Quantifying Economic Interdependence between Canada and the United States: A GVAR Analysis

by

Katarina Wasielewski

An essay submitted to the Department of Economics
in partial fulfillment of the requirements for
the degree of Master of Arts

Queen's University
Kingston, Ontario, Canada
August 2019

Acknowledgements

I would like to thank Professor Beverly Lapham for her support in writing this paper. Your aid through the frustrations and joys of research was invaluable to the completion of this essay. Gratitude also goes to friends from whom I learned the most and who constantly provided practical assistance this year. And my family, thank you for the unconditional support and confidence boosting; it is well reflected in my academic career to date.

Abstract

In this paper, economic interdependence between Canada and the United States is analyzed by considering the employment impact of their trade relationship. This paper uses an empirical global vector autoregression (GVAR) model to investigate the employment impact of trade between the US and the ten Canadian provinces. A negative shock to imports results in adverse effects for employment, exports, and GDP levels for all regions. This analysis provides estimates of the magnitude of adverse effects on local economies of a fall in trade volumes, with the understanding that effects will likely be substantially worse in the case of a cessation of trade. The estimates of a one standard deviation fall in imports are that the US experiences a 0.4% decline in current employment while provincial impacts range from approximately a 0.05% to a 0.2% decline in current employment. The conclusions drawn from results of the dynamic analysis suggest that jobs on both sides of the border are significantly supported by current trade levels. There is a high degree of economic interdependence between Canada and the United States, and to maintain economic stability in both countries the current trade relationship must be preserved.

Contents

1 Introduction

In this paper, economic interdependence between Canada and the United States is analyzed through the quantification of the employment impact of ongoing bilateral trade. Dynamic impact analysis is conducted to estimate the effect of a trade shock on employment and other economic variables in this environment to address the proposed question. This analysis is relevant to the literature given the current global trade climate and ongoing trade-related tensions between Canada and the US which make it pertinent to understand the effects of trade shocks.

The globalized world has important consequences for local economies. Global economic events are increasingly affecting economic outcomes for individual countries and it is essential to understand and quantify the interdependencies economies may have to guard against adverse impacts. Trade between countries is a primary reason economies have become so integrated as global trade levels continue to rise and new trade agreements are negotiated. Understanding the linkages created by trade will lead to more effective policy and governance, better securing the economic futures of countries.

Global trade has also been subject to economic turmoil in recent years, as protectionist policies threaten to destabilize ongoing trade and long established cross-country value chains. Concerned economists and researchers have actively pursued analysis of the potential global and local impacts of these relationships deteriorating. This includes considering the impacts on a number of key variables, such as employment and GDP, using a variety of empirical methods. Many analyses have focused on identifying the number of jobs trade created, i.e. with the implementation of a new free trade agreement, or how much of a GDP boost countries received when trade barriers were lowered. But recent shifts by countries, particularly the United States, to less open trading positions have made it relevant to consider the debate about trade and its effect on employment from the perspective of increasing barriers to trade. Focus has moved to the more nuanced question of how many jobs are tied to ongoing trade or supported by it. For a job to be supported by trade it does not have to be in a directly trade exposed industry. This type of analysis accounts for more indirect links between trade and employment and speaks to the impacts of reversing current trading positions. Opinions vary on the precise employment impacts of trade shocks, but a consensus remains that adverse effects will be felt to some extent. The uncertainty about effects leaves room for additional research and analysis in this area.

I propose to use the global vector autoregression (GVAR) framework as a new approach to quantifying the employment impact of Canada/US trade. The model includes the US and ten Canadian provinces, and models trade across the Canada/US border from 1997 to 2019. The structure of the proposed model allows for linkages between employment and trade levels, consistent with theories of economic integration. Economic impact analysis is designed as a trade shock to the Canada/US trading environment to capture the corresponding effect on employment and other key variables.

Impact analysis conducted using the empirical GVAR model results in important findings on this topic. A trade shock of a one standard deviation decline in imports for all units is designed to estimate the number of jobs supported by trade. All Canadian provinces and the US experience job losses when this shock is imposed, however the magnitude of effects varies across units in the model. The US experiences a 0.4% decline in employment from current levels, whereas provincial impacts range from approximately a 0.05% to 0.2% decline in employment. This employment response suggests that employment on both sides of the border is dependent, at least in part, on the continuing trade relationship. Likewise, the trade shock results in a decline in GDP and exports for all units in the model. Taken in combination with the estimated employment effects, there is clear economic interdependence between Canada and the United States as a result of their substantial bilateral trade.

This evidence provides insight into the potential effects of a larger trade shock or even a potential reversal of openness to trade. It also provides insight into the magnitude of adverse effects from a trade shock, rather than just the direction of effects. Knowledge of the number of jobs supported by ongoing trade and the way employment levels would be affected in the absence of this trade should play a role in current and future policy decisions that affect the Canada/US trading relationship.

This paper contributes to a growing area of the literature by concluding that Canada and the US have become highly economically integrated as a result of bilateral trade in the NAFTA era. Additional research in this area, as discussed in this paper, would take this analysis further to consider the employment impact on an even more disaggregated level.

The paper begins with a brief review of the relevant literature, covering research on the Canada/US trade relationship, the employment impact of trade, and previous uses of the GVAR methodology. Section 3 presents the methodology, including a detailed explanation of the theoretical structure of the GVAR model and its solution. The theory behind dynamic analysis under the GVAR framework is also described, specifically the type of impulse response analysis used in this paper. The GVAR analysis also requires a number of specification tests to consider model stability and suitability. The specifics of each test are discussed as part of the methodology. Lastly, the empirical setup of the GVAR for this analysis is presented, as well as the sources of data used in the modelling process. The results are discussed in section 5 and include specification test and dynamic impact analysis results. The relevant figures are included in this section to support conclusions drawn. Other supporting figures and tables can be found in the appendix.

2 Literature Review

Historically, trade relationships were discussed in terms of deficits and surpluses, with exports being good for the economy and imports bad. This view belongs to mercantilism trade theory which was developed between the sixteenth and nineteenth centuries.[1] Mercantilists believed that nations with trade surpluses would have successful domestic industries that would in turn boost economic wealth. This led proponents of the theory to favour the active protection

[1] Cohen et al (2003), page 50.

of industries considered vital to economic success.[2] Trade theory and analysis has advanced beyond this view of trade as a zero-sum framework, and prevailing theories consider the economic impacts of trade in more nuanced ways. But mercantilist type views of trade have resurfaced in the protectionist policies advanced by the current US administration.

Many economists reject this protectionist based trade and foreign policy in favour of considering the importance of cross-border value chains to local economies.[3] Conventional measures of trade, like volumes of trade, no longer provide a full understanding of trading relationships and this understanding has led to the development of the value chain approach.[4] Value chains are the activities necessary for a firm to produce a product or service. Increasingly firms are moving parts of this production process to different countries and relying on free trade to move intermediate products from one stage to the next, creating cross-border value chains.[5] When trade policy is designed based on a country having a trade surplus or deficit, the benefit of these cross-border value chains is missed. Analyzing value chains in the context of trade has important implications for how we interpret the employment and other economic impacts of bilateral trade.

Economic theory has extensively considered the interrelations between trade and labour outcomes. It is well documented that trade openness affects a number of labour market variables, including employment levels, and that trade shocks result in noticeable adjustments in local labour markets. Employment and other labour indicators are also more meaningful to the economy compared to monetary valuations of merchandise and services trade. Labour market effects also highlight the interdependence between economies that develop from ongoing trade and cross-border value chain creation. This type of traceable effect transferred through economic transmission channels indicates the dependency countries have on existing trade levels to support employment. The employment impact of trade is potentially quite different in the context of cross-border value chains. It is no longer only the jobs in directly

[2] Ibid, page 51.
[3] Laura Adkins-Hackett, PNREC (2018).
[4] Armstrong and Burt (2012).
[5] Armstrong (2011), page 1.

trade exposed industries that are tied to trade levels, but also those in the value chains that have indirect trade exposure. This advancement in how trading relationships are studied has affected the way labour market outcomes of trade are quantified. Without considering value chains created by trade, and how jobs are supported by trade in that context, improper views of trading relationships like mercantilism prevail. Public policy based on mercantilist type views of trade are insufficient to address current trade related concerns.

Given the abundance of analysis and theoretical work done on the connections between employment and trade, there are a number of opinions on the resulting outcomes. Presumably, an increase in trade between countries happens because it is advantageous. Proponents of comparative advantage trade theory suggest that trade allows for an efficient use of resources in each local economy such that prices are lowered, consumers benefit, and there are gains from trade.[6] This theory also suggests that trade results in positive aggregate labour outcomes in the long run.[7] Other theories disagree on the mechanisms of why countries engage in trade and on short-run effects on employment. Regardless of whether theory predicts a positive shock to labour outcomes in an industry or a negative one based on a country's openness to trade, the employment impact of a bilateral trade relationship provides important evidence for the interdependence of trading partners.

The close economic relationship between Canada and the United States has developed over many years of economic interaction. Beginning in 1989 with the Canada-United States Free Trade Agreement (CUSFTA), Canada and the US have become continuously more integrated as a result of increasing trade levels. This continued with the implementation of the North American Free Trade Agreement (NAFTA) in 1994 which superseded CUSFTA and included Mexico. Recent political tribulations that have threatened the future of the Canada-US trading relationship make it invaluable to understand the effect a decline in trade would have on local economies. This knowledge can be used to support a number of policy initiatives and provide insight into regional economic interdependence in North

[6] Jansen et al (2007) page 19.
[7] Hiebert and Vansteenkiste (2007).

America. Additionally, it could provide decision-makers with knowledge that may help Canada diversify its trading partners.

In the literature, the free trade relationship between Canada and the US has been quantified in many ways to highlight the inter-connectivity of the two economies. Dixon and Rimmer (2014) analyzed the impact of bilateral trade on US employment with the intention of quantifying the number of jobs that are exposed to trade with Canada.[8] Modelling a complete cessation of trade, they use a dynamic CGE model designed for this purpose with 2013 trade data. They find that a cessation of Canada/US trade results in a GDP and employment decline of 6.47 and 4.54 percent respectively.[9] From this they conclude that trade with Canada has a profound effect on the US economy, and the labour market effects of a cessation in trade would be widespread throughout the US, covering all states and the District of Columbia.

Similar results are found in a US Chamber of Commerce study on US free trade agreements which highlights a significant dependence of US employment levels on continued trade with Canada.[10] Using the Global Trade Analysis Project model, the authors estimate that around 60 percent of the US' realized gains from all FTA's comes from their trade relationship with Canada.[11] This implies that the majority of the 5 million jobs gained and billions of dollars in GDP impacts from moving to free trade are attributable to Canada.[12]

A number of papers have been written on the economic, and specifically labour, impact of implementing NAFTA. An OECD Working Paper presents an overview of the predicted effects of NAFTA on employment by a variety of studies.[13] Many predicted employment impacts in the US using theory, but there are some empirical studies discussed that cite overall realized employment gains from trade.[14] This includes Almon (1990) who concluded

[8] Dixon and Rimmer (2014).
[9] Ibid, page 1.
[10] Baughman and Francois (2010).
[11] Ibid, page 13.
[12] Ibid, page 12.
[13] O'Leary et al (2012).
[14] Ibid.

employment gains of NAFTA implementation would outweigh losses using macroeconomic forecasting models.[15] Huffbauer and Schott (1992) varied in their assessment, citing a 175,000 job gain in the US resulting from NAFTA using a CGE model.[16] These estimates are all forward-looking, having been made prior to NAFTA's implementation, but highlight the potential employment impacts of increased Canada/US trade. Studies conducted after the signing of NAFTA showed small or negligible employment gains were realized in the US from its implementation.[17] This type of trade analysis does not provide a full picture of the employment impact of Canada/US trade because it does not account for how jobs could come to be supported by trade over time. It is prudent to consider the employment impact if NAFTA was revoked, or trade between Canada and the US ceased, which would highlight the interdependency that has developed over the length of the trading relationship versus only considering the short term impacts of a new agreement.

Of particular interest is the analysis done by Dan Ciuriak et al (2017) considering the economic impact of terminating NAFTA.[18] The authors estimate that this trade shock would result in the loss of thousands of jobs on both sides of the border. The analysis also finds profound effects of a cessation of trade on all NAFTA partners, but the authors suggest that the true impact is likely to be worse as adjustment costs are unaccounted for in their analysis.[19] A revocation of NAFTA would likely lead to considerable uncertainty for member countries, further emphasizing the negative impacts predicted.[20] Further to this, the study does not directly account for the extensive cross-border value chains that have developed and expanded since NAFTA's implementation, also leading to more negative impacts than expected.[21] Employment effect predictions by Curiak et al (2017) are evidence of the high degree of economic integration between Canada and the US resulting from trade.

[15] Ibid, page 22.
[16] Ibid, page 23.
[17] Ibid, page 25.
[18] Ciuriak et al (2017).
[19] Ibid, page 16.
[20] Ibid, page 17.
[21] Ibid.

In an earlier empirical analysis, Ciuriak (2008) considers the distributional economic effects of NAFTA implementation.[22] When NAFTA came into effect there were job losses in Canada and an overall decline in the labour force participation rate.[23] This adjustment of Canada's labour force continued for the next decade, as employment levels were responsive to the new trade structure.[24] Ciuriak (2008) notes that there are negative employment effects of implementing free trade agreements, and that it is somewhat unclear at what point these short-run costs are overcome by the long-term gains.[25] From Ciuriak et al (2017) and Ciuriak (2008) it is clear that Canada and the US experienced job losses when NAFTA was implemented, but once it was in place the Canadian and US economies became integrated such that a reversal of these agreements would likewise be harmful to employment in both countries.

The short-run adjustment costs versus the long-run gains of a reduction in barriers to trade are also considered by Trefler (2004) in the context of the Canada-US free trade agreement (CUSFTA). Trefler finds strong evidence that the implementation of the first free trade agreement between Canada and the US resulted in Canadian employment losses of 5-15% depending on the sector considered.[26] Like Ciuriak (2008), this finding suggests that there are negative employment effects of moving to free trade as industries adjust to being exposed to trade. This is balanced with long-run gains realized in the form of labour productivity increases of approximately 17% over the FTA-period defined as 1988-1996.[27] The findings suggest that industries and employment levels adjust to the new trade structure when trade liberalization occurs. This implies that a disruption to trade levels could also result in adverse employment effects since the employment structure is at least to some extent defined by ongoing trade.

[22] Ciuriak (2008).
[23] Ibid, page 6.
[24] Ibid, page 6.
[25] Ibid.
[26] Trefler (2004), page 37.
[27] Trefler (2004) defines this period as the FTA-period, as opposed to the pre-FTA period of 1980-1986, found on page 13.

The longtime integration of the Canadian and US economies has engendered a number of analyses focusing on the trade and labour market relations. These analyses have also taken on a variety of forms, as evident above.[28] Global vector autoregressive models (GVARs), as proposed by Pesaran et al (2004), are adept at modelling the global economy, overcoming problems faced by other global macroeconomic models.[29] GVAR modelling was initially intended for credit-risk analysis in light of the 1997 Asian financial crisis, but its further applications became readily apparent.[30] Using a combination of time series, panel data, and factor analysis, the GVAR methodology is used to address a variety of economic questions from finance to policy. Several characteristics of GVAR models make them appealing for assessing global economic questions. This includes capturing interdependence on a variety of levels, long-run relationships consistent with theory, and short-run relationships based on collected data. An additional benefit is that it provides a consistent resolution to the curse of dimensionality often faced in global modelling - the rapid increase in the number of parameters to be identified as the dimension of the model increases.[31] The usefulness of the GVAR model is its flexibility as a framework. It can be used for forecasting or for impulse response analysis, and since it is a closed system these properties make it ideal for scenario analysis.[32]

GVAR models capture interactions between economies and account for transmission channels making them adept to analysis of economic interdependencies. The modelling technique has frequently been used to assess trade related scenarios, specifically using the impact analysis function of the framework. Examples include modelling global trade flows to investigate underlying factors as done by Bussiere et al (2012).[33] Their paper cites two benefits of the GVAR model for trade related analysis. The first is that it captures international linkages,

[28] For example CGE, GTAP, and others.
[29] Chudik and Pesaran (2014).
[30] Ibid, page 1.
[31] Ibid.
[32] Ibid.
[33] Bussiere et al (2012).

and the second being that it models exports and imports jointly.[34]

Other trade related research includes Çakir and Kabundi's (2011) analysis of trade shocks from the BRIC countries to South Africa using the GVAR methodology.[35] The application of the GVAR model focuses on assessing South Africa's integration into the global economy, and its resulting susceptibility to trade shocks.[36] Hiebert and Vansteenkiste (2007) examined the effect of trade openness on US employment by designing the GVAR model to capture various US manufacturing sectors. An example of the flexibility of the unit structure of the GVAR model, their results suggest trade openness in each sector has a corresponding effect on the employment level in that sector.[37]

Applications of the GVAR framework to the Canada/US economic relationship include financial shock transmission analysis by Beaton and Desroches (2011).[38] Analysis by Kuszczak and Murray (1987) pre-dates the introduction of the GVAR model, but their use of VAR type analysis to study the economic integration between the economies suggests its suitability to the topic.[39]

Analyses such as the above show the GVAR framework to be suitable for addressing the employment impact of Canada/US bilateral trade and economic interdependence. These applications of the GVAR analysis motivate its use in this paper. This paper is an addition to the GVAR analysis previously done as it considers trade and the employment impact thereof for Canada and the US.

3 Methodology

This section presents the GVAR methodology, including the theoretical derivation of the model and its solution. The theory behind dynamic analysis within the GVAR framework

[34]Ibid.
[35]Çakir and Kabundi (2011).
[36]Ibid.
[37]Hiebert and Vansteenkiste (2007).
[38]Beaton and Desroches (2011).
[39]Kuszczak and Murray (1987).

is also discussed, specifically the derivation of the generalized impulse response functions which are the result of impact analysis. This paper will use the notation of Smith and Galesi (2014) which is based on the original model by Pesaran et al (2004).[40] In section 4.3 the specification tests relevant to the GVAR model are presented to complete the theoretical setup of the model.

3.1 Theoretical GVAR Framework

The theoretical GVAR model is based on the original model presented by Pesaran et al (2004).[41] Chudik and Pesaran (2014) describe the GVAR model as a two-step process. First, unit-specific small-scale models are estimated while conditioned on the rest of the world. Included in these models are a set of domestic variables and weighted cross section averages of foreign variables (the star variables). The aforementioned curse of dimensionality problem is resolved by using these conditional models, linked together with cross sectional averages, rather than relying on large dimensional VARs.[42] The final step requires stacking these individual unit models and solving them simultaneously as a global model. Impact analysis and forecasting are then done using the solution of the GVAR model. The flexibility of the GVAR is that the individual units within the model need not be countries, but could also be regions, industries or other unit categories.[43] The literature has even gone as far as to propose mixed cross section models in which country data could be linked with industry level data for example.[44]

The assumption of weak exogeneity is key to the GVAR framework because it facilitates the estimation of the individual VARX* models before solving simultaneously for the endogenous variables in the system. Weak exogeneity applies to the foreign (star) variables, which are considered weakly exogenous or long-run forcing in the model.

[40] Smith and Galesi (2014).
[41] Pesaran et al (2004).
[42] Chudik and Pesaran (2014), page 5.
[43] Ibid.
[44] Ibid.

3.1.1 The VARX* Structure

The VARX* models make up the first step of the GVAR framework. They are vector autoregressive (VAR) models for every unit in the GVAR model that include the domestic and foreign (star) variables. The unit-specific foreign variables are assumed to be weakly exogenous, implying they are long-run forcing for the domestic variables in each VARX* model.[45] This means that foreign variables affect the domestic variables in the long run, but not vice versa.[46] This assumption is tested later in the analysis, but is found to hold in general in the literature.[47] The domestic variables are considered endogenous in the VARX* for every unit.[48] And VARX* models are designed as small open economies, with the exception of the dominant or reference economy.[49] Global variables can be included in the GVAR framework via a dominant unit in which they are endogenous, but they remain weakly exogenous to all other units. Without the inclusion of a dominant unit, global variables can still be included in the analysis but they are left as weakly exogenous to all units in the GVAR model.

The basic structure of the VARX* for unit i where $i = 0, 1, 2..., N$ over $t = 1, 2, ..., T$ with unit 0 used as the dominant unit, is as follows[50]:

$$x_{it} = \Phi_i x_{i,t-1} + \Lambda_{i0} x^*_{it} + \Lambda_{i1} x^*_{i,t-1} + u_{it}, \tag{1}$$

where x_{it} is a k_ix1 vector of the domestic variables, x^*_{it} is a k^*_ix1 vector of the foreign variables, and u_{it} is a process with weak dependency over the cross sections but no serial correlation.[51]

[45] de Waal and van Eyden (2013), page 6.
[46] Ibid.
[47] Ibid, page 7.
[48] Ibid.
[49] It is common to include a dominant economy in which global variables to be included in the model are considered endogenous to that economy. In de Waal and van Eyden (2013), the US is advanced as a dominant economy. It is however not necessary to include a dominant unit in the analysis and is left up to the user.
[50] Note this representation abstracts from the inclusion of global variables. Their addition would result in further variables on the right hand side of the equation. Further, this representation abstracts from deterministic and higher order lags as done in Smith and Galesi (2014).
[51] Note that the size of the foreign and the domestic variables vectors can differ across units in the model, as not all VARX* models have to have the same number of variables.

In addition we have x_{it}^* is defined as

$$x_{it}^* = \sum_{j=0}^{N} w_{ij} x_{jt}, \ w_{ii} = 0 \tag{2}$$

where w_{ij} is a set of weights for $j = 0, 1, ..., N$ such that $\sum_{j=0}^{N} w_{ij} = 1$. The residuals, u_{it}, are cross sectionally weakly correlated in that $\bar{u}_{it} = \sum_{j=0}^{N} w_{ij} u_{jt} \xrightarrow{p} 0$ as $N \to \infty$. The literature has examples of weights based on both trade data and financial data, and the choice of either is primarily based on the type of analysis. The weights capture the relative importance of country j to country i's economy.

In this paper, weights are calculated using trade flows. w_{ij} reflects the trade share of unit j (where $j = 0, 1..., N$) in the trade (exports and imports) of unit i. This paper uses fixed trade weights to calculate the foreign variables, but the literature has made use of time-varying trade weights also.[52]

Following the setup of each VARX* model, the lag orders of the domestic and foreign variables, p_i and q_i respectively, are determined using the Akaike information criterion (AIC) or the Schwarz Bayesian criterion (SBC). For the purposes of this analysis the AIC have been selected based on their exclusive use in other trade related GVAR analysis.[53]

The individual VARX*(p_i,q_i) model, expressed in a general form that abstracts from the inclusion of global variables is

$$x_{it} = a_{i0} + a_{i0}t + \Phi_{i1} x_{i,t-1} + ... + \Phi_{ip_i} x_{i,t-p_i} + \Lambda_{i0} x_{it}^* + \Lambda_{i1} x_{i,t-1}^* ... + \Lambda_{iq_i} x_{i,t-q_i}^* + u_{it} \tag{3}$$

for $i = 0, 1, 2..., N$.[54]

[52]de Waal and van Eyden (2013), page 2.
[53]Ibid, page 7.
[54]Note that the inclusion of global variables would add contemporaneous and lag values of these variables to the right hand side of this equation. Their omission is for ease of exposition.

The AIC calculations of p_i and q_i are based on

$$AIC_{i,pq} = -\frac{Tk_i}{2}(1 + log2\pi) - \frac{T}{2}log \mid \hat{\sum}_i \mid -k_i s_i \tag{4}$$

where the maximized value of the log-likelihood estimator is represented by the first two terms in (4) with $\hat{\sum}_i = \sum_{t=1}^{T} \hat{u_{it}} \hat{u}_{it'}{}' / T$. This is found using the estimated residuals $\hat{u_{it}}$ from (3). T is the sample size, | . | is the determinant of $\hat{\sum}_i$, and $s_i = k_i p_i + k_i^* q_i + 2$. As before, k_i and k_i^* are the number of domestic and foreign variables chosen, . The result of this process is that the model with the highest AIC is chosen.

Assuming $p_i = 2$ and $q_i = 2$, the VARX* structure becomes

$$x_{it} = a_{i0} + a_{i0}t + \Phi_{i1}x_{i,t-1} + \Phi_{i2}x_{i,t-2} + \Lambda_{i0}x_{it}^* + \Lambda_{i1}x_{i,t-1}^* \Lambda_{i2}x_{i,t-2}^* + u_{it} \tag{5}$$

This model can be transformed into its error correction form (VECMX*) written as

$$\Delta x_{it} = c_{i0} - \alpha_i \beta_i' [z_{i,t-1} - \gamma_i(t-1)] + \Lambda_{i0}\Delta x_{it}^* + \Gamma_i \Delta z_{i,t-1} + u_{it} \tag{6}$$

where $z_{it} = (x_{it}', x_{it}'^*)'$. α_i is a k_i x r_i matrix of rank r_i capturing the speed of adjustment coefficients, and β_i is a $(k_i + k_i^*)$ x r_i matrix of rank r_i capturing the cointegrating vectors.

Error-correction terms (r_i of them) can now be written as

$$\beta_i'(z_{it} - \gamma_i t) = \beta_{ix}' x_{it} + \beta_{ix^*}' x_{it}^* - (\beta_i' \gamma_i)t \tag{7}$$

based on the partitioning of β_i as $\beta_i = (\beta_{ix}', \beta_{ix^*}')'$.

By partitioning β_i, there are r_i error correction terms resulting from (6) which allow for the possibility of cointegration within x_{it} and between x_{it} and x_{it}^*, and also across x_{it} and x_{jt} for $i \neq j$. Through the estimation process of the VARX* models, the number of cointegrating relations β_i, the rank r_i, and the speed of adjustment coefficients α_i are determined.

VARX* models are estimated using reduced rank regression, taking into account the cointegration possibilities. The rank order of the VARX* model's cointegrating space is computed using Johansen's trace and maximal eigenvalue statistics for models with weakly exogenous I(1) regressors.[55] Global variables would be combined with foreign specific variables and treated as jointly weakly exogenous.

3.1.2 GVAR Model Solution

Once the individual unit models have been estimated, the GVAR model is solved for all units together. The global model contains $N + 1$ units, with unit 0 being the dominant unit within which the global variables are endogenous.[56] This solution accounts for all variables being endogenous to the system as a whole, and is in terms of a kx1 global variable vector where $k = \sum_{i=0}^{N} k_i$.[57]

The VECMX* models above are solved and then the corresponding general VARX* models are expressed as

$$x_{it} = a_{i0} + a_{i1}t + \Phi_{i1}x_{i,t-1} + ... + \Phi_{ip_i}x_{i,t-p_i} + \Lambda_{i0}x^*_{it} + \Lambda_{i1}x^*_{i,t-1} + ... + \Lambda_{iq_i}x^*_{i,t-q_i} + u_{it} \quad (8)$$

Define $z_{it} = \begin{pmatrix} x_{it} \\ x^*_{it} \end{pmatrix}$. By assuming that $p_i = q_i$ for simplicity, each unit in the model is now

$$A_{i0}z_{it} = a_{i0} + a_{i1}t + A_{il}z_{it-1} + ... + A_{ip_i}z_{it-p_i} + u_{it} \quad (9)$$

with

$$A_{i0} = (I_{ki}, -\Lambda_{i0}),\ A_{ij} = (\Phi_{ij}, \Lambda_{ij}) \quad (10)$$

for $j = 1, ..., p_i$. Using the trade weights w_i which are unit specific, $z_{it} = W_i x_t$ is defined using

[55] This is as set out in Pesaran, Shin and Smith (2002) and used by Smith and Galesi (2014). Note that the foreign variables are treated as I(1) weakly exogenous in reference to the parameters of the VARX* models.

[56] Assuming a dominanct economy is included in the model.

[57] Smith and Galesi (2014), page 136.

the matrix W_i which is $(k_i + k_i^*)$x k. $x_t = (x'_{0t}, x'_{1t}, ..., x'_{Nt})'$ is a kx1 vector which collects the endogenous variables of the system. At this point in the modelling process, all variables are considered endogenous to the system. W_i, which is derived from the trade weights, links all the individual systems together to allow the model to be solved simultaneously.

Using the new trade weight identity, (9) can be re-written as

$$A_{i0}W_i x_t = a_{i0} + a_{i1}t + A_{i1}W_i x_{t-1} + ... + A_{ip_I}W_i x_{t-p_i} + u_{it} \tag{11}$$

which holds for $i = 0, 1, 2, ..., N$. These individuals models are stacked to yield

$$G_0 x_t = a_0 + a_1 t + G_1 x_{t-1} + ... + G_p x_{t-p} + u_t. \tag{12}$$

The individual terms of this specification are defined as follows:

$$G_0 = \begin{pmatrix} A_{00}W_0 \\ A_{10}W_1 \\ \vdots \\ A_{N0}W_N \end{pmatrix}, \ G_j = \begin{pmatrix} A_{0j}W_0 \\ A_{1j}W1 \\ \vdots \\ A_{Nj}W_N \end{pmatrix} \tag{13}$$

for $j = 0, ..., p$ and

$$a_0 = \begin{pmatrix} a_{00} \\ a_{10} \\ \vdots \\ a_{N0} \end{pmatrix}, \ a_1 = \begin{pmatrix} a_{01} \\ a_{11} \\ \vdots \\ a_{N1} \end{pmatrix}, \ u_t = \begin{pmatrix} u_{0t} \\ u_{1t} \\ \vdots \\ u_{Nt} \end{pmatrix} \tag{14}$$

G_0 depends on the trade weights and parameter estimates calculated when solving the individual models.

As a non-singular matrix, pre-multiplying (12) by the inverse of G_0 results in the GVAR model

$$x_t = b_0 + b_1 t + F_1 x_{t-1} + ... + F_p x_{t-p} + \epsilon_t, \tag{15}$$

where the components of this equation are defined as

$$b_0 = G_0^{-1}a_0, \ b_1 = G_0^{-1}a_1 \tag{16}$$

$$F_j = G_0^{-1}G_j, \ j = 1, ..., p, \ \epsilon_t = G_0^{-1}u_t. \tag{17}$$

This final equation is solved recursively to solve the GVAR model. No restrictions are made on the covariance matrix $\sum_\epsilon = E(\epsilon_t\epsilon_t')$. The above model is expressed in general terms where the number of lags is not specified, however a small number of lags suffices for GVAR analysis due to the multivariate dynamic nature. In fact, the literature commonly suggests that a maximum of two lags is sufficient for quarterly data.[58] It is this solution that is used for further dynamic analysis under the GVAR framework.[59]

3.2 Impulse Response Analysis

The usefulness of the GVAR modelling framework is its applicability to variable-specific shock analysis. Researchers are able to consider the impact on other variables in the model of a shock to a variable of interest which forms part of a cointegrating relationship. This results in a time-profile of the effects, known as the persistence profile. Persistence profiles provide specific information on the speed at which the cointegrating relationships return to their equilibrium states in the event of a shock.[60]

Using the GVAR model as specified in (15), the moving average representation of the model is

$$x_t = d_t + \sum_{s=0}^{\infty} A_s\epsilon_{t-s} \tag{18}$$

where d_t is the deterministic component and A_s can be derived from

$$A_s = F_1A_{s-1} + ... + F_pA_{s-p}, \tag{19}$$

[58] de Waal and van Eyden (2013), page 10.
[59] For example impulse response functions or forecast based analysis.
[60] Smith and Galesi (2014), page 139.

where $s = 1, 2, ...$ and $A_0 = I_m,\ A_s = 0$ for $s < 0$.

The number of cointegrating relations are given as $\beta_i' z_{it}$ and the number of GVAR variables is x_t. Using the previously defined identity $z_{it} = W_i x_t$ we have

$$z_{it} = W_i d_t + W_i A_0 \epsilon_t + \sum_{s=1}^{\infty} W_i A_s \epsilon_{t-s}. \tag{20}$$

The persistence profiles of $\beta_{ji}' z_{it}$ for a system wide shock are realized from

$$PP(\beta_{ji}' z_{it}; \epsilon_t; n) = \frac{\beta_{ji}' W_i A_n \sum_{\epsilon} A_n' W_i' \beta_{ji}}{\beta_{ji}' W_i A_0 \sum_{\epsilon} A_0' W -_i \beta ji} \tag{21}$$

where β_{ji}' is the j^{th} cointegrating relation in the i^{th} unit, n is the horizon of the shock and $\sum_{\epsilon}$ is the covariance matrix.[61]

There are a number of shock analyses that can be performed including: generalised impulse response functions (GIRFs), structural impulse response functions (SIRFs), or orthogonalised IRFs.[62] For the purposes of this analysis, generalized impulse response functions are selected. Beyond the type of impulse response function (IRF) selected, users of the GVAR framework can additionally select the type of shock. The GVAR framework is conducive to three types: unit-specific shocks, region-specific shocks, or global shocks. To shock a variable across all units simultaneously, global shocks to that variable are imposed. Global shocks can also extend to shocking a global variable, whereas other shock-types involve shocking only those variables specific to individual models. All shocks are typically structured as a one-standard deviation shock to the variable of choice.

[61]Note the shock is imposed on the estimated residuals of the GVAR model's solution.

[62]These differ in several respects but primarily in the fact that SIRFs and OIRFs require specific ordering of the variables names entering the GVAR as this affects the outcome - Smith and Galesi (2014).

3.2.1 Generalized Impulse Response Functions

The responses to shocks to specific variables in the GVAR system are called generalized impulse response functions (GIRFs).[63] GIRFs, as discussed above, are not dependent on the ordering of variables and units in a GVAR and are therefore more suited to analysis when there are no strong a priori beliefs for a certain ordering.[64] They provide evidence of the transmission of shocks, although they do not explain why the shocks have these observed effects.[65]

GIRFs are setup as

$$GIRF(x_t; u_{ilt}, n) = E(x_{t+n} \mid u_{ilt} = \sqrt{\sigma_{ii,ll}}, I_{t-1}) - E(x_{t+n} \mid I_{t-1}) \tag{22}$$

where I_{t-1} is the information available at t=1 in the model. $\sigma_{ii,ll}$ is the diagonal element of the variance covariance matrix $\sum_u$ which is attached to the l^{th} equation in the i^{th} unit model, and n is the chosen horizon.[66]

The GIRFs of a one unit (one standard deviation) shock at time t, on the assumption u_t has a multivariate normal distribution, to the l^{th} equation of (12) on the j^{th} variable at time $t + n$ is given by the j^{th} element of:

$$GIRF(x_t; u_{ilt}, n) = \frac{e_j' A_n G_0^{-1} \sum_u e_l}{\sqrt{e_j' \sum_u e_l}}, \tag{23}$$

$n = 0, 1, 2, ...$ and $j = 1, 2, ..., k$.

Note $e_l = (0, 0, ..., 0, 1, 0, ...0)'$ is the selection vector which indicates the l^{th} variable the shock is imposed upon. In the case of a unit-specific shock, the selection vector contains one in place of that variable and zeros elsewhere. For a global shock, e_l has GDP weights that

[63] These were introduced by Koop,Pesaran, and Potter (1996) and adapted to the VAR methodology by Pesaran and Shin (1998) - Smith and Galesi (2014), page 140.

[64] Dees et al (2007), page 26.

[65] Ibid.

[66] Smith and Galesi (2014), page 140.

sum to one corresponding to the shock of the variable in each unit and zeros elsewhere. Note that while the ordering of variables does not matter for GIRFs, the results of this must still be carefully interpreted since using GIRFs allows for correlations of the error terms i.e. the error terms are not orthogonal.[67]

3.3 Specification Tests

3.3.1 Unit Root Tests

The first test performed in the course of GVAR analysis is the unit root test for all domestic, foreign, and global variables in the VARX* models. The tests used are the Augmented Dickey-Fuller (ADF) and Weighted-Symmetric Augmented Dickey-Fuller (WS) tests. The GVAR framework can be applied to stationary or integrated variables, but assuming the variables used are I(1) is useful for looking at short run and long run relationships.[68] It also allows for conclusions about long run relations being cointegrating.[69] Using the AIC as defined above, the test considers whether the time series variables are non-stationary and possess a unit root. Under the null hypothesis of non-stationarity and a unit root, against the alternative of stationarity, results for the test are provided for the levels, first, and second differences of all variables. When testing the levels, two types of regressions are run: one with both an intercept and a time trend, and another with an intercept only. The two instances of differences testing use only an intercept in the model. Since the foreign, and by extension global variables are treated as I(1) it is appropriate to use difference estimation.[70]

3.3.2 Residual Serial Correlation Testing

Testing for residual serial correlation is also conducted as part of the GVAR analysis. The test assesses whether there is serial correlation that has not been included in the proposed model,

[67] Ibid, page 141.
[68] Dees et al (2007), page 11.
[69] Ibid.
[70] *Economics 584 - Unit Root Tests*, Washington State University.

and whether incorrect conclusions may be drawn from the model based on its presence. The GVAR framework asks for user-specified lag orders for performing the F-version of the Lagrange Multiplier serial correlation test on the residuals of the individual unit models.[71] The null hypothesis being tested is one of no serial correlation, against the alternative of serial correlation. The residual serial correlation F-statistics are calculated for both the VARX* model residuals and the residuals of the VECMX* models. The performance of this test in done in conjunction with the GVAR model specification, selecting the lag orders for relevant variables based on the selected criterion as discussed above.[72]

3.3.3 Testing for Over-identifying Restrictions

Testing for over-identifying restrictions is another test run as part of the GVAR analysis if the user opts to impose over-identifying restrictions. Examples in the literature include imposing long-run restrictions like the Fisher equation relationship on variables in individual models.[73] Since this analysis makes no restrictions on long-run relationships between variables it is not necessary to perform the test for over-identifying restrictions, individual models will be estimated subject to exact identifying restrictions.[74] All subsequent results post-identification are based on this.

3.3.4 Testing for Weak Exogeneity

The assumption that x^*_{it} is weakly exogenous with respect to the long run parameters of the conditional VARX* models is an underlying assumption of the GVAR methodology. This implies that x^*_{it} is long-run forcing for x_{it} such that the error correction terms of the above VECMX* models don't enter the marginal model of x_{it}. The formal test for weak exogeneity is conducted as in Johansen (1992) and Johansen, Nielsen and Rahbek (1998).[75] It involves

[71] Smith and Galesi (2014), page 130.
[72] Ibid, page 37.
[73] Ibid, page 47.
[74] Ibid, page 131.
[75] Ibid, page 132.

a test, for the unit-specific foreign variables, of the joint significance of the estimated error correction terms in auxiliary equations equations.

Specifically, the following regression is used

$$\Delta x^*_{it,l} = a_{il} + \sum_{j=1}^{r_i} \delta_{ij,l} E\hat{C}M_{ij,t-1} + \sum_{s=1}^{p_i^*} \phi'_{is,l} \Delta x_{i,t-s} + \sum_{s=1}^{q_i^*} \psi'_{is,l} \Delta \tilde{x}^*_{i,t-s} + \eta_{it,l}. \tag{24}$$

In this regression, $E\hat{C}M_{ij,t-1}$ represents the error correction terms that correspond to the r_i cointegrating relations within the i^{th} model. Weak exogeneity is tested via an F-test in which the joint null is that $\delta_{ij,l} = 0, j = 1, 2, ..., r_i$ in the relevant regression.[76] The lag orders can also be selected by a criterion of the users choosing, AIC in the case of this analysis. This process is reliant on the marginal model for x_{it} with the foreign variables, which is independent from the conditional model.

3.3.5 Testing for Contemporaneous Effects

Contemporaneous effects of the foreign variables on the domestic equivalents is an additional feature of the GVAR. These effects capture the inter-linkages between variables across units in the model, which forms a key part of the GVAR analysis. The framework estimates these effects and their t-ratios based on standard, White, and Newey-West adjusted variance matrices.[77] Contemporaneous effects can also be thought of as impact elasticities. A strong co-movement between domestic and foreign variables is supported by a high elasticity, or contemporaneous effect. This can support the supposition that two units are intimately connected.[78] Additionally, it is possible to support the results of contemporaneous effects testing with economic theory for why two units may have higher impact elasticities with regards to a specific variable than others.[79]

[76] Ibid, page 133.
[77] Ibid, page 133.
[78] Beaton and Desroches (2011), page 5.
[79] Ibid.

3.3.6 Average Pairwise Cross-Section Correlations

In GVAR modelling, it is further assumed that the idiosyncratic shocks of the individual models should be cross-sectionally weakly correlated such that $Cov(x^*_{it}, u_{it}) \rightarrow 0$ with $N \rightarrow \infty$. Weak exogeneity of the foreign variables is ensured by this. Intuitively, conditioning the individual unit models on weakly exogenous foreign variables serves as a proxy for global unobserved factors held in common by these units. Since the models are conditioned, one would expect the remaining degree of correlation across units to be low.[80] The GVAR framework uses average pairwise cross-section correlations for the levels and first differences of the endogenous variables in the model to test the success of the foreign variables.[81] The test is merely diagnostic. If resulting correlations are relatively small, then the model is considered successful in capturing the common effects without omitting substantial connections.

3.3.7 Structural Stability Tests

In addition to previously performed tests, the GVAR framework is designed to perform structural stability tests as well. The GVAR toolbox specifically performs a number of tests to detect the possibility of breaks.[82] The first is Ploberger and Krämer's (1992) maximal OLS cumulative sum (CUSUM) statistic. Additionally, tests for parameter constancy against non-stationary alternatives given by Nybolm (1989). Wald tests of a one-time structural change at an unknown time are also included. The critical values are found based on a null hypothesis of parameter stability using bootstrapped samples.[83] For the purposes of these tests, the l^{th} equation of the i^{th} error correction model as described above is now given by

$$y_{lt} = \theta'_{lt} z_t + e_{lt}; \tag{25}$$

[80]Smith and Galesi (2014), page 134, suggest that residual interdependencies would be things like policy spillovers.

[81]The purpose of using first differences is also to convert the data to stationarity to see how correlations change - di Mauro et al (2013), page 24.

[82]Smith and Galesi (2014), page 134.

[83]These are obtained from the GVAR solution.

where $\theta_{lt} = (\mu_{lt}, \gamma_{jlt}, \varphi'_{nlt}, \nu'_{slt})'$, and the parameters can vary over time as well. The null hypothesis for the relevant tests is that $\theta_{lt} = \theta_l$, i.e. that the parameters are constant over time. The alternative hypothesis is specific to each of the conducted tests and so is the conclusion of the test. Solutions to these tests are provided as part of the GVAR output.

4 Data and Empirical Model

While GVAR modelling is technically complex, Smith and Galesi (2014) have developed an open source toolbox which is the starting point for several empirical GVAR papers.[84] This toolbox provides Matlab code and excel-based interface files for GVAR modelling; customizable to the users specifications.[85]

This toolbox is used to conduct the empirical analysis in this paper. The relevant changes were made to customize the program to the specifics of the analysis to address the proposed research question.

4.0.1 Setup

The GVAR model in this analysis consists of eleven units: the United States, and ten Canadian provinces.[86] There are therefore eleven individual VARX* models being solved as part of the GVAR model.

The GVAR framework is structured by Smith and Galesi (2014) such that the user can decide which variables to include as domestic in which individual models. For the purposes of this analysis, the variable of interest is employment in each unit model (provinces and the US). Employment is included as a domestic variable in each VARX* model. Imports and exports between the province and the US are in each VARX* model as further variables of interest. For a more robust setup of the individual unit economies, real GDP is included as an additional domestic variable. In the modelling, all domestic variables are included

[84] Chudik and Pesaran (2014).
[85] Smith and Galesi (2014).
[86] The territories are excluded from analysis due to data limitations.

in every model.[87] Only employment and GDP are included as foreign variables in the unit models. This is due to concerns of potential multicollinearity between exports and imports as foreign variables which may cause model instability.

GVAR models also allow for the inclusion of global variables, which are oil prices and Canada/US exchange rates in this analysis. Global variables are considered weakly exogenous to all unit models, except the US in which they are included as endogenous.

For this analysis, fixed trade weights are chosen for determining the unit-specific foreign variables. The trade weights are determined using annual trade data between all units in the model for 1997-2015. The fixed-weight matrix used to determine the foreign variables is generated by the GVAR framework based on user specifications.

4.0.2 Data

All data used in domestic, foreign, and global variables is quarterly, spanning the first quarter of 1997 through to the fourth quarter of 2018. Graphical representations and summary statistics for all the data can be found in the Appendix.

The data used in both the individual VARX* models and for global variables is from a number of sources. Data for employment in each province and the US is sourced from Statistics Canada's Labour Force Survey and the Federal Reserve Economic Data (FRED) respectively.[88] The US employment data excludes farm employees.[89] Both series' are published monthly in thousands, and an average of three months data was taken to convert the series to quarterly.

To conduct the GVAR analysis, various types of trade data are needed for the units included in the overall model. Data is needed on the exports and imports of each province to and from the US. Provincial exports and imports by principal trading partner are available

[87]The GVAR toolbox allows the user to select which VARX* model to include certain variables in, and the domestic/foreign variables can be included to different degrees across units if desired or data dependent

[88]Statistics Canada, Table 14-10-0287-01.

[89]Federal Reserve Economic Data, *All Employees: Total Nonfarm Payrolls.*

at a monthly level from Statistics Canada.[90] It is assumed in this analysis that the sum of provincial exports to the US is equivalent to the value of US imports from the provinces, and likewise for US exports. Statistics Canada reports provincial imports based on province of clearance (or customs basis), and not based on final destination (or place of consumption).[91] Therefore, there is the possibility that import values for certain provinces may be under reported in the data. This is most likely to affect provinces such as Alberta which are landlocked and where the majority of their imports from the US travel through Ontario or British Columbia (BC) ports.[92] The lack of more accurately determined provincial import data means this analysis must be carried out under this caveat.

Each unit model also included GDP as a domestic variable. This is sourced from Statistics Canada for the provinces and from FRED for the US.[93] Both series' are chained 2012 dollars and capture real GDP. FRED publishes GDP data for the US on a quarterly basis so no aggregation was necessary for this series.[94] Statistics Canada only publishes provincial GDP on an annual basis, with the most recent data for 2018. Using the provinces share of annual Canadian GDP for each year, this share was applied to quarterly Canadian GDP as an approximation for quarterly provincial GDP from 1997-2018.[95]

Additionally, the WTI oil price data and the USD/CAD exchange rate included as global variables in the GVAR are sourced from FRED for the relevant period.[96] Both are published monthly, and an averaging assumption was applied to convert the data to quarterly figures.

To build the connections between individual VARX* models using trade flows, additional data on the trade between each unit included in the GVAR is needed. Statistics Canada publishes interprovincial trade flows and data on US trade with each province from Trade

[90] Statistics Canada, Table 12-10-0119-01.
[91] Statistics Canada, Table 12-10-0119-01.
[92] Government of Alberta (2017).
[93] Statistics Canada, Table 36-10-0402-01.
[94] Federal Reserve Economic Data. *Real Gross Domestic Product.*
[95] Statistics Canada, Table 36-10-0104-0.
[96] Federal Reserve Economic Data. *Canada/U.S. Foreign Exchange Rate and Crude Oil Prices: West Texas Intermediate (WTI) - Cushing,Oklahoma.*

Data Online (TDO) addressed this need.[97] Due to limitations on available interprovincial trade data, data used is annual from 1997-2015. This data is used by the GVAR framework in creating the w_{ij} set of weights for estimating the foreign variables included in the individual models. The weights matrix is determined using all years of available data rather than only a single year. This is to abstract from potential trends in the data and effects from other economic events.[98]

5 Results

This section presents the results of the GVAR analysis as well as the results of the impact analysis. Based on existing literature on the impact of a trade shock on employment in local economies, one should expect negative labour outcomes at least for some period of time while adjustment takes place. Additionally, economic integration as a result of a close trade relationship implies a trade shock is likely to impact GDP and other indicators in local economies in addition to employment.[99] The results of this analysis will be compared to this economic intuition.

Table 1 presents the final model specification which includes the number of lags (for both domestic and foreign variables) and the number of cointegrating vectors (rank) for each unit model.

[97]Statistics Canada, Table 12-10-0088-01.

[98]For example abstracting from the effects the financial crisis or various oil price shocks that may have affected trade between the units of the GVAR model.

[99]Both of these explanations were advanced by Dixon and Rimmer (2014) discussed in the literature review.

Table 1: Model Specifications

Unit	p	q	rank
United States	1	1	1
Newfoundland and Labrador	1	1	1
Prince Edward Island	1	1	1
Nova Scotia	1	1	1
New Brunswick	1	1	1
Quebec	1	1	1
Ontario	1	1	1
Manitoba	1	1	1
Saskatchewan	1	1	1
Alberta	1	1	1
British Columbia	1	1	1

5.1 Test Results

This section discusses the results for the various tests performed as part of the GVAR framework. All results and the relevant critical values can be found in the Appendix.

The first test conducted considers whether the data is stationary by using Augmented Dickey-Fuller (ADF) and Weighted-Symmetric Augmented Dickey-Fuller (WS) tests for unit roots. Under the null hypothesis, the series has a unit root and is non-stationary against the alternative of stationarity. The GVAR framework provides the critical values for the relevant tests at the 5% significance level. Based on the results of the domestic variable unit root tests for the levels with an intercept and time trend included in the regression, the null hypothesis cannot be rejected for majority of the variables at the 5% significance level. This result holds whether the ADF or WS test statistic is considered against the relevant critical value.

The first difference unit root tests yield different results. When considering the WS test statistics, it is possible to reject the null in favour of the alternative for all domestic variables for all units at the 5% level. The same result holds for the ADF statistics, with the exception of employment and exports in the US. However, in both instances the test statistics are very close to the critical value. This indicates that all domestic variables are likely I(1) with the exception of these two. The second difference test results indicate that employment and exports are I(2) in the US whether we consider the ADF or WS test statistics. The test results support the general conclusion that the GVAR variables are likely stationary.

For unit root tests of the foreign variables we find similar results to the domestic variables. When testing the levels, the null hypothesis cannot be rejected in majority of cases. However, the results of the WS first difference test allow for the rejection of the null hypothesis in all cases. Therefore it is reasonable to treat the foreign variables as I(1). The global variables, oil price and the exchange rate, are also I(1) based on a rejection of the null at the 5% significance level.[100]

The second test considers residual serial correlation in the VECMX* equations. This is an F-test, and the model generated test statistic is compared to the relevant critical value to draw conclusions. Based on the resulting F-statistics and relevant critical values, the null hypothesis is rejected at a 5% significance level for a few of cases. It is also not rejected in a number of cases. From this we can conclude that there may be some concerns regarding unaccounted for serial correlation in the model specification. This concern could be addressed in future analysis.

The test for weak exogeneity conducted as part of the GVAR analysis also results in test statistics and the relevant F-statistic critical values. Based on the results of this test we can see that weak exogeneity assumptions cannot be rejected for all units in the GVAR analysis with four exceptions. GDP leads to a rejection of the null hypothesis at the 5% level for Prince Edward Island, Ontario, and British Columbia. Additionally, the null is rejected for employment in Alberta. This failure of the assumption in even one case is not overly concerning, since as suggested by Dees et al (2007) this is not a serious violation and could be due to incomplete dynamics.[101] The assumption of weak exogeneity appears to

[100]This is true regardless of whether the WS or ADF tests are used when looking at the first difference results.

[101]Dees et al (2007), page 19.

hold reasonably well in this analysis.

The model results also capture the contemporaneous effects of foreign variables on their domestic equivalents. As previously discussed, these values represent the impact elasticities. The higher the contemporaneous effect, the more impact the foreign variable has on its domestic counterpart. The results of this test only consider the contemporaneous effects of employment and GDP on their domestic counterparts since exports and imports are excluded as foreign variables.

The results indicate a mix of both high and low contemporaneous effects, with some elasticities even being negative. In the US, for example, foreign employment has the highest effects on its US counterpart at approximately 14%. Contemporaneous effects for the provinces are fairly small, which is unsurprising given their relative size. For a 1% increase in foreign GDP, all the Canadian provinces see corresponding increases in GDP of less than 5%, with majority below 1%. The impact elasticities for foreign employment are equally small for the provinces.

Average pairwise cross-section correlations are part of the output of the GVAR framework. The GVAR model is considered relatively successful if these correlations are rather small. In this analysis, the correlation statistics are computed for the levels, first differences, and VECMX* residuals. The average pairwise correlations are generally high for the levels, with the exception of exports in which majority fall below 50%. Looking at the results for the first difference, the correlation figures fall substantially for employment across all GVAR units. GDP has less clear of a response, however all correlations now fall below the 70% mark. Imports has a similar first difference result where majority of correlations fall substantially compared to the levels based test. The model has clearly been successful in capturing the common effects across all variables for a number of units when the VECMX* residual test results are considered. Correlations range from small negative to small positive numbers. Though this test is diagnostic only, it highlights the dependencies across macroeconomic variables.

The results of the generation of these correlation statistics indicate that there is likely little remaining correlation across units after accounting for weakly exogenous foreign variables. The specified model is therefore successful in capturing common effects, and does not appear to be omitting substantial connections between units in most cases.

Structural breaks are a serious concern in econometric modelling, a problem to which GVARs are not immune. However, the practice of conditioning individual unit models alleviates these concerns to some degree.[102] Dees et al (2007) suggests that this is because of the possibility of co-breaking across unit models which is something the GVAR model can overcome.[103]

Structural stability tests assess whether the GVAR model is subject to any structural breaks. A number of tests are performed to this end, with results presented for the robust Nybolm (1989) test for parameter constancy against an alternative of non-stationarity. In a majority of cases the null hypothesis of constancy cannot be rejected at the 5% level, with three exceptions. While it is concerning that there may be structural instability in the model, the test statistics are fairly close to their corresponding critical values and conditioning the models alleviates some concern.

5.2 Generalized Impulse Response Function Results

This section discusses the results from the dynamic GVAR analysis. Using GIRFs, a one standard deviation negative shock to global imports is simulated to capture the corresponding effects on the remaining domestic variables in the model. Practically, this shock considers the effects on other variables (i.e. employment) of a one standard deviation decline in each provinces imports from the US and the US' imports from the provinces. Because the shock is applied globally, GDP weights are used in the selection vector e_l.[104] This implies that

[102] Ibid, page 36.

[103] Ibid.

[104] The GDP weights are calculated using average GDP from 1997-2018 in 2012 dollars for all units. This data is sourced from Statistics Canada, Table 36-10-0402-01 and Table 36-10-0104-0.

the shock to each unit is based on their GDP share relative to the other units.[105] This is important to keep in mind when comparing the results of the shocks across units.

While this shock does not fully capture the full employment effect of a cessation of trade between Canada and the US, it is an appropriate starting point for approximating the true dependency of employment on the ongoing trade relationship. It allows for assessing the degree of economic integration between the units as suggested by the shock results.

GIRFs are subject to stability concerns of the GVAR model, and whether they stabilize over time is a fair indicator of model stability. This is the reason for choosing a longer horizon for impulse response, even when the horizon provides no more evidence of the shock impact. The figures for this analysis support the conclusion that the model is stable as the shocks stabilize over time.

The following graphs show the effects of a one standard deviation negative shock to imports for all units in the GVAR. The time horizon is represented in quarters, while the magnitude of the shock is shown on the vertical axes.

5.2.1 Import Shock

It is clear from the graphs in Figure 1 that the proposed shock to import trade results in an employment decline in most provinces and the US. Adverse effects in each province are presented as a percentage of employment in the first quarter of 2019 to allow for comparison across units. The individual responses do vary both in magnitude and duration of the shock. Some provinces feel a more severe impact than others, a fact discussed in this section.

The magnitude of the resulting shock to the level of employment in the US is substantially higher than for other units in the GVAR model. Since the US is a much larger economy than the others with considerably higher levels of employment, this is not a surprising result. The employment IRF in Figure 2 suggests approximately 600,000 jobs could be lost as a result of this shock, approximately 0.4% of current employment in the US.[106] This outcome is over

[105]For example, units with higher GDP will experience a larger shock.

[106]Note US employment data is in thousands, and current employment refers to all non-farm employment

the course of 12 quarters or 3 years. This clear labour market effect is supportive of other results in the literature which find that a significant number of jobs in the US are supported by trade with Canada.[107] It is also indicative of US employment dependency on trade with Canada that has developed over time, since the employment impact is much higher than estimated impacts immediately following NAFTA's implementation.[108]

The variation among provincial employment impacts is an interesting result of this analysis. Theory informs us that the employment impact would likely be larger in those provinces that trade more directly with the US or are more integrated.[109] This is because these provinces likely derive higher economic value from ongoing trade, whereas less trade exposed provinces may have alternative trade partners they depend on or they do not rely as extensively on the US as a market since they trade less overall. The results shown in Figure 2 are fairly supportive of this intuition. More negative employment effects occur in the provinces that make up the bulk of Canada's trade with the US, which suggests they are more economically integrated with the US compared to the remaining provinces.[110] Since the import shock is distributed to the units of the GVAR model based on GDP weights, this effect may be obscured to some extent.[111]

Of the ten provinces in the model, Ontario's employment decreases by the highest magnitude as a result of this shock. Ontario imports the highest volume from the US of all the provinces across a variety of goods and services, as seen in Table 2 in the Appendix. Based on this high volume of trade, it is likely that a number of jobs in the province are exposed to trade shocks and uncertainty. The graph of Ontario's employment effect in Figure 1 supports this conclusion since there is a clear downturn in employment as a direct result of the shock.

in the US as of January 2019 as reported by FRED.

[107]See literature review.

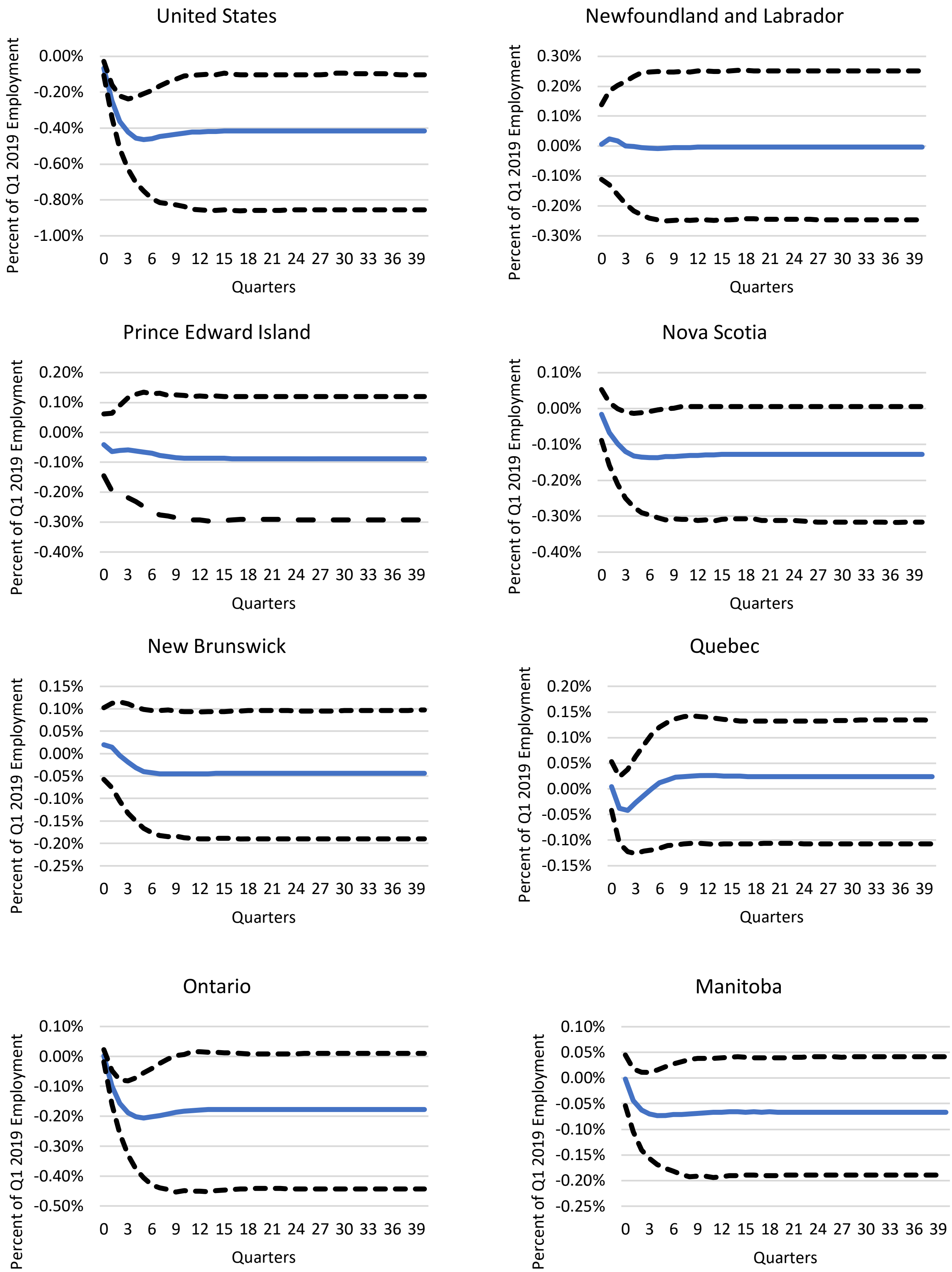
[108]As seen in the literature review.

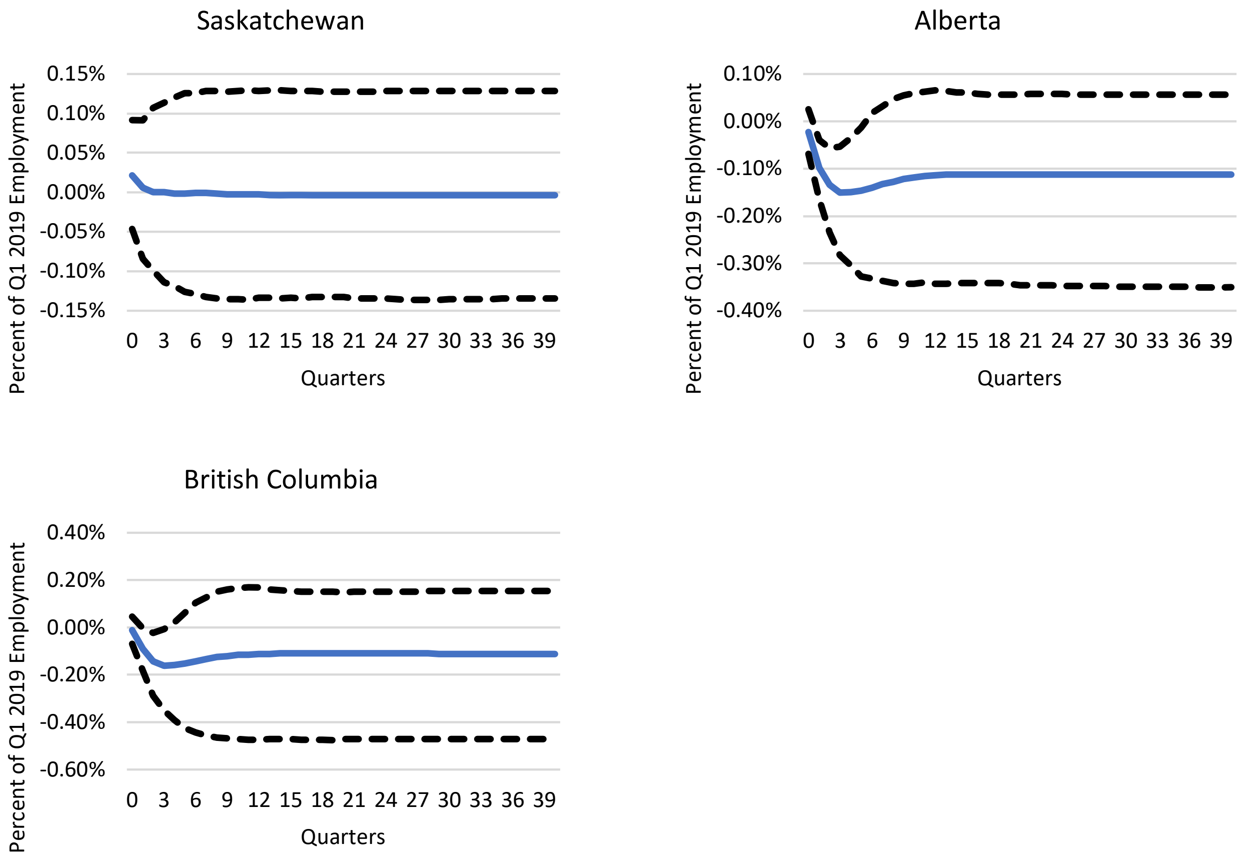
[109]This integration could take many forms, for example if the province has extensive supply chains with US firms one would expect larger employment impacts of a disruption of these value chains.

[110]Table 2 in the Appendix contains each provinces share in total provincial trade, indicating which provinces trade the most with the US.

[111]Economic intuition may still imply that higher magnitude impacts will be felt by provinces more closely integrated with the US economy since they are likely to have the highest GDP weights.

Figure 1: Employment IRFs for a one standard deviation negative shock to imports





The IRF suggests that the losses are approximately 0.2% of current employment over a period of 8 quarters or 2 years.[112]

If Ontario ceased importing from the US altogether the job losses would likely be extensive based on this one standard deviation adverse shock. This indicates a high degree of economic integration with the US on Ontario's part. The magnitude and time frame of the shock both indicate that the Ontario economy is fairly dependent on maintaining a trade relationship with the US at current levels. Should this relationship waiver, there could be substantial job losses in the province. This is not to say that the labour market would not adjust after the shock, it likely would, but as the literature suggests this adjustment would probably be lengthy and include a high degree of uncertainty.[113] Any move toward adjustment of the labour market would still include job losses and possibly economic downturn in the

[112]Note current employment is defined as Q1 2019 employment.
[113]Ciuriak et al (2017).

meantime.[114]

The employment impact in Alberta is also a larger magnitude effect and shows a prolonged decline in employment for a number of quarters after the initial shock. Although the extent of this impact may be understated as it is possible that Alberta's imports from the US are underrepresented in the data.[115] As seen in the graph of Alberta's trade with the US in the Appendix, Alberta's imports from the US are substantially lower than their exports to the US which might be evidence of this concern. If in fact their true imports are substantially higher, the adverse employment impact could be of a magnitude closer to Ontario's, and there may be more job losses in this province than the results suggest. With the data used in this analysis, the results of the shock analysis indicate Alberta would see a 0.15% decline in employment within a year at the lowest point of the shock.

Quebec, Newfoundland and Labrador, and Saskatchewan have minor adverse employment impacts resulting from this shock. Considering the bootstrapped lower bounds indicates the potential for substantially worse employment impacts.[116]

The other large provinces also see adverse effects from the shock to their imports from the US. Within a year of the shock, British Columbia could lose approximately see a decline in employment of almost 0.2% and Manitoba may see losses around 0.05%. While not large numbers, these are only the responses to a one standard deviation shock, and the bootstrapped lower bounds indicate the possibility of substantially larger adverse effects. It is likely that any trade shock in reality would have significantly worse effects.

Further evidence of economic integration between Canada and the US due to their close trading relationship is seen in Figure 2. The IRFs for exports represent the impact of the adverse import shock on the export decisions of all units in the GVAR. Since Canada and the US have extensive cross-border supply chains, the shock to imports is likely to disrupt

[114] Some of these adjustment effects could be mitigated if provinces could turn to other markets to trade, but it would be difficult to replace the amount of trade with the US in a meaningful way over a short period of time.

[115] Recall above discussion under Empirical Model and Data.

[116] Bootstrapping is conducted using 999 replications and using the inverse bootstrap method.

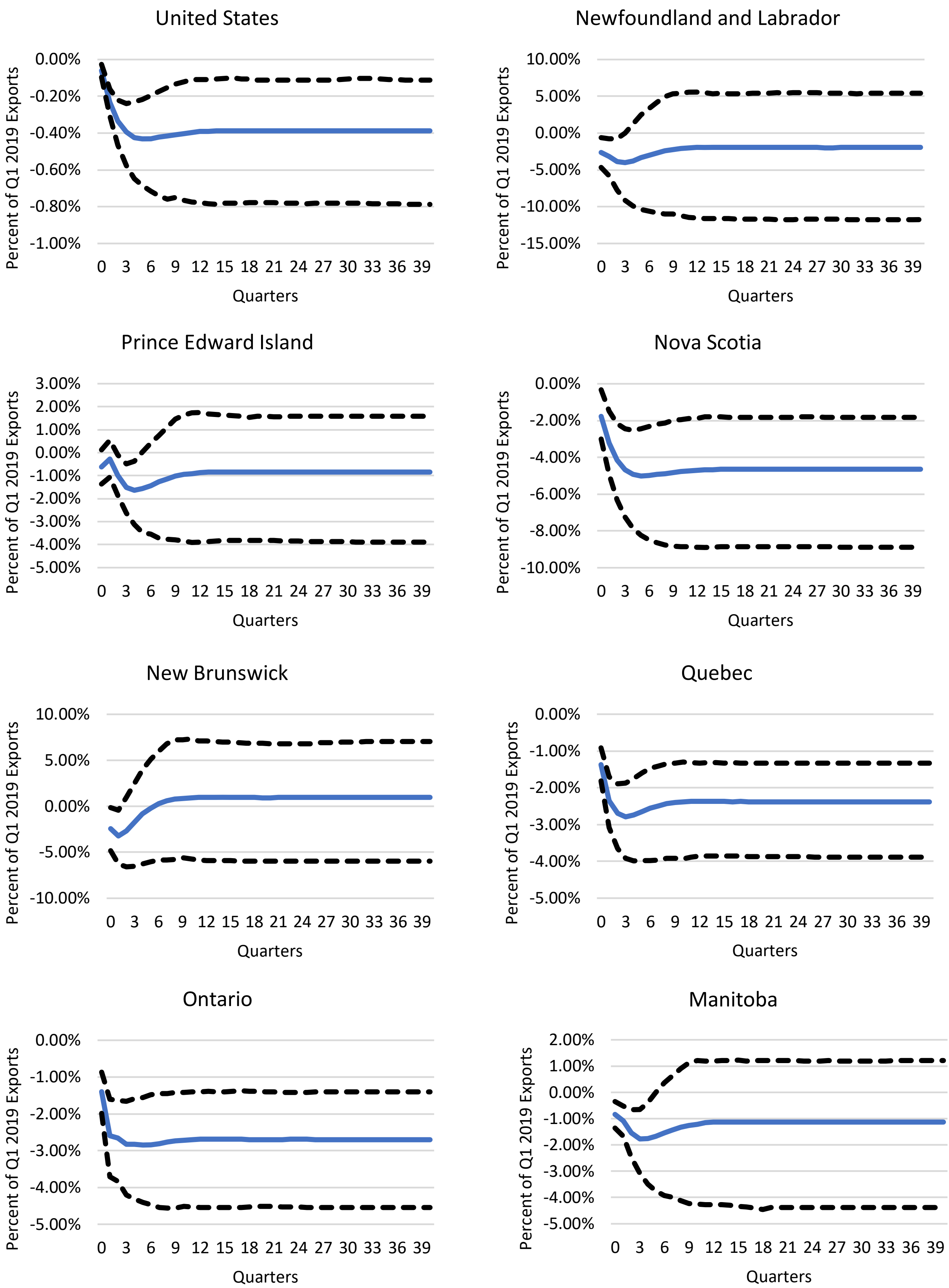
firms on both sides of the border that rely on ongoing trade to source inputs for various products. This decline in available inputs will likely lead to a decline in the production of the final product, at least in the interim before inputs can be sourced elsewhere. The US is Canada's primary export market which implies that this decline in production of goods using US sourced inputs would likely cause Canadian exports to the US to decline. In theory, the same would likely hold from the US perspective though potentially to a lesser extent since the US relies less on Canada as an export market. This theoretical prediction is more relevant to industries in which inputs are used to produce final products, versus those that do not have much intermediate production, but results in this paper are considered on an aggregate level only.

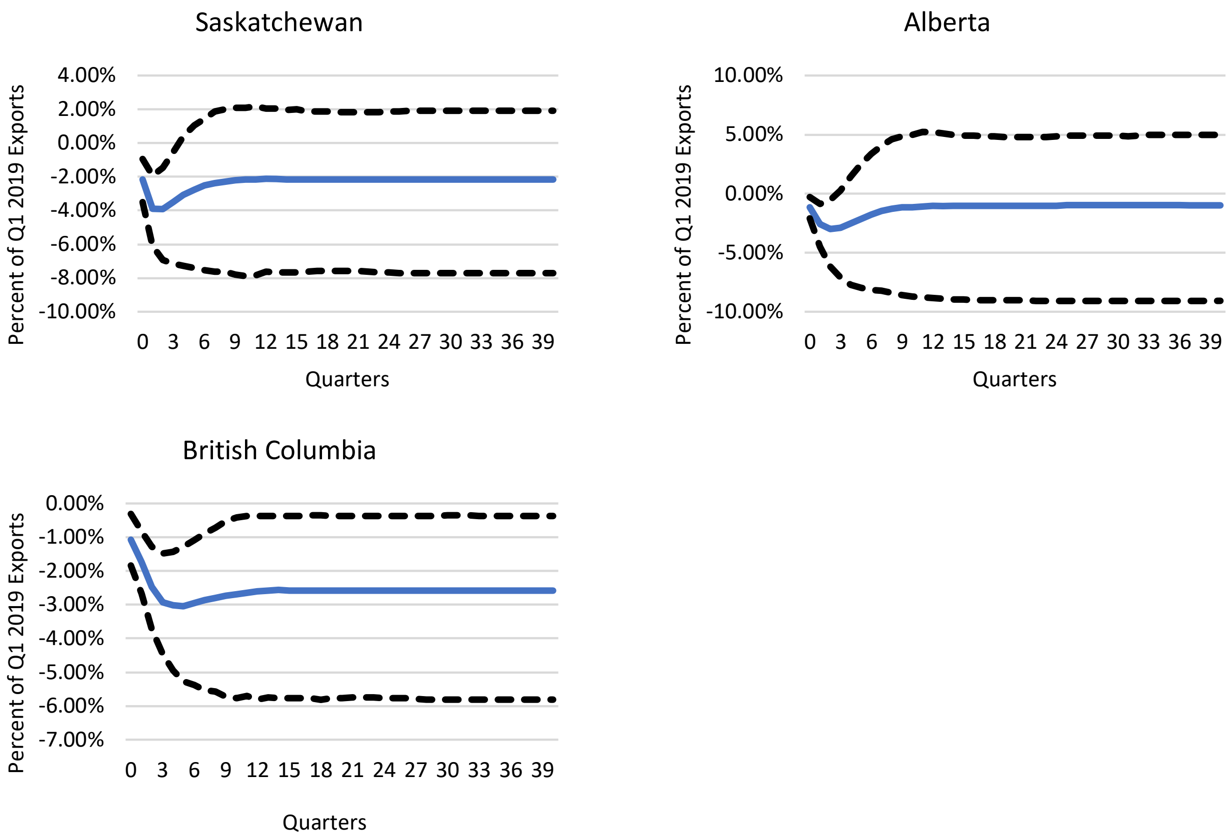
Every province has a decline in their exports to the US as a result of the import shock. More trade exposed provinces like Ontario and Quebec see substantial declines of approximately 3% of their exports to the US.[117] This highlights the reciprocity of the Canada-US trading relationship. When there is a general shock to the provincial ability to import from the US there is a subsequent decrease in provincial exports to the same trade partner.

The GVAR framework provides no specific explanation for this result but intuition and other research provide insight. This result could be related to the extensive cross-border value chains between Canada and the US. Theory suggests that the decline in exports is due to the fall in imported inputs needed for products that are then exported. This may explain the export response seen in Figure 2. This also provides intuition for why the export effect is far stronger in the provinces compared to the US. The US has more export and import opportunities than the provinces, and likely a better ability to pivot to another partner when there is a shock to their trade with Canada.

[117] Adverse impact results are represented as a percentage of exports in the first quarter of 2019.

Figure 2: Export IRFs for a one standard deviation negative shock to imports



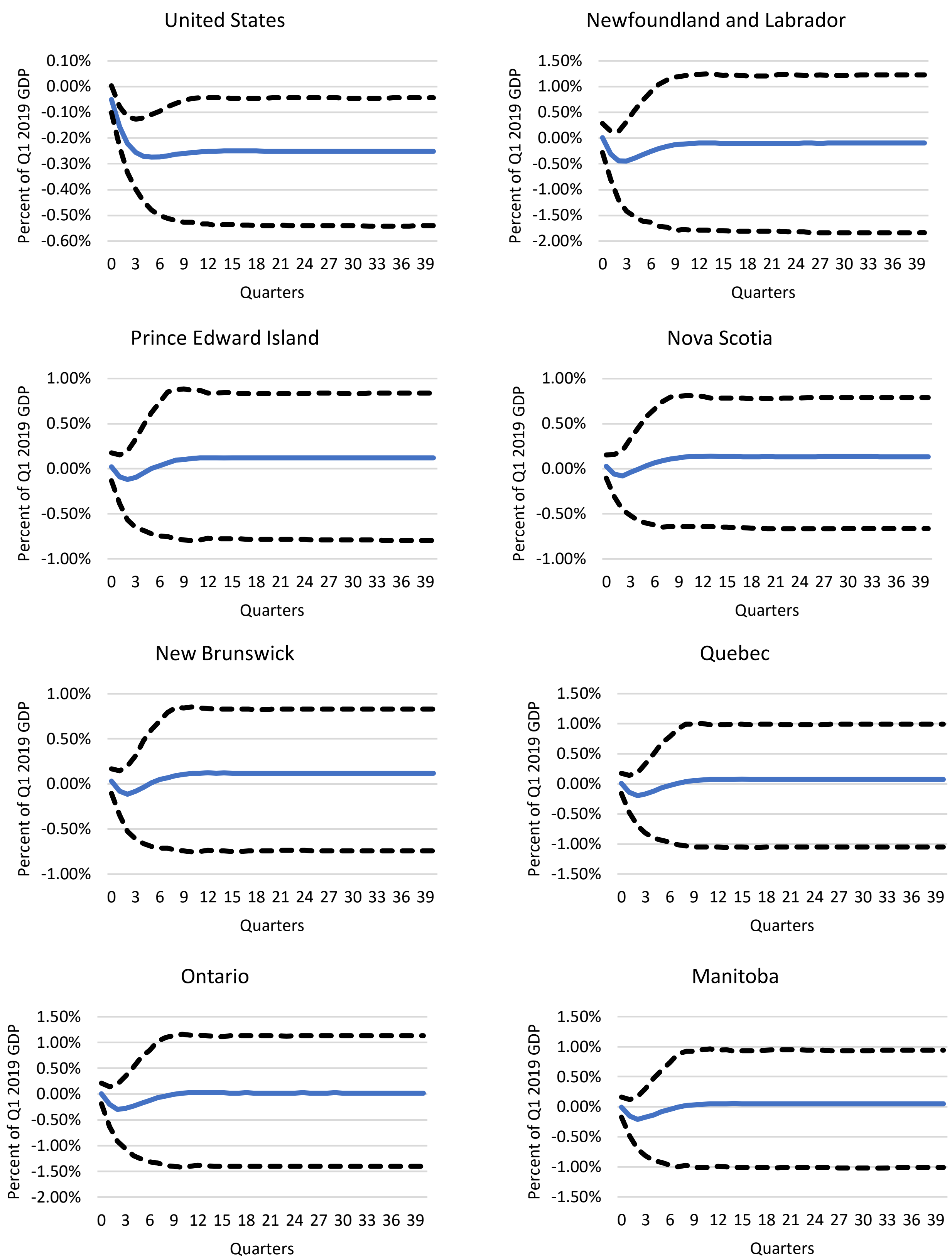


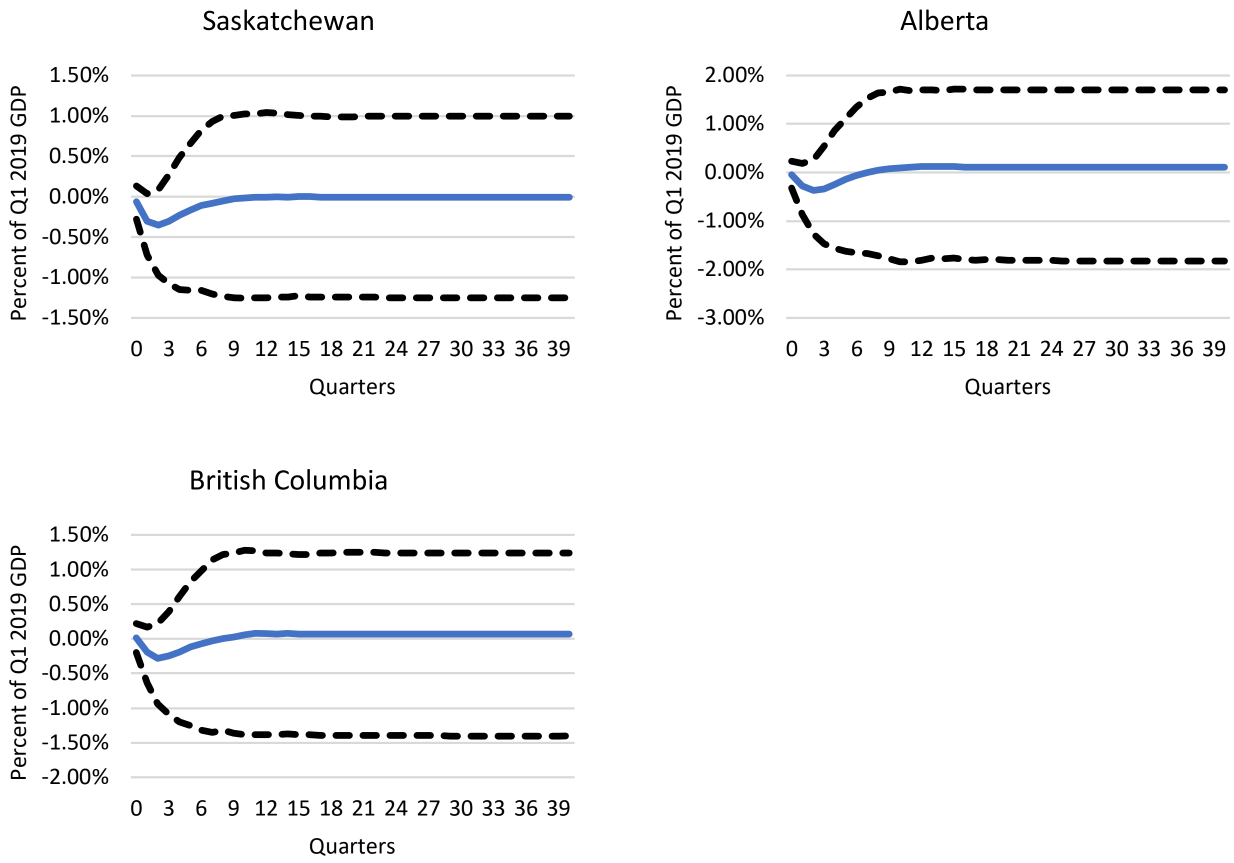
While employment is the primary variable of interest in this analysis, it is also interesting to consider the impact of the negative import shock on GDP in the local economies. The following graphs capture this for each unit. As can be seen in Figure 3, all provinces and the US experience a decline in GDP as a direct result of this shock. Similarly to the employment IRFs, the magnitude of this impact varies across units but results are presented as percentage shares of GDP in the first quarter of 2019 for context. Most IRFs also appear to stabilize around zero within several quarters.[118]

Unsurprisingly, there is a large GDP impact in the US from the adverse import shock. A one standard deviation decline in imports from the Canadian provinces could potentially lead to a substantial decline in US GDP for a number of quarters following the initial shock. The IRF stabilizes at approximately -0.3% of US GDP as reported in the first quarter of 2019. This effect could also be larger or smaller as indicated by the bootstrapped bounds.

[118] A longer shock horizon is used only to indicate the stability of the IRFs.

Figure 3: GDP IRFs for a one standard deviation negative shock to imports





This result is in line with US GDP impacts from a cessation of trade with Canada as seen in the literature.[119] Dixon and Rimmer (2014) acknowledge that there are not only direct effects on GDP from a trade shock but likely also indirect effects that come from the US substituting to less desirable markets for goods/services previously sourced in Canada.[120] Such substitution would not be captured by the GVAR framework, so the GDP impact is likely higher than results here suggest.

The GVAR model is not structured to capture these adjustment effects that constitute part of the GDP impact of a trade shock, so effects are likely underrepresented. Coupled with the employment effect, the GDP effect is evidence of the high degree of integration between the US and Canada. It is also evidence of US economic dependency on trade with Canada, at least to some extent.[121]

[119]Dixon and Rimmer (2014).
[120]Ibid, page 1.
[121]A result that has also been discussed in the literature, especially by Dixon and Rimmer (2014).

Ontario and Alberta also see substantial GDP impacts resulting from this shock. For a one standard deviation adverse shock, the resulting GDP decline is approximately 0.5% of first quarter 2019 GDP levels for both provinces.[122] The remaining provinces all experience GDP declines in the range of 0.1% to approximately 0.5%. When combined with the adverse employment effects there is evidence of substantial economic integration between Canada and the US based on trade.

Impulse response analysis suggests export and import flows between Canada and the US are closely linked with each other and employment levels in the local economies. The GIRFs for all variables of interest suggest that employment in Canada and the US is closely tied to the ongoing relationship and subsequently is exposed to trade shocks. There is also substantial economic integration between Canada and the US. This integration is to the extent that even a minor shock to the relationship results in adverse effects for key economic indicators, employment and GDP. The dynamic results support findings in the literature.

6 Conclusions and Further Research

Canada and the United States have engaged in substantial trade under both CUSFTA and NAFTA, and are likely to continue to trade at this level under CUSMA when it is ratified next year. This level of trade has had a profound economic impact on both sides of the border. It has fostered the development of extensive supply chains and the exchange of an increasing variety of goods and services. Ongoing trade has also led to substantial economic integration, such that economic well-being in both countries is to an extent dependent on current trade levels. Recent developments in trade politics, particularly for Canada and the US, have made it imperative to understand the intimacies of bilateral trade. These developments have made researchers keen to estimate the dependencies nations have on trade to highlight the adverse effects of raising barriers to trade. This analysis is conducted to attempt to quantify the degree of economic interdependency between Canada and the

[122] Note these are Canadian dollars.

United States in light of these developments. This is done in the context of estimating the employment effect of bilateral trade between the two countries.

The empirical GVAR model used to analyze the employment impact of Canada/US trade yields important results for policy decisions. A one standard deviation decline in the Canadian provincial imports from the US and US imports from the ten provinces results in negative effects across variables of interest. Employment levels decline at varying magnitudes across all units in the model. This implies that a shock to the existing trade relationship would result in job losses across the Canadian provinces and the US. The US is the largest economy in the model and suffers the highest magnitude of losses at 0.4% of current employment. But the larger Canadian provinces also suffer substantial job losses ranging from 0.05% to approximately 0.2% of current employment in each. Ongoing bilateral trade therefore supports a number of jobs in both Canada and the United States. And even a relatively minor adjustment in the volume traded will lead to a decline in employment levels. If the results of this analysis were extended to a cessation of trade, the job losses would likely be more severe and widespread, a finding consistent with the literature. It is likely that the number of jobs supported by ongoing trade is even higher than estimated in this paper due to extensive cross-border value chains that are not directly accounted for in this analysis.

The impact of the imposed shock on GDP and exports is considered as supplementary analysis to the employment effect. Examination of the results indicates a decline in both indicators across all units in response to the adverse shock. In combination with the anticipated job losses, the adverse effects on other variables suggests economic dependency on the existing bilateral trade relationship.

This analysis is a first step of further research into the employment impact of Canada-US trade. In using a new type of modelling framework it contributes a new perspective to the existing literature, while providing support for existing findings and theories. However, there remains analysis to be done using this framework. In an ideal world, this analysis would be conducted using the Canadian provinces and US states as units in the GVAR model. The suitability of the GVAR to this analysis would lead to well defined linkages between the units and potentially interesting analysis on the state/province level. Due to data limitations, that analysis could not be performed here but is left by the author as a future project. Other research might include more direct consideration of the cross-border value chain implications for quantifying the number of jobs supported by trade. Additionally, given the flexibility of the GVAR model to various specifications there are many other analyses that could be performed on this topic using this framework.

The conclusion of this paper is that trade has led the US and Canadian economies to become highly integrated and dependent on continued trade with each other to support jobs. With economic stability for Canadian and American workers at stake, the findings of this analysis are highly relevant to policy decisions, particularly pertaining to trade, and can be used to inform future initiatives.

7 References

[1] Adkins-Hackett, Laura (2018). US-Alberta Trade: Job Profiles by State. *2018 Pacific Northwest Regional Economics Conference.*

[2] Armstrong, Maxim and Michael Burt (2012). Adding Value to Trade Measures: Understanding Canada's Role in Global Value Chains. *Conference Board of Canada.*

[3] Armstrong, Maxim (2011). Adding Value to Trade Measures: An Introduction to Value-Added Trade. *Conference Board of Canada.*

[4] Baughman, Laura M. and Joseph F. Francois (2010). Opening Markets, Creating Jobs: Estimated US Employment Effects of Trade with FTA partners. *US Chamber of Commerce.*

[5] Beaton, Kimberly and Brigitte Desroches (2011). Financial Spillovers Across Countries: The Case of Canada and the United States. *Bank of Canada*, discussion paper 2011-1.

[6] Çakir, Mustafa Yavuz and Alain Kabundi (2011). Trade Shocks from the BRIC to South Africa: A Global VAR Analysis. *University of Johannesburg*, no 250.

[7] Chudik, Alexander and M. Hashem Pesaran (2014). Theory and Practice of GVAR Modeling. *Globalization and Monetary Policy Institute*, Federal Reserve Bank of Dallas, Working Paper No. 180.

[8] Chudik, Alexander, Matthieu Bussiere and Giulia Sestieri (2012). Modelling Global Trade Flows: Results from a GVAR model.*Globalization and Monetary Policy Institute*, Federal Reserve Bank of Dallas, Working Paper No. 119.

[9] Ciuriak, Dan, Lucy Ciuriak, Ali Dadkhah, and Jingliao Xiao (2017).The NAFTA Renegotiation: What if the US walks away? *Working Papers Trade and International Policy*, C.D. Howe Institute.

[10] Ciuriak, Dan (2008). Winners and Losers in International Economic Integration: The distributional effects of the NAFTA. *ASEAN-Canada Forum 2008, Regional Economic Perspectives: ASEAN and Canadian Perspective*, Singapore.

[11] Cohen, Stephen D, Robert A. Blecker and Peter D. Whitney (2003). *Fundamentals of U.S. Foreign Trade Policy: Economics, Politics, Laws and other issues.* California: Westview Press.

[12] Dees, Stephane, Filippo de Mauro, M. Hashem Pesaran, and L. Vanessa Smith (2007). Exploring the international linkages of the euro area: a global VAR analysis. *Journal of Applied Econometrics*, 22, 1-38.

[13] de Waal, Annari and Renee van Eyden (2013). The impact of economic shocks in the rest of the world on South Africa: Evidence from a global VAR. *University of Pretoria.*

[14] Dixon, Peter B. and Maureen T. Rimmer (2014). The Dependence of U.S. Employment on Canada, 2013. *Centre of Policy Studies*, Victoria University.

[15] di Mauro, Filippo and M. Hashem Pesaran (2013). *The GVAR Handbook: Structure and Applications of a Macro Model of the Global Economy for Policy Analysis.* Oxford University Press.

[16] Federal Reserve Economic Data. *Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma*, Federal Reserve Bank of St. Louis.

[17] Federal Reserve Economic Data. *Real Gross Domestic Product*, Federal Reserve Bank of St. Louis, Web.

[18] Federal Reserve Economic Data. *Canada/U.S. Foreign Exchange Rate*, Federal Reserve Bank of St. Louis, Web.

[19] Federal Reserve Economic Data. *All Employees: Total Nonfarm Payrolls*, Federal Reserve Bank of St. Louis, Web.

[20] Hiebert, Paul and Isabel Vansteenkiste (2007). International trade, technological shocks and spillovers in the labour market: A GVAR analysis of the US Manufacturing Sector. *European Central Bank: Working Paper Series*, no 731.

[21] Jansen, Marion and Eddy Lee (2007). Trade and Employment: Challenges for Policy Research. *International Labour Office and the Secretariat of the World Trade Organization*, World Trade Organization Secretariat.

[22] Kuszczak, John and John D. Murray (1987). A VAR Analysis of Economic Interdependence: Canada, the United States, and the Rest of the World. *Bank of Canada*, Technical Report no. 46.

[23] O'Leary, C. J., R. W. Eberts and B. M. Pittelko (2012). Effects of NAFTA on US Employment and Policy Responses. *OECD Trade Policy Working Papers*, No. 131, OECD Publishing.

[24] Pesaran, M. H., T. Schuermann, and S. M. Weiner (2004). Modelling regional interdependencies using a global error-correcting macroeconometric model. *Journal of Business and Economics Statistics*, 22.

[25] Smith, Vanessa and Alessandro Galesi (2014). GVAR Toolbox 2.0 User Guide. *Global VAR Modelling Google Site.*

[26] Smith, Vanessa and Alessandro Galesi (2014). GVAR Toolbox 2.0. Global VAR Modelling Google Site.

[27] *Economics 584 - Unit Root Tests.* Washington State University, no date.

[28] *Alberta Imports from the U.S. - an Update* (2017). Government of Alberta.

[29] Statistics Canada. *Interprovincial and international trade flows, basic prices, summary level (x 1,000,000)*, Table: 12-10-0088-01, Statistics Canada, Web.

[30] Statistics Canada. *Labour force characteristics, monthly, seasonally adjusted and trend-cycle, last 5 months*, Table 14-10-0287-01, Statistics Canada, Web.

[31] Statistics Canada. *International merchandise trade by province, commodity, and Principal Trading Partners (x 1000)*, Table 12-10-0119-01, Statistics Canada, Web.

[32] Statistics Canada. *Gross Domestic Product (GDP) at basic prices, by industry, provinces and territories (x 1,000,000)*, Table 36-10-0402-01, Statistics Canada, Web.

[33] Statistics Canada. *Gross Domestic Product, expenditure based, Canada, quarterly (x 1,000,000)*, Table 36-10-0104-0, Statistics Canada, Web.

[34] Trade Data Online, Statistics Canada, Web.

[35] Trefler, Daniel (2004). The Long and the Short of the Canada-U.S. Free Trade Agreement. *American Economic Review*, vol.94, no 4.

8 Appendix

Table 2: Shares in Total Provincial Trade with the US

Newfoundland and Labrador	1.1%
Prince Edward Island	0.1%
Nova Scotia	0.8%
New Brunswick	2.2%
Quebec	12.8%
Ontario	56.0%
Manitoba	3.3%
Saskatchewan	3.5%
Alberta	14.2%
British Columbia	6.0%

Provincial shares are calculated as the provinces share of total provincial trade with the US, using an average of total trade from 1997-2015.[123]

Table 3: Summary Statistics for Employment

	Mean	**Median**	**Maximum**	**Minimum**	**Standard Deviation**	**Skewness**	**Kurtosis**	**Jarque-Bera**	**Probability**
United States	134812.93	133158.00	150058.33	121684.33	6366.60	0.52	2.84	4.20	0.12
Newfoundland and Labrador	217.78	216.33	246.00	184.90	15.18	-0.05	2.13	2.50	0.29
Prince Edward Island	68.20	68.28	76.30	57.87	5.00	-0.36	2.12	4.56	0.10
Nova Scotia	436.22	445.92	458.97	377.63	21.11	-1.17	3.19	21.06	0.00
New Brunswick	345.81	351.93	361.70	306.03	14.18	-1.20	3.43	22.75	0.00
Quebec	3785.04	3855.93	4274.07	3152.00	314.34	-0.37	2.03	5.16	0.08
Ontario	6408.79	6473.75	7284.13	5212.97	525.41	-0.51	2.42	4.93	0.08
Manitoba	591.65	597.45	652.10	522.87	36.83	-0.17	1.80	5.36	0.07
Saskatchewan	514.28	511.00	577.83	454.63	42.08	0.17	1.41	9.32	0.01
Alberta	1940.29	2014.58	2345.23	1426.80	286.14	-0.21	1.63	7.15	0.03
British Columbia	2146.29	2196.57	2528.73	1844.40	189.73	0.02	1.94	3.80	0.15

[123] Data was sourced from Trade Data Online.

Table 4: Summary Statistics for Exports

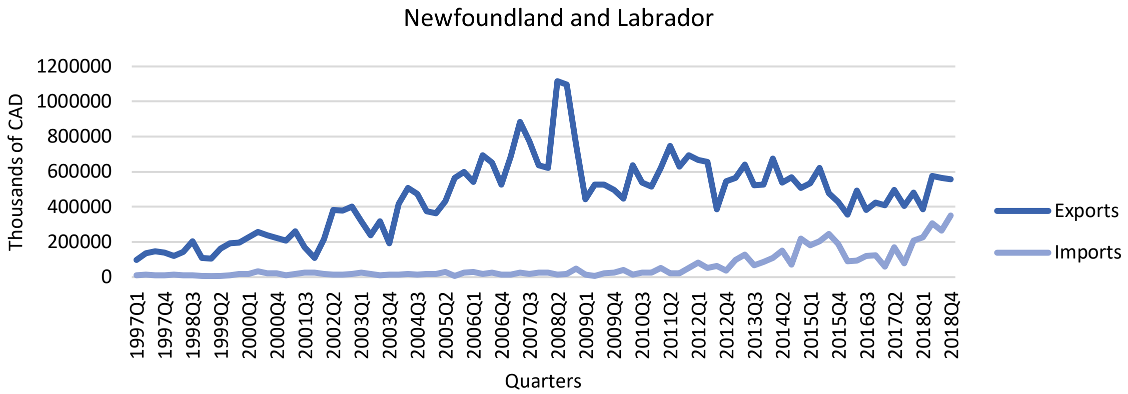
	Mean	Median	Maximum	Minimum	Standard Deviation	Skew-ness	Kurtosis	Jarque-Bera	Probability
United States	149120.99	147750.15	166305.33	133387.83	7451.40	0.39	2.75	2.44	0.30
Newfoundland and Labrador	452790.64	479939.33	1116288.00	97979.67	213443.42	0.38	3.36	2.92	0.23
Prince Edward Island	52794.69	50243.50	105088.67	19182.67	16168.42	0.96	4.00	18.31	0.00
Nova Scotia	306323.97	304965.33	422279.67	171816.00	61691.88	-0.16	2.42	1.43	0.49
New Brunswick	772990.35	773383.00	1173732.00	344740.00	235930.93	-0.19	1.96	4.19	0.12
Quebec	4302926.16	4398843.33	5586462.67	3148528.33	605326.61	-0.06	2.22	2.01	0.37
Ontario	12221309.97	12764059.17	14885846.33	7888950.33	1741904.89	-0.50	2.27	5.48	0.06
Manitoba	648410.60	622662.50	1011662.33	386500.67	110856.02	0.50	3.36	4.53	0.10
Saskatchewan	1048886.22	992535.33	2090722.00	417322.67	463229.95	0.29	1.82	6.03	0.05
Alberta	5556040.95	5692544.50	9312970.33	1950712.00	2020027.24	-0.07	2.15	2.45	0.29
British Columbia	1534981.88	1566849.67	2177885.33	1043763.33	284332.24	0.02	2.16	2.32	0.31

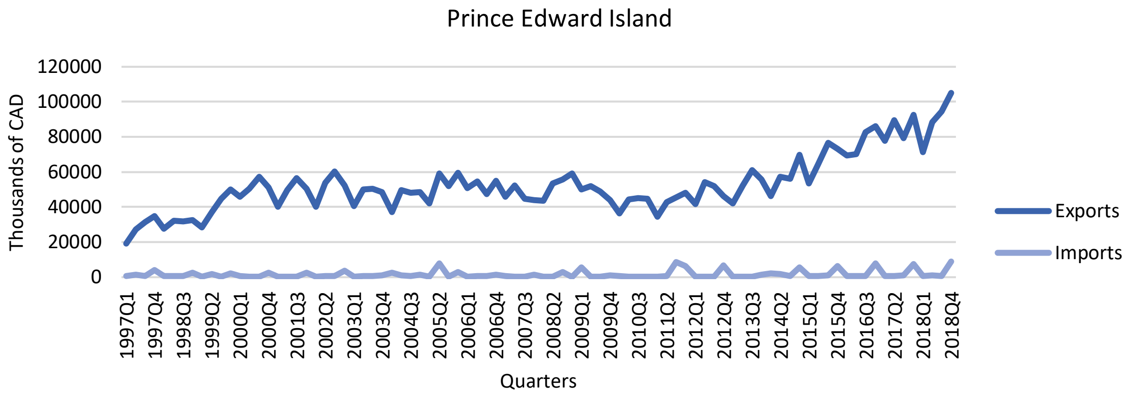
Table 5: Summary Statistics for Imports

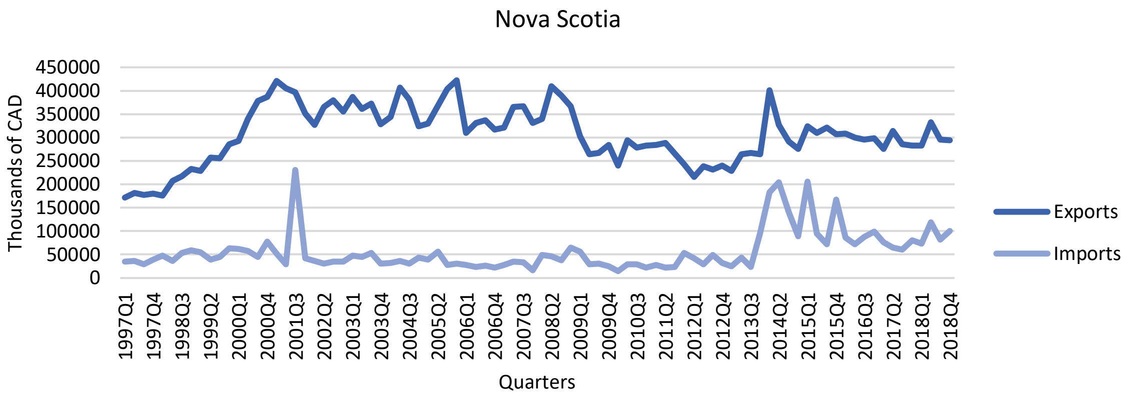
	Mean	Median	Maximum	Minimum	Standard Deviation	Skew-ness	Kurtosis	Jarque-Bera	Probability
United States	25511594.55	25607170.48	32757359.77	17261530.17	3542419.29	-0.37	2.64	2.43	0.30
Newfoundland and Labrador	60020.67	24220.67	351113.00	6009.00	75334.13	1.93	6.07	94.01	0.00
Prince Edward Island	1617.88	606.67	8948.00	147.33	2177.62	2.02	6.04	99.00	0.00
Nova Scotia	57119.04	43345.33	230835.33	14665.33	42674.10	2.24	8.13	179.87	0.00
New Brunswick	259497.86	209542.17	686116.00	99983.33	125903.70	1.48	4.41	41.67	0.00
Quebec	1825058.35	1720099.00	2995885.33	1368561.33	352929.89	1.19	3.70	23.75	0.00
Ontario	13109846.22	12829679.00	17549088.33	9847827.33	1655631.84	0.45	2.71	3.25	0.20
Manitoba	963209.36	881727.67	1538555.67	500790.00	297819.11	0.32	1.65	7.80	0.02
Saskatchewan	541122.01	507669.17	969774.00	271528.00	201166.04	0.32	1.68	7.59	0.02
Alberta	1129905.56	1059429.50	1973785.33	531795.67	382360.63	0.39	1.91	6.28	0.04
British Columbia	1334162.55	1312328.00	2132847.33	878322.67	292779.64	0.36	2.18	4.18	0.12

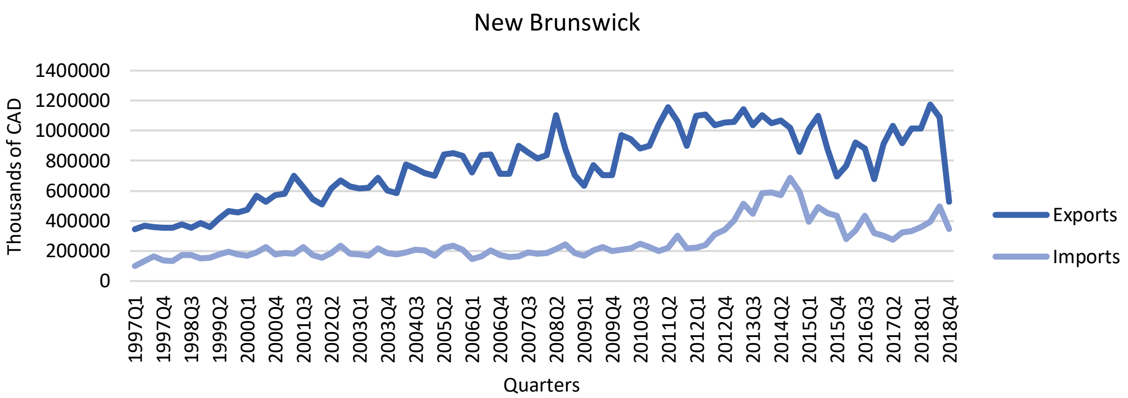
Table 6: Summary Statistics for GDP

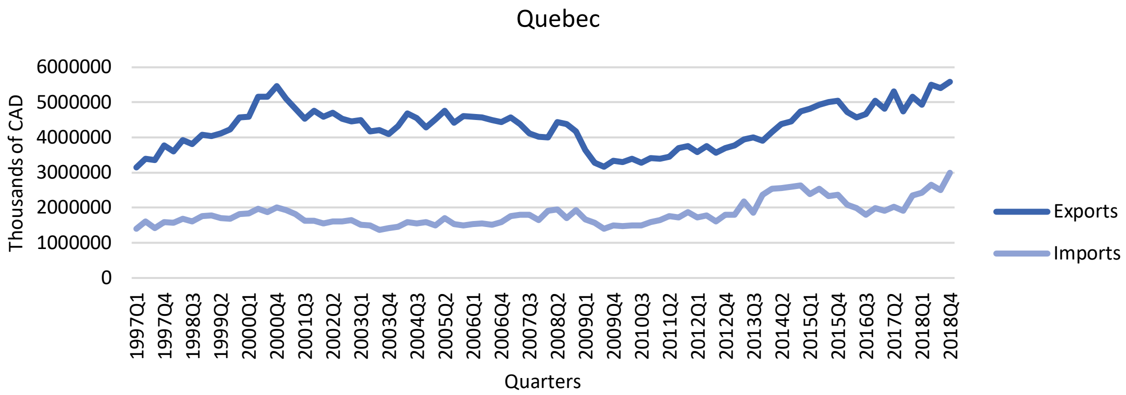
GDP	Mean	Median	Maximum	Minimum	Standard Deviation	Skewn-ess	Kurtosis	Jarque-Bera	Probability
United States	15169.42	15385.60	18765.26	11284.59	1927.08	-0.13	2.13	2.73	0.26
Newfoundland and Labrador	39133.43	42948.36	54592.61	18512.02	11285.54	-0.44	1.82	7.72	0.02
Prince Edward Island	6642.03	6771.65	10017.04	3724.97	1789.36	0.08	1.90	4.22	0.12
Nova Scotia	45501.34	47197.05	64176.18	25942.94	10884.61	-0.15	1.90	4.43	0.11
New Brunswick	38583.07	40680.30	53240.21	21991.87	8984.80	-0.27	1.91	5.06	0.08
Quebec	427257.00	436819.51	642521.67	233697.80	116064.06	0.05	1.90	4.12	0.13
Ontario	836800.43	846077.46	1280008.28	439450.98	233839.34	0.09	2.04	3.19	0.20
Manitoba	70895.97	71514.24	110243.84	38333.84	21503.94	0.18	1.78	5.59	0.06
Saskatchewan	94841.44	92649.05	144988.20	54030.47	28063.84	0.22	1.69	6.63	0.04
Alberta	373061.18	370922.68	588888.69	182536.99	126462.81	0.11	1.67	6.29	0.04
British Columbia	266888.23	270858.00	433204.05	140490.46	85728.42	0.23	1.94	4.59	0.10

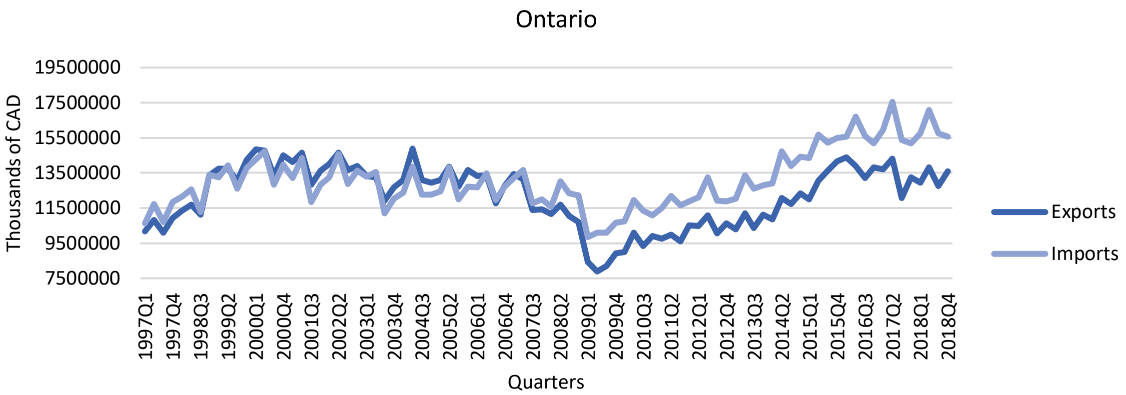

Newfoundland and Labrador
1200000
1000000
800000
600000
400000
200000
0
Thousands of CAD
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters
Exports
Imports

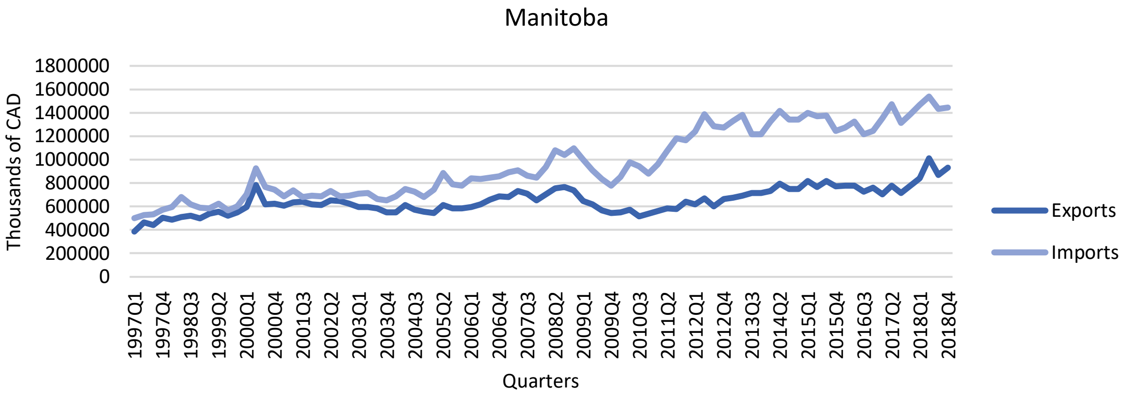

Prince Edward Island
120000
100000
80000
60000
40000
20000
0
Thousands of CAD
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters
Exports
Imports

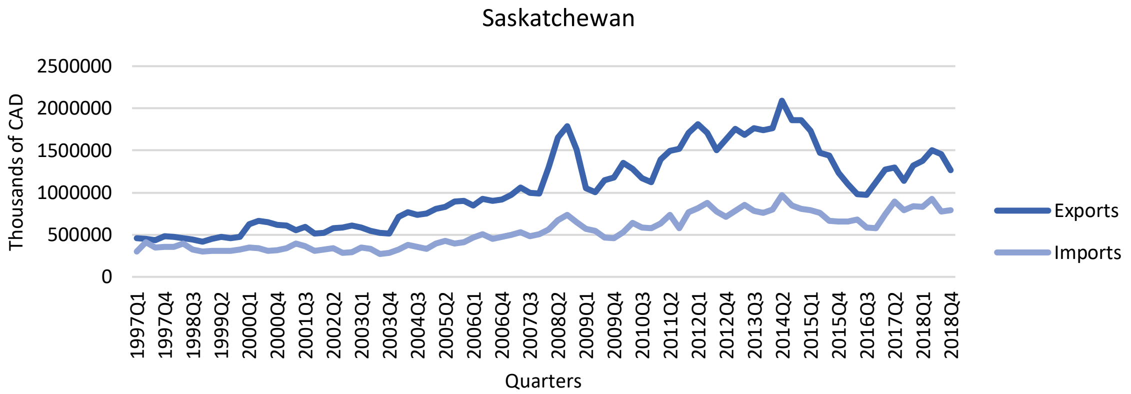

Nova Scotia
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Thousands of CAD
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters
Exports
Imports

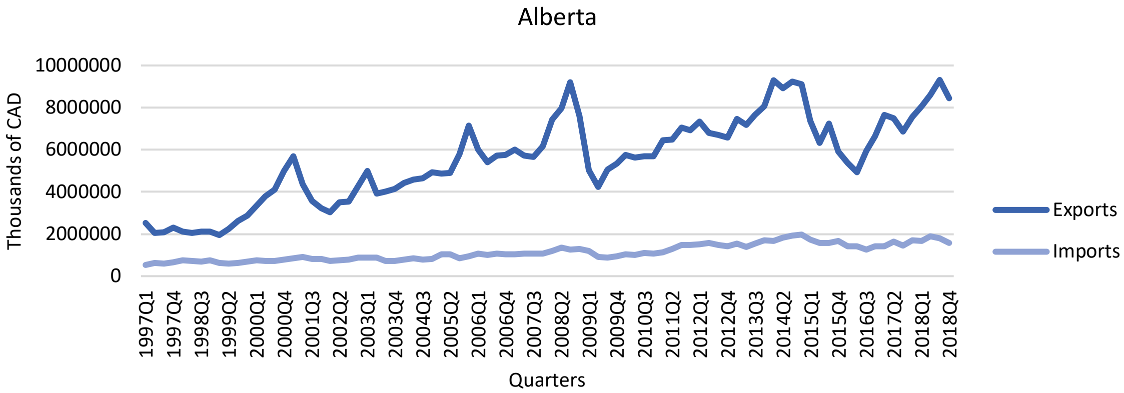

New Brunswick
1400000
1200000
1000000
800000
600000
400000
200000
0
Thousands of CAD
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters
Exports
Imports

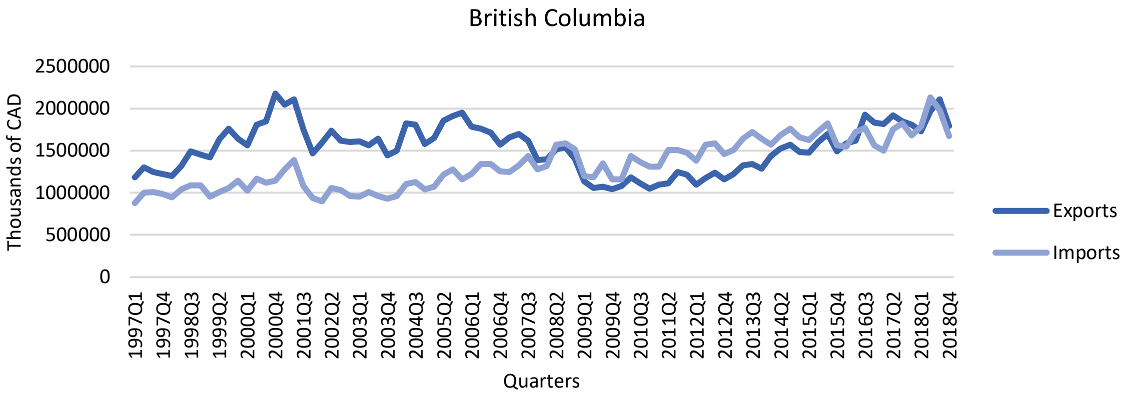

Quebec
Thousands of CAD
Quarters
Exports
Imports

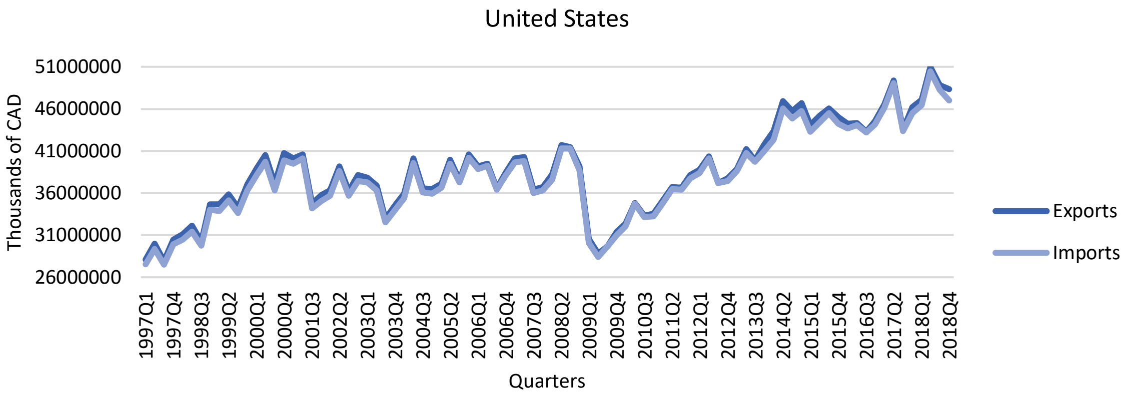

Ontario
Thousands of CAD
Quarters
Exports
Imports


Manitoba
Thousands of CAD
Quarters
Exports
Imports

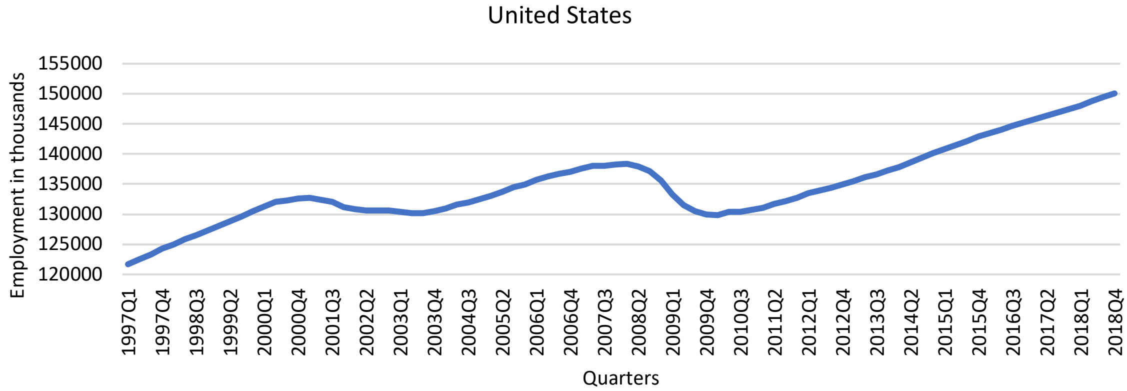

Saskatchewan
Thousands of CAD
Quarters
Exports
Imports

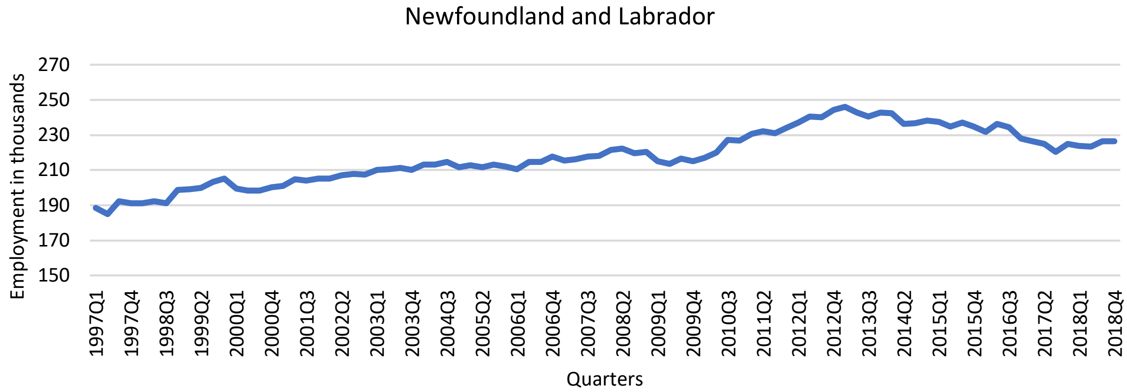

Alberta
Thousands of CAD
10000000
8000000
6000000
4000000
2000000
0
1997Q1
1997Q4
1998Q3
1999Q2
2000Q1
2000Q4
2001Q3
2002Q2
2003Q1
2003Q4
2004Q3
2005Q2
2006Q1
2006Q4
2007Q3
2008Q2
2009Q1
2009Q4
2010Q3
2011Q2
2012Q1
2012Q4
2013Q3
2014Q2
2015Q1
2015Q4
2016Q3
2017Q2
2018Q1
2018Q4
Quarters
Exports
Imports

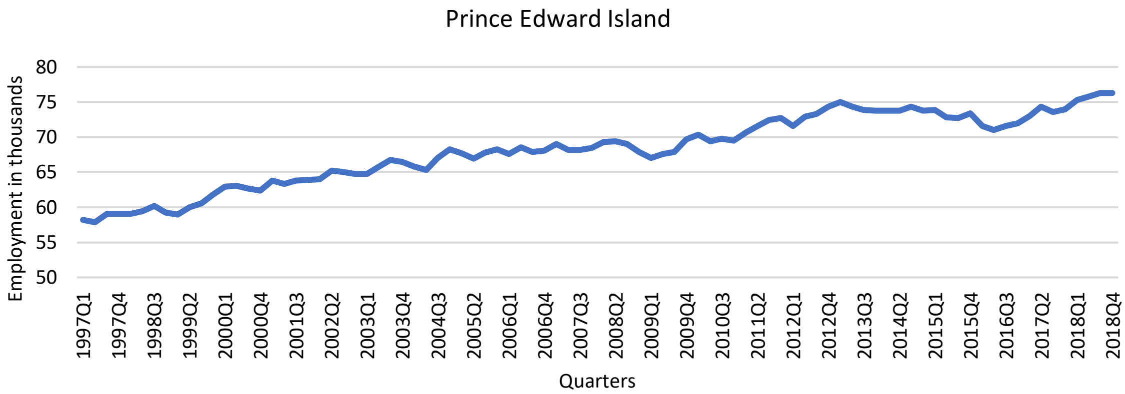

British Columbia
Thousands of CAD
2500000
2000000
1500000
1000000
500000
0
1997Q1
1997Q4
1998Q3
1999Q2
2000Q1
2000Q4
2001Q3
2002Q2
2003Q1
2003Q4
2004Q3
2005Q2
2006Q1
2006Q4
2007Q3
2008Q2
2009Q1
2009Q4
2010Q3
2011Q2
2012Q1
2012Q4
2013Q3
2014Q2
2015Q1
2015Q4
2016Q3
2017Q2
2018Q1
2018Q4
Quarters
Exports
Imports

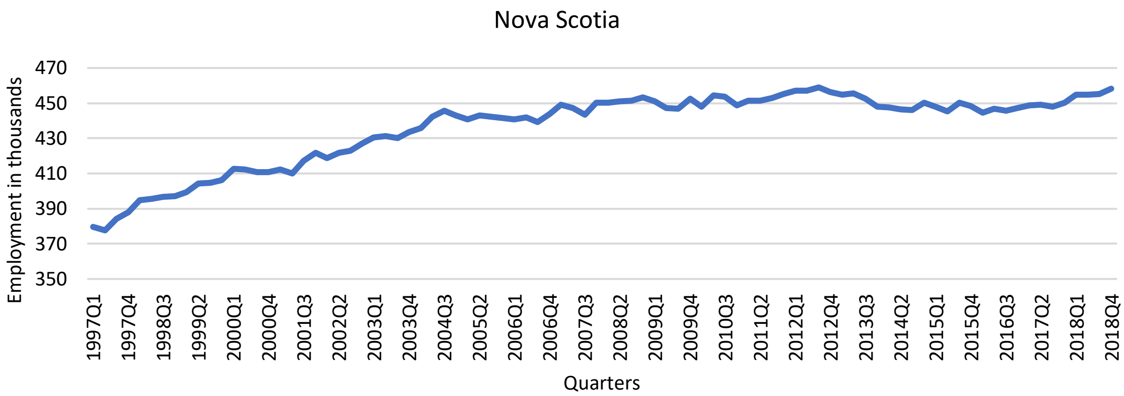

United States
Thousands of CAD
51000000
46000000
41000000
36000000
31000000
26000000
1997Q1
1997Q4
1998Q3
1999Q2
2000Q1
2000Q4
2001Q3
2002Q2
2003Q1
2003Q4
2004Q3
2005Q2
2006Q1
2006Q4
2007Q3
2008Q2
2009Q1
2009Q4
2010Q3
2011Q2
2012Q1
2012Q4
2013Q3
2014Q2
2015Q1
2015Q4
2016Q3
2017Q2
2018Q1
2018Q4
Quarters
Exports
Imports

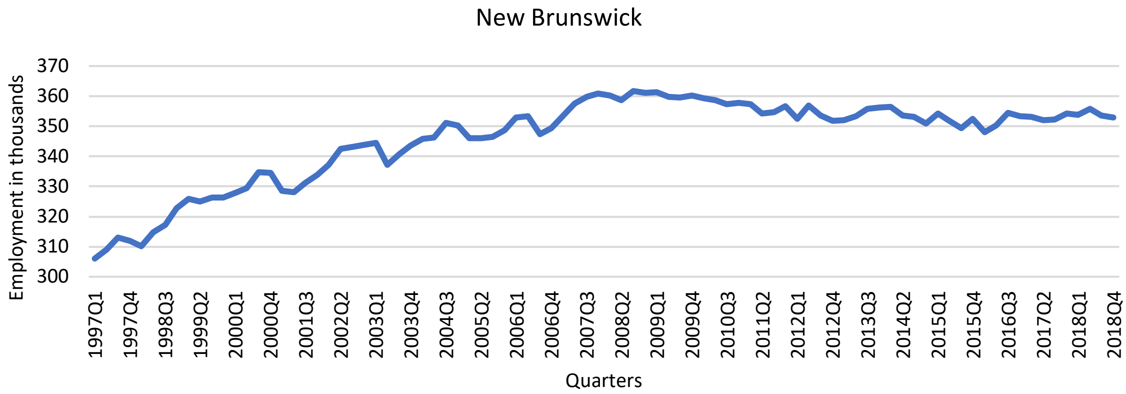
Employment Data

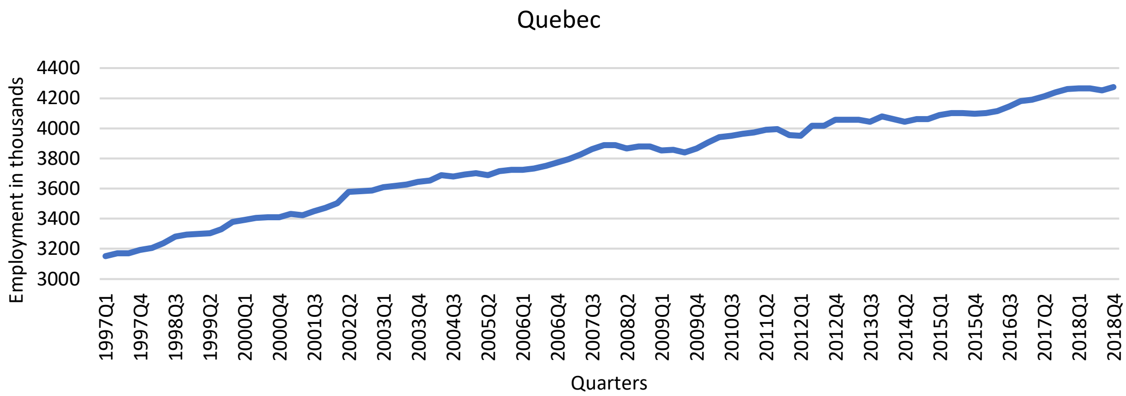


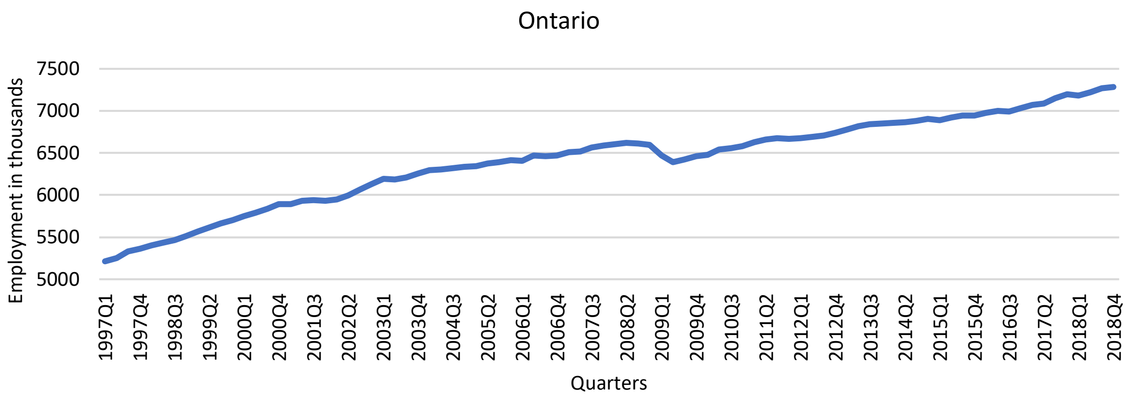


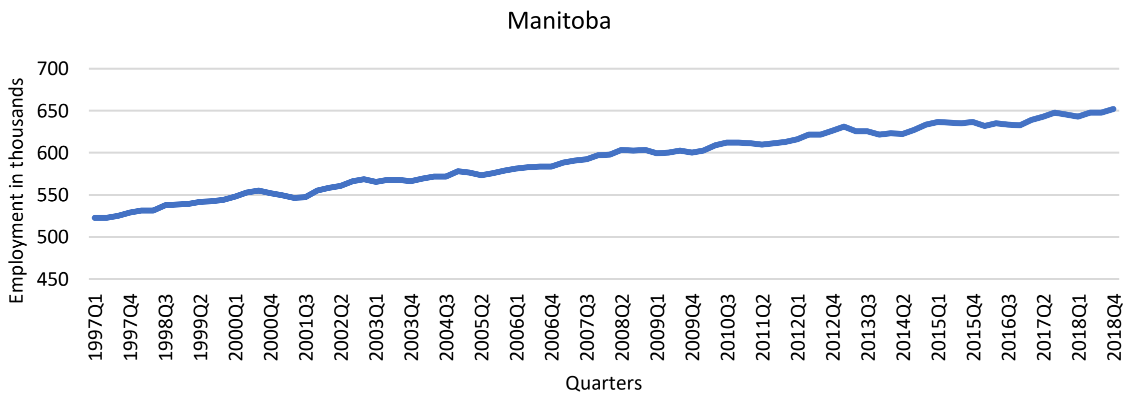


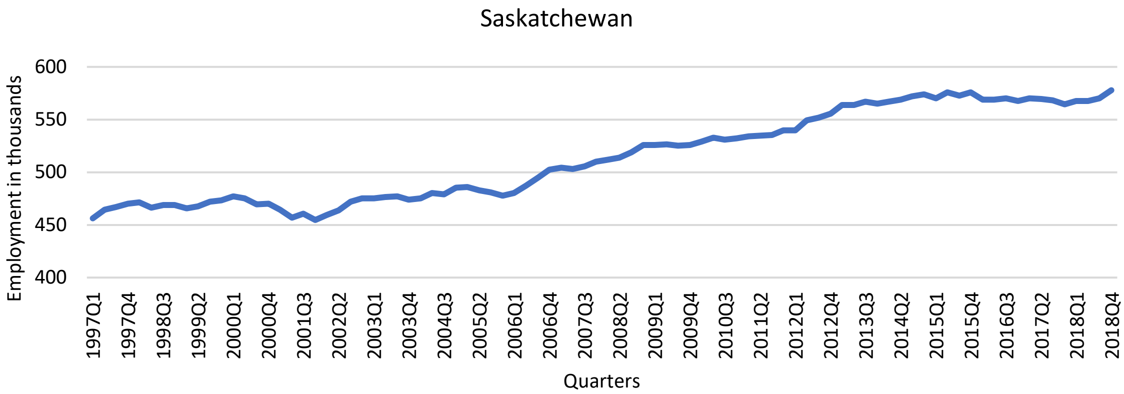


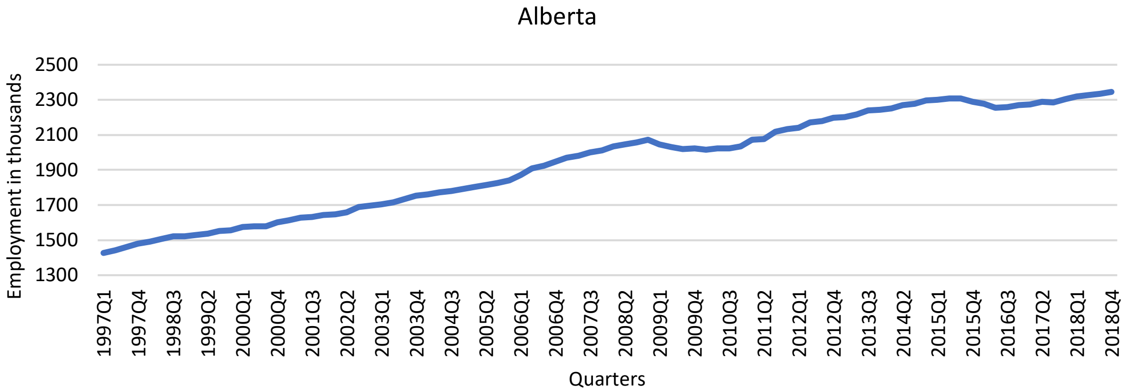

New Brunswick
Employment in thousands
370
360
350
340
330
320
310
300
1997Q1
1997Q4
1998Q3
1999Q2
2000Q1
2000Q4
2001Q3
2002Q2
2003Q1
2003Q4
2004Q3
2005Q2
2006Q1
2006Q4
2007Q3
2008Q2
2009Q1
2009Q4
2010Q3
2011Q2
2012Q1
2012Q4
2013Q3
2014Q2
2015Q1
2015Q4
2016Q3
2017Q2
2018Q1
2018Q4
Quarters

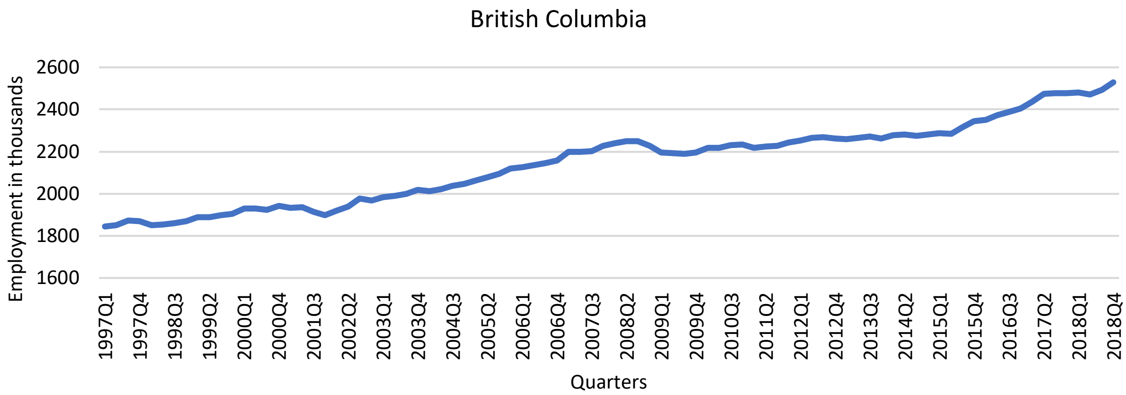

Quebec
Employment in thousands
4400
4200
4000
3800
3600
3400
3200
3000
1997Q1
1997Q4
1998Q3
1999Q2
2000Q1
2000Q4
2001Q3
2002Q2
2003Q1
2003Q4
2004Q3
2005Q2
2006Q1
2006Q4
2007Q3
2008Q2
2009Q1
2009Q4
2010Q3
2011Q2
2012Q1
2012Q4
2013Q3
2014Q2
2015Q1
2015Q4
2016Q3
2017Q2
2018Q1
2018Q4
Quarters


Ontario
Employment in thousands
7500
7000
6500
6000
5500
5000
1997Q1
1997Q4
1998Q3
1999Q2
2000Q1
2000Q4
2001Q3
2002Q2
2003Q1
2003Q4
2004Q3
2005Q2
2006Q1
2006Q4
2007Q3
2008Q2
2009Q1
2009Q4
2010Q3
2011Q2
2012Q1
2012Q4
2013Q3
2014Q2
2015Q1
2015Q4
2016Q3
2017Q2
2018Q1
2018Q4
Quarters

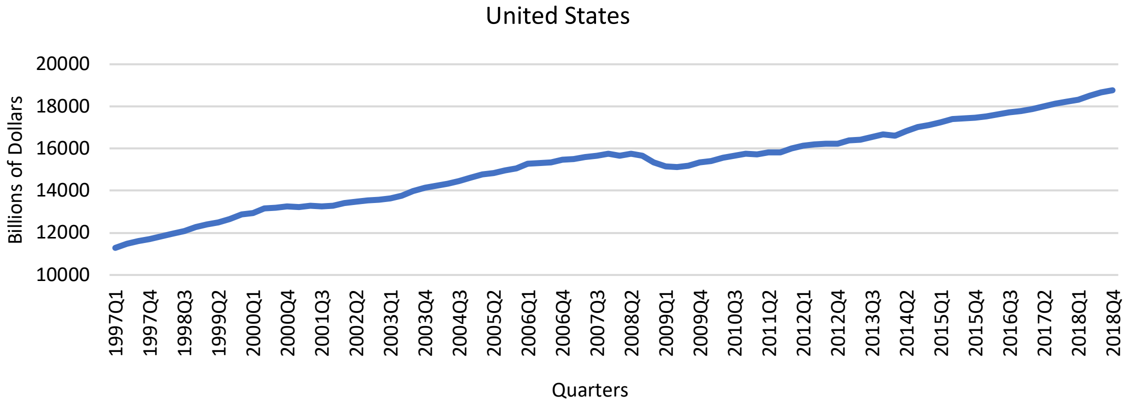

Manitoba
Employment in thousands
700
650
600
550
500
450
1997Q1
1997Q4
1998Q3
1999Q2
2000Q1
2000Q4
2001Q3
2002Q2
2003Q1
2003Q4
2004Q3
2005Q2
2006Q1
2006Q4
2007Q3
2008Q2
2009Q1
2009Q4
2010Q3
2011Q2
2012Q1
2012Q4
2013Q3
2014Q2
2015Q1
2015Q4
2016Q3
2017Q2
2018Q1
2018Q4
Quarters

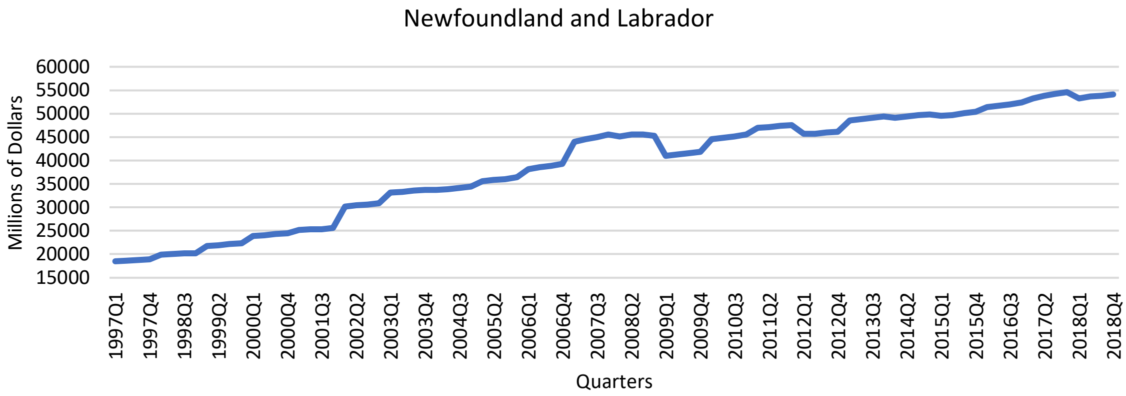

Saskatchewan
Employment in thousands
600
550
500
450
400
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters

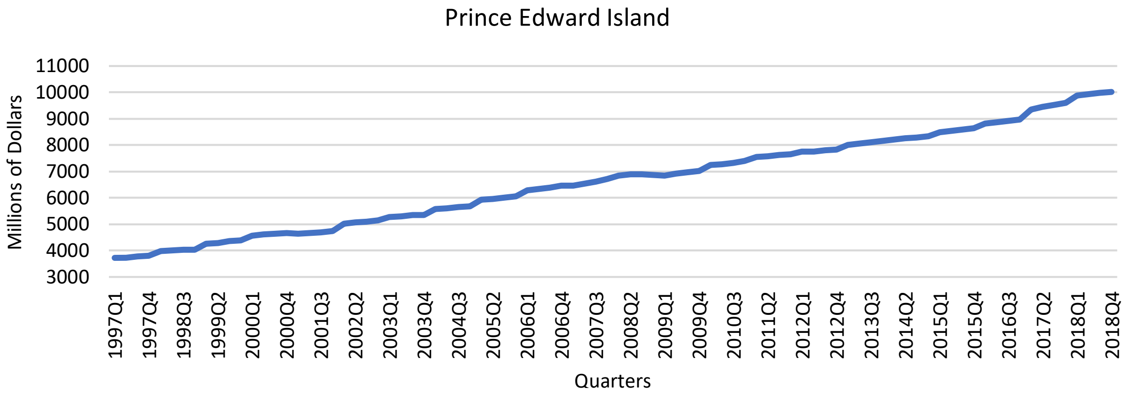

Alberta
Employment in thousands
2500
2300
2100
1900
1700
1500
1300
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters

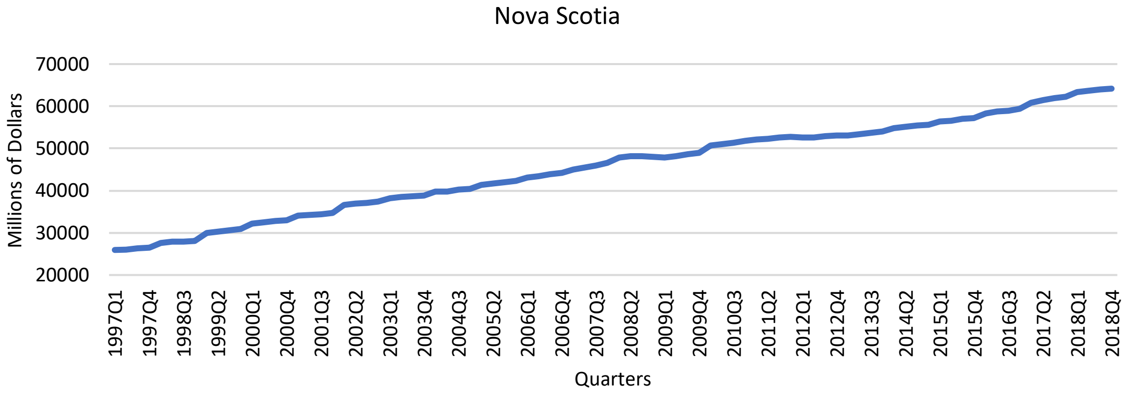

British Columbia
Employment in thousands
2600
2400
2200
2000
1800
1600
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters

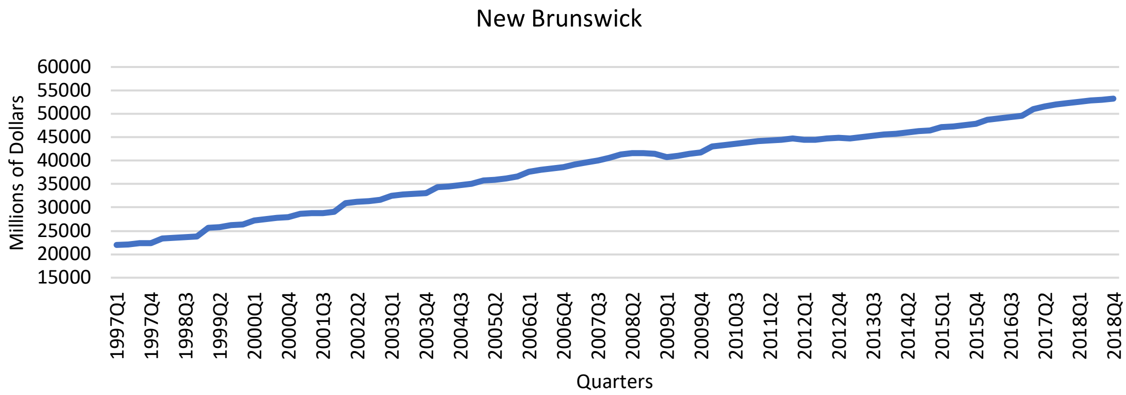
Gross Domestic Product Data

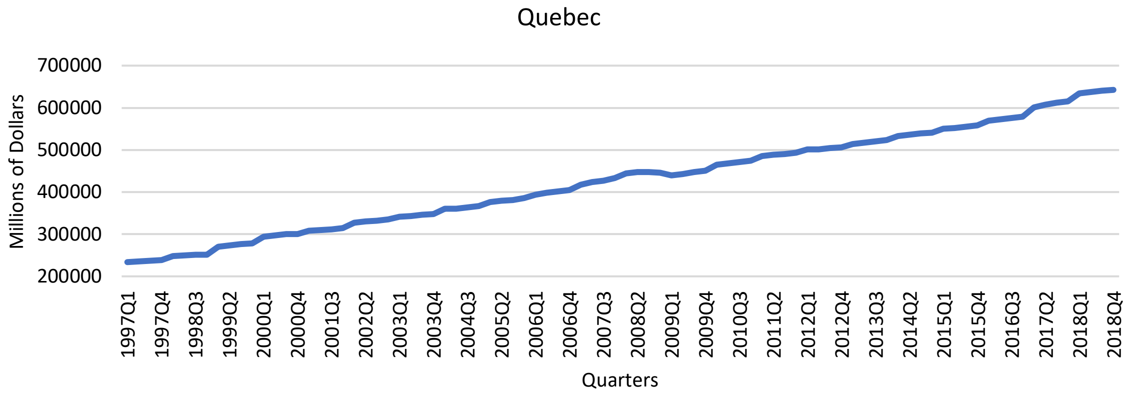


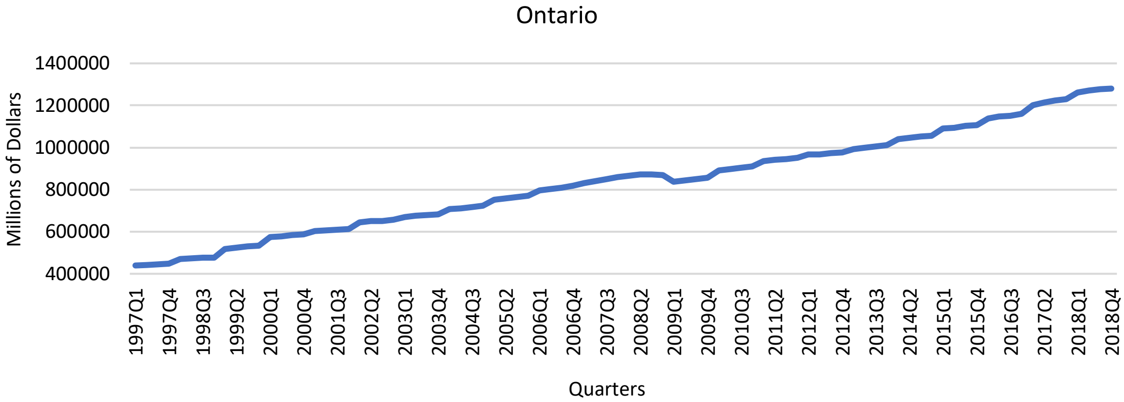


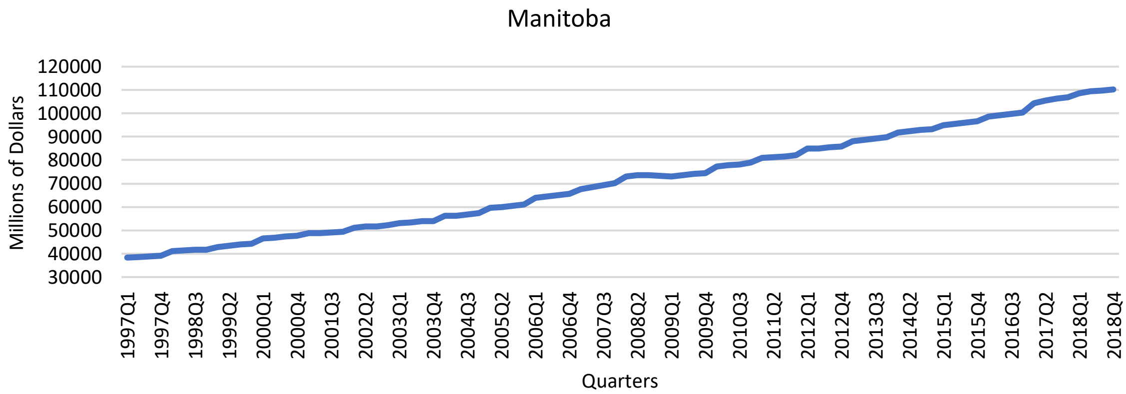


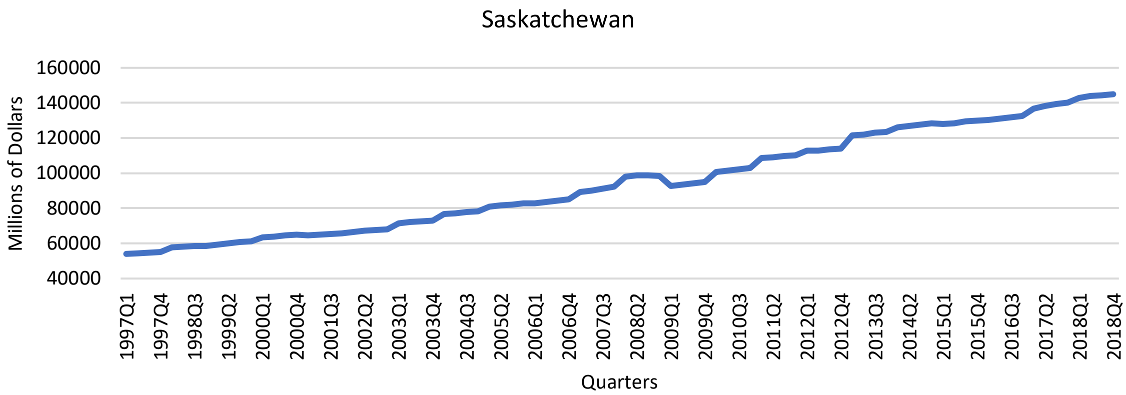


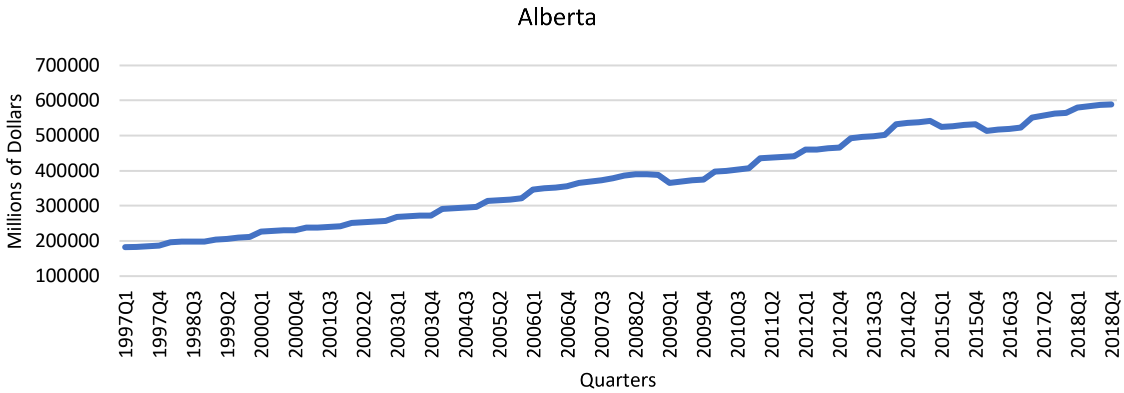

New Brunswick
Millions of Dollars
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters

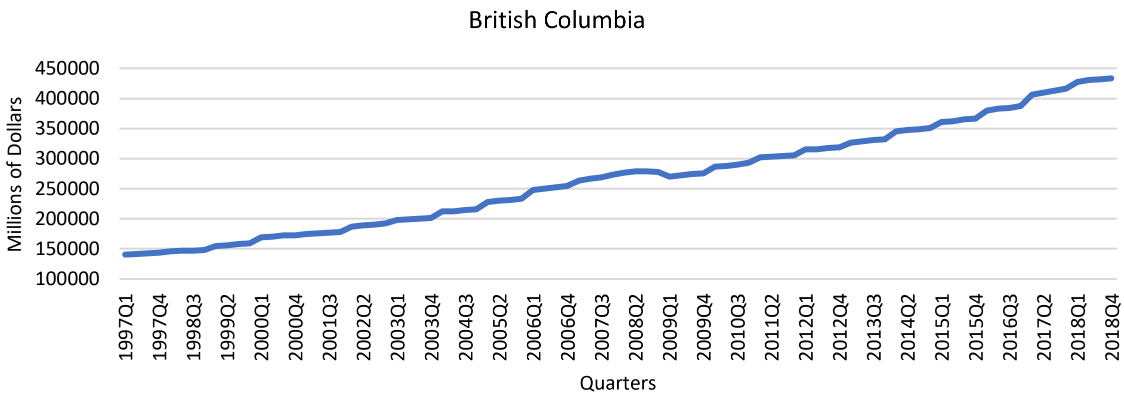

Quebec
Millions of Dollars
700000
600000
500000
400000
300000
200000
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters


Ontario
Millions of Dollars
1400000
1200000
1000000
800000
600000
400000
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters

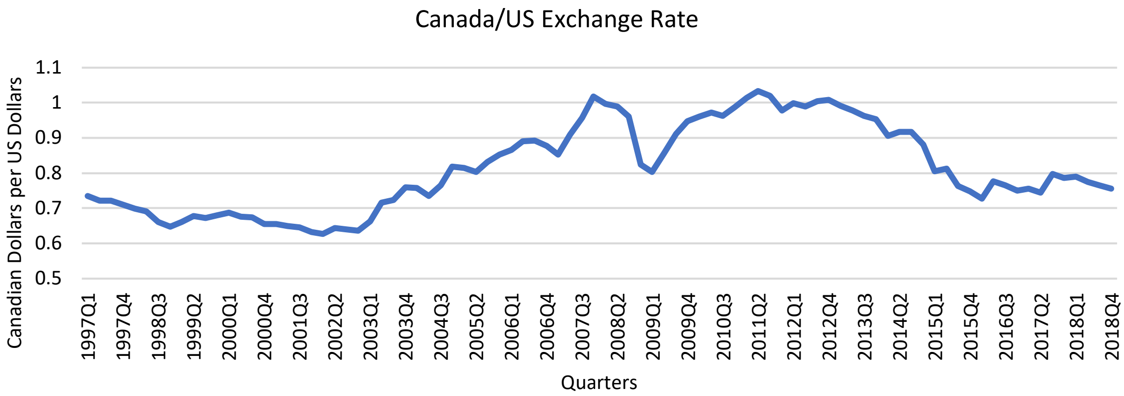

Manitoba
Millions of Dollars
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters


Saskatchewan
Millions of Dollars
160000
140000
120000
100000
80000
60000
40000
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters


Alberta
Millions of Dollars
700000
600000
500000
400000
300000
200000
100000
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters


British Columbia
Millions of Dollars
450000
400000
350000
300000
250000
200000
150000
100000
1997Q1 1997Q4 1998Q3 1999Q2 2000Q1 2000Q4 2001Q3 2002Q2 2003Q1 2003Q4 2004Q3 2005Q2 2006Q1 2006Q4 2007Q3 2008Q2 2009Q1 2009Q4 2010Q3 2011Q2 2012Q1 2012Q4 2013Q3 2014Q2 2015Q1 2015Q4 2016Q3 2017Q2 2018Q1 2018Q4
Quarters

Global Variables Data



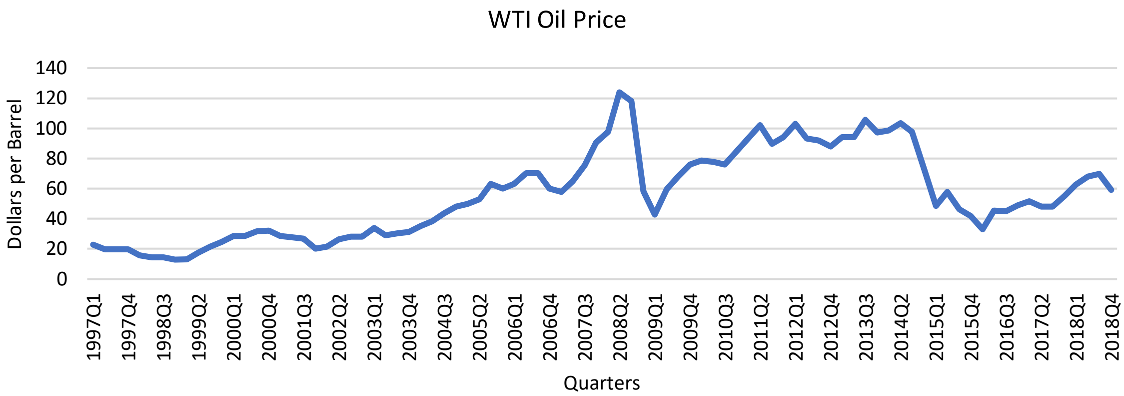


Table 7: Fixed Weight Matrix

Unit	**United States**	**Newfoun-dland and Labrador**	**Prince Edward Island**	**Nova Scotia**	**New Brunswick**	**Quebec**	**Ontario**	**Manitoba**	**Saskatch-ewan**	**Alberta**	**British Columbia**
United States	0.00	0.29	0.13	0.17	0.35	0.35	0.59	0.34	0.33	0.40	0.30
Newfoun-dland and Labrador	0.01	0.00	0.04	0.07	0.06	0.02	0.01	0.01	0.00	0.00	0.00
Prince Edward Island	0.00	0.01	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Nova Scotia	0.01	0.08	0.15	0.00	0.09	0.02	0.02	0.01	0.00	0.01	0.01
New Brunswick	0.02	0.11	0.19	0.13	0.00	0.04	0.01	0.01	0.00	0.01	0.01
Quebec	0.13	0.17	0.14	0.16	0.20	0.00	0.17	0.08	0.05	0.07	0.09
Ontario	0.56	0.26	0.28	0.32	0.19	0.42	0.00	0.26	0.21	0.24	0.27
Manitoba	0.03	0.02	0.01	0.02	0.01	0.02	0.03	0.00	0.07	0.04	0.03
Saskatch-ewan	0.03	0.00	0.01	0.01	0.01	0.01	0.02	0.08	0.00	0.08	0.03
Alberta	0.14	0.05	0.03	0.05	0.04	0.07	0.09	0.15	0.26	0.00	0.25
British Columbia	0.06	0.02	0.03	0.04	0.02	0.05	0.06	0.06	0.06	0.14	0.00

Table 8: Unit Root Test Results for Domestic Variables

Domestic Variables	Statistic Type	Critical Value	United States	Newfoundland and Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia
Employment													
With trend	ADF	-3.45	-2.836	-1.285	-3.076	-2.785	-2.033	-2.361	-2.801	-4.363	-2.121	-1.329	-1.713
With trend	WS	-3.24	-2.900	-1.245	-2.818	-0.327	-0.496	-1.533	-0.892	-4.043	-1.899	-1.560	-1.972
No trend	ADF	-2.89	-0.878	-2.290	-1.405	-3.850	-3.054	-1.640	-1.998	-1.017	0.070	-1.359	0.563
No trend	WS	-2.55	-0.317	-0.135	0.702	1.708	0.775	2.201	2.165	1.639	0.641	1.372	1.698
First difference	ADF	-2.89	-2.460	-6.763	-7.901	-7.509	-7.306	-6.165	-5.292	-6.664	-5.011	-3.917	-5.373
First difference	WS	-2.55	-2.563	-6.881	-8.091	-7.665	-7.247	-6.351	-5.191	-6.853	-4.943	-4.023	-5.516
Second difference	ADF	-2.89	-5.279	-13.589	-11.177	-13.828	-11.154	-10.467	-10.108	-10.484	-9.998	-10.196	-9.735
Second difference	WS	-2.55	-5.459	-13.816	-11.410	-13.889	-11.303	-10.703	-10.338	-10.618	-10.109	-10.430	-9.931
Exports													
With trend	ADF	-3.45	-2.869	-3.151	-1.800	-2.940	-3.492	-1.293	-1.806	-2.275	-2.758	-4.283	-2.329
With trend	WS	-3.24	-2.879	-3.255	-1.922	-2.043	-3.662	-1.014	-1.614	-2.222	-2.980	-4.450	-2.331
No trend	ADF	-2.89	-0.711	-2.752	-0.652	-2.912	-2.610	-1.241	-1.756	-1.244	-1.934	-2.293	-2.340
No trend	WS	-2.55	0.009	-2.413	0.159	-2.059	-2.087	-0.573	-1.758	-0.176	-1.748	-1.887	-2.344
First difference	ADF	-2.89	-2.640	-9.402	-9.024	-8.063	-10.494	-5.202	-6.698	-7.235	-7.008	-6.879	-8.665
First difference	WS	-2.55	-2.723	-9.618	-9.091	-8.270	-10.673	-5.357	-6.889	-7.378	-7.198	-7.044	-8.869
Second difference	ADF	-2.89	-5.529	-10.760	-10.767	-11.290	-12.395	-8.835	-8.910	-10.942	-9.494	-9.464	-11.066
Second difference	WS	-2.55	-5.712	-10.996	-10.991	-11.539	-12.611	-9.011	-9.122	-11.165	-9.709	-9.644	-11.252

Table 9: Unit Root Test Results for Domestic Variables

Domestic Variables	Statistic Type	Critical Value	United States	Newfound land and Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat- chewan	Alberta	British Columbia
Imports													
With trend	ADF	-3.45	-3.265	-0.777	-7.731	-3.969	-2.494	-1.038	-2.124	-3.744	-3.702	-3.291	-5.747
With trend	WS	-3.24	-3.064	-1.003	-7.941	-4.160	-2.727	-1.411	-2.332	-3.930	-3.605	-3.488	-5.914
No trend	ADF	-2.89	-2.530	0.866	-7.110	-3.556	-1.744	0.015	-1.808	-1.044	-1.228	-1.355	-2.070
No trend	WS	-2.55	-1.566	0.572	-7.284	-3.704	-1.662	-0.076	-1.691	-0.478	-1.278	-0.895	-1.865
First difference	ADF	-2.89	-6.500	-7.377	-9.700	-11.534	-9.098	-5.069	-8.433	-9.095	-8.609	-6.335	-13.470
First difference	WS	-2.55	-6.686	-7.570	-9.912	-11.783	-9.244	-5.261	-8.643	-9.312	-8.797	-6.516	-13.688
Second difference	ADF	-2.89	-7.993	-12.597	-10.784	-16.167	-13.300	-10.752	-9.393	-11.762	-11.068	-9.616	-14.741
Second difference	WS	-2.55	-8.180	-12.857	-10.958	-16.492	-13.479	-10.979	-9.614	-12.018	-11.205	-9.835	-14.953
GDP													
With trend	ADF	-3.45	-1.969	-1.719	-1.752	-2.105	-1.777	-2.089	-1.430	-2.074	-2.591	-2.877	-1.410
With trend	WS	-3.24	-1.322	-1.855	-1.976	-1.943	-1.543	-2.374	-1.757	-1.255	-2.000	-2.663	-0.879
No trend	ADF	-2.89	-0.521	-1.457	1.024	-0.759	-1.326	0.716	0.591	1.485	0.717	0.173	1.826
No trend	WS	-2.55	2.322	1.013	2.536	2.412	2.299	2.540	2.702	2.267	1.731	1.549	2.381
First difference	ADF	-2.89	-4.391	-6.430	-7.646	-7.349	-6.918	-7.701	-7.528	-8.055	-6.719	-6.924	-7.548
First difference	WS	-2.55	-4.412	-6.606	-7.758	-7.461	-7.053	-7.799	-7.645	-8.150	-6.875	-7.083	-7.666
Second difference	ADF	-2.89	-9.565	-10.835	-10.498	-10.519	-10.538	-10.474	-10.569	-10.424	-10.479	-10.736	-10.645
Second difference	WS	-2.55	-9.715	-11.079	-10.737	-10.758	-10.778	-10.713	-10.809	-10.662	-10.718	-10.978	-10.886

Table 10: Unit Root Test Results for Foreign Variables

Foreign Variables	Statistic Type	Critical Value	United States	Newfoundland and Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia
Employment													
With trend	ADF	-3.45	-2.739	-2.849	-2.845	-2.855	-2.840	-2.872	-2.834	-2.868	-2.887	-2.851	-2.884
With trend	WS	-3.24	-1.002	-2.879	-2.823	-2.848	-2.880	-2.900	-2.895	-2.906	-2.928	-2.897	-2.914
No trend	ADF	-2.89	-1.876	-0.788	-0.713	-0.721	-0.801	-0.808	-0.843	-0.795	-0.799	-0.815	-0.781
No trend	WS	-2.55	2.020	-0.130	0.075	0.035	-0.168	-0.150	-0.266	-0.157	-0.168	-0.202	-0.121
First difference	ADF	-2.89	-5.003	-2.587	-2.766	-2.735	-2.542	-2.648	-2.466	-2.589	-2.583	-2.562	-2.611
First difference	WS	-2.55	-4.921	-2.677	-2.837	-2.810	-2.637	-2.731	-2.569	-2.679	-2.674	-2.655	-2.699
Second difference	ADF	-2.89	-9.549	-5.432	-5.708	-5.634	-5.378	-5.490	-5.284	-5.412	-5.397	-5.370	-5.449
Second difference	WS	-2.55	-9.770	-5.614	-5.893	-5.819	-5.559	-5.673	-5.465	-5.595	-5.579	-5.553	-5.632
Exports													
With trend	ADF	-3.45	-2.028	-1.878	-1.919	-1.927	-1.808	-1.979	-3.695	-2.515	-3.318	-1.766	-2.976
With trend	WS	-3.24	-1.810	-1.607	-1.622	-1.662	-1.524	-1.767	-3.644	-2.329	-3.214	-1.542	-2.832
No trend	ADF	-2.89	-2.042	-1.894	-1.937	-1.943	-1.819	-1.988	-2.356	-2.371	-2.600	-1.761	-2.527
No trend	WS	-2.55	-1.655	-1.464	-1.531	-1.536	-1.369	-1.743	-1.561	-1.689	-1.846	-1.589	-1.765
First difference	ADF	-2.89	-6.658	-6.356	-6.382	-6.417	-6.177	-6.732	-6.197	-6.750	-7.093	-6.429	-6.965
First difference	WS	-2.55	-6.846	-6.546	-6.572	-6.607	-6.367	-6.920	-6.385	-6.934	-7.273	-6.620	-7.146
Second difference	ADF	-2.89	-8.577	-8.460	-8.484	-8.461	-8.321	-8.711	-8.332	-8.437	-8.789	-8.650	-8.620
Second difference	WS	-2.55	-8.780	-8.660	-8.689	-8.664	-8.518	-8.919	-8.503	-8.632	-8.979	-8.861	-8.808

Table 11: Unit Root Test Results for Foreign Variables

Foreign Variables	Statistic Type	Critical Value	United States	Newfoundland and Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia
Imports													
With trend	ADF	-3.45	-2.105	-2.711	-2.392	-2.446	-2.829	-2.675	-3.231	-2.815	-2.893	-2.886	-2.761
With trend	WS	-3.24	-2.324	-2.641	-2.431	-2.469	-2.727	-2.619	-3.054	-2.730	-2.794	-2.777	-2.694
No trend	ADF	-2.89	-1.655	-2.049	-1.800	-1.836	-2.131	-2.071	-2.431	-2.110	-2.133	-2.183	-2.051
No trend	WS	-2.55	-1.479	-1.210	-1.132	-1.142	-1.251	-1.273	-1.475	-1.245	-1.231	-1.297	-1.197
First difference	ADF	-2.89	-8.336	-6.626	-7.018	-6.976	-6.505	-6.863	-6.414	-6.641	-6.574	-6.610	-6.663
First difference	WS	-2.55	-8.546	-6.816	-7.213	-7.170	-6.693	-7.055	-6.600	-6.831	-6.764	-6.799	-6.853
Second difference	ADF	-2.89	-9.328	-8.073	-8.405	-8.369	-7.981	-8.241	-7.927	-8.066	-8.016	-8.035	-8.097
Second difference	WS	-2.55	-9.548	-8.269	-8.611	-8.574	-8.174	-8.441	-8.115	-8.263	-8.212	-8.230	-8.294
GDP													
With trend	ADF	-3.45	-1.711	-1.704	-1.673	-1.695	-1.772	-1.582	-2.818	-2.005	-2.420	-1.433	-2.322
With trend	WS	-3.24	-2.021	-2.018	-1.987	-2.009	-2.080	-1.905	-2.789	-2.258	-2.565	-1.764	-2.536
No trend	ADF	-2.89	0.652	0.624	0.590	0.625	0.624	0.633	0.718	0.666	0.608	0.837	0.565
No trend	WS	-2.55	2.599	2.618	2.632	2.614	2.599	2.627	2.290	2.497	2.367	2.621	2.429
First difference	ADF	-2.89	-7.579	-7.577	-7.576	-7.574	-7.574	-7.522	-7.374	-7.517	-7.445	-7.539	-7.479
First difference	WS	-2.55	-7.693	-7.689	-7.688	-7.687	-7.685	-7.640	-7.499	-7.634	-7.569	-7.653	-7.600
Second difference	ADF	-2.89	-10.535	-10.506	-10.519	-10.520	-10.491	-10.538	-10.431	-10.508	-10.533	-10.520	-10.520
Second difference	WS	-2.55	-10.774	-10.745	-10.758	-10.759	-10.730	-10.777	-10.669	-10.747	-10.772	-10.759	-10.759

Table 12: Unit Root Test Results for Global Variables

Global Variables	Test	Critical Value	Statistic
Oil Price			
With trend	ADF	-3.45	-2.542
With trend	WS	-3.24	-2.774
No trend	ADF	-2.89	-2.310
No trend	WS	-2.55	-2.216
First difference	ADF	-2.89	-7.577
First difference	WS	-2.55	-7.772
Second difference	ADF	-2.89	-10.526
Second difference	WS	-2.55	-10.761
Exchange Rate			
With trend	ADF	-3.45	-1.292
With trend	WS	-3.24	-1.631
No trend	ADF	-2.89	-1.515
No trend	WS	-2.55	-1.712
First difference	ADF	-2.89	-5.895
First difference	WS	-2.55	-6.074
Second difference	ADF	-2.89	-9.298
Second difference	WS	-2.55	-9.521

Table 13: Serial Correlation Test Results

	F Critical Value	Employment	Exports	Imports	GDP	Oil Price	Exchange Rate
United States	2.487	11.657	11.086	4.652	0.662	2.189	1.143
Newfoundland and Labrador	2.490	1.491	3.386	6.511	0.014		
Prince Edward Island	2.490	2.620	0.632	8.788	0.183		
Nova Scotia	2.490	1.166	2.826	1.824	8.446		
New Brunswick	2.490	1.122	2.528	4.608	4.315		
Quebec	2.490	0.730	2.319	2.801	7.315		
Ontario	2.490	1.190	3.772	15.060	5.396		
Manitoba	2.490	2.722	0.289	3.970	3.862		
Saskatchewan	2.490	2.410	1.491	5.612	0.099		
Alberta	2.490	5.263	0.927	2.768	1.708		
British Columbia	2.490	1.022	0.943	5.396	8.875		

Table 14: Weak Exogeneity Test Results

	F Critical Value	Employment	GDP	Oil Price	Exchange Rate
United States	3.967	0.027	0.751		
Newfoundland and Labrador	3.967	0.038	1.452	3.710	0.204
Prince Edward Island	3.967	0.009	8.098	0.000	0.598
Nova Scotia	3.967	0.466	0.000	0.280	0.566
New Brunswick	3.967	0.648	0.430	1.675	0.821
Quebec	3.967	2.466	0.026	0.098	0.118
Ontario	3.967	1.146	11.892	0.424	0.320
Manitoba	3.967	1.522	2.243	0.236	0.022
Saskatchewan	3.967	1.794	0.191	0.075	0.355
Alberta	3.967	10.058	2.683	2.589	2.292
British Columbia	3.967	0.033	5.358	0.136	0.092

Table 15: Contemporaneous Effects Test Results

		Employment	**GDP**
United States	Coefficient	14.2318	0.0005
	Standard error	2.4384	0.0011
	t-ratio	5.8366	0.3995
	White's adjusted SE	3.2387	0.0011
	t-ratio_White	4.3944	0.4253
	Newey-West's adjusted SE	4.2230	0.0013
	t-ratio_NeweyWest	3.3701	0.3504
Newfoundland and Labrador	Coefficient	0.0010	0.1334
	Standard error	0.0018	0.0259
	t-ratio	0.5363	5.1582
	White's adjusted SE	0.0019	0.0411
	t-ratio_White	0.4889	3.2437
	Newey-West's adjusted SE	0.0017	0.0412
	t-ratio_NeweyWest	0.5474	3.2349
Prince Edward Island	Coefficient	0.0006	0.0158
	Standard error	0.0011	0.0011
	t-ratio	0.5820	14.3210
	White's adjusted SE	0.0008	0.0018
	t-ratio_White	0.8186	8.8534
	Newey-West's adjusted SE	0.0008	0.0019
	t-ratio_NeweyWest	0.8195	8.4205
Nova Scotia	Coefficient	0.0044	0.0725
	Standard error	0.0033	0.0059
	t-ratio	1.3562	12.2112
	White's adjusted SE	0.0030	0.0086
	t-ratio_White	1.4982	8.4696
	Newey-West's adjusted SE	0.0025	0.0087
	t-ratio_NeweyWest	1.7659	8.3376
New Brunswick	Coefficient	-0.0009	0.0876
	Standard error	0.0016	0.0084
	t-ratio	-0.5614	10.4678
	White's adjusted SE	0.0011	0.0141
	t-ratio_White	-0.7916	6.1999

	Newey-West's adjusted SE	0.0011	0.0147
	t-ratio_NeweyWest	-0.7962	5.9772
Quebec	Coefficient	0.0378	0.8199
	Standard error	0.0109	0.0363
	t-ratio	3.4761	22.5806
	White's adjusted SE	0.0102	0.0561
	t-ratio_White	3.7268	14.6124
	Newey-West's adjusted SE	0.0116	0.0582
	t-ratio_NeweyWest	3.2706	14.0987
Ontario	Coefficient	0.0410	5.9910
	Standard error	0.0089	0.3905
	t-ratio	4.6169	15.3414
	White's adjusted SE	0.0147	0.4150
	t-ratio_White	2.7816	14.4363
	Newey-West's adjusted SE	0.0145	0.4300
	t-ratio_NeweyWest	2.8374	13.9341
Manitoba	Coefficient	0.0021	0.1646
	Standard error	0.0016	0.0104
	t-ratio	1.3200	15.8652
	White's adjusted SE	0.0016	0.0157
	t-ratio_White	1.3325	10.5142
	Newey-West's adjusted SE	0.0015	0.0159
	t-ratio_NeweyWest	1.3791	10.3607
Saskatchewan	Coefficient	0.0008	0.2366
	Standard error	0.0022	0.0248
	t-ratio	0.3406	9.5420
	White's adjusted SE	0.0018	0.0384
	t-ratio_White	0.4204	6.1550
	Newey-West's adjusted SE	0.0019	0.0382
	t-ratio_NeweyWest	0.3944	6.1994
Alberta	Coefficient	0.0161	1.3771
	Standard error	0.0049	0.1892
	t-ratio	3.2728	7.2790
	White's adjusted SE	0.0040	0.3198
	t-ratio_White	3.9893	4.3058

	Newey-West's adjusted SE	0.0051	0.3398
	t-ratio_NeweyWest	3.1622	4.0524
British Columbia	Coefficient	0.0198	0.7229
	Standard error	0.0079	0.0401
	t-ratio	2.5070	18.0206
	White's adjusted SE	0.0062	0.0519
	t-ratio_White	3.2172	13.9384
	Newey-West's adjusted SE	0.0064	0.0518
	t-ratio_NeweyWest	3.1094	13.9682

Table 16: Average Pairwise Cross-Section Correlations for Employment and Exports: Variables and Residuals

		Levels	**First Differences**	**VECMX* Residuals**
Employment	United States	0.759	0.174	-0.112
	Newfoundland and Labrador	0.842	0.097	0.060
	Prince Edward Island	0.915	0.146	0.112
	Nova Scotia	0.852	0.142	0.098
	New Brunswick	0.792	0.093	0.079
	Quebec	0.932	0.138	0.046
	Ontario	0.926	0.231	0.064
	Manitoba	0.926	0.164	0.114
	Saskatchewan	0.862	0.106	0.089
	Alberta	0.926	0.179	0.052
	British Columbia	0.907	0.151	0.045
Exports	United States	0.560	0.246	0.008
	Newfoundland and Labrador	0.310	0.352	0.151
	Prince Edward Island	0.501	0.179	0.038
	Nova Scotia	0.271	0.315	0.148
	New Brunswick	0.373	0.201	0.086
	Quebec	0.418	0.391	0.176
	Ontario	0.172	0.278	0.126
	Manitoba	0.554	0.313	0.126
	Saskatchewan	0.318	0.307	0.131
	Alberta	0.485	0.236	0.030
	British Columbia	0.313	0.329	0.116

Table 17: Average Pairwise Cross-Section Correlations for Imports and GDP: Variables and Residuals

		Levels	**First Differences**	**VECMX* Residuals**
Imports	United States	0.606	0.324	0.152
	Newfoundland and Labrador	0.665	0.217	0.143
	Prince Edward Island	0.193	0.061	-0.009
	Nova Scotia	0.451	0.011	0.015
	New Brunswick	0.628	-0.026	0.008
	Quebec	0.686	0.291	0.141
	Ontario	0.490	0.293	0.162
	Manitoba	0.702	0.295	0.168
	Saskatchewan	0.634	0.245	0.133
	Alberta	0.704	0.254	0.147
	British Columbia	0.673	0.138	-0.007
GDP	United States	0.984	0.109	0.011
	Newfoundland and Labrador	0.970	0.449	0.034
	Prince Edward Island	0.992	0.656	0.130
	Nova Scotia	0.990	0.592	0.115
	New Brunswick	0.986	0.599	0.105
	Quebec	0.992	0.703	0.100
	Ontario	0.991	0.692	-0.120
	Manitoba	0.989	0.651	0.093
	Saskatchewan	0.984	0.530	0.029
	Alberta	0.986	0.512	-0.161
	British Columbia	0.989	0.671	0.026

Table 18: Nybolm Structural Stability Test Results

	Employment	Exports	Imports	GDP	Oil Price	Exchange Rate
United States	0.921	0.918	0.619	0.441	0.284	0.441
Newfoundland and Labrador	0.568	0.677	1.066	1.784		
Prince Edward Island	0.618	0.381	0.896	0.873		
Nova Scotia	0.914	0.901	0.713	1.757		
New Brunswick	1.267	1.642	1.048	3.017		
Quebec	1.022	1.211	0.617	0.923		
Ontario	1.481	1.883	0.815	1.667		
Manitoba	0.843	0.692	0.387	0.951		
Saskatchewan	0.587	0.593	0.435	1.311		
Alberta	1.107	0.825	0.868	1.255		
British Columbia	0.662	0.551	1.255	2.051		

Table 19: Critical Values for Nybolm Structural Stability Test Results

95% Critical Values	Employment	Exports	Imports	GDP	Oil Price	Exchange Rate
United States	0.982	1.123	1.065	1.100	1.237	1.128
Newfoundland and Labrador	1.495	1.261	1.487	1.426		
Prince Edward Island	1.618	1.254	1.346	1.486		
Nova Scotia	1.554	1.523	1.227	1.285		
New Brunswick	1.407	1.257	1.315	1.460		
Quebec	1.463	1.473	1.268	1.507		
Ontario	1.545	1.373	1.229	1.417		
Manitoba	1.388	1.316	1.444	1.551		
Saskatchewan	1.585	1.510	1.465	1.569		
Alberta	1.491	1.448	1.660	1.446		
British Columbia	1.604	1.382	1.407	1.435		