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Income and Exchange Rate Sensitivities of Cross-Border Freight Flows: Evidence from U.S.-Canada Exports and Imports by Truck, Rail, Air, and Pipeline

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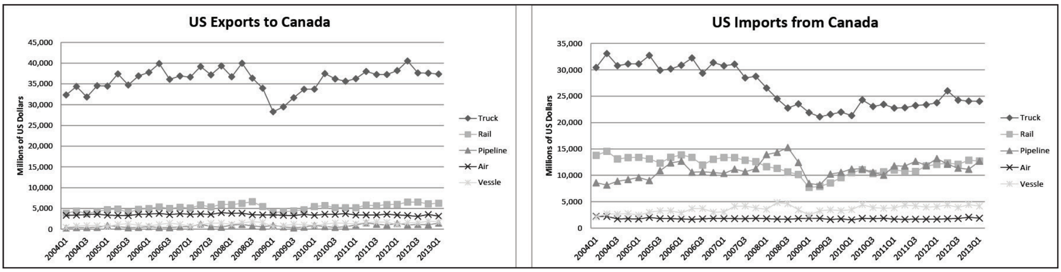
This paper aims to improve understanding of the long-run impacts of the gross domestic product (GDP), real exchange rate, and the producer price index (PPI) on U.S.-Canada bilateral freight flows in a dynamic framework. Special attention is given to cross-border exports and imports by truck, rail, pipeline, and air. Using the fully modified ordinary least squares (FM-OLS) approach, the paper finds that the GDP of the importing country is a pronounced factor influencing U.S.-Canada cross-border trade, suggesting that economic growth of the country is a powerful driver in the relative intensity of bilateral freight flows. The real exchange rate tends to be positively associated with U.S. imports, but negatively associated with U.S. exports, indicating that the U.S. dollar depreciation against the Canadian dollar increases demand for U.S. commodities in Canada, but weakens demand for Canadian commodities in the United States. The long-run effects of the selected economic variables on cross-border exports and imports are found to vary by mode of transportation. The Canadian GDP has a positive and significant effect on U.S. freight exports by all transportation modes, but U.S. exports by pipeline are more sensitive to a change in Canadian GDP than U.S. exports by truck and rail. The findings in this paper provide important policy and managerial implications for cross-border transportation planning in the United States and Canada.

INTRODUCTION

Canada is the largest trading partner of the United States with cross-border exports and imports playing an important role in determining the trade balance between the two countries. Since the North American Free Trade Agreement (NAFTA) was implemented, cross-border exports of freight from the U.S. to Canada have substantially increased. For example, U.S. exports of freight to Canada have risen from $44.6 billion to $54.5 billion during 2004:Q1 to 2013:Q1 (Bureau of Transportation Statistics 2013). Trucking is the dominant transport mode compared to other modes (i.e., air, rail, vessel, and pipeline), accounting for approximately 70% of total U.S. exports in 2012. However, there are different patterns of exports and imports between the United States and Canada, and the intensity of freight trade flows appears to vary by mode of transportation (Figure 1). For example, U.S. exports to Canada by truck show an upward trend from 2004:Q1 to 2013:Q1, while U.S. imports from Canada by truck are in a downward trend over the same period. In addition, U.S. imports from Canada by rail and pipeline fluctuate more over time compared with U.S. exports to Canada by those same modes. These patterns suggest that key determinants of freight flows can differ between exports and imports, and the impacts of the determinants on bilateral freight flows may vary by modes of transportation.

Figure 1: US Exports to Canada and US Imports from Canada by Transportation Modes (Indexed Exports and Imports Adjusted for Inflation)



Source: Bureau of Transportation Statistics (2013).

Several studies have investigated bilateral international trade (Srivastava and Green 1986; Bahmani-Oskooee and Brooks 1999; McKenzie 1999; Bahmani-Oskooee and Ardalani 2006; Bahmani-Oskooee and Bolhassani 2014). These papers tend to focus on the impacts of income and exchange rate on bilateral trade. For example, Srivastava and Green (1986) examined the determinants of bilateral trade flows between 45 exporting countries and 82 importing countries and found that GDP of the exporting country is a pronounced factor affecting bilateral trade. Using cointegration technique, Bahmani-Oskooee and Brooks (1999) investigated the bilateral trade elasticities between the United States and its six largest trading partners. Their results showed that a cointegration relationship exists in the variables in the U.S. import and export demand functions, and a depreciation of the U.S. dollar improves the U.S. bilateral trade balance. In addition, Bahmani-Oskooee and Bolhassani (2014) examined the impact of exchange rate uncertainty on trade flows of 152 industries between the United States and Canada. Their paper suggested that an increase in exchange rate uncertainty has a little long-run impact on industries. McKenzie (1999) provided a comprehensive literature review and found mixed results of the impact of exchange rate volatility on trade flows.

A group of studies focused more on cross-border trade and transportation policy issues (Baier and Bergstrand 2001; Taylor et al. 2004; Globerman and Storer 2009; Bradbury 2013). Baier and Bergstrand (2001) assessed the impacts of income, tariff liberalization, and transport-cost on the growth of world trade among the selected OECD countries. Their results showed that income growth, tariff-rate declines, and transport-cost reductions explain about 67%, 25%, and 8% of the average world trade growth, respectively. Taylor et al. (2004) also explored the cost effects of border and trade policies on U.S.-Canada cross-border trade and transportation. They found that border and trade policies have a negative impact on the economies of two countries of $10.3 billion annually. Globerman and Storer (2009) examined the effects of border security-related costs and delays on Canadian exports to the United States and concluded that post-9/11 border security developments had a significant negative impact on Canadian exports to the United States.

Although previous studies have improved the understanding of the characteristics of cross-border trade flows, the determinants of the U.S.-Canada bilateral trade flows by transportation modes have not been investigated in existing literature. The impacts of the economic factors on freight flows may differ among transportation modes because of different shipment characteristics of trading commodities. For example, machinery and parts are main U.S. export commodities shipped by trucks to Canada, while petroleum products are mostly exported by pipeline. The income and exchange rate elasticities of demand for these commodities can vary for Canadian consumers and producers, which lead to a different magnitude of impacts of these factors on the trade flows by truck and pipeline. Bahmani-Oskooee and Ardalani (2006) also supported the proposition that income and exchange rate elasticities vary by commodity groups between the United States and its major trading partners.[1] This is likely to influence trade flows among transportation modes. Furthermore, it is essential for policymakers and logistics managers to understand the long-run determinants of bilateral freight flows to develop long-term transportation infrastructure and service plans.

The purpose of this paper is to advance understanding of the cross-border freight flows between the United States and Canada by examining the long-run determinants of bilateral freight flows *by transport modes*. Special attention is paid to the assessment of dynamic impacts of economic growth, exchange rate, and export price on U.S. freight exports and imports among transportation modes (i.e., truck, rail, pipeline, and air). To the best of my knowledge, this paper is the first to examine the dynamic effects of these economic variables on bilateral freight flows by transport modes between the United States and Canada. This paper adopts a fully modified ordinary least squares (FM-OLS) approach, developed by Phillips and Hansen (1990). The FM-OLS model is widely used to provide unbiased estimates of the dynamic relationship between variables of interest if variables are non-stationary $I(1)$ processes. Another advantage of the FM-OLS is that it is less sensitive to changes in lag length and superior to other cointegration techniques when a small number of observations are used (Engle and Granger 1987; Chi and Baek 2011). The sample size can be a major concern for validation of time-series techniques because limited data are available for the cross-border trade analysis at an aggregate level. The information derived from this paper can be used to improve understanding of the driving forces of the increasing cross-border freight flows between the United States and Canada. Further, this information may help build appropriate investment planning for transportation infrastructure based on the projection of long-term economic growth and exchange rate trends.

The remainder of the paper is organized as follows. The second section presents the FM-OLS model, variable description, and data sources. The third section provides the empirical findings of FM-OLS model, the results of unit root and cointegration tests, and long-run coefficients of freight exports and imports between the United States and Canada. Policy implications and concluding remarks are provided in the final section.

THE MODEL

The FM-OLS Approach

In examining the cross-border freight flows, this paper follows a theoretical framework of the bilateral trade model developed by Bahmani-Oskooee and Goswami (2004) and examines the long-run relationship between economic growth, exchange rate, export price, and trade flows between the United States and Canada. The reduced-form equations for U.S. freight exports (EX_{it}) and imports (IM_{it}) by transportation mode *i* are specified as follows:

$$(1)\quad EX_{it} = f\,(GDP_t^{ca}, ER_t, P_t^{us}),$$

$$(2)\quad IM_{it} = f\,(GDP_t^{us}, ER_t, P_t^{ca}),$$

where GDP_t^{us} (GDP_t^{ca})is the real Gross Domestic Production of the United States (Canada); ER_t is the real exchange rate of the Canadian dollar against the U.S. dollar; and is the export price of commodities including transportation costs in the United States (Canada). P_t^{us} (P_t^{ca}) The freight transportation mode *i* includes truck, rail, pipeline, vessel, and air ($i = t, r, p, v,$ and a).

To conduct the FM-OLS approach, Equations (1) and (2) are expressed in a log linear form as follows.

$$(3)\quad \ln EX_{it} = \alpha_0 + \alpha_1 \ln GDP_t^{ca} + \alpha_2 \ln ER_t + \alpha_3 \ln P_t^{us} + \varepsilon_t,$$

$$(4)\quad \ln IM_{it} = \beta_0 + \beta_1 \ln GDP_t^{us} + \beta_2 \ln ER_t + \beta_3 \ln P_t^{ca} + \mu_t,$$

where ε_t and μ_t are error terms and all the variables are hypothesized to be integrated of order one $I(1)$. With regard to the expected signs of coefficients, it is assumed that $a_1 > 0$ and $\beta_1 > 0$, because economic growth in Canada (the United States) is positively associated with demand for imported goods from the United States (Canada). For the real exchange rate, a decrease in the value of the U.S. dollar against the Canadian dollar leads to a price reduction of imported U.S. goods in Canada, which causes an increase in demand for U.S. goods ($a_2 < 0$). However, the U.S. dollar depreciation increases the price of imported goods in the United States and weakens demand for Canadian goods ($\beta_2 > 0$). A price increase in exporting goods in the United States (Canada) has a negative effect on demand for United States (Canadian) products in an international market; therefore, it is expected that $a_3 < 0$ and $\beta_3 < 0$.

Data

This paper uses quarterly data from 2004:Q1 to 2013:Q1. Freight exports and imports by mode of transportation are taken from the indexed trade data from the Bureau of Transportation Statistics (2013). The data are adjusted for inflation and exchange rate fluctuations. The paper uses the real GDP index (2005=100) collected from International Financial Statistics data, the International Monetary Fund (IMF 2013a). The GDP is used as a proxy for economic growth in the country. In addition, the real exchange rate is calculated by multiplying the nominal exchange rate by the ratio of the consumer price indices (CPI) of the two countries. The real exchange rate data are obtained from Economic Research Service (ERS), the United States Department of Agriculture (ERS 2013). This paper employs the producer price index (PPI) as a proxy for the export price of commodities and the PPIs for all commodities (2005=100) are collected from the International Financial Statistics data (IMF 2013a). It should be noted that the 2004:Q1 to 2013:Q1 period is the best available export and import data for all transportation modes from the Bureau of Transportation Statistics when the analysis is conducted. Table 1 presents the summary statistics of the data used in the models. All variables are expressed in natural logarithms.

EMPIRICAL RESULTS

The first step of the FM-OLS procedure is to test the non-stationarity of data. To apply the FM-OLS approach, the variables in Equations (3) and (4) must be non-stationary. This paper uses the Phillips-Perron (PP) test for unit root (Perron 1989); the main advantage of the PP test over the Augment Dickey-Fuller (ADF) test is that it can be more robust to general forms of heteroskedasticity. The optimal lag length is determined by the Newey-West estimator. The results of the PP test show that for all the variables, the null hypothesis of non-stationarity cannot be rejected at the 5% significance level for the level series, while it is rejected for the first-differenced series (Table 2). It is concluded that all the variables are non-stationary and $I(1)$, and therefore, all the selected variables can be used in the FM-OLS procedure.

Table 1: Summary Statistics (Quarterly Data from 2004:Q1 to 2013:Q1)

Variable	Unit	Mean	Median	Minimum	Maximum	Standard Deviation
GDP_t^{us}	Index	103.07	103.29	96.00	108.74	3.23
P_t^{us}	Index	111.37	110.91	95.66	125.97	9.81
EX_{tt}	US$ (mil.)	36,034.29	36,731.21	28,304.47	40,514.34	2,779.25
EX_{rt}	US$ (mil.)	5,254.53	5,295.52	3,772.10	6,627.57	799.38
EX_{pt}	US$ (mil.)	756.17	628.53	304.36	1,541.14	347.98
EX_{at}	US$ (mil.)	3,504.20	3,518.88	3,053.50	3,984.46	200.99
EX_{vt}	US$ (mil.)	1,226.48	1,203.13	453.57	1,953.34	379.20
GDP_t^{ca}	Index	104.67	105.06	95.40	112.29	4.2
P_t^{ca}	Index	102.62	101.10	93.70	117.80	5.47
IM_{tt}	US$ (mil.)	26,556.62	24,506.19	21,100.70	33,087.18	3,954.60
IM_{rt}	US$ (mil.)	11,834.26	12,094.88	7,708.89	14,535.06	1,669.46
IM_{pt}	US$ (mil.)	11,070.02	11,151.38	8,147.13	15,273.93	1,698.34
IM_{at}	US$ (mil.)	1,795.20	1,777.38	1,555.38	2,217.55	139.96
IM_{vt}	US$ (mil.)	3,580.03	3,691.83	2,097.46	4,840.41	673.77
ER_t	CA$/US$	1.12	1.09	1.00	1.36	0.10

Table 2: Results of Phillips-Perron (PP) Test for Unit Root

Variable	Level	First Difference	Decision	Variable	Level	First Difference	Decision
$\ln GDP_t^{us}$	1.99	-2.65**	I(1)	$\ln GDP_t^{ca}$	2.81	-2.81**	I(1)
$\ln P_t^{us}$	1.89	-3.83**	I(1)	$\ln P_t^{ca}$	1.76	-4.65**	I(1)
$\ln EX_{tt}$	0.44	-7.68**	I(1)	$\ln IM_{tt}$	-0.87	-7.84**	I(1)
$\ln EX_{rt}$	0.91	-6.86**	I(1)	$\ln IM_{rt}$	-0.20	-5.18**	I(1)
$\ln EX_{pt}$	1.05	-7.68**	I(1)	$\ln IM_{pt}$	0.56	-4.74**	I(1)
$\ln EX_{at}$	-0.33	-10.62**	I(1)	$\ln IM_{at}$	-0.57	-9.09**	I(1)
$\ln EX_{vt}$	1.23	-9.33**	I(1)	$\ln IM_{vt}$	1.25	-8.31**	I(1)
$\ln ER_t$	-1.94	-4.71**	I(1)				

Notes: ** denotes rejection of the null hypothesis of a unit root at the 5% level. The 5% critical value for the PP test is -1.95. The Newey-West lag length is used to compute the standard error for the PP test.

Before estimating the U.S. export and import models, the optimal lag length and cointegration rank should be chosen. Trace statistics and eigenvalues are widely used to determine the number of cointegrating vectors in the Johansen Likelihood Ratio (LR) Test for Cointegration.[2] However, the Johansen LR Test (Johansen 1988) is derived from asymptotic results and critical values may be misleading for small sample size (Cheung and Lai 1993; Toda 1995). To avoid the small-sample bias, this paper adopts a model selection method based on information criteria suggested by Yu et al. (2007) and Park et al. (2008). Table 3 shows Schwarz's Bayesian (SIC) and Hannan and Quinn (HQ) information criteria on alternative lag lengths of zero through four. The test results show that the optimal lag lengths are not consistent between SIC and HQ measures for seven models. This paper employs HQ information criterion to select the optimal lag length because of the over-penalization problem of SIC (Park et al. 2008).

Table 3: Results of Optimal Lag Length of U.S. Export and Import Models

U.S. Exports										
	ln EX_{tt}		ln EX_{rt}		ln EX_{pt}		ln EX_{at}		ln EX_{vt}	
Lag	HQ	SIC	HQ	SIC	HQ	SIC	HQ	SIC	HQ	SIC
0	-25.18	-25.18	-25.18	-25.18	-22.55	-22.55	-26.28	-26.28	-23.29	-23.29
1	-30.86	-30.13*	-30.04*	-29.38*	-26.97	-26.24*	-30.52	-30.03*	-27.54	-27.06*
2	-31.51	-30.06	-29.87	-29.09	-26.99*	-25.54	-30.71*	-29.75	-27.94*	-26.98
3	-31.37	-29.19	-29.51	-28.07	-26.91	-24.73	-30.51	-29.06	-27.70	-26.25
4	-31.56*	-28.66	-29.16	-27.23	-26.89	-23.99	-30.41	-28.48	-27.70	-25.78
U.S. Imports										
	ln IM_{tt}		ln IM_{rt}		ln IM_{pt}		ln IM_{at}		ln IM_{vt}	
Lag	HQ	SIC	HQ	SIC	HQ	SIC	HQ	SIC	HQ	SIC
0	-26.40	-26.40	-25.93	-25.93	-25.77	-25.77	-27.45	-27.45	-26.11	-26.11
1	-31.46	-30.97*	-31.40	-30.92*	-30.24*	-29.76*	-31.09	-30.60*	-30.22	-29.74
2	-31.41	-30.44	-31.49	-30.52	-30.22	-29.26	-30.99	-30.03	-31.08*	-30.11*
3	-31.65*	-30.21	-31.69*	-30.26	-30.20	-28.75	-31.438	-29.99	-30.99	-29.55
4	-39.93	-29.01	-31.67	-29.74	-30.00	-28.07	-30.98	-29.05	-30.71	-28.78

Note: * indicates the optimal lag length; Schwarz's Bayesian information criterion (SIC) = $\ln(|\sum u|) + \frac{\ln(T)}{T}\, pK^2$; Hannan and Quinn information criterion (HQ) = $\ln(|\sum u|) + \frac{2\ln\{\ln(T)\}}{T}\, pK^2$.

One important requirement for application of the FM-OLS model is that a single cointegration vector[3] must exist in Equations (3) and (4). This paper uses HQ information criterion to identify the number of cointegration vectors (Table 4). The results show that one cointegration vector is present for the U.S. exports by truck, rail, pipeline, and air. This indicates that a long-run cointegration relationship exists among the variables in these cases. In other words, there is a statistically significant linear combination of U.S. exports, GDP, exchange rate, and PPI. However, there is no cointegrating vector found for U.S. exports by vessel. Since the FM-OLS model is a single-equation cointegration technique, the vessel models must be dropped. Thus, the paper proceeds with four transportation modes for the analysis. For U.S. imports, the test results support the hypothesis that a unique steady state relationship is present in the models for truck, rail, pipeline, and air.

Table 4: Results of Johansen Test for Cointegration

U.S. Exports					
Maximum Rank	ln EX_{tt}	ln EX_{rt}	ln EX_{pt}	ln EX_{at}	ln EX_{vt}
r = 0	-18.64	-17.55	-14.36	-17.09	-15.13*
r = 1	-18.79*	-17.75*	-14.76*	-17.63*	-15.09
r = 2	-18.73	-17.71	-14.67	-17.62	-14.87
r = 3	-18.66	-17.57	-14.58	-17.46	-14.66
r = 4	-18.60	-17.50	-14.51	-17.37	-14.60
U.S. Imports					
Maximum Rank	ln IM_{tt}	ln IM_{rt}	ln IM_{pt}	ln IM_{at}	ln IM_{vt}
r = 0	-18.39	-18.92	-17.98	-17.74	-18.26
r = 1	-18.61*	-18.95*	-18.16*	-17.82*	-18.80
r = 2	-18.45	-18.86	-18.12	-17.55	-19.33*
r = 3	-18.48	-18.79	-17.94	-17.34	-19.23
r = 4	-18.43	-18.73	-17.88	-17.28	-19.19

Note: * indicates the rank of the cointegration vector determined by Hannan and Quinn Information Criteria (HQ).

The results of long-run coefficient estimates of U.S. freight exports show that Canadian GDP has a positive effect on U.S. freight exports by all transportation modes and is statistically significant at the 5% level for truck, rail, and pipeline (Table 5). This result indicates that economic growth in Canada is an important long-run determinant of U.S. freight exports. Among transportation modes, U.S. exports by pipeline are more sensitive to a change in Canadian GDP than U.S. exports by truck and rail, while exports by air are non-significant. This finding can be explained by the unique shipment characteristics of natural gas and petroleum products by pipeline. Unlike other commodities demanded by either consumers or producers, the quantity demanded for imported natural gas and petroleum products can be derived by both domestic consumers and producers. That is, an increase in Canadian GDP, causing a rise in Canadian personal consumption as well as private investment, can increase the consumption of energy and petroleum products substantially.

Table 5: Results of Estimated Long-run Coefficients of U.S. Freight Exports to Canada

		U.S. Exports			
Dependent variable		$\ln EX_{tt}$	$\ln EX_{rt}$	$\ln EX_{pt}$	$\ln EX_{at}$
Independent variable	$\ln GDP_t^{ca}$	6.99** (1.06)	4.70** (1.32)	9.83** (4.59)	0.22 (0.77)
	$\ln ER_t$	-0.20 (0.26)	-0.68** (0.33)	2.37** (1.15)	-0.66** (0.19)
	$\ln P_t^{us}$	-2.74** (0.43)	-1.24** (0.54)	0.90 (1.87)	-0.70** (0.31)
	Constant	-9.05** (3.31)	-7.33* (4.13)	-43.72** (14.33)	10.51** (2.42)

Note: ** and * denote rejection of the null hypothesis at the 5% and 10% significance levels, respectively. Standard errors are given in parentheses.

The real exchange rate has a negative long-run impact on U.S. freight exports by truck (-0.20), rail (-0.68) and air transportation (-0.66). However, the effect of the exchange rate is found to be statistically significant only for rail and air. Since a depreciation of the U.S. dollar against the Canadian dollar reduces the price of U.S. commodities in Canada, it can increase demand for U.S. commodities in Canada; thus, the exchange rate is negatively associated with U.S. freight exports by truck, rail, and air. Interestingly, only for pipeline, the results reveal that the exchange rate has a positive effect on U.S. freight exports, indicating that a depreciation of the U.S. dollar against the Canadian dollar reduces U.S. exports by pipeline. A plausible explanation for this finding is that if the U.S. dollar depreciates against the Canadian dollar, then the domestic consumption of U.S. energy products may increase due to cheaper U.S. products relative to imported Canadian energy products. This is likely to reduce U.S. energy exports by pipeline. Further, improved price competitiveness of U.S. products in foreign markets due to the U.S. dollar depreciation may increase energy consumption of export industries in the United States, which can reduce the exports of U.S. energy products to Canada.

In addition, U.S. PPI has a significant negative influence on U.S. exports by truck, rail, and air, suggesting that in the long run, an increase in export price and transportation rates in the United States leads to a drop in demand for imported U.S. commodities in Canada. In particular, U.S. freight exports by truck (-2.74) and rail (-1.24) are highly responsive to a change in U.S. PPI. One reasonable explanation for this finding is that these transportation modes are relatively competitive and more inter- and intra-modal competition exists for the commodities shipped by truck. For example, if a rail rate increases, a truck can be substituted for a railroad to ship exporting products such as machinery and parts, vehicles, and plastics, which can lead to a reduction in U.S. freight exports by rail. A positive and non-significant coefficient for pipeline can be explained by limited accessibility of pipeline in Canadian markets. Pipeline access is limited from oil-producing regions in western Canada to eastern refineries (Williams 2014), which is likely to reduce a substitute effect between imported U.S. and domestic Canadian crude oil in western Canadian markets. This may result in U.S. exports by pipeline being insensitive to changes in the export price of U.S. energy products in Canada.

Table 6 provides the results of estimated coefficients of U.S. freight imports from Canada. U.S. GDP has a positive long-run effect on U.S. freight imports and it is significant at least at the 5% significance level for all modes. The results show that the impacts of U.S. GDP on U.S. freight imports are greater for truck, rail, and pipeline than air. As shown in the U.S. freight exports to Canada (Table 5), the GDP of the importing country is found to be a pronounced factor influencing

U.S.-Canada cross-border trade. Coupled with the findings of Srivastava and Green (1986), this paper finds evidence supporting the idea that economic growth of the country is a powerful driver in the relative intensity of bilateral trade flows.

The real exchange rate is positively associated with U.S. freight imports from Canada by all transportation modes although pipeline is non-significant, indicating that the U.S. dollar depreciation relative to the Canadian dollar decreases demand for Canadian commodities in the United States. Compared with other modes of transportation, U.S. imports by truck (2.27) are shown to be more sensitive to an exchange rate change. This finding may reflect the shipment characteristics by truck. Trucking is the dominant mode of importing consumer goods rather than raw materials, and U.S. consumption of imported consumer goods can be more sensitive than other imported raw materials to an exchange rate change.

Canadian PPI is found to have a negative effect on U.S. imports by truck (-4.38) and rail (-3.52), indicating that a decline in export price and transportation rates in Canada increases freight imports from Canada to the United States. The impact of Canadian PPI is statistically insignificant on U.S. imports by pipeline and air. One possible explanation for the non-significant effect is that there is a small substitution effect between these modes and other transportation modes. For example, pipeline is generally the most economical mode to ship oil and natural gas, which substantially reduces a substitution effect between pipeline and other transportation modes. This effect may lead to an insignificant or little impact of exporting price on trade flows by pipeline. Similarly, many commodities shipped by air are time-sensitive and have high values per unit and, therefore, rail or truck may not be a viable substitute for air, especially long-haul services.

Table 6: Results of Estimated Long-run Coefficients of U.S. Freight Imports from Canada

		U.S. Imports			
Dependent variable		ln IM_{tt}	ln IM_{rt}	ln IM_{pt}	ln IM_{at}
Independent variable	ln GDP_t^{us}	7.65** (1.34)	7.21** (1.59)	4.14** (1.66)	1.72** (0.77)
	ln ER_t	2.27** (0.37)	1.49** (0.44)	0.27 (0.46)	0.86** (0.21)
	ln P_t^{ca}	-4.38** (0.67)	-3.52** (0.80)	-0.82 (0.83)	0.01 (0.39)
	Constant	-5.15 (4.93)	-7.85 (5.85)	-6.11 (6.11)	-0.68 (2.85)

Note: ** and * denote rejection of the null hypothesis at the 5% and 10% significance levels, respectively. Standard errors are given in parentheses.

One area of concern in using a single equation model of the bilateral cross border freight flows is that the residuals of Equations (3) and (4) (i.e., ε_t and μ_t) could be correlated. For example, a trade dispute between the United States or Canada on commodities (e.g., softwood lumber, beef, and agricultural products) can influence both inbound and outbound freight flows. Because of this effect, a simultaneous equations model may perform more efficiently than a single equation estimator. This paper employs a seemingly unrelated regression (SUR) model to address a potential of correlated residuals of the export and import equations. The results show that the signs of coefficients tend to be consistent between the two approaches, but more variables are found to be statistically significant in the FMOLS (Table 7 in Appendix).

CONCLUSION

The contribution of this paper is to investigate the determinants of U.S.-Canada bilateral freight flows by mode of transportation in a dynamic framework. Using an FM-OLS model, the paper evaluates the long-run impacts of economic growth, exchange rate, and export price on U.S. freight exports and imports. The empirical results show that a dynamic effect of the selected variables on cross-border freight exports and imports varies by mode of transportation. For example, the Canadian GDP is a primary determinant of U.S. freight exports by all transportation modes, but U.S. exports by pipeline are found to be more sensitive to a change in Canadian GDP than U.S. exports by truck and rail.

Several policy implications can be drawn from the findings of this study. First, this paper provides empirical evidence that U.S.-Canada cross-border freight flows are highly responsive to the economic growth in the importing country in the long run. An important implication from this finding is that the relative growth of Canadian and U.S. economies can be a crucial factor in determining the balance of trade in the United States and Canada. The International Monetary Fund (IMF 2013b) reports that U.S. GDP (3.06%) is forecasted to grow faster than Canadian GDP (2.20%) for the period 2013-2018. This growth could increase freight inflows from Canada to the United States and lead to the bilateral U.S. trade deficit with Canada. More specifically, Canada is the largest energy exporter to the United States and a growing U.S. economy is likely to increase energy expenditures and imports of petroleum from Canada. This likelihood further increases the need for improvement in transport capacity for energy exports by rail and pipeline.[4]

Second, the real exchange rate has a significant impact on both U.S. freight exports and imports. This finding implies that U.S. dollar depreciation can be used to improve U.S. exports and reduce imports from Canada, since U.S. dollar depreciation against the Canadian dollar increases demand for U.S. commodities in Canada, but weakens demand for Canadian commodities in the United States. Canada's healthy fiscal and economic position is likely to continue to maintain its strength against the U.S. dollar,[5] causing strong demand for imported U.S. products (e.g., motor vehicles and parts, machinery, electronics, chemicals, and durable consumer goods). For example, Statistics Canada (2013) reports that imports from the United States to Canada grew by 1.0 %, while exports to the United States increased by only 0.2% in October, 2013. This recent trend of U.S. dollar depreciation would help improve the U.S. trade balance and increase demand for transportation services for exporting commodities in the United States.

Finally, both exports and imports by truck and rail are negatively influenced by the producer price index (PPI), suggesting that a rise in export price and transportation cost can reduce the trade flows between the United States and Canada. This finding further implies that improved productivity and cost-efficient transportation services could positively affect cross-border freight flows in the long run. Nelder (2012) found that fuel efficiency in the rail industry improved by 20% from 1990 to 2006, and some of the efficiency gains are due to technological improvements. For example, lightweight, high-capacity railcars and stronger motors have reduced the number of locomotives required to pull a train. New technology, such as global positioning systems (GPS), radio frequency identification (RFID), and maintenance and safety monitoring systems, is evolving to realize further technological and efficiency improvements. In the long-run, the bilateral trade flows and cross-border markets in the United States and Canada may be affected by these improvements.

This paper was intended to examine the impacts of income and exchange rate changes on trade flows by using aggregate freight data among transportation modes. It is worth mentioning that this macro demand approach does not capture the dynamic relationships between these variables and trade flows at an industry or commodity level. Future research could extend to a bilateral freight flow model at the regional or city level to provide various policy implications on cross-border freight infrastructure and investment.

Endnotes

1. Bahmani-Oskooee and Ardalani (2006) found that the long-run coefficients of the rest of world income on U.S. exports are 3.89 and 0.43 for electrical machinery and petroleum preparations, respectively. The coefficients of the real exchange rate are -0.37 and 1.44, respectively, for these commodity groups.
2. The null hypothesis of the trace test is that the number of cointegrating vectors is less than or equal to r. If the trace statistic for given $r=0$ exceeds its critical value, then it is concluded that at least one cointegrating vector is present. The distribution of the trace statistic proposed by Johansen (1995) is -), where T is the number of observations and are the estimated eigenvalues.
3. If two or more variables are individually integrated (i.e., I(1)) but a certain linear combination of them to be I(0), then the variables are said to be cointegrated. A stationary equilibrium relationship between variables is present if a cointegrating vector of coefficients exists (Engle and Granger 1987).
4. To meet a strong need for transport improvement, Canada is currently enhancing its rail export capacity to transport oil across the border. It was almost zero capacity in 2011, but will reach 200,000 and 300,000 barrels per day by the end of 2013 and 2014, respectively (Crooks 2013).
5. The currency exchange rate decreased from 1.44 to 1.07 Canadian dollar per U.S. dollar from January 3, 2000, to December 28, 2013 (Bank of Canada 2013).

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APPENDIX

Table 7: Results of Seemingly Unrelated Regression (SUR) Model

		U.S. Exports			
Dependent variable		$\ln EX_{tt}$	$\ln EX_{rt}$	$\ln EX_{pt}$	$\ln EX_{at}$
Independent variable	$\ln GDP_t^{ca}$	1.06* (0.57)	1.52 (1.12)	1.08 (4.85)	0.08 (0.76)
	$\ln ER_t$	-0.80** (0.25)	-0.51 (0.35)	1.21 (1.29)	-0.70** (0.20)
	$\ln P_t^{us}$	-0.63** (0.29)	0.25 (0.49)	3.61* (2.02)	-0.55* (0.31)
	Constant	8.63** (1.96)	0.35 (3.59)	-15.71 (15.14)	10.47** (2.38)
		U.S. Imports			
Dependent variable		$\ln IM_{tt}$	$\ln IM_{rt}$	$\ln IM_{pt}$	$\ln IM_{at}$
Independent variable	$\ln GDP_t^{us}$	3.31** (0.63)	3.11** (1.20)	0.56 (1.36)	1.21 (0.93)
	$\ln ER_t$	0.32 (0.32)	0.55 (0.53)	0.48 (0.49)	0.56* (0.29)
	$\ln P_t^{ca}$	-2.08** (0.27)	-1.67** (0.44)	0.82* (0.42)	-0.20 (0.26)
	Constant	4.71* (2.70)	2.92 (5.02)	8.22 (5.52)	2.73 (3.73)

Note: ** and * denote rejection of the null hypothesis at the 5% and 10% significance levels, respectively. Standard errors are given in parentheses.

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