

# Identification of the Long-Run Determinants of U.S.-Canada Softwood Lumber Trade

Zara Liaquat<sup>1</sup> & Xinya Wang<sup>2</sup>

<sup>1</sup> Department of Economics, University of Waterloo, Waterloo, Canada

<sup>2</sup> Department of Economics, York University, Toronto, Canada

Correspondence: Zara Liaquat, Department of Economics, University of Waterloo, Waterloo, ON., N2L 3G1, Canada. Tel: 1-519-888-4567. E-mail: zliaquat@uwaterloo.ca

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## Abstract

This paper uses monthly data from 1994 to 2016 in order to analyze the time series properties of the determinants of Canadian softwood lumber exports to the United States. The key findings generally support the hypotheses of previous studies with the exception of the significance of bilateral exchange rate movements. Based on dynamic ordinary least square estimates and several robust cointegration tests, the paper finds that the estimated coefficients of exchange rate, softwood lumber price ratio and the two softwood lumber trade agreements are highly sensitive to the lag order used in econometric models. On the other hand, the coefficient of housing starts index remains independent of the variation in number of lags included. In addition, we study the long-run response of Canadian exports of lumber to shocks in these determinants by generating impulse response functions.

**Keywords:** softwood lumber, stationary time series, cointegration, exchange rate

## 1. Introduction

Canada has been the principal supplier of softwood lumber to the United States for decades. There are a large number of studies which attempt to highlight the key determinants of Canadian lumber exports to the U.S., including some ex ante studies simulating the probable effects of likely changes in macroeconomic variables (Adams et al., 1986; Chen et al., 1988), and likewise, ex post estimations of the effects of trade restrictions and key macroeconomic variables (Zhang, 2001; Buongiorno et al., 1988; Sarker, 1996). The existing studies estimating the demand for Canadian lumber control for a wide variety of factors, such as, the price in Canadian dollars received by Canadian sawmills, U.S. market price of softwood lumber, Canadian to U.S. dollar exchange rate, a housing starts index, prices of input factors (for example, timber material price, wage rate of Canadian sawmill workers, and electricity price), and the impact of softwood lumber trade agreements between the two countries (Note 1). Figure 1 displays the long-term evolution of Canadian lumber exports, housing starts, relative market price of softwood lumber in the two countries, and the Canadian to U.S. dollar exchange rate from January 1994 to December 2016.

While there is generally a consensus amongst researchers with regards to the effect of housing starts, relative price of lumber, and softwood lumber trade agreements on the volume of exports of lumber from Canada to the U.S., the role of an essential variable remains largely debated. In this paper, we focus on the significance of changes in these factors in explaining the variation of softwood lumber trade between the two countries. Moreover, by analyzing the time series properties of the determinants of Canadian softwood lumber exports to the U.S., we propose the most appropriate econometric techniques which should be utilized in empirical studies when modeling the dynamic behaviour of Canadian lumber exports. Accordingly, the paper also attempts to reconcile the opposing findings obtained by the earlier studies foreseeing an insignificant effect of several crucial determinants, including the exchange rate (Buongiorno et al., 1988; Jennings et al., 1991; Sarker, 1996; Bolkesjo & Buongiorno, 2006; Baek, 2012), with those obtained by a handful of others revealing a substantial long-run effect of some or all of these variables (Adams et al., 1986; Wear & Lee, 1993; Baek, 2007). It does so by highlighting the variation in estimated coefficients obtained by making alternative time-series modeling assumptions. We make use of a dynamic ordinary least squares model (DOLS) and forecast both the short-term and long-term impacts of several shocks on the volume of Canadian lumber exports by generating impulse

response functions. The most notable finding of the paper is that, other than the role of housing starts, the effect of a majority of the factors affecting the volume of Canadian softwood lumber exports to the U.S. appears to be highly sensitive to the lag order used in the estimated econometric model. The significance of the ratio of Canadian to U.S. lumber price and both softwood lumber agreements greatly diminishes if a higher order of lag is applied in predicting the regression model. However, the outcome is projected to become stronger in the case of exchange rate if a longer time horizon is taken into account. Consequently, given the current decline in the value of the Canadian dollar in terms of its U.S. counterpart, the findings obtained in this study offer valuable insight into adequately modeling the probable long-term effects of the latest exchange rate trend (Note 2).

In the context of U.S.-Canada lumber trade, the subject that has attracted perhaps greater attention than identifying the determinants of trade between the two countries is the bitter trade dispute. The primary concern raised by the U.S. lumber industry is the subsidized stumpage pricing practices and log export controls held in place by the Canadian government (Note 3). The low stumpage rates have allowed Canadian producers to gain an unfair competitive advantage compared to their U.S. counterparts. For a long time, the Canadian lumber industry and the government disregarded these allegations on the grounds that lumber exports to the U.S. have mounted due to the exchange rate advantage, superior production efficiency, and U.S. consumer preference in favour of superior quality Canadian lumber (Sarker, 1996). This continuing controversy has led to a large number of studies exploring the political and legal issues pertinent to the 1996 Softwood Lumber Agreement (SLA), and more recently, SLA 2006, essentially because lumber industries and governments on both sides of the border have recurrently expressed their discontent with the trade agreements. With the expiration of SLA 2006 in October 2015, the dispute has become more hostile, resulting in U.S. producers filing for countervailing and anti-dumping duties with the federal government (Note 4).

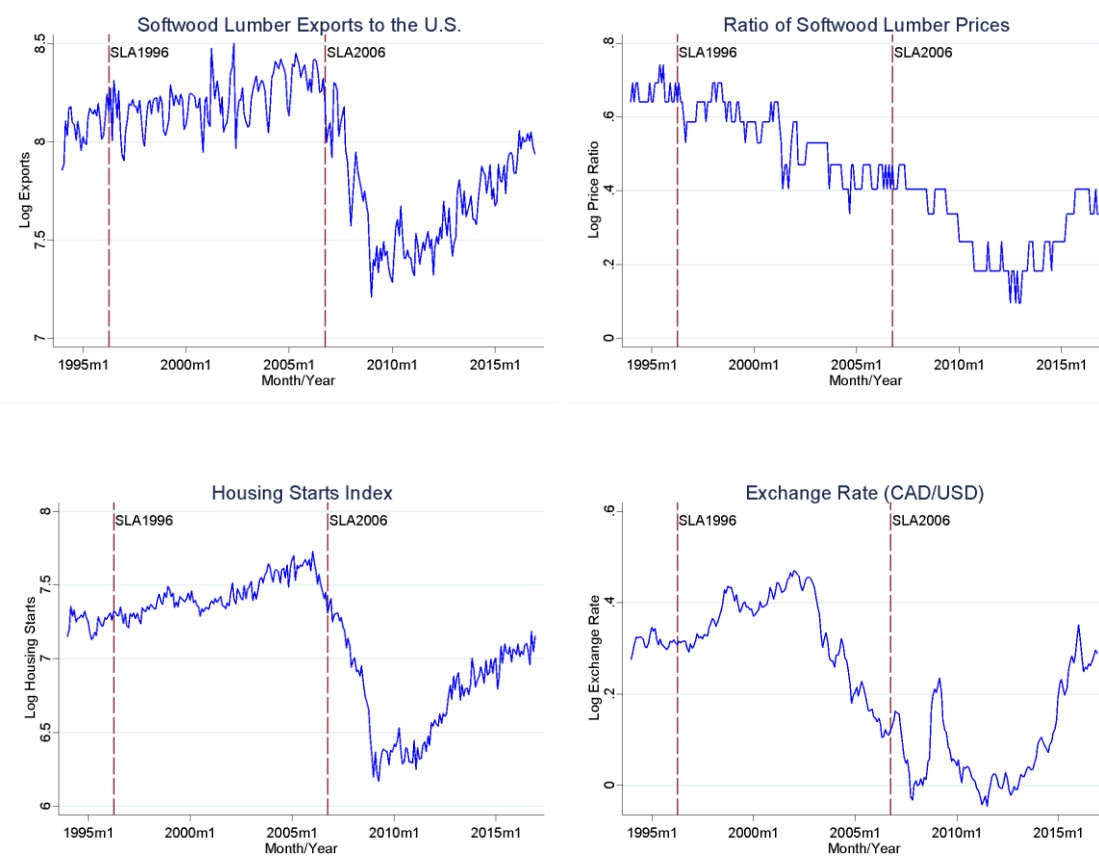


Figure 1. Time-series plots (1994-2016)

Nevertheless, the Canadian lumber companies have insisted on the competitive advantage that they enjoy due to U.S. consumer preference and weaker Canadian dollar, and subsequently, claiming that quotas and other trade restrictions imposed by the U.S. are not legal under the rules of the North American Free Trade Agreement

(NAFTA) and WTO. Since the effect of exchange rate on the volume of Canadian softwood lumber exports to the U.S. has profoundly remained contradictory across existing studies, possibly indeterminate at best, we think it is worthwhile to revisit the relationship between exchange rate and quantity of exports. This question has lately become particularly relevant because of the expiration of SLA 2006 and a forthcoming renegotiation of NAFTA in the wake of recent political developments in the U.S. The newly elected U.S. government has repeatedly named the softwood lumber industry as a sensitive subject a propos trade with Canada and has threatened to impose countervailing and anti-dumping duties on Canadian lumber entering the U.S.

The paper is organized as follows. Section 2 provides a summary of the earlier studies as well as the theoretical foundation used to build our empirical model. Section 3 explains the empirical methodology in detail and describes the data set used in our analysis. In section 4, we exhibit the empirical estimates of the econometric framework used in the paper. A systematic explanation of the long-term effects of our set of control variables on Canadian lumber exports is provided in section 5. Lastly, section 6 offers policy discussion and conclusion.

## 2. Literature Review and Theoretical Framework

We follow the theoretical background offered by Babula et al. (2012) and assume that the demand for softwood lumber at the regional level in a given time period can be expressed as a Cobb-Douglas function:

$$Q_{US} = \alpha P_{US}^{\beta_1} P_{CAN}^{\beta_2} H^{\beta_3} M^{\beta_4} \quad (1)$$

where  $Q_{US}$  is quantity demanded for softwood lumber in the U.S.,  $P_{US}$  is the price of lumber in the U.S.,  $P_{CAN}$  is the price of a substitute good i.e. Canadian lumber,  $H$  is housing starts, and  $M$  is maintenance or repairing activities. The empirical methodology used in this paper builds on the theoretical framework founded in Buongiorno et al. (1988) and Chen et al. (1988), and later employed by Baek (2012) for the application of a fully-modified ordinary least squares estimation (FM-OLS). According to these studies, the demand for softwood lumber imports is derived from the demand for new housing or remodeling of the existing houses. While housing starts reasonably measures the demand for lumber for constructing new houses, disposable income more adequately captures the demand accounted for by house repairs or remodeling. However, as pointed out by Baek (2012), housing starts and disposable income are highly correlated. To avoid the problem of multicollinearity, we only include the housing starts index in our estimation. The imported lumber market in the U.S. is imperfectly competitive since the lumber produced in the U.S. is not a perfect substitute of that produced in Canada (Baek 2012). As defended by the Canadian industry and the government in the course of the dispute, consumers in the U.S. often perceive imported lumber as a distinct commodity due to the differing species composition of lumber imported from Canada. It is, therefore, essential to incorporate the influence of both the domestic as well as imported price of lumber.

As pointed out by Babula et al. (2012), the U.S. producers may consider price expectations as an indicator of the total demand for softwood lumber. For that reason, the demand function for softwood lumber imported into the U.S. must be expressed in terms of not only the relative prices of U.S. and Canadian lumber, but also must account for the exchange rate changes overtime. However, as far as the significance of the Canadian/U.S. dollar exchange rate is concerned, many earlier studies predict an insignificant effect of exchange rate, such as, Sarker (1996), Bolkesjo and Buongiorno (2006), Buongiorno et al. (1988), Jennings et al. (1991), and Baek (2012). On the other hand, a handful of others disclose an important long-term effect of Canadian/U.S. dollar exchange rate. Some examples include Wear and Lee (1993), Baek (2007), and Adams et al (1986). Finally, the demand for Canadian lumber is affected by the different trade restriction measures placed on Canadian lumber imports. We used two dummy variables to account for the effects of softwood lumber agreements signed in 1996 and 2006, as explained in the next section.

This study makes use of a dynamic ordinary least squares (DOLS) estimation methodology and projects both the short-term and long-term impacts of various shocks on the volume of Canadian lumber exports by generating impulse response functions. Many researchers have used aggregated structural econometric models by either estimating a system of simultaneous equations (SSEs) of softwood lumber markets in the two countries, or by employing a reduced form equation (RFE) of U.S. lumber market (Note 5). The non-structural time-series models, on the other hand, adopt a system of dynamic relationships among market variables relevant to the lumber trade. Yin and Baek (2004) propose a summary of the strengths and weaknesses of structural econometric and non-structural time-series models in the setting of estimating the demand and supply in the softwood lumber market. Building on a finding of Zellner and Palm (1974), they conclude that the results of non-structural models can be interpreted as general equilibrium ones because the dynamic structural models are simply special cases of multivariate time-series processes. In comparison to reduced form structural models, by not imposing a priori theoretical structure, non-structural time-series analysis can fully determine the relationship among lumber

market variables. Multivariate time-series models not only investigate the dynamic effects of variables but also test the endogeneity of one or more of these variables. It is for that reason that the primary empirical results of this paper are generated through the use of multivariate time-series models.

There are numerous studies which utilize the cointegration approach to model the demand for lumber in the U.S., either produced domestically or imported from Canada. Song et al. (2011) derive long run supply and demand equations using two-stage least squares using monthly data from 1990 to 2006, and estimate demand and supply elasticities in the U.S. lumber market. The Canadian export supply equation was derived from the Cobb-Douglas profit function and controlled for log-transformed price index in Canadian dollars received by Canadian sawmills exported to the U.S., U.S. market price of softwood lumber, Canadian to U.S. dollar exchange rate, tariff rate, prices of input factors, inventory of Canadian sawmills, dummy variables for the months when softwood lumber export from Canada to the U.S. was taxed under Memorandum of Understanding (MOU), dummy variable for months from October 1991 to February 1992 when the U.S. taxed imported softwood lumber from Canada based on the expired MOU, and another dummy variable for the months from April 1996 to March 2001 when the SLA was effective (Note 6). In addition, up to 12 lags of the lumber supplied from Canada were also included. Interestingly, the Canadian softwood lumber supply to the U.S. was found to be more price elastic than the domestic lumber supply. Their study claims that the U.S. import tariffs have had limited impact on the volume of lumber imported from Canada. However, a number of other studies have produced contrasting findings, and the consequence of imposing trade restriction measures on Canadian lumber imports have been shown to have a positive impact on demand for U.S.-produced lumber (Babula et al., 2012).

### 3. Data and Methodology

As discussed in the previous section, the key determinants of demand for lumber are housing starts and the domestic and import prices of lumber. Because the demand of imported lumber is expected to rise if the domestic currency appreciates, the bilateral exchange rate between the U.S. and Canadian dollars is also predicted to have a significant impact on the demand for Canadian lumber imported into the U.S. As a result, the U.S. demand for Canadian lumber can be modeled in the following log-linear way:

$$\ln(X_t) = \gamma_0 + \gamma_1 \ln(R_t) + \gamma_2 \ln(H_t) + \gamma_3 \ln(E_t) + \mu_t. \quad (2)$$

$\ln(X_t)$  measures the natural log of Canadian softwood lumber exports to the U.S. The variable  $R_t$  is the ratio of U.S. price of lumber to the Canadian price, and  $H_t$  is the housing starts. The bilateral exchange rate is given by  $E_t$ , measured as the number of Canadian dollars (CAD) per U.S. dollar (USD). Lastly,  $\mu_t$  is the error term. It is expected that  $\gamma_1$  will be positive because higher domestic price of lumber in the U.S. (or a fall in the price of imported Canadian lumber) will likely result in an upsurge in the Canadian exports of lumber to the U.S. As explained above, a rise in  $H_t$  is predicted to increase the demand for lumber imports. Since  $E_t$  is defined as CAD/USD, an increase in  $E_t$  implies a depreciation of the Canadian currency, making lumber imports more affordable for U.S. consumers. Therefore, we expect  $\gamma_3$  to be significant and positive.

Because we estimate equation (2) using monthly time series data, there is a possibility of non-stationarity of all the four variables defined in equation (2). This is also visible in Figure 1 illustrated above. In order to propose a more reliable interpretation of the estimates generated and to detect any potential cointegration relationship within our nonstationary variables, we first run Phillips-Perron (1988) unit root tests on all of our variables. As shown in the discussion of empirical results in the next section as well as in Figure 2, the first differences of all four variables turn out to be stationary. Consequently, our baseline model becomes:

$$\Delta \ln(X_t) = \gamma_0 + \gamma_1 \Delta \ln(R_t) + \gamma_2 \Delta \ln(H_t) + \gamma_3 \Delta \ln(E_t) + \mu_t. \quad (3)$$

This finding is followed by testing for the number of cointegrating equations and optimal number of lags in order to fit a dynamic time series model which takes into consideration the long term relationship between our variables of interest. The resulting estimates are very sensitive to the lag order, especially the coefficient of  $E_t$ . For that reason, as well as to support the findings of the DOLS estimates, we generate orthogonalized impulse response functions depicting the overtime response of Canadian exports of softwood lumber to the U.S. when there is a change in bilateral exchange rate (Note 7).

It is also crucial to examine the effect of U.S. trade policies on the price and quantity demanded of Canadian lumber. As indicated in Figure 1, there was a decline in softwood lumber imported into the U.S. after both the softwood lumber agreements in 1996 and 2006. Perhaps the most appropriate way to model the impact of the trade agreement is through the use of a dummy variable which assumes the value of one during the time period the agreement was in force. Due to the step-wise nature of tariff rates implemented by the SLA, it is almost impossible to incorporate tariff rates in a simple regression model. In order to test the effect of the softwood

lumber agreements (SLA), equation (3) is extended to include two additional dummy variables,  $SLA_{1996}$  and  $SLA_{2006}$ :

$$\Delta \ln(X_t) = \gamma_0 + \gamma_1 \Delta \ln(R_t) + \gamma_2 \Delta \ln(H_t) + \gamma_3 \Delta \ln(E_t) + \gamma_4 SLA_{1996} + \gamma_5 SLA_{2006} + \mu_t, \quad (4)$$

where  $SLA_{1996}$  takes the value of one for the months the Softwood Lumber Agreement (1996) was in place, i.e. from April 1996 until March 2001, while  $SLA_{2006}$  is assumed to be one from October 2006 to October 2015. As some of the existing studies have substantiated, the coefficient of both of these dummy variables turn out to be negative.

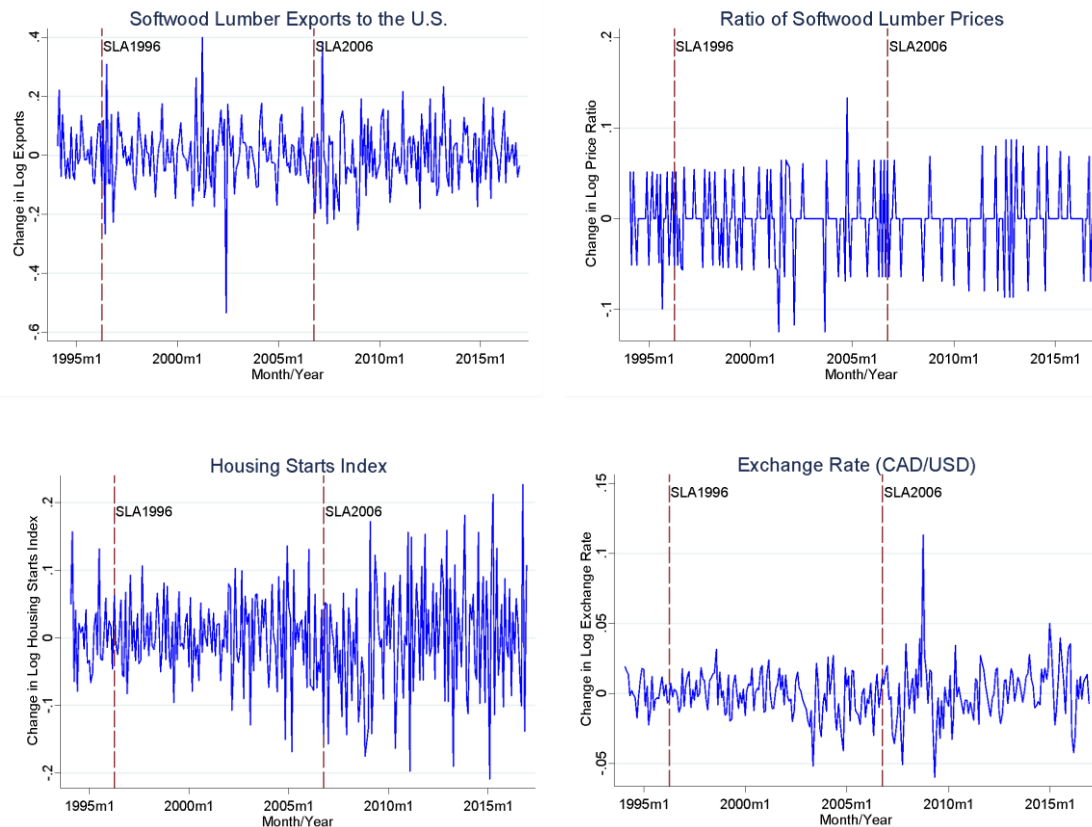


Figure 2. First-differenced time-series plots (1994-2016)

The previous studies described in the literature review have shown the endogeneity bias inherent in a simple OLS estimation of the equation above since, in general, imports and domestic prices of lumber are predicted to be endogenously determined. DOLS generates consistent estimates and allows valid inferences based on estimation, with sufficient lags and leads included, even in the presence of endogenous variables and serial correlation problems:

$$\begin{aligned} \Delta \ln(X_t) = & \gamma_0 + \sum_{k=0}^L \gamma_{1k} \Delta \ln(R_{t-k}) + \sum_{k=0}^L \gamma_{2k} \Delta \ln(H_{t-k}) + \sum_{k=0}^L \gamma_{3k} \Delta \ln(E_{t-k}) + \gamma_4 SLA_{1996} + \gamma_5 SLA_{2006} + \\ & \sum_{k=1}^L \gamma_{6k} \Delta \ln(X_{t-k}) + \sum_{k=0}^L \gamma_{7k} \Delta \ln(R_{t+k}) + \sum_{k=0}^L \gamma_{8k} \Delta \ln(H_{t+k}) + \sum_{k=0}^L \gamma_{9k} \Delta \ln(E_{t+k}) + \\ & \sum_{k=1}^L \gamma_{10k} \Delta \ln(X_{t+k}) + \mu_t. \end{aligned} \quad (5)$$

$\Delta \ln(X_t)$  is regressed on the group of control variables along with leads and lags of  $\Delta \ln(R_t)$ ,  $\Delta \ln(H_t)$ , and  $\Delta \ln(E_t)$ . Moreover, equation (5) provides both the long-run and short-run estimates (Note 8). The subsequent section examines these results in detail.

We collect monthly data for all the variables defined above from January 1994 to December 2016, which yields 276 observations. The dependent variable is taken directly from the Statistics Canada website. The data for  $R_t$  is collected from the U.S. Federal Reserve Bank of St. Louis. Housing starts data is taken from the U.S. Census Bureau. The exchange rates for Canadian dollars per U.S. dollar are also generated from the Statistics Canada's website. Table 1 reports the descriptive statistics of the variables used.

Table 1. Definitions and descriptive statistics of variables

Variable	Definition	Mean	Standard Deviation	Minimum	Maximum
$X_t$	Canadian lumber exports to the U.S.	3034.8	865.79	1351	4922
$\ln(X_t)$	Natural log of $X_t$	7.972	0.314	7.21	8.50
$R_t$	Ratio of U.S. to Canadian price of lumber	1.578	0.254	1.1	2.1
$\ln(R_t)$	Natural log of $R_t$	0.443	0.164	0.095	0.74
$H_t$	Housing starts	1329.7	451.03	478	2273
$\ln(H_t)$	Natural log of $H_t$	7.123	0.395	6.170	7.73
$E_t$	Exchange rate (CAD/USD)	1.267	0.189	0.96	1.60
$\ln(E_t)$	Natural log of $E_t$	0.226	0.152	-0.046	0.47
$SLA_{1996}$	April 1996 to March 2001	0.217	0.413	0	1
$SLA_{2006}$	October 2006 to October 2015	0.395	0.490	0	1

Note. Author's calculations based on data from Statistics Canada ( $X_t$  and  $E_t$ ), U.S. Federal Reserve Bank of St. Louis ( $R_t$ ), and U.S. Census Bureau ( $H_t$ ). The number of observations is 276 for all variables.

#### 4. Dynamic OLS Estimation Results

In order to carry out an extensive time series analysis of the determinants of Canada's exports of lumber to the U.S. and to apply the dynamic modeling techniques, we need to first establish stationarity of the time series variables reported in equation (3). The test statistics generated by the Phillips-Perron (1988) test can be viewed as Dickey-Fuller statistics robust to serial correlation. This is done by employing the Newey-West (1987) heteroskedasticity and autocorrelation consistent covariance matrix. The null hypothesis for the Phillips-Perron (1988) is that the variable in question contains a unit root, while the alternative is that it was generated by a stationary process. Table 2 displays the results of the unit root test. The null hypothesis can not be rejected for the levels of all variables, since the test statistic is smaller than 10 percent, 5 percent, and 1 percent critical values of the Phillips-Perron, including a trend and a constant term. The only exception is  $\ln(R_t)$  for which the unit root hypothesis can not be rejected only at 1 percent level of significance. Conversely, nonstationarity can be rejected for first-differenced values of all four variables.

Table 2. Phillips-Perron test of stationarity

Variable	Level	First Difference
$\ln(X_t)$	-3.108	-21.973***
$\ln(R_t)$	-3.806**	-24.338***
$\ln(H_t)$	-1.418	-24.379***
$\ln(E_t)$	-1.227	-11.871***
No. of observations	275	274
Newey-West Lags	5	5

Note. \*\*\* denotes the rejection of the null hypothesis of non-stationarity at 1% significance level. The 10%, 5% and 1% critical values for the Phillips-Perron, including a constant and a trend, are -3.130, -3.429, and -3.989, respectively.

Once we have established the stationarity of each of our data series, the next step is to detect the number of cointegrating relationships between the set of dependent and independent variables. The Johansen (1988) cointegration test computes a trace statistic as well as maximum eigenvalues, either of which can be used to determine the number of cointegrating equations, conditional on a trend specification and a lag order. The optimal number of lags in the underlying vector autoregressive (VAR) is determined by running the Dickey-Fuller generalized least squares (DF-GLS) test on  $\ln(X_t)$  (Elliott et al., 1996). Based on the lag order estimates generated by Ng-Perron (2001) modified Akaike information criterion (MAIC) and Ng-Perron (1995) sequential-t methods, a lag order of fourteen is used to run the Johansen's cointegration test (Note 9). The corresponding trace statistics and eigenvalues are shown in Table 3. As indicated by the test statistics, we reject the null of no cointegrating vector, but do not reject the null of one cointegrating vector at the 5 percent significance level. Thus, the foremost results so far are fairly consistent with those derived in some of the earlier studies mentioned above, including Baek (2012).

Table 3. Johansen cointegration test

Null hypothesis	Eigenvalue	Trace statistics
$H_0: r=0$	.	39.5104**
$H_0: r \leq 1$	0.06644	21.4990
$H_0: r \leq 2$	0.04972	8.1379
$H_0: r \leq 3$	0.02344	1.9247
$H_0: r \leq 4$	0.00732	.

Note. \*\* denotes rejection of the null hypothesis at 5% significance level. The trend specification and lag order of fourteen in the underlying VAR is determined using the Dickey-Fuller generalized least squares (DF-GLS) test.

The Phillips-Perron unit root and Johansen's cointegration tests imply that there exists a unique relationship among the four first-difference transformed stationary variables. These properties of the time series data set the stage for DOLS estimation stated in Table 4. Columns (1) to (4) report the estimated coefficients for our set of independent variables, with the inclusion of two indicator variables,  $SLA_{1996}$  and  $SLA_{2006}$ , in the order of increasing number of lags. Each column produces Newey-West standard errors for coefficients estimated using OLS as proposed by Stock and Watson (1994). Using the standard DOLS estimation,  $\Delta \ln(X_t)$  is regressed on the group of control variables along with their leads and lags, as specified in equation (5). As we move from column (1) to (4),  $L$  becomes larger (Note 10). For instance, column (1) presents the estimated coefficients of the set of independent variables when  $L = 5$ . Similarly, column (2) runs equation (5) incorporating fourteen leads and lags of ratio of prices, housing starts and exchange rate. Finally, column (3) and (4) further augment the number of leads and lags of control variables. In each column, the Newey-West standard errors for coefficients are reported in parentheses.

The estimated results reinforce a majority of the earlier findings. The relative price of U.S. and Canadian lumber is predicted to have a positive and significant effect on the demand for Canadian lumber imported into the U.S. Since the Canadian lumber is a close substitute of the domestically produced lumber in the U.S., a more expensive domestically supplied lumber naturally leads to a rise in Canadian lumber exports. This effect remains significant with the inclusion of 14 or 24 lags, but disappears when the lag order is raised to 48 months. Moreover, the magnitude of the coefficient is also sensitive to the lag order used, with longer lag periods resulting in lowering the size of the estimated coefficient. On the other hand, the effect of housing starts on lumber exports is positive and significant at 1 percent level and its significance does not appear to diminish overtime. A greater degree of economic activity and housing construction in the U.S. augments the demand for lumber imports, and as a consequence, significantly boosts bilateral trade of lumber between the two countries (Chen et al., 1988; Wear & Lee, 1993; Sarker, 1996; Zhang, 2006). Housing starts is perhaps the only determinant of Canadian lumber exports to the U.S. which is not sensitive to the order of lags incorporated in our dynamic least squares estimation, and remains consistently significant at 1% level despite the inclusion of lags ranging from 5 to 48.

Table 4. The dynamic OLS (DOLS) estimation

Variables	(1)	(2)	(3)	(4)
$\ln(R_t)$	0.219*** (0.0704)	0.171*** (0.0607)	0.186** (0.0783)	0.108 (0.122)
$\ln(H_t)$	0.620*** (0.0297)	0.569*** (0.0282)	0.450*** (0.0380)	0.428*** (0.0877)
$\ln(E_t)$	0.00270 (0.0525)	0.106* (0.0613)	0.258*** (0.0826)	0.379*** (0.0826)
$SLA_{1996}$	-0.0287** (0.0141)	-0.0379** (0.0147)	-0.0508** (0.0202)	-0.0275 (0.0191)
$SLA_{2006}$	-0.0662** (0.0332)	-0.0935*** (0.0352)	-0.114*** (0.0395)	-0.0832 (0.0867)
Constant	3.492*** (0.229)	3.868*** (0.214)	4.693*** (0.261)	4.829*** (0.625)
Observations	265	247	227	179
Lag order	5	14	24	48

Note. The dependent variable is log of softwood lumber exports from Canada to the U.S. \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% levels, respectively.  $SLA_{1996}$  and  $SLA_{2006}$  represent dummy variables for the Softwood Lumber Agreements 1996 and 2006, respectively. Newey-West standard errors for coefficients are reported in parentheses.

The results depicted in Table 4 pose an interesting finding with regards to the effect of bilateral exchange rate of the U.S. and Canadian dollars. At a lag order of five, the exchange rate is expected not to have a significant and positive impact on the U.S.-Canada softwood lumber trade; a depreciation of the Canadian dollar lowers the U.S. dollar price of imported lumber, and consequently, increases the volume of lumber exports to the U.S. More intriguingly, as we extend the time dimension under consideration, the effect of exchange rate not only becomes noticeably more significant, but the magnitude of its coefficient also soars substantially. At a lag order of five, for example, the value of the coefficient is insignificant at 0.0027, but it becomes significant at 5 percent level of significance at a lag order of fourteen and rises to 0.106. Furthermore, the coefficient escalates to 0.258 and 0.379 at lag orders of twenty-four and forty-eight, respectively, both at 1 percent level of significance. This implies that time-series estimation techniques focusing on relatively immediate or short-run effect of exchange rate fluctuations on the volume of Canada's exports of softwood lumber to the U.S. may tend to miss out the imperative role of Canadian to U.S. dollar exchange rate in affecting softwood lumber exports to the U.S. The bilateral exchange rate tends to influence the scale of Canadian lumber exports to the United States only after controlling for longer term trends, with the lag orders of over 24 months yielding the highest significance. This key finding is in contrast with a bulk of the earlier studies, including Buongiorno et al. (1988), Bolkesjo and Buongiorno (2006), and Baek (2012), all of which discover an insignificant effect of exchange rate on Canadian lumber exports. Baek (2007) and Sarker (1996), on the other hand, do reveal a sizable long-run effect of exchange rate on U.S. lumber imports.

Both the Softwood Lumber Agreements (1996 and 2006) significantly lowered the quantity of softwood lumber imported by the U.S. from Canada, with the effect dying out at the lag order of over four years. The former result contrasts with the findings obtained by Baek and Yin (2006) and Baek (2007, 2012). However, the significant effect of SLA1996 was also corroborated by Zhang (2001, 2006). Nonetheless, the adverse effect of SLA2006 on Canadian lumber exports has been widely established in the previous studies and the results generated here support that outcome by reporting the small degree of variation in estimates over a lag order of up to 24 months.

## 5. Impulse Response Functions

One of the main contributions of this paper is to reconcile the conclusions of the previous studies by offering a feasible explanation of the ambiguous effect of exchange rate on lumber exports. As shown above, the effect of exchange rate on the volume of exports becomes noticeably evident only if a lag order of over 14 months is used in a dynamic econometric model. The most apparent rationale for this result points towards the J-curve hypothesis in the empirical international economics literature which describes a weak (or even negative) immediate impact of depreciation on the trade balance (Note 11). As the volume to exports and imports begin to adjust in response to a depreciated currency, the current account balance gradually starts to improve.

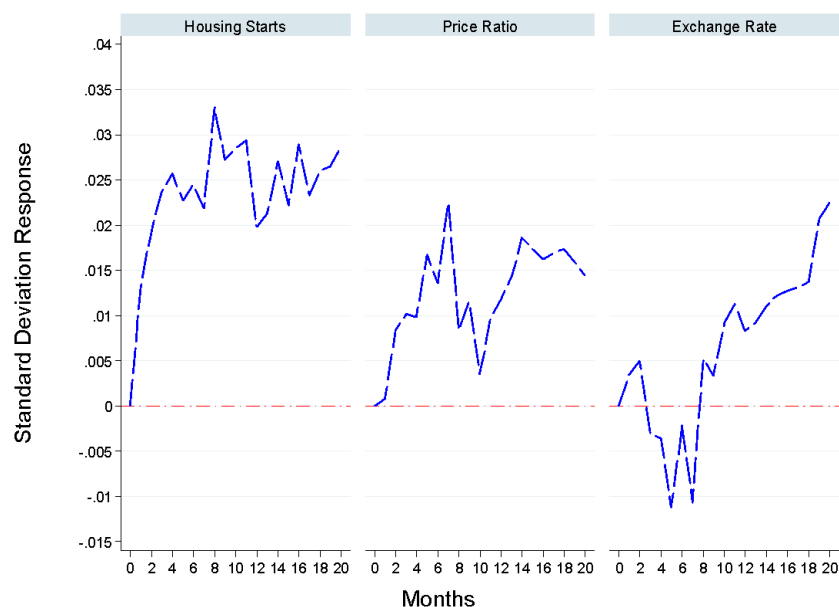


Figure 3. Impulse responses to shocks in housing starts, relative price ratio and exchange rate

Note. Author's calculations based on data from Statistics Canada ( $X_t$  and  $E_t$ ), U.S. Federal Reserve Bank of St. Louis ( $R_t$ ), and U.S. Census Bureau ( $H_t$ ).



In order to test this theory in the context of Canada's lumber exports, we employ another valuable time series technique assessing the response of exports to a sudden shock in the bilateral exchange rate. Impulse response functions (IRFs) are frequently used in empirical studies to gauge the effect of a shock on the dependent variable. To isolate the contemporaneous response of  $\ln(X_t)$  arising exclusively because of an impulse in the same equation, we fit the orthogonalized impulse response functions by decomposing the estimated variance-covariance matrix into a lower triangular matrix in the VECM estimation. We test the response of  $\ln(X_t)$  to a change in each of the control variables used in our DOLS estimation. These impulse responses are illustrated in Figure 3 (Note 12).

Figure 3 provides support for the long-run effect of exchange rate deviations on Canadian lumber exports. Although the instantaneous effect of a depreciation of the Canadian dollar is weak and indistinguishable, the J-curve tends to end within a period of eight to ten months and leads to a surge in exports of lumber to the U.S. Furthermore, the long-term effect grows stronger overtime. In fact, this effect is more compelling in comparison to the dynamic response of exports to shocks in housing starts and relative price changes (Note 13).

Baek (2007) used quarterly bilateral trade data from 1989 to 2005 to test the J-curve hypothesis for the U.S.-Canada trade in five forest commodities (softwood lumber, hardwood lumber, panel/plywood product, logs and chips, and other wood product). Using the autoregressive distributed lag (ARDL) approach to cointegration, the paper finds little evidence of the J-curve phenomenon. Nonetheless, the results offer key support to the earlier studies by isolating the short and long run effects of exchange rate changes, and hence, are closest to the empirical estimates generated in this paper. However, our paper delivers stronger and more refined results by extending the data set to include two major episodes of depreciation of the Canadian dollar since 2005 (refer to Figure 1), and by building on a more highly disaggregated (monthly as opposed to quarterly) trade data.

For the sake of completeness, we also generate impulse responses to the index of housing starts as well as softwood lumber price ratio, as shown in Figure 3. The immediate effect of a rise in either of these variables leads to an increase in the volume of exports of lumber to the U.S. This effect is more pronounced in the case of housing starts and is validated by the more significant and higher magnitudes of the coefficients of  $H_t$  in Table 4.

## 6. Conclusion and Policy Discussion

There is generally an agreement amongst researchers with regards to the principal determinants of Canadian lumber exports to the U.S. However, most of the present studies observe differing effects of bilateral exchange rate in describing the volume of softwood lumber trade between the two countries. The goal of this paper is to resolve the discrepancy in earlier results. It does so by disentangling the short-run and long-run impacts of exchange rate adjustments using an advanced time-series methodology and extending the time horizon of existing studies by updating the data set. The most noteworthy discovery of the paper is that, despite the short-run effect of exchange rate on the level of Canada's exports of softwood lumber to the U.S. not being apparent, exchange rate has a positive and significant effect on the volume of lumber exports to the U.S. if longer-term trends are taken into account.

While the effects of both softwood lumber agreements as well as ratio of lumber prices also vary with the inclusion of different number of lags, the level of significance of estimates falls as higher lag orders are employed. Housing starts is the only factor affecting lumber exports that is independent of the order of lags included and remains persistently highly significant. In addition, based on the regression results derived from a dynamic ordinary least squares estimation, we project the long-term impact of exchange rate shocks on the size of Canadian lumber exports by generating impulse response functions. The results obtained are robust across a wide range of diagnostic tests. The empirical specification used is consistent with economic theory which predicts the quantity of exports to rise overtime in the face of a depreciating currency, reflected in the renowned J-curve effect of exchange rate depreciation. As shown above, the affirmative effect of exchange rate is noticeably manifest within a period of eight to ten months and grows stronger overtime.

Although the empirical methodology used in the paper does control for the potential impact of the most recent softwood lumber trade agreements (SLA1996 and SLA2006), the subject of U.S.-Canada lumber trade dispute (or suggestions for its resolution) is beyond the scope of this paper. With the expiration of SLA 2006 in October 2015, the disagreement has become more bitter, resulting in U.S. producers filing for countervailing and anti-dumping duties with the federal government. A systematic overview of the literature can highlight the factors pertinent to the longstanding lumber trade dispute between the two countries and the appropriate policy measures needed to resolve the differences. This issue has become all the more critical recently due to a growing pressure inflicted by the U.S. government and lumber industry on their Canadian counterparts. Perhaps the key challenge for the U.S. government is to implement suitable restrictive measures in the form of a renewed

softwood lumber trade agreement. At the same time, the present Canadian stumpage pricing system may need to be reassessed. There is a need to weigh the various policy options available to the Canadian government and lumber industry. As pointed out by Anderson and Cairns (1988), a change in stumpage policy represents a loss in provincial sovereignty over resources, and hence, an export tax is perhaps a superior policy response. It is hoped that in view of the results generated in this paper highlighting the dynamic response of lumber exports to changes in the relevant market forces overtime as well as numerous policy factors, a suitable mix of policy alternatives is adopted.

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## Notes

Note 1. The demand for lumber is essentially derived from the demand for new houses as indicated by housing starts. Housing starts is, therefore, a reasonable proxy for quantifying the probable impact of the greater economic activity in the U.S. on the demand for Canadian lumber.

Note 2. On 24 April 2017 the Canadian to U.S. dollar exchange rate reached a four-month low of 1.3555 Canadian dollars (CAD/USD). Quite intriguingly, this coincided with the announcement by the U.S. Commerce Secretary Wilbur Ross that the U.S. will impose up to 24 percent of anti-subsidies duties on softwood lumber exports of Canada, the effects of which might begin to be felt as early as in September 2017.

Note 3. Stumpage rates are defined as the fees paid by forest product companies to the provinces for the rights to cut trees on Crown land (Yin & Baek, 2004).

Note 4. See Yin and Baek (2004) or Biggs et al. (2006) for a brief overview of the trade dispute. Gulati and Malhotra (2006) provide a useful summary of the dispute up to the Softwood Lumber Agreement.

Note 5. While SSEs are econometric models in which each endogenous variable is a function of other endogenous variables, exogenous variables and an error term, the endogenous variable in an RFE is a function of exogenous variables and unobserved error terms (Yin & Baek, 2004).

Note 6. They use a dummy variable for MOU in their model because tariff rates were different for different provinces.

Note 7. If the impulse response function is orthogonalized, the magnitude of the shock corresponds to one unit standard deviation, and the orthogonalization is produced using the Cholesky decomposition.

Note 8. Additionally, DOLS can be used when the variables involved have different orders of integration. Thus, the unit root tests are necessary to ensure if a formal test of cointegration is needed to validate that the long-run estimates provided by DOLS.

Note 9. The DF-GLS reports optimal number of lags using three different criteria: Schwarz criterion (SC), modified AIC (MAIC), and sequential-t methods. It also provides a maximum lag order which in our case was equal to fourteen. Although these statistics are not reported in the paper, they can be made available upon request.

Note 10. An alternative method to run the DOLS model is through the vector error correction model (VECM). The results derived from both, VECM and Newey-West standard errors estimation, are broadly consistent. VECM estimates are, thus, not reported in the paper for the sake of brevity.

Note 11. This arises primarily due to the volume effect of depreciation being smaller than its effect on the value of imported or exported commodities, resulting in a short term decline in trade balance.

Note 12. The VECM estimates used to produce the IRFs are obtained by including the optimal number of lags

and cointegrating equations determined by the tests performed prior to running the DOLS model. Thus, the IRFs are created based on the lag order and rank of cointegration suggested by the DF-GLS and Johansen's cointegration tests, respectively. The Lagrange-Multiplier test finds no evidence of autocorrelation in the residuals for any of the lag orders tested, confirming that there exists no model misspecification.

Note 13. As shown in Figure 3, the IRFs created from a cointegrating error correction model do not always die out over time. This is in contrast to a vector autoregressive model since each variable in a stationary VAR has a time-invariant mean and variance, thereby resulting in transitory shocks. Variables in a VECM may not be mean-reverting, and consequently, the effect of the shock appears to be permanent.

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