	68.07	13.11	18.82
Kuwait	85.42	4.91	0.01	0.00	90.33	7.96	1.70
Libya	90.88	4.77	0.00	0.00	95.65	3.42	0.92
Mexico	12.86	0.05	0.00	0.07	12.98	76.64	10.37
Nigeria	86.83	7.61	0.00	0.03	94.47	1.78	3.75
Norway	43.28	20.27	0.00	0.45	63.99	18.84	17.17
Oman	64.34	12.26	0.00	0.00	76.61	12.30	11.09
Qatar	46.69	41.04	0.00	0.00	87.73	7.44	4.83
Russia	46.25	13.93	1.98	0.23	62.61	17.16	20.43
Syria	10.39	1.45	0.03	0.17	12.04	62.95	25.01
Saudi Arabia	82.08	3.02	0.01	0.00	85.10	12.76	2.14
Trinidad & Tobago	29.06	0.03	0.05	0.00	29.14	54.96	15.90
Turmenistan	1.16	0.03	0.05	0.00	1.20	85.02	13.77
UAE	53.73	5.13	0.03	0.00	58.89	23.02	18.10
UK	8.78	0.87	0.05	0.04	9.73	70.50	19.77
Venezuela	81.53	0.50	0.73	0.03	82.79	11.85	5.37
Yemen	19.24	0.03	0.07	0.00	19.34	46.75	33.91

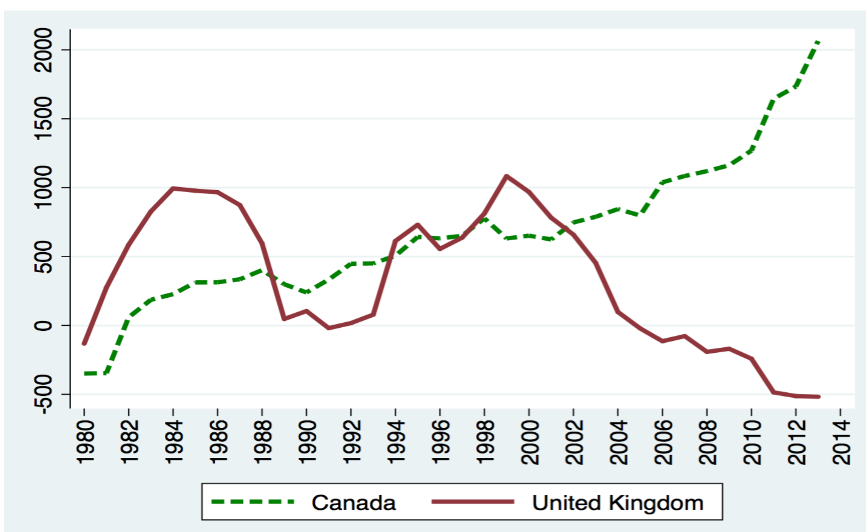
Note: Data from UNCTAD's database on the structure of trade by product.

Figure 2: Exports diversification index for main oil-exporting countries (1982-2010)



Note: This figure reports the Thiel export diversification index average for the period 1982-2010 from the International Monetary Fund (based on an updated version of the UN-NBER dataset). A lower index indicates that the economy is more diversified.

Figure 3: Crude oil trade balance of UK and Canada



Note: This figure reports the crude oil (including lease condensate) trade position of the UK and Canada (i.e. the difference between crude oil exports and imports) over the period 1980-2012 in thousand barrels per day.

3 Empirical methodology

This section described briefly the dataset and the empirical methodology. More specifically, it justifies the theoretical and empirical reasoning of our time-varying framework with sign restrictions.

3.1 Data

The North American crude oil market framework has profoundly changed over time, especially during recent years with the development of the unconventional oil production, in particular "tight" oil from oil-bearing shale formations.[29],[30] Coupled with this rapid expansion of North American crude oil production from unconventional sources, an accumulation of an oil surplus in the U.S. Midwest have lead to a segmentation of the North American crude oil market from the global market.[31] This segmentation has contributed to the increasing divergence between continental benchmark (such as the West Texas Intermediate (WTI)) with seaborne benchmark (such as the Brent). In order to account for such divergence in the impact of oil shocks on current account in Canada, we use the WD commodity price index which is the nominal price of oil computed as the average of the Brent, Dubai Fateh and WTI prices. We then deflated the considered index by the U.S. consumer price index in order to obtain the real price of oil. Data about global oil market or macroeconomic aggregates are described in Appendix C.

3.2 Disentangling shocks in oil price

One important issue when investigating the impact of oil price shocks on current account is to understand the intrinsic nature of the oil price fluctuations. As seen in previous Section, previous studies (expect the one of Kilian et al. 2009) treated oil shock as the same regardless the origin of the fluctuations. This seemingly minor question is yet of primary importance in the literature since it opposes the view in favor of the exogeneity of oil against the one of endogeneity. In this debate, it is now widely accepted that oil prices are not only determined by supply-side factors but also driven by demand conditions (i.e. oil price is mainly endogenous with respect to macroeconomic activity). Indeed,

[29] Three factors have enabled the development of the shale oil revolution, specifically in the U.S., such as a history of shale gas exploitation, a legal and institutional attractive environment, and an advanced oil production infrastructure (see Alquist and Guénette 2014).

[30] The shale oil revolution was also made possible because of a relatively high level of crude oil price during past decade. Indeed, a precondition for the commercial viability of the extraction of tight oil is a price level above about $50 per barrel.

[31] According to Alquist and Guénette (2014), logistical constraints, legal restrictions of the export, and shipping of domestically produced crude oil have segmented the North American market from the global one.

the empirical literature has provided overwhelming evidence that oil prices (and commodity prices in general) have been driven by global macroeconomic activity (see Barksy and Kilian 2002, 2004; Kilian 2008c; Hamilton 2009; Kilian 2009; Alquist et al. 2013; Kilian and Murphy 2014).[32] More importantly, it appears that the effects of demand and supply shocks in the crude oil market on macroeconomic aggregates are different depending on whether the oil price increase is driven by demand from global economic activity, disruption in global production, or by oil-specific demand shock (the so-called speculative demand shock).[33]

Therefore as it is common in the literature, four types of shocks can be distinguished when looking at the effect of oil price on current account: (i) shocks to the flow supply, (ii) shocks to the flow demand for crude oil reflecting the state of the global business cycle, (iii) shocks to the speculative demand for oil stocks above the ground (oil specific demand shock), and (iv) other idiosyncratic oil demand shocks.[34] The economic significance of the supply and demand components on current account is quantified in the structural model developed in Section 3.3.

3.3 The time-varying nature: a TVP-VAR model

There is a considerable evidence in the empirical and theoretical literature that the relationship between oil prices and macroeconomic activity (especially in the U.S.) has been instable over time (see among other, Edelstein and Kilian 2009; Herrera and Pesavento 2009; Blanchard and Galí 2010; Ramey and Vine 2011; Baumeister and Peersman 2013).[35] According to the literature, such time-varying effects may have different features, such as an improved monetary policy (Bernanke, Gertler and Watson 1997; and Blanchard and Galí 2010); a more flexible labour markets (Blanchard and Galí 2007); the changes in oil intensity of economic activity; the changes in the regulation of energy market; the changes in the composition of automobile production (Edelstein and Kilian 2009; Kilian 2009; and Ramey and Vine 2011); or the less elastic global demand curve over time (Baumeister and Peersman 2013).

For the specific case of Canada, several other factors can explain the time-varying nature of the relationship. The canadian economy switched from crude oil net importer to net exporter. Indeed, since the beginning of 1970s the current account has fluctuated over time almost at the same amplitude than the price of crude oil (as we can see on the Figure 1). Moreover, the structure of the crude oil exports has changed recently (and will change in the near future) because economic and political considerations are leading Canada to consider ways to diversify its trading parterns, especially by expanding ties with asian emerging markets. Finally, the time-varying specification is in line with the well known intertemporal nature of the current

[32] One empirical exception is the oil price shock of the 1990s which according to Kilian and Murphy (2014) was mainly supply-driven.

[33] See Kilian 2009; Kilian and Park 2009; Peersman and Van Robays 2009; and Baumeister et al. 2010.

[34] The adequate proxy of these shocks are described in Appendix C.

[35] For a cross-country evidence of this instability see Baumeister et al. (2010).

account viewed as the outcome of forward-looking dynamic saving and investment decisions.[36] Thus, in order to assess the evolution of the oil price pass-through into current account and to distinguish between different sources of oil price shocks within a unified framework, we use the time-varying parameters vector autoregressive (TVP-VAR) model with sign restriction in line with Primicery (2005), Cogley and Sargent (2005), and Baumeister and Peersman (2013).

The model is a multivariate structural VAR representation with both time-varying coefficients and time-varying standard-error of innovations:

$$B_t Y_t = d_t + C_{1,t} Y_{t-1} + \cdots + C_{p,t} Y_{t-p} + \Sigma_t \upsilon_t, \tag{1}$$

where $Y_t = [\Delta \ln(q_t), \Delta \ln(p_{o,t}), mis_t, ca_t]'$ is a vector of 4 endogenous variables. q_t, $p_{o,t}$, mis_t and ca_t denote respectively the global oil production[37], the real oil price, the real exchange rate misalignment and the ratio of current account relative to gross domestic product.[38] The variable d_t is a vector of time-varying constants, $C_{p,t}$ is the matrix of time-varying lag coefficients of the structural model and υ_t is a vector of structural innovations which is assumed to follow a multivariate normal distribution $\upsilon_t \rightsquigarrow \mathcal{N}(\mathbf{0}, \mathbf{I}_n)$.

The introduction of the global oil production permits to control for unexpected changes in the world oil supply caused by exogenous events (such as those coming from the Middle East), and to disentangle demand and supply components of the oil shocks (see Rebucci and Spatafora 2006; and Baumeister and Peersman 2013). From a macroeconomic viewpoint, this is also in line with the literature dating back the 1970s about the dynamic effect of aggregate demand and supply disturbance on macroeconomic adjustments (see Sachs 1982; Blanchard and Quah 1989, to name few). Besides, we introduce the exchange rate misalignment as an indicator of competitiveness to capture the influence of under- and overvaluation on current account.[39] Figure 7 in the Appendix suggests that the competitiveness channel could play an important role for Canada since it clearly shows that the phases of exchange rate overvaluation coincide with a deterioration of the current account, while the phases of exchange rate undervaluation are associated with an improvement in the current account.

We assume that the matrix of time-varying contemporaneous coefficients B_t is lower triangular with one along its diagonal elements and the matrix of standard-error Σ_t is diagonal. That is,

[36] One of the key insights of the intertemporal approach to the current account is that permanent terms of trade shocks have significantly different effects on the current account than transitory shocks.

[37] Note that since the share of canadian oil production is about 5% of the total, the global oil production shock is not endogeneous to the production of the country.

[38] Detailed description of the data can be found in the appendix C.

[39] For more details on the estimation of misalignments of Canada, please refer to the Appendix C.

$$B_t = \begin{pmatrix} 1 & 0 & \cdots & \cdots & 0 \\ b_{21,t} & 1 & 0 & \cdots & 0 \\ b_{31,t} & b_{32,t} & 1 & \ddots & \vdots \\ \vdots & \vdots & \ddots & \ddots & 0 \\ b_{n1,t} & b_{n2,t} & \cdots & b_{nn-1,t} & 1 \end{pmatrix} \text{ and } \Sigma_t = \begin{pmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{n,t} \end{pmatrix}$$

Indeed, changes in the relationship between variables might come from changes in either the contemporaneous relationship, the propagation mechanism or the size of the shock that hits the model. Thus, letting parameters of interest B_t, $C_{p,t}$ and $\sigma_{n,t}$ vary across time let the data determine the nature of changes that affects the relationship between variables in the model.

The reduced form representation of the structural model (1) is defined as:

$$Y_t = c_t + A_{1,t}Y_{t-1} + \cdots + A_{p,t}Y_{t-p} + \epsilon_t, \tag{2}$$

where $A_{p,t} = B_t^{-1}C_{p,t}$ are matrices of lag-coefficients, $c_t = B_t^{-1}d_t$ is the vector of constants and $\epsilon_t = B_t^{-1}\Sigma_t\upsilon_t$ is the vector of reduced-form residuals. Following the structure of the contemporaneous coefficients matrix B_t and that of the standard-error of the structural innovations matrix Σ_t, we can assume that reduced-form residuals follow a multivariate normal distribution $\epsilon_t \rightsquigarrow \mathcal{N}(\mathbf{0}, \Omega_t)$ where Ω_t is a symmetric and positive definite time-varying variance-covariance matrix that verifies the following equality,

$$B_t\Omega_tB_t' = \Sigma_t\Sigma_t' \tag{3}$$

The time paths for parameters of interest are assumed to be random walks without drift.[40] If we denote $b_t = (b_{21,t}\ b_{31,t}\ b_{32,t}\ \cdots\ b_{nn-1,t})'$ the vector column that contains elements of the matrix of contemporaneous relationship B_t, α_t the vector column that contains stacked columns of matrix $A_t = (c_t\ A_{1,t}\ \cdots\ A_{p,t})$, $\sigma_t = (\sigma_{1,t}\ \cdots\ \sigma_{n,t})'$ the vector column that contains diagonal elements of the matrix of standard error Σ_t, and $h_t = \ln(\sigma_t)$ the natural logarithm of the standard error, parameters evolve according to:

$$\begin{aligned} \alpha_t &= \alpha_{t-1} + \omega_t \\ b_t &= b_{t-1} + \zeta_t \\ h_t &= h_{t-1} + \eta_t \end{aligned} \tag{4}$$

This specification presents the main advantage of modeling both the possible abrupt break and a gradual evolution of the relationship between variables. Innovations in the reduced-form

[40] Even though the dynamics of the parameters can be easily extended to a more general autoregressive process, we assume random walk process in order to capture possible permanent shifts.

model are assumed to be jointly normally distributed

$$\begin{pmatrix} \upsilon_t \\ \omega_t \\ \zeta_t \\ \eta_t \end{pmatrix} \rightsquigarrow \mathcal{N}(\mathbf{0}, V) \text{ with } V = \begin{pmatrix} \mathbf{I}_n & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & Q & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & S & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & W \end{pmatrix}$$

where the matrix S is assumed to be block diagonal. That is, we assume that blocks, corresponding to contemporaneous coefficients in each equation, are mutually independent. Each block of S corresponds to the variance-covariance matrix of contemporaneous coefficients of each equation in (1).

3.4 Identification scheme

The structure of the variance-covariance matrix of the reduced-form residuals Ω_t in (3) implies a Cholesky identification scheme restricting the matrix of contemporaneous relationship to be lower triangular. In the literature of oil price studies such as Kilian (2009), it is equivalent to an exclusion restriction. Hamilton (2003) in turn uses a counterfactual experiment to identify oil supply shocks. In this study, we use sign restriction to disentangle oil supply shock from oil demand one.[41]

The sign-restriction approach in this paper is the Householder Transformations method developed by Fry and Pagan (2011), based on QR decomposition of randomly selected squared matrices from a normal distribution $\mathcal{N}(0, I(n))$.[42] As an identification scheme, we assume that after a negative oil production shock, world production decreases while oil price increases. In turn, after a positive oil demand shock, world production is not affected at least on impact (zero restriction) while oil price increases. Kilian (2009) evidenced that aggregate demand shock increases oil production with a delay of 6 months. This is because changes in oil production are costly and, thus, oil producers set their productions on the basis of expected trend growth rather than on variation of world demand. As it is widely accepted in the literature, we assume that an increase in demand for crude oil (precautionary or related to global activity) causes a somewhat sustained increase in the real price of oil that is substantial and persistent (the rise in oil prices holds four quarters following a demand shock).[43] In contrast, crude oil production disruptions is assumed to cause a small and transitory increase in the

[41] In our model specification we do not distinguish the oil demand from the global economic activity to the one from precautionary purpose. This is to deal with dimensionality problem arising from the number of parameters to be estimated.

[42] However, as argued by Fry and Pagan (2011), the difference between Givens Matrices (GM) method and Householder Transformations (HT) method is simply a matter of computational speed. These two methods are equivalent but HT is more efficient than GM in terms of computational speed when the size of VAR grows.

[43] After a precautionary demand shock the price of oil responds immediately while an aggregate demand disturbance causes a somewhat delayed oil price movements (Kilian 2009). Note that our approach does not distinguish the two demands but rather include both of them.

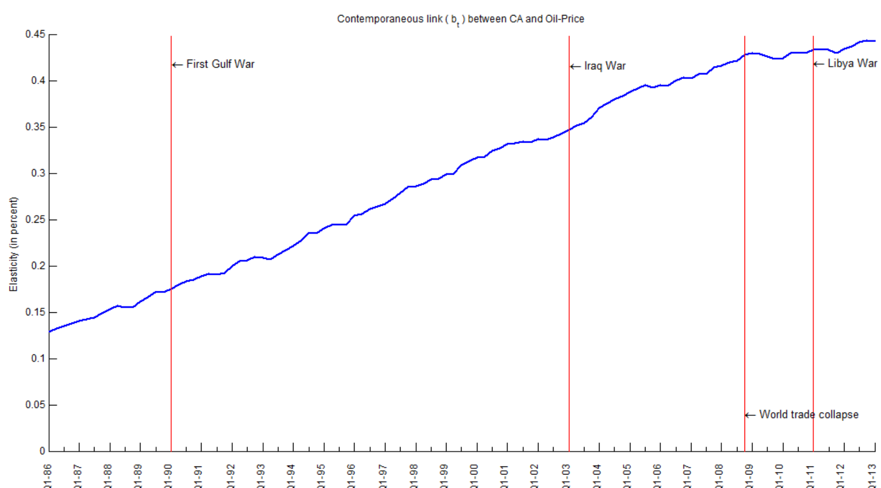
real price of oil within the first year. In this context, we can expect that persistent shocks will affect curent account more significantly than transitory ones. Finally, we assume that the real effective exchange rate misalignment of Canada does not affect directly oil production and oil price.

4 Results

4.1 Current account and oil price relationship

There is considerable evidence in the literature regarding the contemporaneous responses of the current account of oil-exporting countries following an oil price shocks via a positive impact on the terms of trade (see Cashin et al. 2004; Chen and Chen 2007; to name few). For the case of Canada, this fact is confirmed by the Figure 4 where the oil price elasticity of current account has increased positively overtime given the oil-trade balance surplus. It indicates that an oil price increase whatever the origins of the shock will trigger a current account surplus for the Canada.

Figure 4: Contemporaneous relation between CA and Oil price.



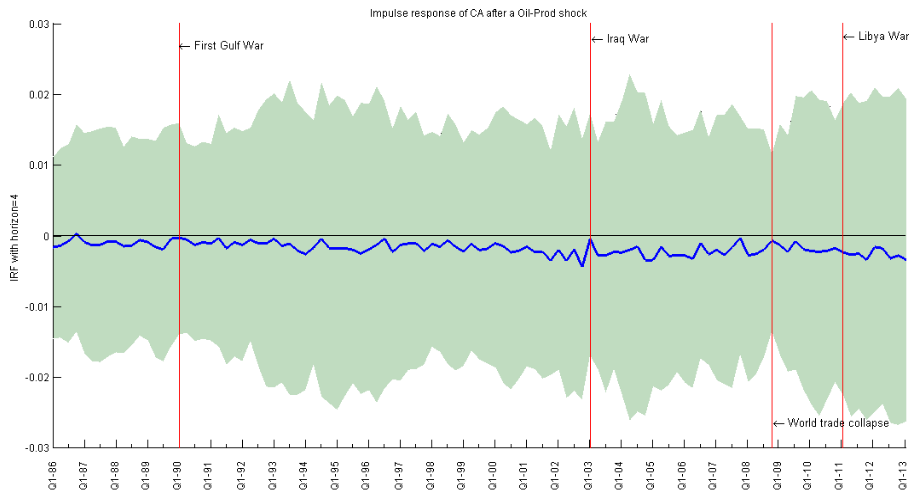
Moreover, the elasticity follows an upward trend with a value that is in general less than one. This indicates that the pass-through of oil price changes to the current account has increased over the considered period as the level of the oil price raise given the high energy demand from emerging countries such as India and China and the limited oil supply capacity (see Rebucci and Spatafora 2006; and Stefanski 2014). It remains that the pass-through is incomplete over the period and that some additional adjustment mechanisms are needed to mitigates the effect of the oil price shocks on the current account. The adjustments at play in the current account go through the non-oil trade balance adjustment. The more the country runs a non-oil trade balance deficit after an oil price increase, the greater extent the initial oil-trade balance surplus is offset. This effect is materialized by the low value of the oil price elasticity of the current account in the Figure 4. The adjustment proportion depends on several external and internal factors. First, as an external aspect, the strength of the oil price movements and the origins of the shocks are of course the most important factor in our context, especially because we now know that not all oil shocks are alike. Second, as internal aspect, the propensity to spend oil-extra revenues on imports, the ability to manage exchange rate reserve, the economic policy, the degree of openness, and the degree of international financial market integration are the main factors. In the next section, we look at the effect of the oil price on current account by disentangling supply and demand shocks, and then we provide a formal assessment of the role of each factors in the adjustments of the trade balance.

4.2 Impulse response function

We assess in this section the responses of the current account to an unexpected rise in oil prices of different nature (such as supply and demand shocks). It is worth mentioning that the size of innovations in our analysis is time-varying. As a consequence, the magnitude of impulse responses depends on the size of the shock hitting the model each period. Therefore, standard approach of depicting responses of variables following a given shock of one standard deviation size is not appropriate in the context of time-varying parameters. In order to make impulse responses comparable across periods, normalization is required. We consider that for each period a negative oil supply generates a increase in the oil price of 1% while a positive demand shocks leads to a 10% increase. In addition, as argued by Baumeister and Peersman (2013), the feedback effet of macreconomic variables following an oil price shocks occurs with a delay of one year. Therefore, the following impulse response functions are the four quarters cumulative impulse response of the current account after an oil supply and oil demand shocks.

Figure 5 depicts the impulse response function of the canadian current account following an oil production shortfall.

Figure 5: IRF of the current account following an oil supply shock.



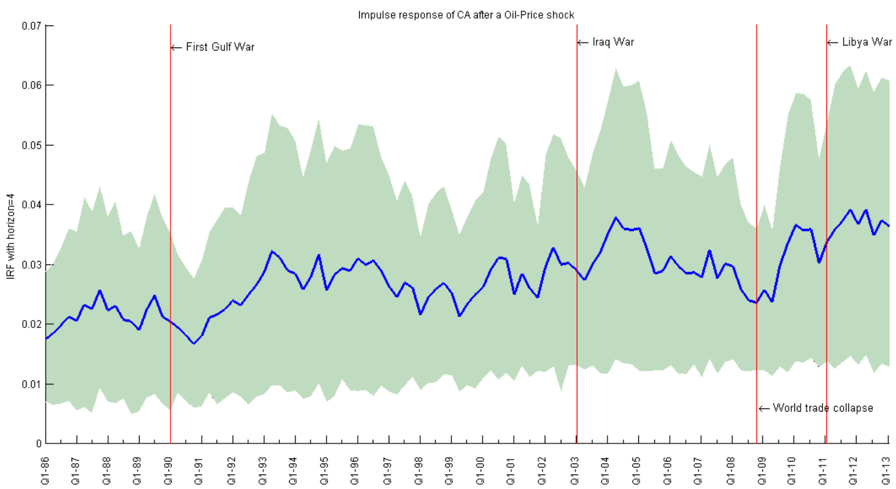
It appears that the world oil production shortfall generates a non-significant negative impact on the current account of Canada over the considered period. Two reflexions can emerge from this observation: (i) most of oil price shocks from 1980s are demand-driven and so the price oil too, then we have a negligible impact of the oil supply shock on current account; and (ii) supply shocks have, by definition, transitory effects on the oil price movements, and so the response of the current account following the shock can only be short-lived. Since 1974, the empirical literature has provided overwhelming evidence that oil prices have been driven by global demand shocks (see Alquist and Kilian 2010 among other). One exception is the 1990s, where the flow supply shocks have played an important role (see Kilian and Murphy 2014). However, even during this period the effect of an unexpected flow supply disruption remains minor leaving further needed discussion regarding the demand channel.

Figure 6 reports the impulse response function of the current account following an oil demand shock.[44] It indicates that oil demand shocks have a delayed but significant and persistent positive impact on current account. Results also reveal that the contribution of the oil demand shock to current account is also different depending on the oil price intensity. For instance, the period that just follows the invasion of Kuwait in 1990, the Afghan war in 2001, and the Iraq War in 2002-03 are episodes characterized by sharp spikes in oil prices and are also those that have lead to important current account fluctuations. This result is even more relevant during the 1990 and 2002-2003 episodes, where the empirical literature has identified evidence of surge in speculative demand for oil (see Kilian 2009; and Kilian and Murphy 2014). The

[44] As discussed in previous Section, a demand shock in our model includes both the demand for precautionary purpose and the one related to global economic activity.

1999 OPEC meeting is, in contrast, associated with small price movements and a rather parsimonious response of the current account. The most interesting episode in the oil market over the last decades is obviously the unprecedented price flucutation during the 2007-2009 recession period. According to a popular view, this price increase was the consequence of speculative behaviors on the market the so-called financialization of oil futures markets and could not be explained by changes in fundamentals (see Fattouh et al. 2013 for an interesting discussion). However whatever the origin of the demand (i.e. precautionary or linked to business cycle) this particular episode has lead to an important fluctuations in the current account of Canada.

Figure 6: IRF of the current account following an oil demand shock.



4.3 The role of adjustment factors

As shown in Figure 6, the magnitude of the oil demand shock pass-through into current account has increased over time on the considered period. However, the pass-through remains incomplete indicating that adjustment factors are at play on the non-oil trade balance. For instance, following a positive oil price shock on current account the non-oil trade balance should vary in an opposive direction with respect to the initial oil-trade surplus. The same reasoning applies when oil price decrease. In order to look which adjustment factors (i.e. the propensity to spend oil-extra revenues on imports, the ability to manage exchange rate reserve, the economic policy, the degree of openness, and the degree of international financial market integration) deal with the initial effect of the oil price fluctuations on the current account, we run two robust OLS regressions that capture the propension of each factors that affect the oil demand shock pass-through into current account. Equation

(a) regresses the oil demand shock pass-through into current account on a set of adjustment factors, such as the propensity to spend oil revenues into imports (MP), the logarithm of foreign exchange reserve (LRES), and the degree of domestic financial market development (DEPH). In order to examine potential monetary policy that controls the pass-through, Equation (b) replaces LRES by the ratio of the foreign exchange reserves to money supply (RES_M2). An increase in this ratio can be interpreted as an attempt to sterilize foreign exchange inflows to avoid overvaluation. By nature, the relationship between RES_M2 and the oil demand shock pass-through should be positive in case of sterilization.[45]

Table 3 reports estimation results of Equations (a) and (b) and shows that the propensity to spend oil revenues into import (MP) has a significant negative influence on the oil demand shock pass-through (in line with Rebucci and Spatafora, 2006; Kilian et al., 2009). However as we have seen, the pass-through has continuously increased over time leaving some space for other tools that Canada could use to adjust the current account. More formally, we uncover that both the degree of domestic financial market development (DEPH) and the management of foreign exchange reserve (LRES) have positive and significant impact on the pass-through. First, the degree of domestic financial market development reflects mechanism behind the accounting identity that links current account to net saving investment. Deeper financial market development allows higher propensity to save for intergenerational equity arguments, precautionary motives and consumption smoothing considerations. Second, the monetary authority may accumulate foreign exchange reserves following oil revenue windfall in order to release appreciation pressure on the real effective exchange rate. It permits to contain domestic price increase that hurts competitiveness of exporting firms and raises imports. Management of foreign exchange reserve allows to control non-oil trade balance deficit and thus, to obtain higher final impact of oil price increase to current account. Results of Equation (b) show the sign and significance of the different explanatory factors remain valid once we control for possible sterilization policy using the variable foreign exchange reserve to M2 ratio (RES_M2).

[45] More details on the macroeconomic data are provided in the Appendix.

Table 2: Oil price demand shock

	(a)		(b)	
	Coefficient	z-Statistic	Coefficient	z-Statistic
MP	−0.92**	−2.33	−0.91**	−2.12
DEPH	0.20***	2.90	0.33***	7.63
LRES	0.35***	2.95		
RES_M2			0.06*	1.65
Constant	−3.28	−1.16	3.91**	2.44
Observation	103		103	
R-squared	0.41		0.38	

Note: Robust Least Squares are used for estimations. *** (resp. **, *): significant at the 1% (resp. 5%, 10%) level.

4.4 Policy implications

As stated previously, oil price surge has been advanced in the literature as the main cause of the recent observed global imbalances. The link between oil prices and current account thus plays an important role both in the academic and policy debates, in particular for oil exporting countries. Indeed, as a natural resources, oil reserves are intended to be depleted. Moreover, it is well known that oil prices are characterized by strong volatility and that oil windfall is temporary by its very nature. In the literature of management of oil revenues, this saving-investment trade-off has lead to a constellation of studies for which Berg et al. (2013) provides a comprehensive and recent review of the literature. In line with this ongoing issue, it is worthwhile to derive some policy implications from findings that are uncoverd in this study. On the one hand, previous results show the important role played by the domestic import-competitive firms in the link between current account and oil prices. If oil revenues are spent on imports, the positive effect of oil price increase on current account will be mitigated. To a certain extent, this finding highlights the benefic impact of diversification on oil exporting countries that is well documented in the literature. On the other hand, our results however show that in a context of diversified economy, as is the case of Canada in this study, the degree of domestic financial development and the management of foreign exchange reserve are positively correlated with the oil prices and current account nexus. The former permits higher propensity to save. Even for developing oil resource-rich countries with higher spending and investment needs, saving a part of oil revenues is necessary for precautionary motives given the volatility of oil prices and to sustain capital built during oil windfall as argued by Berg et al. (2013). In turn, active monetary policy is necessary to contain real exchange rate appreciation pressure. This permits to shield non-oil export firms and domestic import-competitive firms from competitiveness loss.

5 Conclusion

This study revisit the current account and oil price nexus. This is an important issue raised by global imbalances that follow recent oil price surge. More importantly, this is still an ongoing issue. For oil-importing countries, it permits to measure the extent of the negative impact of oil price increase on the economy and to know the different, possibly automatic, adjustment mechanisms that permit to cushion this adverse effect. In turn, for oil-exporting countries, this issue is closely linked to the well-management of oil revenue windfall for intergenerational equity concern and to avoid the phenomenon of "resource curse" that might affect resource-rich countries. The particular characteristic of Canada makes the country-case study in this paper more appealing. Namely, it is classified among the largest oil-exporters but has a sufficiently diversified export structure.

Indeed, there is a large theoretical and empirical studies that treat directly or indirectly this issue which we provide a recent review of the literature. What we have learned from this literature is that positive oil price surge will generate a current account surplus for oil-exporting countries at the expense of oil-importing countries. The magnitude of the relationship, however, will depend on various adjustment factors that are country-specific, which make this subject an outstanding issue. Using an innovative methodology that permits to capture the time-varying nature of the relationship between current account and oil price, and also to distinguish between different sources of oil price innovations, we uncover the following results.

First, during the whole sample period, we estimate a positive relationship between current account and oil price. This finding supports the well-documented evidence that an oil price increase generates a current account surplus for oil exporting countries. Second, oil supply shock has a short-lived and non-significant impact on the current account. Third, oil physical or precautionary demand shock has a delayed but sustained significant positive impact on current account which in addition has increased over time. Fourth, the initial oil-trade balance surplus that follows unexpected demand driven oil price increase might be partially transmitted to current account. Mainly, we uncover that the propensity to import oil revenue has a significant negative influence on the oil demand shock pass-through into current account while the degree of domestic financial market development and the management of foreign exchange reserve have a significant inverse effect.

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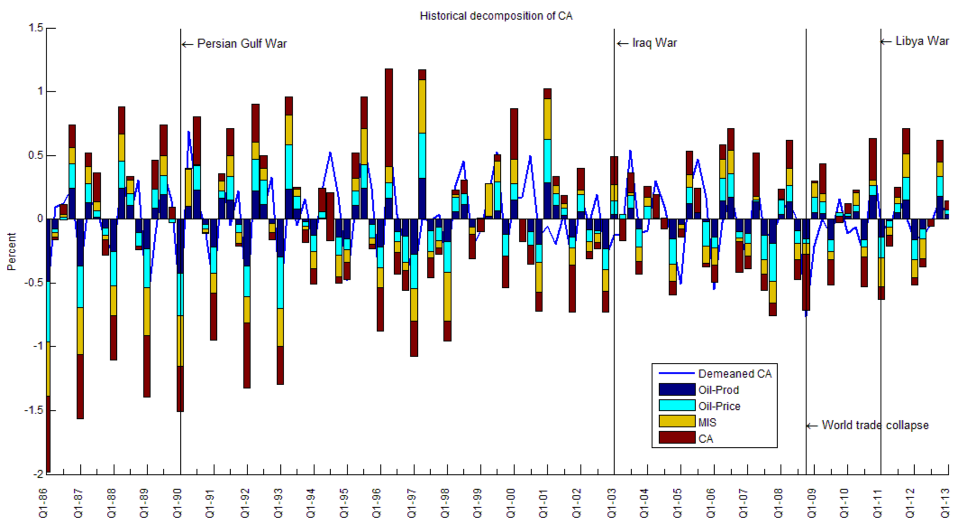
A Figures

A.1 Historical decomposition

Historical decomposition of the current account of Canada is given by:

Figure 7: Historical decomposition of the current account

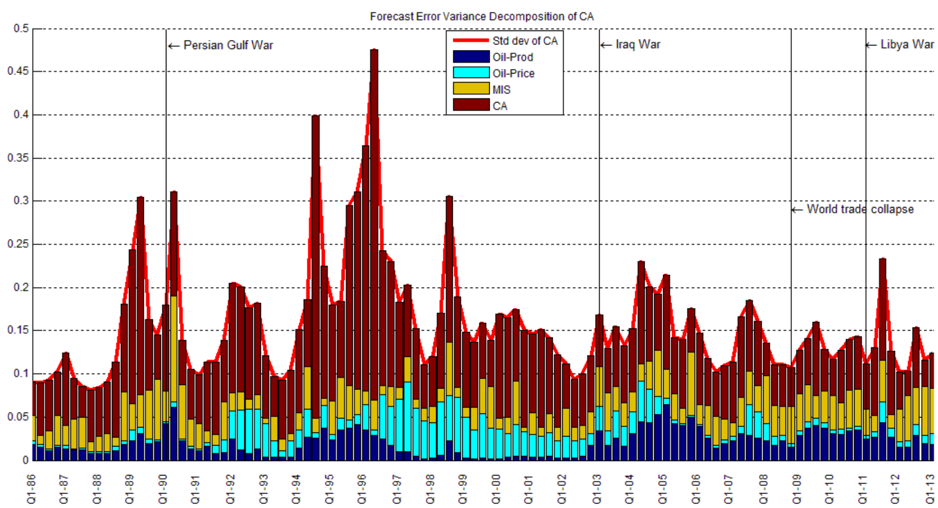


It represents the historical contribution of different variables in the system to the evolution of the current account.

A.2 Forecast error variance decomposition (FEDV)

Forcast error variance decomposition of the current account of Canada is given by:

Figure 8: FEDV of the current account



The standard-error of structural innovations in our analysis are time-varying. The FEDV permits both to analyze the evolution of the size of structural innovations and to measure the contribution of each innovation in the system to this evolution.

B Tables

C Data appendix

In this section, we present a detailed description of the data used in the paper. The sample period of our database is quarterly and covers 49 years from 1964Q1 to 2013Q1. All data are extrated from Datastream or Macrobond databases.

The measure of fluctuation in global economic activity is proxied by the dry cargo shipping index developed by Kilian (2009), the global crude oil production comes from the Energy Information Agency (EIA), and the speculative component of the oil demand relies on data for the U.S. crude oil inventories provided by the EIA.

- q_t: the serie of the global oil production is from the BP Statistic Review of Worl Energy (from Macrobond). The serie starts from 1973Q1. We therefore use interpolated version of the annual series "WD Oil Production - World VOLN" from Datastream (code: WDOPPOI) to approximate its value before 1973Q1.

- $p_{o,t}$: the series of nominal oil price is the "WD Commodity Prices: Crude Oil nadj (2005=100)" from Datastream (code: WDQ76AADF). It is the average of U.K. Brent, Dubai and West Texas Intermediate end of period prices in USD. This series is deflated by the United States consumer price index to obtain the real oil price used in the estimation.

- The CPI index used as deflator is the "United States, IMF IFS, Interest Rates, Prices, Production & Labor, Consumer Prices, CPI All Items City Average, 2005=100" from Macrobond.

- mis_t: the series of exchange rate misalignments. Roughly speaking, exchange rate misalignments are defined as the difference between the observed real effective exchange rate and its estimated equilibrium level. The latter is derived from the estimation of a cointegrating relationship between the real effective exchange rate ($reer$) and its two usual determinants, namely the net foreign asset position (nfa) and a proxy for relative productivity ($prod$). This approach is based on a simple stock-flow model, following Alberola et al. (1999) and Bénassy-Quéré et al. (2009, 2010) among others. The estimation of misalignments is given by:

$$mis_t = reer_t - \widehat{lreer}_t = lreer_t - \underset{(4.68)}{1.23}nfa - \underset{(5.78)}{2.16}lprod$$

The equilibrium exchange rate ($\widehat{lreer}_t$) is estimated by the Dynamic OLS (DOLS) method and t-statistics are in parentheses. $prod$ and $reer$ are taken in logarithms while nfa is as percentage of GDP. Before estimating the long-term relationship between the real effectif exchange rate and its fundamentals, the preliminary tests of unit root and cointegration have been made. Their results are shown in the tables below:

Table 3: Unit root test and Cointegration test

ADF Unit root test (a)			
	Level	First difference	
Variables	t-Statistic	t-Statistic	Conclusion
$lreer$	-1.49	-9.91	I(1)
nfa	-1.53	-15.05	I(1)
$lprod$	-0.80	-15.52	I(1)
Engle and Granger cointegration test (b)			
	$\|t - Statistic\|$	Engle and Yoo critical value at 5%	
$residues$	4.30	3.78	I(0)

Note: (a) The results show that the three series are not stationnaries and are integrated of order 1. KPSS tests also confirm these results.
(b) The results also confirm the existence of a cointegrating relationship between the real effective exchange rate and its long-term fundamentals.

- The real effective exchange rate (REER) comes from the database of the Bank for International Settlements (BIS), narrow indices comprising 27 economies, with data from 1964 (100=2010). The real effective exchange rate is defined as the weighted average of bilateral exchange rates adjusted by relative consumer prices.

- nfa_t: the series of nets foreign assets (as a Percentage of GDP) used in the estimation of misalignments. The NFA are from the IMF database on International Financial Statistics (IFS) and are provided by Macrobond.

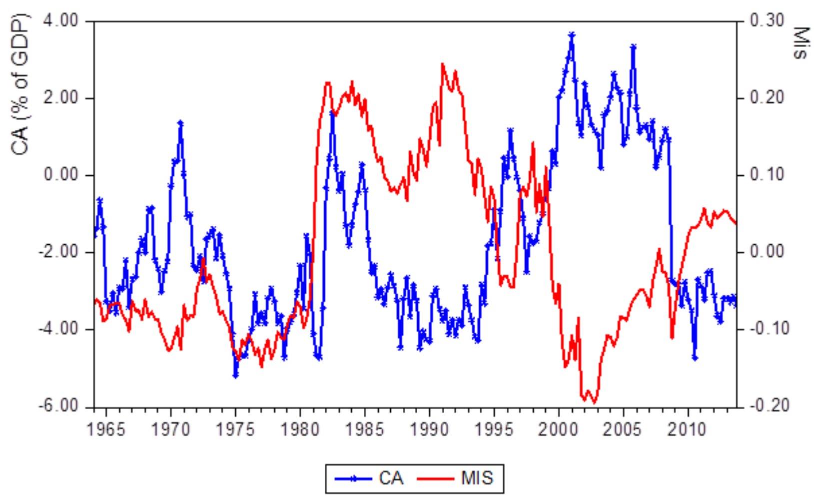
- $prod_t$: the series of relative productivity. Prod is the level of GDP per capita PPP-adjusted measured in relative to a weighted-average of GDP per capita PPP-adjusted of Canada's trading partners (the same as those used in REER calculation).

- ca_t: the series of the ratio of current account to gross domestic product is the "OECD MEI, BOP Current Account as a Percentage of GDP, SA" from Macrobond. This series starts only from 1990Q1. To obtain previous values, we backcast the series using the "Current Account Balance, as a Percentage of GDP, OECD Economic Outlook, Estimate, Calendar Adjusted, SA" from macrobond.

- MP: A measure of the propensity to spend oil revenues into imports. This is the ratio between import expenditure (at constant prices) and oil export revenues (at constant prices). Data come from Statistics Canada.

- $DEPH$: A measure of the degree of domestic financial market development. This is the amount of credit extended by domestic banks to the private sector to GDP. Data on loans granted come from the Bank for International Settlements (BIS) and are obtained from Macrobond.
- $LRES$: Logarithm of official international reserves. The data are from International Financial Statistics (IFS) of the IMF.

Figure 9: Exchange rate misalignmeents and current account in Canada



D Bayesian inference

As in Cogley and Sargent (2005), parameters of interest A_t, B_t and Σ_t, are expressed in a state-space representation. Using the reduced form equation (2), the law of motion of parameters (4) and the normality assumption of innovations v_t and w_t, lag coefficients A_t have a linear Gaussian state-space representation. In turn, lower triangular, diagonality and bloc diagonality assumption of B_t, Σ_t and S respectively, ensure a linear-Gaussian state space representation of contemporaneous coefficients. Therefore, joint posterior density for A_t and B_t is a product of independent normal distribution. However, standard error coefficients Σ_t can be transformed into linear state-space representation which is no longer Gaussian. Instead, they are distributed as $\ln\left(\chi^2(1)\right)$. As in Kim et al. (1998), $\ln\left(\chi^2(1)\right)$ distribution can be approximated with a mixture of 7 normal distributions.

The entire sequence of parameters of interest A_t, B_t and Σ_t is generated via forward and backward recursion of Kalman filter using Gibbs sampler. Namely, estimates of parameters are obtained using Carter and Kohn (1994) simulation smoother.

D.1 Priors

Specifications of prior distribution in this paper follow Primiceri (2005). Initial value for time-varying parameters and variance-covariance matrices are assumed to be mutually independent. An initial training sample of 80 observations are used to generate OLS point estimates of the parameters of interest. Priors of the initial value of the reduced form VAR parameters A_0, the contemporaneous coefficients B_0 and the logarithm of volatilities $\ln \Sigma_0$ are assumed to follow a normal distribution with mean equals to the corresponding OLS estimates of the parameter and variance equals to four times the corresponding OLS variance for A_0 and B_0, and equals to the identity matrix for $\ln \Sigma_0$. That is,

$$\begin{aligned} \alpha_0 &\rightsquigarrow \mathcal{N}\left(\hat{\alpha}_{ols}, 4 \cdot V\left(\hat{\alpha}_{ols}\right)\right) \\ b_0 &\rightsquigarrow \mathcal{N}\left(\hat{b}_{ols}, 4 \cdot V\left(\hat{b}_{ols}\right)\right) \\ h_0 &\rightsquigarrow \mathcal{N}\left(\hat{h}_{ols}, \mathbf{I}_n\right) \end{aligned}$$

Priors of different blocks of the variance-covariance matrix V, in turn, are assumed to be independent and to follow an inverted Wishart distribution. That is,

$$\begin{aligned} Q &\rightsquigarrow \mathcal{IW}\left(k_Q^2 \cdot 80 \cdot V\left(\hat{b}_{ols}\right), 80\right) \\ S_{[i]} &\rightsquigarrow \mathcal{IW}\left(k_S^2 \cdot (i+1) \cdot V\left(\hat{b}_{ols}\right), (i+1)\right) \\ W &\rightsquigarrow \mathcal{IW}\left(k_W^2 \cdot (n+1) \cdot \mathbf{I}_n, (n+1)\right) \end{aligned}$$

where $k_Q^2 = 0.01$, $k_S^2 = 0.1$, $k_W^2 = 0.01$, n is the number of endogenous variables in the system and $S_{[i]}$ corresponds to the i^{th} block of the matrix S. Notice that these priors assumption, together with random walk assumption in (4), imply normal priors on the entire sequences of A_t, B_t and Σ_t conditional on Q, S and W. Set this way, priors are not flat but sufficiently diffuse and uninformative to let data determine the best estimates of parameters.

D.2 Posterior distribution

Given that the state-space models of parameters of interest are linear and Gaussian, posterior distributions of the state variables $\alpha_t|Y_t, B_t, \Sigma_t, Q$, $b_t|Y_t, \alpha_t, \Sigma_t, S$ and $h_t|Y_t, \alpha_t, B_t, W$ are generated using forward and backward recursion of Kalman filter. Variance-covariance matrices Q, S and W are generated from their respective independent posterior distributions which are assumed to follow an inverted Wishart distribution. That is,

$$
\begin{aligned}
Q|Y_t, A_t, B_t, \Sigma_t &\rightsquigarrow \mathcal{IW}\left(\left(\sum_{t=p+1}^{T} \omega_t\omega_t' + \underline{Q}\right), (T-p+\underline{q})\right) \\
S_{[i]}|Y_t, A_t, B_t, \Sigma_t &\rightsquigarrow \mathcal{IW}\left(\left(\sum_{t=p+1}^{T} \zeta_{[i]t}\zeta_{[i]t}' + \underline{S_{[i]}}\right), \left(T-p+\underline{s_{[i]}}\right)\right) \\
W|Y_t, A_t, B_t, \Sigma_t &\rightsquigarrow \mathcal{IW}\left(\left(\sum_{t=p+1}^{T} \eta_t\eta_t' + \underline{W}\right), (T-p+\underline{w})\right)
\end{aligned}
$$

where $\underline{Q}$, $\underline{S_{[i]}}$ and $\underline{W}$ are positive definite scale matrices from the inverted Wishart prior distributions of Q, block matrix $S_{[i]}$ of S and W, and $\underline{q}$, $\underline{s_{[i]}}$, $\underline{w}$ their respective degree of freedom.

D.3 Markov Chain Monte Carlo (MCMC) algorithm

To resume, the Markov Chain Monte Carlo (MCMC) algorithm takes the following form:

1. Specify the initial sequence of A_t, B_t, Σ_t, D_t and V.
2. Generate the states α_t conditional on Y_t, B_t, Σ_t and Q using Kalman filter for $t = 1, \ldots, T$.
3. Generate off-diagonal elements b_t of the contemporaneous matrix B_t conditional on Y_t, α_t, Σ_t and S using Kalman filter for $t = 1, \ldots, T$.
4. Generate volatilities σ_t conditional on Y_t, α_t, b_t, D_t and W using Kalman filter for $t = 1, \ldots, T$.
5. Generate a new selection matrix D_t by sampling from $P\left(d_{it} = k|Y_{it}^{**}, h_{it}\right)$ conditional on Y_t, α_t, b_t, σ_t for $t = 1, \ldots, T$.
6. Generate variance-covariance matrix V by sampling from independent inverted Wishart distribution.
7. Check for stationarity of the VAR, and if, and only if, it is the case, store parameters of interest.
8. Go to step 2.

It is worth noting that step 7 is implemented in order to ensure that realizations of the VAR are stationary and only stationary draws are accepted and stored.