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# Effects of Canadian Exchange rate Volatility on Imports and Exports

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## Abstract

This paper examines effects of exchange rate volatility proxied by GARCH model on Canadian total exports, exports to the USA, total imports, and imports from the USA and used monthly data from 1997M04 to 2017M08. To estimate long-run relationship ARDL co-integration bound test technique has been used. The results conclude that long-run equilibrium relationship does exist between exchange rate volatility and Canadian total exports, exports from the USA, total imports, and imports from the USA. Further results indicate that exchange rate volatility has a significant inverse long-run relationship with total exports (=-20394705), exports to USA (=-11,195,316), and total imports (=-144,000,000), but an insignificant inverse relationship with Canadian imports from the USA. Further, vector error correction mechanism (VECM) confirms long-run equilibrium relationship between variables. The absolute magnitudes of error correction terms 2.8098, 4.5239, 0.3818, and 0.5306 represent speeds of adjustment for exchange rate volatility, and Canadian total exports, exports to the USA, total imports, and imports from the USA, respectively, in case of any departure from long-run equilibrium. In short term Toda and Yamamoto test finds bi-directional between exchange rate volatility and Canadian total exports, exchange rate volatility and exports to the USA, exchange rate volatility and Canadian total imports, and exchange rate volatility and imports from the USA. Findings of the current study have very important implications for policymakers to design such policies that can establish both short term and long-run equilibrium relationship between exchange rate volatility, exports and imports adjusting short-term exchange rate and trade deficit shocks to avoid violation of international budget constraints.

**Keywords:** Canadian exchange rate volatility; Exports; Imports; Unit root; ARDL Co-integration; VECM; Granger causality

## Introduction

Ever since the collapse of Bretton Woods system in March 1973 of bilateral fix exchange rate, a new era of unpredictable bilateral floating exchange rate provoked high exchange rate volatility that in turn, theoretically adversely affects economies, value and volume of trade flows [1-5]. Contrary to it, empirical investigations present exchange rate volatility, in some cases, optimistically affects the trade flows [6].

However, exchange rate volatility differently influences exports and imports of developed and developing countries [7,8] counting on developed and underdeveloped financial markets, respectively. Further, exchange rate volatility dampens growth in the countries where financial markets are underdeveloped, and exchange rate volatility has insignificant impact in the countries where financial markets are developed. Contrary to it, studies discovered a positive linkage between exchange rate volatility and international trade in developing countries where financial markets are underdeveloped [9-11].

The erratic nature of the exchange rate volatility leads risk-averse traders to reduce collective trading activities with foreign countries that in turn reduces international trade volume as a consequence of a shift from high risk exports and imports to less risky international trades [12]. This shift also interrupts price parity and disturbs the bilateral trade balance. Conflicting, studies find exchange rate volatility has positive influence on international trades [13] due to risk-return view based on high risk high return that leads to a noticeable increase in volume on existence of high exchange rate volatility [14]. Meanwhile, ability to insight exchange rate movements in advance could help to avoid adverse effects of exchange rate volatility on international trade [15]. Besides this, inconsistent theoretical and empirical findings about the effects of exchange rate volatility on international trade are mainly because of models devised and used and context of the researches, for instance researchers are inclined to find adverse effect between low frequency exchange rate volatility and bilateral trade flows between developing countries [16].

Up till now, there are conflicting views about theoretical and empirical findings in literature on nexus of exchange rate volatility and international trade included exports and imports. The differences in findings are mainly due to developed and underdeveloped financial markets; behavior of risk-averse traders, different methodologies devised and employed differences in to proxy volatility, nature of data used, and finally ability to insight exchange rate movements. Though, contradictory studies are conducted about effects of exchange rate volatility on international trade but only few of them have been undertaken in the context of Canada. As far as our knowledge goes, there is not a single study that has been conducted to examine the simultaneous effects of exchange rate volatility on the exports and imports of Canada. Therefore, this paper aims to examine effects of Canadian exchange rate volatility gauged by GARCH-based model on total Canadian exports, exports to the USA, total Canadian imports, and imports from the USA using wide-ranging time-series data from 1997M04 to 2017M08. This will fill the gap and contribute in the literature.

The main contribution of this paper, for the first time, is to bring together ARDL co-integration test bound technique and GARCH modeling to estimate both long run and short-term interactions between exchange rate volatility and trade flows including Canadian total exports, exports to the USA, Canadian total imports, and imports from the USA. Additionally, this paper employed vector error

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correction mechanism (VECM) devised by Toda and Yamamoto (1995) to detect short-term association between exchange rate volatility and Canadian total exports, exports to the USA, total imports, and imports from the USA. The significance of current paper enhances further as, on one hand, on average 77.90 percent of total exports of Canada is to the USA, and at the same time 66.84 percent of total imports is from the USA. And at the same time, Canada has undertaken re-negotiations and abolishment of NAFTA but at the same time agreed to join on new trilateral international trade integration between the USA, Mexico and Canada to form United States, Mexico, and Canada Agreement (USMCA). Rest of the study is presented as, Section II reviews the existing body of the literature. Next, Section III presents data and methodology. In the last, Section IV results and conclusion are discussed and presented, respectively.

## Literature Review

Exchange rate volatility play essentially pivot role in international trade. In one of the pioneer studies, Ethier [17] finds exchange rate volatility reduces international trade volumes and ultimately dampens down the size of the economy. Similarly, Pozo [18] examines the influence of exchange rate variability measured by standard deviation and generalized autoregressive conditional heteroskedastic (GARCH) process on the volume of exports from Britain to the USA. The estimated results lead to conclude that exchange rate volatility lowers exports. In addition, Doğanlar [4] finds exchange rate volatility decreases exports of Turkey, South Korea, Malaysia, Indonesia, and Pakistan. Similarly, exchange rate volatility adversely affects the exports volume of each G7 member [19] and imports of G7 countries except for Canada [2]. Meanwhile, Bahmani-Oskooee and Hegerty [20] argue that floating exchange rate induce exchange rate volatility inversely influences international flows but theoretically exchange rate volatility can cause an increase in international trade volume to balance expected decrease in revenues.

On the other hand, Broll and Eckwert [21] examine the relationship between exchange rate volatility and volume of export-oriented productions. They find a positive relationship between exchange rate volatility and export volumes. Similarly, inspect effects of exchange rate volatility on the value of exports and finds that it enhances the value of the firm and in turn intensifies the exports or in other words, theoretically, an increased exchange rate volatility increases exports [22]. This positive association between exchange rate volatility and international trade export volumes proxied by exports is mainly caused by amid profit exploiting behavior of the international traders or exporting firms [23].

Furthermore, the development status of the financial markets affects the effects of the exchange rate volatility on exports and imports and it is mainly due to failure to forecast the exchange rate volatility [2]. Theoretically, exchange rate volatility in short term affects the trade flows volume positively in case of the countries where developed forward markets for currencies exist [4]. Moreover, exchange rate volatility increases further in less developed financial markets that are not offer financial hedging instruments [12]. Contrary to it, in the existence of well-established financial markets the export-oriented firms are able to foresee and hedge future exchange rate volatility that in turn has no impact on international trade [17,25].

Inconsistent findings of studies failed to suggest empirical association between exchange rate volatility and trade flows. In a study, Gotur examines the effects of exchange volatility and trade flows of well-established industrial economies including France, Germany, Japan, UK, and USA. Statistical results lead to conclude exchange rate volatility has no influence on trade flows. Conflicting, Kroner and Lastrapes [6] find exchange rate volatility influences the multilateral exports of these countries when employed multivariate GARCH-in-mean model. These inconsistent findings are also evident in short-term and long run as study by Bredin, et al. [24] find exchange rate volatility has no influence on exports in short-term but directly affects the exports in long run. Further, Bahmani-Oskooee, et al. [26] examines long run relationship between exchange rate volatility and Canada-Mexico trade related to specific product. They conclude, in long run, exchange rate volatility affects inversely and dampens trade flow between Canada and Mexico.

In an empirical study, Kandilov [27] examines the exchange rate volatility proxied by an index on exports of developing and developed countries, respectively, using time-series data for the period of 1974 to 1997. Statistical results lead to conclude that exchange rate volatility inversely affects the trade flows. Additionally, exchange rate volatility affects more, largely, on the exports of the developing countries as compared to the effect on exports from the developed counties. Chit, et al. [28] examine the interaction between exchange rate volatility and real exports of emerging countries China, Indonesia, Malaysia, Philippines, and Thailand using a panel dataset for the period of 1982Q1 to 2003Q4. Results indicate long run significant inverse relationship does exist between exchange rate volatility and real exports.

Asteriou, et al. [29] investigate interaction between exchange rate volatility and trade included exports and imports of Mexico, Indonesia, Nigeria, and Turkey using time series data of the period of 1995M01 to 2012M12. They generated exchange rate volatility series by estimating GARCH model and then estimate long run relationship between exchanger rate volatility on exports and imports by employing ARDL test bounding cointegration techniques. Results indicate exchange rate volatility of Turkish lira has minor negative long run impact on Turkey exports and imports while there is no long run relationship in case of Mexico, Indonesia, and Nigeria. Asteriou, et al. [29] further find short-term relationship does exist between respective exchange rate volatility and exports and imports of Mexico and Indonesia.

A study by Arize and Shwiff [30] inspects effects of exchange rate volatility on imports of G7 countries namely USA, UK, Japan, Italy, Germany, France, and Canada using data for the period of 1973:2 to 1995:1. Statistical results illustrate an evidence exchange rate volatility is negatively related to the imports volume of G7 countries in long run except Canada. However, in case of Canada, exchange rate volatility is positively affiliated with imports. Alike, Godwin and Benson [31] supports the proposition that exchange rate volatility in flexible exchange rate regime negatively affects imports in Africa.

Choudhry and Hassan [32] examine the impact of exchange rate volatility on the imports of UK from three emerging countries Brazil, China, and South Africa using time series data for the period of 1991M01 to 2011M12. They employed asymmetric ARDL approach and find a long run connection between exchange rate volatility, irrespective nominal or real, and UK imports from Brazil, China, and Brazil. Meanwhile, Baum and Caglayan [13] investigate relationship between 13 developed countries exchange rate volatility on bilateral real exports volume and variability of international trade volume. They find no linkage between exchange rate volatility and trade volume, but a positive relationship does exist between exchange rate volatility and international trade volatility. Finally, Bahmani-Oskooee and Arize examines effects of exchange rate volatility gauged by GARCH model on exports and imports of thirteen African countries. They employed non-liner export and import demand functions and discovered exchange rate volatility has long run asymmetric impact on imports and exports of African countries.

## Data Sources and Methodology

This paper uses monthly time series data for Canadian exchange rate versus the US dollar for the period of 1997M04 to 2017M08 and is obtained from Statistics of Canada[1]. Till to date, literature lacks consistency to proxy exchange rate volatility as empirical studies have used different methods to proxy exchange rate volatility. Few empirical studies used standard deviation of the percentage change in nominal exchange rate [33] standard deviation of percentage change of first differences of logarithmic exchange rates [34] and others used generalized autoregressive conditional heteroscedasticity (GARCH) model devised by Bollerslev [35] to proxy exchange rate volatility. For this paper nominal Canadian exchange rate versus the US dollar is used to generate USD/CAD exchange rate variability index to proxy exchange rate volatility by applying GARCH model because this is an suitable method (Chit, et al., 2010) among other methods and is used as independent variable. Moreover, dependent variables such as monthly seasonal adjusted data for Canadian total exports, exports to USA, total imports, and imports from the USA for the period of 1997M04 to 2017M08 have been obtained from Statistics Canada, CANSIM Table 228-0069[2] in dollar (millions) [36].

## Methodology

To estimate long-run effects of Canadian exchange rate volatility (V) on exports and Canadian exchange rate volatility on imports of Canada, the following linear regression models are devised, respectively.

$$Exports_t = \alpha_1 + \beta_{1t} V_t + \varepsilon_t \tag{1}$$

$$Imports_t = \alpha_2 + \beta_{2t} V_t + e_t \tag{2}$$

Where, exports and imports are the dependent variables and exchange rate volatility (V) is the independent variable, $\alpha_1$ and $\alpha_2$ are intercepts, βs are the regression coefficients, "ε" and "e" are the error terms, and at the end "t" is time subscript in model 1 and model 2, respectively. Prior to estimate, the long-run relationships as mentioned above stationarity of time series data is estimated using Augmented Dickey and Fuller (1979) test which is described as given below.

### Augmented Dickey-Fuller (ADF) test

The general form of ADF test is:

$$\Delta X_t = \gamma X_{t-1} + \sum_{i=1}^{q} \phi_i \Delta X_{t-i} + e_{1t} \tag{3}$$

$$\Delta X_t = \alpha + \gamma X_{t-1} + \sum_{i=1}^{q} \phi_i \Delta X_{t-i} + e_{2t} \tag{3a}$$

$$\Delta X_t = \alpha + \beta t + \gamma X_{t-1} + \sum_{i=1}^{q} \phi_i \Delta X_{t-i} + e_{3t} \tag{4}$$

$H_0$: γ=0(Unit root does exist and the time series is non-stationary)

$H_A$: γ=0(Unit root does not exist and the time series is stationary).

[1]Statistics of Canada. Retrieved October 11, 2017, from http://www5.statcan.gc.ca/cansim/a47

[2]Statistics of Canada. Retrieved October 11, 2017, from http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=2280069&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid

OLS method is employed to estimate above mentioned equations and then estimated value of τ-statistic of the estimated coefficient of $X_{t-1}$ is compared with its critical value computed by Dickey and Fuller [37] that leads to conclude about stationarity or non-stationarity of the time-series.

### ARDL Co-integration test

Now to estimate long run effects of Canadian exchange rate volatility on total exports, exports to USA, total imports and imports from USA from models (1) and model (2), respectively, Bound Testing Auto-Regressive Distributed Lag (ARDL) technique is used devised by Pesaran, et al. [38] for the reason that it overcomes, if any, misspecification in linear regression model because of emission of any lag variables. Further, ARDL bound testing co-integration technique is applied once the order of the ARDL has been determined and then the relationship is estimated by OLS. The statistic underlying this procedure is the familiar Wald-statistics or F-statistic in a generalized Dickey-Fuller type regression, which is used to test the significance of the lagged levels of the variables under consideration in a conditional unrestricted equilibrium error correction model devised by Pesaran, et al. [38] as:

$$\begin{aligned}\Delta(Exports)_t &= \upsilon_\circ + \beta_1 (Exports)_{t-1} + \beta_2 (V)_{t-1} \\ &+ \sum_{i=1}^{p-1} \theta_i \Delta(Exports)_{t-i} + \sum_{i=1}^{p-1} \eta_i \Delta(V)_{t-i} + \ldots\ldots\ldots\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta(Imports)_t &= \kappa_\circ + \gamma_1 (Imports)_{t-1} + \gamma_2 (V)_{t-1} \\ &+ \sum_{i=1}^{p-1} \sigma_i \Delta(Imports)_{t-i} + \sum_{i=1}^{p-1} \xi_i \Delta(V)_{t-i} + \ldots\ldots\ldots\end{aligned} \tag{6}$$

After estimating model (5) and model (6) by OLS, and then to estimate long-run relationship between Canadian exchange rate volatility and total exports restricted Wald test is carried out through F-statistic. Restrictions imposed while using Wald test on estimated long-run coefficients as $H_{0:}\ \beta_1=\beta_2=0$ indicate that long-run relationship does not exist between exports and exchange rate volatility. Against it, the alternative hypothesis $H_A$: $\beta_1\neq\beta_2\neq0$, indicates that long-run relationship does exist between exports and exchange rate volatility. Afterwards, comparison of observed F-statistic for Wald test on coefficient restrictions with the critical value of F-statistic has been made. If observed F-Statistic below lower bound critical value indicates then null hypothesis cannot be rejected and in case the observed statistic is above upper bound critical value then it represents the rejection of null hypothesis implying the variables are co-integrated while any value between lower and upper bounds indicates the test is inconclusive. Similarly, long-run relationships between Canadian exchange rate volatility and exports to the USA, total imports, and imports from the USA are estimated.

### Vector error correction mechanism (VECM)

To estimate the short-term effects of Canadian exchange rate volatility on exports and imports, respectively, the models (1) and (2) are transformed in vector error correction mechanism (VECM) of ARDL models (7) and (8), respectively. In addition, first differenced lagged values of exports and exchange rate volatility are regressed along with error correction term. The representation of VECM is given below in eqn. (7) and (8):

$$\Delta Exports_t = \alpha_\circ + \sum_{J=1}^{n} \beta_1 \Delta Exports_{t-j} + \sum_{j=0}^{n} \beta_2 \Delta V_{t-j} + \eta ECT_{t-1} + \varepsilon_t \tag{7}$$

$$\Delta Imports_t = \chi_\circ + \sum_{J=1}^{n} \gamma_1 \Delta Imports_{t-j} + \sum_{j=0}^{n} \gamma_2 \Delta V_{t-j} + \xi ECT_{t-1} + \varepsilon_t \tag{8}$$

The significance of the coefficient of error correction term $ECT_{t-1}$ indicates the existence of short-term relationship. Its estimated negative and positive values indicate the speed and convergence to or divergence from the long-run equilibrium, respectively. Moreover, a significant coefficient of error correction term with the negative sign also indicates the existence of stable long-run equilibrium relationship between variables [39,40].

### Granger causality

The Granger causality linkage exports and Canadian exchange rate volatility has been estimated by employing Toda and Yamamoto (1995) technique as represented by models (9) and model (10).

$$Exports_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} Exports_{t-i} + \sum_{j=k+1}^{d\max} \alpha_{2j} Exports_{t-j} + \sum_{i=1}^{k} \phi_{1j} V_{t-i} + \sum_{j=k+1}^{d\max} \phi_{2j} V_{t-j} + \lambda_{1t} \tag{9}$$

$$V_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} V_{t-i} + \sum_{j=k+1}^{d\max} \beta_{2j} V_{t-j} + \sum_{i=1}^{k} \delta_{1j} Exports_{t-i} + \sum_{j=k+1}^{d\max} \delta_{2j} Exports_{t-j} + \lambda_{2t} \tag{10}$$

To find the optimal lag length Akaike Information (AIC) and Final Prediction Error (FPE)) have been used. Following model (9) Canadian exchange rate volatility does Granger cause exports if $\phi_{1j} \neq o$, (for all i=1,2,3,…..), similarly from model (10) total Canadian exports Granger cause Canadian exchange rate volatility if $\delta_{1j} \neq o$, (for all i=1,2,3,……). Similarly, Granger causality between exports to the USA and Canadian exchange rate volatility is estimated.

Further, Granger causality connection between imports and Canadian exchange rate volatility is also estimated by employing Toda and Yamamoto [41] technique on the model (11) and model (12) as given below.

$$Imports_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} Imports_{t-i} + \sum_{j=k+1}^{d\max} \gamma_{2j} Imports_{t-j} + \sum_{i=1}^{k} \varphi_{1j} V_{t-i} + \sum_{j=k+1}^{d\max} \varphi_{2j} V_{t-j} + \mu_{1t} \tag{11}$$

$$V_t = \chi_0 + \sum_{i=1}^{k} \chi_{1i} V_{t-i} + \sum_{j=k+1}^{d\max} \chi_{2j} V_{t-j} + \sum_{i=1}^{k} \eta_{1j} Imports_{t-i} + \sum_{j=k+1}^{d\max} \eta_{2j} Imports_{t-j} + \mu_{2t} \tag{12}$$

Following model (11) Canadian exchange rate volatility does Granger cause imports if $\varphi_{1j} \neq o$, (for all i=1,2,3,…..), similarly from model (12) imports Granger cause Canadian exchange rate volatility if $\eta_{2j} \neq o$, (for i=1,2,3,……). Similarly, Granger causality between imports from USA and Canadian exchange rate volatility is estimated.

## Empirical Results and Discussion

Prior to estimate linkage between Canadian dollar exchange rate volatility and variables stationarity of time series is estimated and for this purpose, first, optimal lag length of Canadian exchange rate volatility, total exports, exports to the USA, total imports, and imports from the USA is computed by employing vector autoregressive (VAR) lag selection criteria and results are represented in Table 1. Estimated results show different criterion are indicating different lag lengths but Akaike Information (AIC) and Final prediction error (FPE) are indicating lag sections of 3. Therefore, optimal lag length of 3 has been used for further empirical study (Table 1).

Then, stationarity of each time series is estimated by employing Dickey and Fuller (1979) unit root test using an optimal lag length of 3 and results are presented in Table 2. Results indicate that Canadian total exports, exports to USA, total imports, and imports from USA are not stationary at levels with intercept and trend, which implies that the null hypothesis of unit root at levels cannot be rejected. However, all above discussed time series are stationary at the first difference that represents that null hypothesis of unit root is rejected at the 1st difference or in other words time series are integrated of order one ~ I(1). Results also indicate that Canadian exchange rate volatility (V) is stationary at levels, which implies that the null hypothesis of unit root at levels cannot be accepted or is integrated at level ~I (0).

### Effects of exchange rate volatility on exports and imports

Now, to estimate linkage between Canadian exchange rate volatility and total Canadian exports from models ARDL cointegration technique has been applied and results are presented in Table 3. Statistical results indicate that F-statistic (=4.563045) is above the upper bound test value [I (1)=4.16)] at 5% significant level. This means that null hypothesis of no level effect is rejected, and it leads to conclude that Canadian total exports and exchange rate volatility are cointegrated or in other words a long-run equilibrium relationship does exist between total exports and Canadian exchange rate volatility. Meanwhile, long-run relationship between exports to the USA and Canadian exchange rate volatility also has been estimated and results indicate that F-statistic (=5.203370) is above the upper bound test value [I (1) =4.79] at 2.5% significant level. It indicates null hypothesis of no level effect is rejected and exports to USA and Canadian exchange rate volatility are cointegrated or in other words a long-run equilibrium linkage does exist between exports to USA and exchange rate volatility and this finding differs from Baum and Caglayan [13].

Statistical results, as given in Table 3, indicate F-statistics (=6.514661) is greater than upper bound test value [I (1)=5.58] and leads to conclude that total imports and Canadian exchange rate volatility are cointegrated. Results also indicate F-statistics (=6.701664) is greater than upper bound test value [I(1)=5.58] and leads to conclude that imports from the USA and Canadian exchange rate volatility are cointegrated and a long-run equilibrium relationship exists between imports from the USA and Canadian exchange rate volatility.

Next, since total Canadian exports and Canadian exchange rate volatility are cointegrated, so there is need to inspect direction and magnitude. By employing ARDL cointegrating and long-run form long run linkage is estimated, and results are presented in Table 4.

| **Sample: 1997M04 2017M08** | | | | | | |
|---|---|---|---|---|---|---|
| **Included observations: 237** | | | | | | |
| **Lag** | **LogL** | **LR** | **FPE** | **AIC** | **SC** | **HQ** |
| 0 | -8174.346 | NA | 6.52e+23 | 69.02402 | 69.09719 | 69.05351 |
| 1 | -6717.638 | 2839.659 | 3.69e+18 | 56.94209 | 57.38109 | 57.11904 |
| 2 | -6659.202 | 111.4484 | 2.79e+18 | 56.65993 | 57.46475 | 56.98432 |
| 3 | -6627.904 | 58.36939 | 2.64e+18 | 56.60679 | 57.77744 | 57.07863 |
| 4 | -6609.130 | 34.22175 | 2.79e+18 | 56.65932 | 58.19580 | 57.27862 |
| 5 | -6590.490 | 33.19044 | 2.95e+18 | 56.71299 | 58.61530 | 57.47974 |
| 6 | -6569.578 | 36.35288 | 3.06e+18 | 56.74749 | 59.01563 | 57.66170 |
| 7 | -6544.025 | 43.34293 | 3.06e+18 | 56.74283 | 59.37680 | 57.80448 |
| 8 | -6525.353 | 30.88377 | 3.25e+18 | 56.79623 | 59.79602 | 58.00533 |

**Table 1:** VAR Lag selectin criteria.

| Variables | Intercept | | Intercept and Trend | |
|---|---|---|---|---|
| | At Levels | At 1st Difference | At Levels | At 1st Difference |
| V | -7.088662(0.0000) | - | -7.127812(0.0000) | - |
| Total Exports | -2.115749(0.2387) | -14.5608(0.00) | -3.081845(0.1130) | -14.54368(0.00) |
| Exports to USA | -2.578256(0.0989) | -14.94489(0.00) | -2.702728(0.2365) | -14.93229(0.00) |
| Total Imports | -0.753910(0.8296) | -17.67286(0.00) | -2.648609(0.2593) | -17.63657(0.00) |
| Imports from USA | -0.924267(0.7794) | -17.28475(0.00) | -1.965194(0.6169) | -17.25074(0.00) |

Note: Numbers in parentheses represent p-values.

**Table 2:** Results of augmented Dickey-Fuller (ADF) test for unit root

| | | | |
|---|---|---|---|
| **1. Total Exports and Exchange rate volatility** | | | |
| F-statistics | Level of Significate | Lower Bound Value I(0) | Upper Bound Value I(1) |
| 4.563045 | 5% | 3.62 | 4.16 |
| **2.Exports to USA and Exchange rate volatility** | | | |
| 5.203370 | 2.5% | 4.18 | 4.79 |
| **3. Total Imports and Exchange rate volatility** | | | |
| 6.514661 | 1% | 4.94 | 5.58 |
| **4.Imports from USA and Exchange rate volatility** | | | |
| 6.701664 | 1% | 4.94 | 5.58 |

**Table 3:** Bound estimating approach to cointegration ARDL (p, q).

| | | | |
|---|---|---|---|
| **1. Total Exports and Exchange rate volatility** | | | |
| Variable | Coefficient | Std. Error | T-statistic (Prob) |
| V | -20,394,705 | 11214744 | -1.1818562(0.0703) |
| C | 51,424.33 | 7934.135 | 6.481403(0.0000) |
| **2.Exports to USA and Exchange rate volatility** | | | |
| Variable | Coefficient | Std. Error | T-statistic (Prob) |
| V | -111,95316 | 5117566 | -2.187629(0.0297) |
| C | 36,357.60 | 3510.871 | 10.35572(0.0000) |
| **3. Total Imports and Exchange rate volatility** | | | |
| Variable | Coefficient | Std. Error | T-statistic (Prob) |
| V | -$144,000,000 | 2.92E+08 | -0.492311(0.06230) |
| C | 148356.1 | 230277.3 | 0.644250(0.5200) |
| **4.Imports from USA and Exchange rate volatility** | | | |
| Variable | Coefficient | Std. Error | T-statistic (Prob) |
| V | -85,954,144 | 1.64E+08 | -0.525519(0.5997) |
| C | 85,837.51 | 119003.8 | 0.721301(0.4715) |

**Table 4:** Long-run relationship between exports and exchange rate volatility.

Results indicate long-run coefficient of exchange rate volatility (=-20394705) is significant (p-value=0.0703) and has negative impact on the total Canadian exports and consistent with findings of [18,19,25] but differ from Bredin, et al. [42] It further indicates that a unit change in Canadian exchange rate volatility causes reduction of $20,394,705 in exports in the long run. Moreover, results indicate that long-run coefficient of V=-11,195,316 has significant (p-value=0.0297) inverse effect on the exports to USA. It further indicates that a unit change in exchange rate volatility causes reduction of $11,195,316 in exports to the USA in the long run.

Results, as given in Table 4, indicate that long-run coefficient of V (=-144,000,000) has significant (p-value=0.0623) negative long run influence on the imports. It further indicates that a unit change in exchange rate volatility causes reduction of $144,000,000 in imports in the long run. This finding in contrary to Arize and Shwiff [30]. Likewise, results indicate exchange rate volatility has insignificant negative (V=-8,5954,144 with p-value=0.5997) long run effect on imports from the USA. From results it is found that total imports show larger reduction as compared to total exports in response to exchange rate volatility. Therefore, Canada might have more incentive by reducing Canadian dollar volatility but reduction or increase in exchange rate volatility has no impact on imports from the USA. On the other hand, estimated coefficient of exports to the USA shows reduction to exchange rate volatility, so Canada might have incentive by reducing of Canadian dollar volatility.

## Vector error correction representation for ARDL (p, q) model

To validate long run linkage between exchange rate volatility and variables, vector error correction mechanism (VECM) for ARDL (p, q) cointegration is employed, and estimated results are presented in Table 5. Statistical results indicate that short-term coefficient (=-503,096.7) of exchange rate volatility at first difference is significant (p-value=0.0040). It indicates that volatility at the first difference has a negative impact on first difference of total exports and one-unit fluctuation in volatility at first difference reduces exports at first difference by $503,096.7 in short-term. Results also indicate that estimated error correction term (=-0.028098) has expected negative sign and is significant (p-value=0.0003) this leads to conclude that Canadian total exports and exchange rate volatility are cointegrated. Further, the absolute value of error correction term [=0.028098] indicates that total Canadian exports adjust back 2.8098 percent of its last departure from equilibrium due to any short-term shock. Similarly, results indicate that exchange rate volatility at first difference negatively influences Canadian exports to the USA at the first difference and consistent with findings of with Pozo [18]. Additionally, error correction term (=-0.045239) is significant and correctly signed and confirms exports to USA and Canadian exchange rate volatility are cointegrated. Moreover, absolute magnitude [=0.045239] specifies exports to the USA adjusts back 4.52 percent its last month's departure from equilibrium caused by any short-term shock. Hence, this paper finds that in short-term exchange rate volatility has negatively influences Canadian total exports and exports to the USA and consistent with and [18,28] but differ from Bredin, et al. [42] and short-term trade benefits can be attained through more stable exchange rate via interventions.

Statistical results, as given in Table 5, indicate that estimated error correction term (=-0.003818) has expected negative sign and is significant with an associated p-value (0.0000). This leads to conclude that Canadian total imports and exchange rate volatility are cointegrated. Further, the absolute value of error correction term [=0.003818] indicates that Canadian total imports adjusts back 0.3818 percent of its last departure from equilibrium due to any short-term shock. Also, error correction term (=-0.005306) is significant and correctly signed and lead to conclude that imports from USA and Canadian exchange rate volatility are cointegrated or have long-run equilibrium relationship. Moreover, absolute magnitude [=0.005306] indicates that imports from the USA adjusts back 0.53 percent of its last month departure from equilibrium caused by any short-term shock. Hence, this paper finds that in short-term exchange rate volatility has negatively influenced Canadian total imports consistent with and [18,28] but differ from theoretical findings of Bredin et al. [24].

Since results indicate negative short-term relationship does exist between exchange rate volatility and total Canadian export, exports to USA, total Canadian imports, and imports from USA, so policymakers can formulate policies to stabilize Canadian exchange rate to make benefits from international trade.

## Granger causality

Finally, on existence of long run relationship between Canadian exchange rate volatility and total exports, exports to the USA, total imports, and imports from the USA, the next is to identify causation association between variables by applying Toda and Yamamoto (1995) technique, as the order of integration of total exports, exports to the USA, total imports, imports from the USA is one I (1) but of Canadian exchange rate volatility is I(0). In this paper, Toda and Yamamoto [41] technique is estimated with Wald-test that follows Chi-distribution and results are presented in Table 6. Results present that null hypothesis of exchange rate volatility does not Granger cause Canadian total exports cannot be accepted as Chi-square (=27.81481) is significant (p-value=0.000) and finds Canadian exchange rate volatility Granger cause total exports. Statistical results also indicate null hypothesis of Canadian total exports does not Granger cause exchange rate volatility is rejected (Chi-Sq.=11.90260 with p-value of 0.0077). It further indicates that Canadian total exports Granger cause exchange rate volatility. These findings lead to conclude that bi-directional Granger causality does exist between Canadian total exports and exchange rate volatility. Similarly, results, given in Table 6, conclude that bi-directional Granger causality does exist between exchange rate volatility and exports to USA.

Statistical results, as given in Table 6, also indicate that null hypothesis of exchange rate volatility does not Granger cause Canadian total imports cannot be accepted as Chi-square (=23.26496) is significant (p-value=0.0000). This leads to conclude that exchange rate volatility Granger cause Canadian total imports. Results also indicate that null hypothesis of Canadian total imports does not Granger cause Canadian exchange rate volatility is rejected (Chi-Sq.=8.470701 with p-value of 0.0372). It further indicates that total Canadian imports Granger cause exchange rate volatility. These findings lead to conclude that bi-directional Granger causality does exist between total imports and Canadian exchange rate volatility. Similarly, results

| Regressor | Coefficient | Standard Error | T-Ratio [Prob] |
|---|---|---|---|
| 1.VECM for Total Exports and Exchange rate volatility | | | |
| ΔV | -503096.7 | 173173.9 | -2.905153(0.0040) |
| ECM(-1) | -0.028098 | 0.007562 | -3.715728(0.0003) |
| **2.VECM for Exports to USA and Exchange rate volatility** | | | |
| ΔV | -367402.3 | 148569.5 | -2.472932(0.0141) |
| ECM(-1) | -0.045239 | 0.011401 | -3.967884(0.0001) |
| **3.VECM for Total Imports and Exchange rate volatility** | | | |
| ΔV | -0.1828774 | 0.063283 | 2.889781(0.0042) |
| ECM(-1) | -0.003818 | 0.000860 | -4.439710(0.0000) |
| **4.VECM for Imports from USA and Exchange rate volatility** | | | |
| ΔV | -0.164203 | 0.064466 | -2.547143(0.0115) |
| ECM(-1) | -0.005306 | 0.001178 | -4.503228(0.0000) |

**Note:** Number of observations used for estimation 240 (1997M04 to 2017M08).

**Table 5:** Error correction representation for ARDL (p, q) model.

| Null Hypothesis | Wald Test =Chi-Sq. | Df | Prob. | Granger Causality |
|---|---|---|---|---|
| V does not Granger cause Total ExportS | 27.81481 | 3 | 0.0000 | Bidirectional Causality |
| Total Exports does not Granger cause V | 11.90260 | 3 | 0.0077 | |
| V does not Granger cause Exports to USA | 20.52655 | 3 | 0.0001 | Bidirectional Causality |
| Exports to USA does not Granger cause V | 12.04362 | 3 | 0.0072 | |
| V does not Granger cause Total Imports | 23.26496 | 3 | 0.0000 | Bidirectional Causality |
| Total Imports does not Granger cause V | 8.470701 | 3 | 0.0372 | |
| V does not Granger cause Imports from USA | 22.68257 | 3 | 0.0000 | Bidirectional Causality |
| Imports from USA does not Granger cause V | 9.911705 | 3 | 0.0193 | |

**Table 6:** Causality between Canadian exchange rate volatility and exports, and imports.

find bi-directional Granger causality between Canadian exchange rate volatility and imports from the USA.

## Conclusion

This paper examines effects of exchange rate volatility proxied by GARCH model on Canadian total exports, exports to the USA, total imports, and imports from the USA and used monthly data from 1997M04 to 2017M08. To estimate long-run relationship ARDL co-integration bound test technique has been used. The results conclude that long-run equilibrium relationship does exist between exchange rate volatility and Canadian total exports, exports from the USA, total imports, and imports from the USA. Further results indicate that exchange rate volatility has a significant inverse long-run relationship with total exports (=-20394705), exports to USA (=-11,195,316), and total imports (=-144,000,000), but an insignificant inverse relationship with Canadian imports from the USA. Further, vector error correction mechanism (VECM) confirms long-run equilibrium relationship between variables. The absolute magnitudes of error correction terms 2.8098, 4.5239, 0.3818, and 0.5306 represent speeds of adjustment for exchange rate volatility, and Canadian total exports, exports to the USA, total imports, and imports from the USA, respectively, in case of any departure from long-run equilibrium. In short term Toda and Yamamoto (1995) test finds bi-directional between exchange rate volatility and Canadian total exports, exchange rate volatility and exports to the USA, exchange rate volatility and Canadian total imports, and exchange rate volatility and imports from the USA.

Findings of the current study have very important implications for policymakers to design such macroeconomic policies that can establish both short term and long-run equilibrium relationship between exchange rate volatility, exports and imports adjusting short-term exchange rate and trade deficit shocks to avoid violation of international budget constraints. Further, empirical research work can be conducted to examine the impact of Canadian dollar exchange rate volatility on exports and import with Euro-zone, UK, China, and Australia. Additionally, studies can also be undertaken to investigate the comparative effects of exchange rate volatility on exports and imports of developed and developing countries, respectively.

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