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ARTICLE

Welfare impacts of the 2006 United States – Canada Softwood Lumber Agreement

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Abstract: In this paper, we evaluate the market and welfare effects of the 2006 United States (U.S.) – Canada Softwood Lumber Agreement (SLA 2006) based on a U.S. import demand model for Canadian softwood lumber. We find that SLA 2006 reduces the U.S. lumber imports from Canada by 7.78% in the months when export taxes took effect. The welfare analysis based on a partial equilibrium framework shows that U.S. lumber producers gained $1.6 billion and U.S. consumers lost $2.3 billion in 9 years under SLA 2006.

Key words: Canadian lumber, the softwood lumber trade dispute, welfare, cointegration, vector error correction model.

Résumé : Dans cet article, nous évaluons les effets de marché et les impacts sociaux de l'Accord canado–américain sur le bois d'œuvre résineux de 2006 sur la base d'un modèle de demande d'importation de bois d'œuvre résineux canadien. Cet accord a réduit de 7,78 % les importations américaines de bois d'œuvre en provenance du Canada dans les mois qui ont suivi l'entrée en vigueur des taxes à l'exportation. L'analyse des impacts sociaux dans un cadre d'équilibre partiel montre que les producteurs américains de bois d'œuvre ont réalisé des gains de 1,6 G $ et que les consommateurs américains ont perdu 2,3 G $ sur neuf ans dans le cadre de cet accord. [Traduit par la Rédaction]

Mots-clés : bois d'œuvre canadien, différend commercial du bois d'œuvre résineux, bien-être, coïntégration, modèle vectoriel de correction d'erreurs.

As the 2006 United States (U.S.) – Canada Softwood Lumber Agreement (hereafter referred to as SLA 2006) expired on 12 October 2015, the fourth episode — Lumber IV — of the long-lasting softwood lumber trade dispute between the two countries has ended with the exception of a 1 year standstill period that lasts until October 2016. SLA 2006 was the result of 5½ years of litigation and negotiations between industry groups and governments in the two countries from April 2001 to October 2006 and lasted for 9 years, making Lumber IV the longest episode in the dispute. Given the magnitude (the largest forest products trade dispute of the world) and the longevity (3 plus decades already) of this trade dispute, one would expect that it would continue to go on for a while. But, now is the time to assess the market and welfare impacts of SLA 2006 and to find out the winners and losers in Lumber IV before all stakeholders regroup and start to fight the next battle.

The purpose of this paper is to estimate the market and welfare impacts of SLA 2006. SLA 2006 specifies two similar trade protection measures (options) that restrict Canadian lumber shipments to the U.S. Option A is a price-specific export-tax system that has an export tax rate ranging from 0% to 15% depending on the prevailing monthly lumber price in the U.S. Option B is a price-specific export-tax rated quota system that has an export tax of 0%–5% plus a market-share based quota (SLA 2006). British Columbia and Alberta, which account for about 60% of Canadian lumber shipments to the U.S., chose option A. Manitoba, Saskatchewan, Ontario, and Quebec chose option B. Other Canadian provinces, which account for about 5% of Canadian exports to the U.S., are exempt. Under option A, a 15% export tax is levied on Canadian lumber exports to the U.S. when the prevailing monthly softwood lumber price in the U.S. is less than $315 per thousand board feet (mbf); a 10% export tax is applied when the prevailing lumber price is between $316 and $335 per mbf; a 5% export tax is applied when the prevailing lumber price is between $336 per mbf and $355 per mbf; and free trade prevails if the prevailing monthly price is greater than $355 per mbf. The prevailing monthly price is defined as the most recent 4 week mean of weekly Random Lengths Framing Lumber Composite price available 3 weeks before the beginning of each month, which is a weighted index of 15 various structural lumber price series in the U.S. and Canada (Random Lengths 2015). SLA 2006 also places a surge mechanism: if the exports from a particular Canadian region exceed 111% of its allocated share in any period, the export charge for that region is an additional 50% of the applicable export charge. Moreover, a third-country adjustment clause in SLA 2006 stipulates that Canada could refund export charges to its exporters if the (*a*) third-country market share increases by at least 20% in the U.S., (*b*) Canadian market share in the U.S. declines, and (*c*) U.S. domestic producers' market share increases.

As the softwood lumber dispute has received considerable attention since the late 1980s, the literature on this issue is quite rich. With the exception of Zhang (2007), which uses interest group politics and institutional arrangements to explain the dispute, most studies focus on the effects of past trade restrictions on market and welfare in the both countries. Early simulation and empirical studies by Boyd and Krutilla (1987), Chen et al. (1988), Wear and Lee (1993), and Myneni et al. (1994) evaluated the effectiveness of the 1986 Memorandum of Understanding (MOU) that lasted from January 1987 to October 1991. Likewise, Lindsey et al. (2000), Zhang (2001, 2006), van Kooten (2002), Kinnucan and Zhang (2004), and Baek and Yin (2006) studied the effects of SLA 1996 that lasted from April 1996 to March 2001. Other studies that evaluated the effects of the U.S. retaliatory

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countervailing duties (CVD) and antidumping (AD) tariffs during the period of early 2001 to late 2006 include Adams (2003), Devadoss et al. (2005), Devadoss (2006), Mogus et al. (2006), and Song et al. (2011). Recently, Baek (2011, 2012), Nagubadi and Zhang (2013), and Parajuli et al. (2015) looked into the effects of SLA 2006 in its 5–8 years of operation on U.S. lumber imports from Canada.

This study continues the thread of welfare impact study by evaluating the effects of SLA 2006 in its full term of 9 years. Our results show that U.S. producers gained at the expense of U.S. consumers, but the annual gain is smaller than under previous agreements. The next section presents our theoretical framework and empirical specification, followed by data and empirical results. The last section concludes with a discussion.

Theoretical framework and empirical estimation

Our basic model is a monthly econometric model of the U.S. import demand for Canadian lumber. Given that Canadian lumber is not a perfect substitute for domestic lumber in the U.S. (Nagubadi et al. 2004), demand for lumber imports cannot be simply derived from an excess demand function, hence a distinct import demand equation should be formulated (Buongiorno et al. 1979). Buongiorno et al. (1979) developed several import demand models based on a derived demand theory in which demand for Canadian lumber imports is specified as a function of an index of new housing construction, import price and domestic price of softwood lumber, and the price of all other goods. This model has been used in Baek (2012) and Nagubadi and Zhang (2013)[1].

We also specify the equation for U.S. imports for Canadian softwood lumber as

$$\text{(1)} \qquad \mathrm{qc}_t = f(\mathrm{pus}_t,\ \mathrm{pca}_t,\ h_t,\ \mathrm{ppi}_t,\ \mathrm{xc}_t,\ \text{dummies})$$

where qc_t denotes the monthly U.S. imports from Canadian provinces covered by SLA 2006 in month t; pus_t and pca_t represent the domestic price and import price of softwood lumber in the U.S., respectively; h_t represents the monthly housing starts in the U.S.; xc_t is the real exchange rate between Canadian and U.S. dollars; and ppi_t represents the overall producer price index for all commodities in the U.S. The variable ppi_t measures the effects of a change in the price of other goods on softwood lumber imports from Canada (Buongiorno et al. 1979). "dummies" are various binary variables representing past trade restriction measures, recession, and policy factors.

Based on the economic theory and arguments posited by previous studies (Buongiorno et al. 1979; Baek 2012), the expected signs of the first-order partial conditions associated with each variable are presented in eq. 2. The effects of domestic lumber price and U.S. housing starts are expected to be positive, but the import price should have a negative effect on U.S. imports of Canadian lumber. An increase in xc_t or an appreciation of U.S. dollar against Canadian dollar should increase in the Canadian lumber supply to the U.S. The effect of ppi_t is expected to be negative, as an increase in the prices of other goods reduces the construction activity in the U.S. Finally, the effects of trade policy and recession dummy variables are expected to be negative.

$$\text{(2)} \qquad \frac{\delta \mathrm{qc}_t}{\delta \mathrm{pus}_t} > 0;\ \frac{\delta \mathrm{qc}_t}{\delta \mathrm{pca}_t} < 0;\ \frac{\delta \mathrm{qc}_t}{\delta h_t} > 0;\ \frac{\delta \mathrm{qc}_t}{\delta \mathrm{ppi}_t} < 0;\ \frac{\delta \mathrm{qc}_t}{\delta \mathrm{xc}_t} > 0$$

We use cointegration and the multivariate vector error correction (VEC) framework to estimate our econometric model. Several previous studies (Jung and Doroodian 1994; Toppinen and Toivonen 1998; Nanang 2000; Prestemon and Holmes 2000) used Johansen cointegration tests to test the law of one price in regional forest product markets. Similarly, Sun and Zhang (2003), Baek and Yin (2006), and Nagubadi and Zhang (2013) applied cointegration analysis and a VEC model to estimate demand and (or) supply of several forest product markets. However, long time-series data might possess several trends and level breaks in response of certain policy and market events, suggesting potential structural breaks. Any undetected structural break in the time series might result in an under-rejection of unit-root tests (Perron 1989). Moreover, in the presence of potential structural breaks in a system of dataset, the conventional Johansen cointegration tests (Johansen 1988, 1995) must be modified to allow for trend and level breaks at known points (Johansen et al. 2000). Accounting for a structural break in both unit-root test and cointegration analysis, Parajuli and Chang (2015) estimated a system of demand and supply equations of the sawtimber stumpage market in Louisiana. In this study, we consider October 2006, the starting month of SLA 2006, as a structural break point[2] and estimate eq. 1 using the modified cointegration approach of Johansen et al. (2000).

The six-variable system of equations with a structural break in October 2006 can be presented in the reduced form of p dimensional unrestricted VEC as follows (Joyeux 2007):

$$\text{(3)} \qquad \Delta \boldsymbol{X}_t = \alpha \begin{pmatrix} \boldsymbol{\beta} \\ \gamma \end{pmatrix}' \begin{pmatrix} X_{t-1} \\ tD_{t-k} \end{pmatrix} + \mu D_{t-k} + \sum_{i=1}^{k-1} \boldsymbol{\Gamma}_i \Delta X_{t-i} + \sum_{i=0}^{k-1} \sum_{j=2}^{q} kj,\ iI_{j,t-i} + \boldsymbol{\varepsilon}_t$$

where

$$D_{j,t-k} = \begin{cases} 1 & \text{for 2006M10} + k + 1 \le t \le \text{2015M09} \quad \text{for } j = 2, \ldots, q \\ 0 & \text{otherwise} \end{cases}$$

$$I_{j,t} = \begin{cases} 1 & \text{for } t = 2006M11 \\ 0 & \text{otherwise} \end{cases}$$

where Δ is the first difference notation, $\boldsymbol{\Gamma}_i = -\sum_{j=i+1}^{k} \Pi_j$ is a coefficient matrix with a dimension of $p \times q$, μ refers to $p \times 1$ vector of constant terms, D_t represents $p \times q$ deterministic dummy terms, k is the lag length, and $\boldsymbol{\varepsilon}_t$ denotes a vector of IID errors $(0, \Omega)$. The notation 2006M10 indicates the year and month; in this case, it is month 10 of 2006 (i.e., October 2006). Also, α refers to the adjustment parameters that determine the speed of adjustment to disequilibrium, $\boldsymbol{\beta}$ denotes the matrix of long-run coefficients, and γ is the long-run estimate associated with the trend break term, tD_{t-k}. $\boldsymbol{X}_t$ is the (6×1) vector of variables specified in eq. 1:

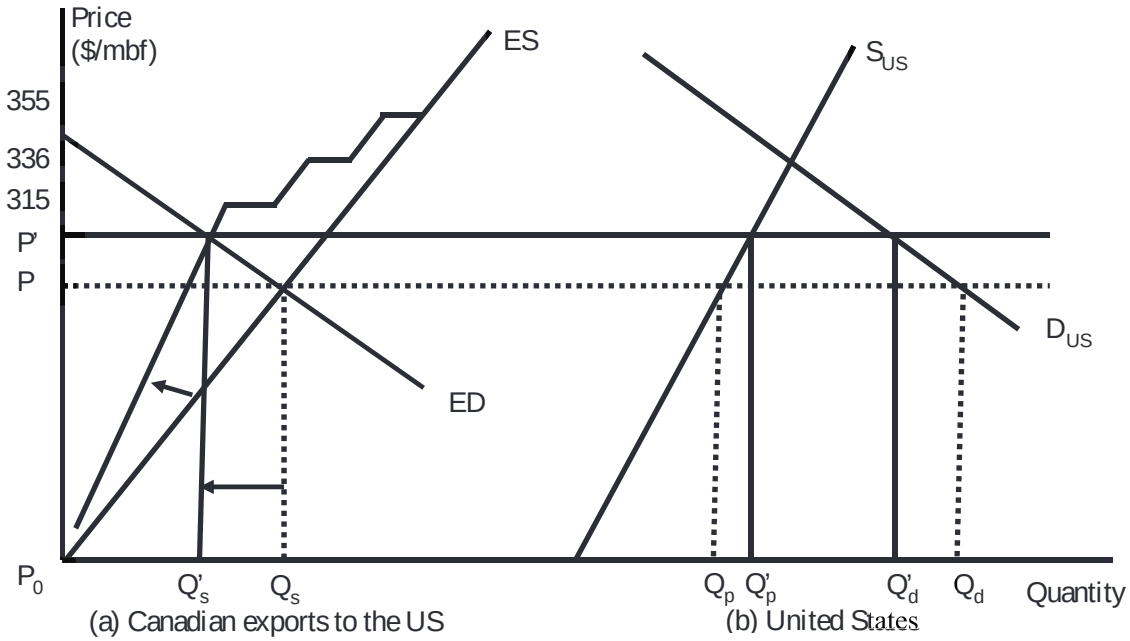
$$\text{(4)} \qquad \begin{aligned} &\boldsymbol{X}_t = [\mathrm{qc}_t,\ \mathrm{pus}_t,\ \mathrm{pca}_t,\ h_t,\ \mathrm{ppi}_t,\ \mathrm{xc}_t]' \\ &t = \text{1980M01, 1980M02, ……, 2015M09} \end{aligned}$$

Testing the unit-root properties of each data series is the first step of the empirical estimation of eq. 1. The Dicky–Fuller generalized least square (DF–GLS) test, a more powerful test first devised by

[1]For comparison, Zhang (2001, 2006) used a reduced price equation to estimate the price and welfare impacts of SLA 1996. Implicitly, the assumption in the reduced price equation is the homogeneity of softwood lumber in the two counties. Our assumption of imperfect substitutes or heterogeneity in this paper is more realistic, as it is based on the empirical evidence presented in Nagubadi et al. (2004). Nonetheless, we do not believe that the estimated market and welfare impacts would be much different in the econometric analysis if softwood lumber was treated as a homogeneous commodity.

[2]Shahi et al. (2006) also selected a break point in a similar fashion. They used the end month of SLA 1996, March 2001, to divide the data series into two periods.

Fig. 1. Welfare impacts of Softwood Lumber Agreement (SLA) 2006. For definitions of abbreviations, see Theoretical framework and empirical estimation.



Elliott et al. (1996), is applied to test the stationarity of the individual data series. Furthermore, as undetected structural breaks in long time-series data might result in under-rejection of the null hypothesis of the unit-root test, we use the Zivot–Andrews unit-root test (Zivot and Andrews 1992) to investigate the stationarity of each data series. The Zivot–Andrews test allows one endogenous structural break test in trend and (or) intercept while performing the unit-root test.

Once the order of integration of each variable is identified, the cointegration test is applied to find the number of long-run cointegrating vectors in a system of variables. Johansen et al. (2000) developed the modified version of conventional cointegration tests, which allows for the break-in intercept only ($H_c(r)$ model) and intercept and linear trend ($H_l(r)$ model). We take the $H_l(r)$ model specification (eq. 3) into account while executing the cointegration test. If variables are found to be cointegrated, eq. 1 can be estimated under the VEC framework, which produces both long-run estimates and short-run adjustments simultaneously. Johansen et al. (2000) and Joyeux (2007) described the detailed procedure of the cointegration test and VEC estimation in the presence of structural breaks. Giles (2011) provided a simple example to describe the methodological procedure of executing the test proposed by Johansen et al. (2000).

Based on the result of the estimated VEC model, we estimate the welfare impacts of SLA 2006 in the U.S. and Canada. Following the approach used by Wear and Lee (1993) and Zhang (2001, 2006), we employ the partial-equilibrium analysis to calculate the market, as well as welfare, impacts of SLA 2006[3]. We simulate the free-trade market conditions in the U.S. softwood lumber market with the help of price elasticity estimates of Canadian export supply to the U.S. and U.S. domestic demand for softwood lumber.

A brief overview of the partial equilibrium analysis is presented in Fig. 1. Q_s, Q_d, Q_p, and P represent the equilibrium quantity of Canadian lumber exports to the U.S., the equilibrium quantity of U.S. domestic consumption, the equilibrium quantity of U.S. domestic production, and the equilibrium lumber price under free trade, respectively. As Canada imposes export taxes according to SLA 2006, the Canadian export supply (ES) curve rotates to the left. The kinks in the new ES line refer to the various export tax rates ranging from 0% to 15%. We obtain monthly data on after-tax U.S. lumber consumption (Q'_d) and production (Q'_p) and Random Length Framing Lumber composite price as a proxy of overall lumber price (P') from Random Lengths (2015). Following Wear and Lee (1993) and Zhang (2001, 2006), we consider the elasticity values of U.S. domestic demand (ε_{dem}) and Canadian export supply (ε_{exp}) as –0.17 and 0.9, respectively. Based on the after-tax lumber market scenario and elasticity values, we simulate what the lumber price and U.S. domestic lumber consumption and production would have been if SLA 2006 had not been imposed on a monthly basis. Based on our estimate that Canadian exports to the U.S. decline by 7.78% each month when the prevailing price is less than $355 per mbf (see below), we calculate the free trade price (P) using ε_{exp}. Once we obtain the value of P, we calculate the monthly value of Q_d using ε_{dem}. We exclude the months in which the prevailing lumber price was greater than $355 per mbf. Note that the U.S. producer surplus includes the lumber supply from rest of the world and SLA-excluded Canadian provinces, which account for 6%–8% of annual U.S. consumption of softwood lumber.

Data

The historical monthly data for all variables from January 1980 to September 2015 are collected from various sources. Table 1 reports the variables, their descriptions, and their respective data sources. The monthly data on Canadian lumber exports to the U.S. from SLA-included provinces are collected from Statistics Canada (2015) and Foreign Affairs, Trade and Development Canada (FATDC 2006–2015). The data on producer price index for softwood lumber (WPU0811), a proxy of the softwood lumber price (pus_t) in the U.S., and the U.S. producer price index for all commodities (WPU00000000) are obtained from U.S. Bureau of Labor Statistics (US BLS 2015). Furthermore, we follow the method of Nagubadi and Zhang (2013) to compute the data on Canadian softwood lumber price (pca_t), i.e., the

[3]Wear and Lee (1993) and Zhang (2001) explained the welfare estimation approaches in detail. The detailed calculations of the market and welfare impacts are available from authors on request.

Table 1. Variables, their descriptions, and their sources.

Variable	Description	Unit	Source
qc_t	Canadian lumber exports to the U.S. from SLA-included provinces	million board feet (mmbf)	Statistics Canada 2015 and FATDC 2006–2015
pus_t	Producer price index (PPI) for lumber and wood products (WPU0811)	Index (1982 = 100)	U.S. Bureau of Labor Statistics
pca_t	Canadian softwood lumber price in U.S. dollars	$1982 per mbf	Ratio of total value to quantity of imported lumber
h_t	Housing starts in the U.S. seasonally adjusted annual rate	1000s	U.S. Census Bureau
xc_t	Canada – U.S. foreign exchange rate	C$/US$	U.S. Federal reserve system
ppi_t	U.S. producer price index for all commodities	Index (1982 = 100)	U.S. Bureau of Labor Statistics
sowl	Pacific Northwest timber harvest reductions due to Spotted Owl	0 or 1	1 for July 1990 and onwards
mou	Memorandum of Understanding	0 or 1	1 for January 1987 – September 1991
sla96	Softwood Lumber Agreement 1996	0 or 1	1 for January 1996 – September 2000
cvdad	Countervailing duties and antidumping tariffs	0 or 1	1 for August 2001 – September 2006
sla06	Softwood Lumber Agreement 2006	0 or 1	1 for October 2006 – June 2015
recs08	Great financial crisis of 2008–2009	0 or 1	1 for December 2007 – June 2009

Note: sla06 is 0 for months in which the prevailing monthly price was greater than $355 per mbf or when free trade prevailed during SLA (2006).

total value of the lumber imports being divided by the quantity of imports and converted into U.S. dollars using the U.S. – Canada exchange rate. The monthly housing starts data in the U.S. are collected from the U.S. Census Bureau (US Census Bureau 2015), and the U.S. – Canada real exchange rate data are obtained from the USDA Economic Research Service (US ERS 2015). All the price series are deflated to real 1982 dollars using the U.S. producer price index for all commodities.

Several policy dummy variables are constructed to capture the effects of those policy actions on Canadian lumber exports to the U.S. (Table 1). We include sowl to capture the effect of timber harvest reductions in U.S. Pacific Northwest due to the Spotted Owl protection. We incorporate the dummy variables mou, sla96, and sla06 into the empirical model to quantify the effects of past trade agreements: MOU, SLA 1996, and SLA 2006, respectively. Similarly, the dummy variables cvdad and recs08 capture the effects of U.S. countervailing duties and antidumping tariffs during the period of 2001–2006 and the great financial crisis of 2008, respectively. The duration of each binary dummy variable is explained in Table 1.

Table 2 presents the summary statistics of the data employed in empirical estimation. Over the last 35 years, about 1 billion board feet (bbf) of Canadian softwood lumber comes to the U.S. each month. More importantly, the mean monthly domestic lumber price in the U.S. is $158 per mbf (in 1982 dollars), whereas the mean import price of Canadian lumber is $189 per mbf. This suggests that Canadian lumber exports to the U.S. possess a 20% premium on U.S. domestic lumber. One should keep in mind that the import price of Canadian lumber is not the domestic lumber price in Canada. The mean housing starts of 1.37 million is the seasonally adjusted annual rate.

Empirical results

The results of DF–GLS and Zivot–Andrews unit-root tests of each variable in the system are presented in Table 3. All data series but binary dummy variables are log transformed. The DF–GLS unit-root test shows that all variables are nonstationary at the level of the variable. When the data series are first-differenced, all variables but lumber imports from SLA-covered Canadian provinces and the U.S. PPI turn out to be stationary, suggesting an order of I(1). Furthermore, results of the Zivot–Andrews test reveal that the nonstationarity property of all variables except softwood lumber imports (qc_t) and the U.S. PPI (ppi_t) is not affected by a structural break in trend and intercept. The Zivot–Andrews test indicates that both qc_t and ppi_t are also of I(1) at the 5% significance level. It can be inferred that a structural break in the data series of qc_t and ppi_t affects the power of the DF–GLS unit-root test. As all variables are an order of I(1) at the 5% significance level, we incorporate all six variables to identify the number of long-run cointegrating vectors in the VAR system.

Table 2. Summary of data used in empirical estimation (before log transformation): January 1980 – September 2015.

Variable	Mean	Standard deviation	Minimum	Maximum
qc_t	1092.35	323.88	371.07	1932.81
pus_t	158.48	36.41	97.20	231.70
pca_t	189.22	33.91	116.30	277.70
h_t	1365.18	408.17	478.00	2273.00
xc_t	1.19	0.14	0.96	1.55
ppi_t	137.56	35.14	85.20	208.30
mou	0.13	0.34	0	1
sowl	0.71	0.46	0	1
cvdad	0.14	0.35	0	1
sla96	0.13	0.34	0	1
sla06	0.19	0.40	0	1
recs08	0.04	0.21	0	1

Note: Variables are defined in Table 1.

Table 3. The results of the unit-root tests of individual time series.

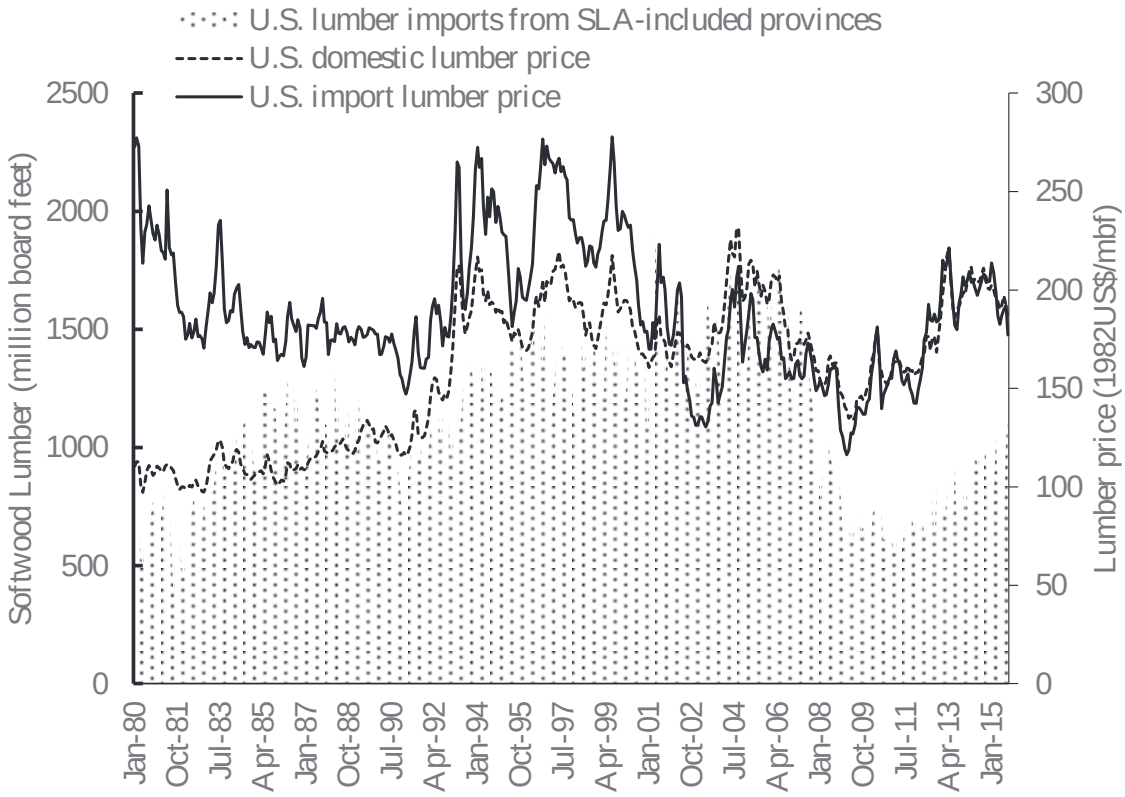
	DF–GLS test				Zivot–Andrew test			
	Levels		First differenced		Levels		First differenced	
Variable	Lags	DF–GLS	Lags	DF–GLS	Lags	Zivot–Andrew	Lags	Zivot–Andrew
lqc_t	16	–1.32	15	–2.58	4	–5.44*	4	–13.53**
$lpus_t$	10	–2.04	16	–3.48**	4	–4.41	3	–11.88**
$lpca_t$	17	–1.77	11	–4.06**	4	–4.18	3	–12.82**
lh_t	6	–2.08	10	–4.51**	4	–3.83	3	–11.42**
lxc_t	1	–1.58	10	–4.74**	4	–2.70	3	–9.62**
$lppi_t$	5	–2.29	15	–1.94	2	–4.14	4	–9.60**

Note: Lag lengths in the DF–GLS test are selected based on the Akaike information criterion, and the T test determines the optimum lag length in the Zivot–Andrew test. Significance levels: *, $p < 0.05$; **, $p < 0.01$. The Zivot–Andrews unit-root test allows for one structural break in both trend and intercept. Variables are defined in Table 1.

In terms of the structural break point, we arbitrarily select the first month of SLA 2006, October 2006, as a month of structural regime change in the lumber imports market in the U.S.[4] Consistent with our intuition, Fig. 2 shows that during the period of 2005–2006, U.S. lumber imports from Canada, U.S. domestic lum-

[4]It is quite common to select exogenous structural breaks supported by actual market events and policy changes, see Parajuli and Chang (2015).

Fig. 2. Lumber prices and Canadian lumber exports to the U.S.



ber price, and Canadian import price had a declining trend. To execute the cointegration test by Johansen et al. (2000), we use the built-in program of JMulTi software (available from www.jmulti.de), which reports the cointegration test statistics and critical values associated with the method of Johansen et al. (2000). Three-lag VAR specification is selected based on the Akaike information criterion. Table 4 reports the results of Johansen cointegration tests and the corresponding critical values at the 5% significance level. The null hypothesis of no cointegration is rejected at the 5% significance level, suggesting that all six variables are cointegrated with each other. The test identifies one long-run cointegrating vector in the system of variables, indicating that we can estimate a single equation of the U.S. lumber imports as specified in eq. 3. Furthermore, we also execute the Johansen trace test and maximum eigenvalue tests, and both tests corroborate the finding of a single cointegrating vector among the six variables (Table 4).

Specifying the U.S. imports model as one long-run cointegrating vector, we estimate eq. 3 under a framework of the VEC model. We incorporate a trend break deterministic term (tD_{t-3}, i.e., trend × D_{t-k}) in the system by following the method of Joyeux (2007), which controls the effect of the structural break. Table 5 reports the estimates of the long-run cointegration equation, in which the $\boldsymbol{\beta}$ vector is exactly identified. As the Johansen normalization restriction on Canadian lumber imports is imposed, we transform the estimates into elasticity values. The three-lag VEC process clearly corrects autocorrelation, as the Lagrange Multiplier (LM) test (χ^2 value at lag 8 = 43.88, $P > \chi^2 = 0.68$) cannot reject the null hypothesis of no autocorrelation. Moreover, the parameter stability test, as shown in Fig. 3, reveals that the cointegrating equation is stationary and there is no additional long-run common trend left in the system.

The elasticity estimates associated with all variables but price index of all commodities are statistically significant and consistent with the expected signs. The trend break associated with the beginning of SLA 2006 (i.e., tD_{t-3}) is significant and negative, which substantiates our intuition of the structural break in October 2006. Both domestic price and import price are found to be important factors determining the U.S. lumber imports from Canada. A 1% increase in U.S. lumber price leads to rise in the lumber imports by 0.75%, and a 1% increase in import price decreases lumber imports from Canada by 0.62%. Likewise, as expected, U.S. housing starts have a positive influence in Canadian lumber supply to the U.S. We find that the effect of the real exchange rate is significant and positive with a value of 0.26. Previous studies reported mixed results on the effect of exchange rate on Canadian lumber exports. Baek (2007) and Song et al. (2011) reported a statistically significant positive effects of the exchange rate, but Buongiorno et al. (1988), Jennings et al. (1991), and Parajuli et al. (2015) found a statistically insignificant effect on the U.S. lumber imports. In terms of the effect of the price index of all commodities, we find a statistically insignificant impact on lumber imports, which is consistent with Nagubadi and Zhang (2013) but differs from Buongiorno et al. (1979), who reported a significant and negative effect of the overall price level on the U.S. imports of Canadian lumber.

Besides long-run cointegrating estimates, the VEC model produces estimates of the $\boldsymbol{\Gamma}$ matrix and the error correction matrix (ECM, α) simultaneously, as specified in eq. 3. The elements of $\boldsymbol{\Gamma}$ represent short-run parameters, and ECM explains the speed of adjustment toward the long-run equilibrium state. We only focus on the equation of Δlqct, the first row of $\boldsymbol{\Gamma}$, which specifies the U.S. imports as a dependent variable. Table 5 also presents the estimates of ECM and other important dummy variables. The significant and negative value of ECM suggests that 53% of the long-run equilibrium error is corrected in each period. In other words, any deviation due to short-term shocks in U.S. lumber imports is adjusted by 53% in each month. Hence, it takes less than 2 months (1/0.53) to adjust any disequilibrium caused by short-term shocks towards the long-run equilibrium.

Most of the dummy variables associated with trade agreements, the financial crisis of 2008, and timber harvest reductions in the

Table 4. The Johansen cointegration rank tests: every test suggests one long-run cointegrating vector (optimum lags = 3).

Hypothesis		Johansen et al. (2000) test		Johansen (1988) cointegration tests			
H_0	H_1	LR statistics	5% critical value	Johansen trace test statistics	5% critical value	Maximum eigenvalue test statistics	5% critical value
$n = 0$	$n > 0$	189.85**	126.15	141.65**	94.15	84.87**	39.37
$n = 1$	**$n > 1$**	**92.03**	**96.05**	**56.78**	**68.52**	**29.15**	**33.46**
$n = 2$	$n > 2$	58.93	69.90	27.62	47.21	14.92	27.07
$n = 3$	$n > 3$	32.37	47.72	12.70	29.68	6.99	20.97
$n = 4$	$n > 4$	12.03	29.33	5.71	15.41	3.61	14.07
$n = 5$	$n > 5$	3.81	14.47	2.10	3.76	2.10	3.76

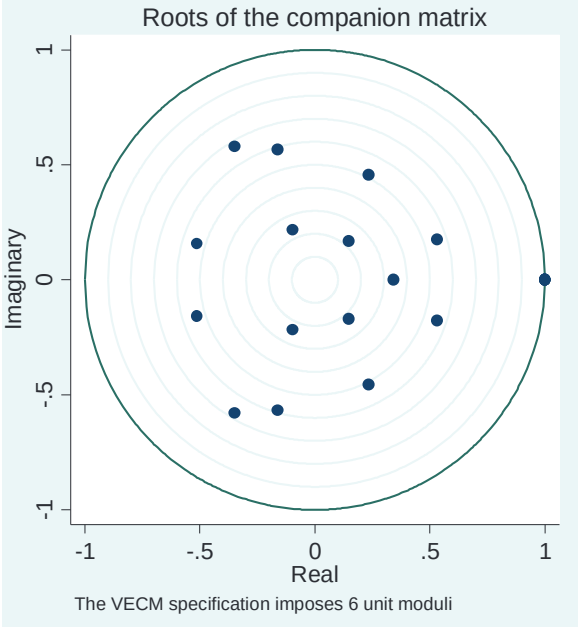
**, $p < 0.01$.

Table 5. Long-run and short-run coefficient estimates of vector error correction models: U.S. lumber imports from Canada (January 1980 – September 2015) (optimum lags = 3).

Variable	Coefficient	Standard error	Elasticity
Long-run coefficients			
Canadian lumber imports (lqc_t)	1		—
U.S. domestic price ($lpus_t$)	−0.745	0.14	0.745**
U.S. import price ($lpca_t$)	0.622	0.12	−0.622**
U.S. housing starts (lh_t)	−0.621	0.05	0.621**
Real exchange rate (lxc_t)	−0.262	0.11	0.262**
Producer price index ($lppi_t$)	0.018	0.20	−0.018
Structural break (tD_{t-3})	0.0046	0.001	−0.0046**
Constant	−2.00		2.00
Short-run coefficients			
ECM	−0.530**	0.05	—
Memorandum of Understanding (mou)	0.048**	0.01	4.707
Softwood Lumber Agreement 1996 (sla96)	−0.008	0.02	—
Countervailing duties and antidumping 2001–2006 (cvdad)	−0.086**	0.02	−8.241
Softwood Lumber Agreement 2006 (sla06)	−0.081**	0.02	−7.781
Great financial crisis (recs08)	−0.107**	0.03	−10.147
Harvest reductions in Pacific Northwest (sowl)	0.032**	0.01	3.252

Note: Significance level: **, $p < 0.05$. The elasticity values associated with dummy variables are calculated as follows: 100% [Exp (coefficient) − 1], see Greene (2011, pp. 150–151). The monthly dummies and other deterministic terms ($i2$ and $i2_{t-1}$) are not reported here. Those results are available from the authors.

Fig. 3. The eigenvalue stability condition of vector error correction model (VECM) estimates.



Pacific Northwest are found to be statistically significant with expected signs. The 2008 financial crisis has significant negative effect on U.S. lumber imports with a magnitude of 0.107, which indicates that U.S. lumber imports from Canada fell by 10% [$e^{0.107} - 1$]. On the other hand, the federal harvest reduction policy in the Pacific Northwest leads to a 3.25% rise in Canadian lumber imports. This long-term federal policy has restricted the domestic lumber production particularly in the western U.S.

Among the four trade protection measures, cvdad and sla06, the U.S. unilateral import tariffs during 2001–2006, and the latest trade agreement have significant negative effects on the Canadian lumber shipments to the U.S. The various rates of CVD and AD tariffs were able to limit the U.S. imports by 8.2%, and the 9 year SLA 2006 reduces Canadian lumber exports to the U.S. by 7.8% in the months when the export taxes are in effect. This is modest compared with Baek (2012) and Nagubadi and Zhang (2013) who found that SLA 2006 reduces the U.S. lumber imports from Canada by 16% and 11% in the study periods that they covered, respectively. Our estimate is reasonable given the fact that the weighted mean of export tax under option A is 10.42% in the 108 months under SLA 2006. Consistent with Nagubadi and Zhang (2013), we find that mou has a positive effect and sla96 is statistically insignificant in a long data series. This might be due to the fact that data in the early periods have smaller variations and are overshadowed by the larger variations of other policy influences in the long time-series dataset (Nagubadi and Zhang 2013).

One outlier in the recent literature was Parajuli et al. (2015) that, based on the limited information likelihood information estimation approach, concluded that SLA 2006 has no statistically significant impact on Canadian lumber exports to the U.S. A closer look reveals that there are fundamental differences between Parajuli et al. (2015) and this study. First, these two studies use two different theoretical frameworks. Parajuli et al. (2015) derived the Canadian export supply model from an excess supply function assuming a single lumber price in the U.S. and Canada. This study, however, derives the U.S. import demand function from a derived demand model assuming that Canadian lumber and U.S. domestic lumber are not perfect substitutes. Second, the empirical estimation in Parajuli et al. (2015) was based only on the monthly data from October 2006 to December 2014 and completely ignored data before SLA 2006, whereas we employ a long data series starting from January 1980. Third, unlike the dummy variable approach that we use to evaluate the effects of SLA 2006, Parajuli et al. (2015) calculated the actual export tax paid by Canadian producers according to option A of the agreement, ignoring the effects of option B and other provisions stipulated in SLA 2006 such as surge mechanism. If we scrutinize the actual export tax paid by Canadian producers, most of time until

Table 6. Estimated market effects of SLA 2006 on the U.S. softwood lumber market, measured by 7.78% drop in U.S. imports of Canadian lumber (ε_{dem} = –0.17 and ε_{exp} = 0.9).

Year	Price (1982 dollars per mbf)	U.S. consumption (mmbf)	U.S. production (mmbf)	Canadian export supply (mmbf)
2006	9.7	–175.1	122.0	–297.1
2007	9.4	–726.9	467.8	–1194.7
2008	7.6	–564.9	269.8	–834.7
2009	7.3	–433.5	154.3	–587.8
2010	8.8	–414.8	141.6	–556.4
2011	7.7	–472.4	131.0	–603.3
2012	9.1	–505.1	125.6	–630.7
2013	10.3	–140.3	29.8	–170.1
2015	9.6	–309.8	127.9	–437.7
Total or mean	8.8	–3742.7	1569.7	–5312.4

Note: For 2006, it is October–December only; for 2010, it excludes June; for 2013, it is August–October only; and for 2015, it is January–September only. The prevailing monthly price was greater than $355 per mbf in each month in 2014. mmbf, million board feet.

Table 7. Estimated welfare effects (1982 dollars, millions) of SLA 2006.

Year	U.S. consumer surplus	U.S. producer surplus	U.S. net impact	Export tax revenue	Canadian producer surplus	Canadian net impact
2006	–161.7	104.5	–57.2	71.2	–72.9	–1.7
2007	–649.4	428.2	–221.2	341.8	–283.8	58.0
2008	–406.3	286.8	–119.5	209.8	–159.3	50.5
2009	–300.7	222.3	–78.4	153.0	–108.4	44.5
2010	–347.9	260.0	–87.9	159.5	–111.0	48.5
2011	–349.9	265.9	–80.0	170.5	–117.2	53.3
2012	–435.6	333.5	–102.1	139.8	–90.5	49.3
2013	–137.5	105.6	–31.9	23.3	–10.4	12.9
2015	–281.6	230.0	–78.6	67.7	–32.7	35.0
Total	–3066.5	2209.9	–856.6	1336.6	–986.3	350.3

Note: For 2006, it is October–December only; for 2010, it excludes June; for 2013, it is August–October only; and for 2015, it is January–September only. The prevailing monthly price was greater than $355 per mbf in each month in 2014. The export tax revenue was calculated as follows: tax rate × prevailing monthly price × Canadian export supply to the U.S.

2012 they had paid a flat rate of 15%, and since the early 2013, free trade of softwood lumber prevails for 20 plus months. Hence, the statistically insignificance of the export tax variable in Parajuli et al. (2015) might be due to the little variation in the export tax data.

The results of market impact assessment reveal that due to the restrictions on the Canadian lumber shipments to the U.S., the lumber price, and U.S. lumber production increase over the years with a significant drop in lumber consumption in the U.S. (Table 6). It is estimated that the U.S. imports of Canadian softwood lumber was reduced by 5.3 bbf, leading to an increase in U.S. lumber price by $8.8 per mbf in 1982 dollars, on average, which is about 5.6% in the 84 months when the export tax was in effect (the weighted mean of export tax under option A in these 84 months is 13.39%). In the last 9 years, SLA 2006 decreased the U.S lumber consumption by 3.7 bbf, and the lumber supply in the U.S. market increased by 1.6 bbf. The impact is quite high in 2007 when Canadian lumber exports to the U.S. fell by about 1.1 bbf. The price effect was highest in 2013 with an annual mean of $10.3 per mbf.

Table 7 presents the results of partial equilibrium analysis on the welfare effects of SLA 2006. Based on the market impacts presented in Table 6, we estimate that U.S. producers gained $2.2 billion and consumers lost $3.1 billion in 1982 dollars. The net loss to the U.S. social welfare, including dead weight loss, was around $857 million. The largest change in the welfare was in 2007, as U.S. consumers lost $649 million with a gain of $428 million by U.S. lumber producers. On the other hand, the effect of SLA 2006 in 2013 and 2014 was limited because free trade prevailed in most months in these 2 years.

On the Canadian side, the total welfare effect is unknown because only the export supply function is estimated (Myneni et al. 1994). The Canadian provinces collected US$1.33 billion in 1982 dollars export tax revenue, but Canadian producers lost US$986 million under SLA 2006. Because the Canadian domestic market is not included in this study, the net impact of SLA 2006 in Canada is positive US$350 million. The net dead weight loss in both countries due to the imposition of SLA 2006 is around $506 million.

Compared with the findings of Wear and Lee (1993) and Zhang (2006), SLA 2006 has more modest effects in both market and welfare aspects than MOU and SLA 1996 on an annual basis (Table 8). Wear and Lee (1993) concluded that MOU brought a gain of $2.6 billion to U.S. producers and a loss of $3.8 billion to U.S. consumers in 1982 dollars in 5 years. Likewise, Zhang (2006) reported that SLA 1996 increased U.S. producer surplus by $2.5 billion and reduced consumer surplus by $4.3 billion in 5 years in 1997 dollars. The net impacts of both 5 year agreements in the U.S. are reported to be above $1 billion loss. As the prevailing monthly price was well above $355 per mbf in most of the months in 2013 and 2014, SLA 2006 had minimal effects in the softwood lumber trade between the two countries in these 2 years.

Conclusions and discussion

We evaluate the market and welfare impacts of SLA 2006 based on a demand model of U.S. imports for Canadian softwood lumber. Given that our empirical estimation is based on the entire period of SLA 2006 with an up-to-date time-series econometric methodology, this study provides an estimate of the full impact of SLA 2006. We find that, after controlling for other factors, SLA 2006 reduces the U.S. imports of Canadian softwood lumber by 7.8% in the months when the lumber price was less than $355 per mbf. Compared with previous agreements, SLA 2006 had modest welfare impacts, which has something to do with the structure of SLA 2006, the mountain pine beetle infestation in western Canada, and the increased exports to non-U.S. markets by Canadian producers. In particular, SLA 2006 allowed for free trade of softwood lumber for 24 months in the 9 years, and the weighted mean of export tax in the whole 108 months was only about 10.4% compared with the 15% under MOU and the export-tax rated quota system in SLA 1996. This demonstrates the law of diminishing returns for the U.S. producers in the 30 plus years of continuous softwood lumber fight and represents a marginal improvement for these who lobbied for free trade in softwood lumber in the two countries.

As interest groups in both countries align their position for the next stage of the dispute, it is reported that Canada's position is to renew SLA 2006 as is as "a pragmatic solution." On the other hand, the main U.S. producers group — a renamed U.S. Lumber Coalition — is calling for a tougher agreement (Christensen 2015). The position taken by both sides are understandable. Canada had won most of the legal cases in international bodies prior to SLA 2006. The Canadian government agreed to SLA 2006, as it has been concerned by its wider relationships with the U.S. and as it thought SLA 2006 would provide its industry with a temporary and predictable access to its main export destination. The Canadian government and industry do not want another costly litigation. Furthermore, Canadian lumber producers have not been paying export tax in most of the months in 2013 and 2014. The U.S. Lumber Coalition, on the other hand, cannot simply accept SLA 2006 for the future for the following three reasons: doing so will impact its ability to do fund-raising, some U.S. lumber producers fear that lumber prices will rise to and stay above $355 per mbf when the housing market recovers in the U.S., and it has garnered support from some U.S. forest landowners who simply want higher stumpage prices irrespective of the merit in the lumber case.

Table 8. A comparison of welfare impacts under MOU, SLA 1996, and SLA 2006 in 1982 dollars.

Trade agreement (source)	U.S. consumer surplus (U.S. dollars, billion)	U.S. producer surplus (U.S. dollars, billion)	Annual consumer surplus (U.S. dollars, million)	Annual producer surplus (U.S. dollars, million)	Net annual U.S. welfare (U.S. dollars, million)
MOU (Wear and Lee 1993)	–3.8	2.6	–760	520	–240
SLA (Zhang 2006)*	–3.4	2.0	–674	392	–282
SLA 2006 (this paper)	–3.1	2.2	–344	244	–100

*Converted to 1982 dollars using the U.S. Producer Price Index.

Although the dispute is far from over, recent developments in the U.S. and Canadian softwood lumber markets may further weaken the incentive for continuing this trade dispute. First, several Canadian lumber-producing provinces have implemented an auction–bid timber pricing system similar to the one used in the U.S. (Niquidet 2008; BC Timber Sales 2015; Farnia et al. 2015). This will weaken the argument of U.S. lumber producers that Canadian provincial governments subsidize their lumber industry through an administrative pricing system.

Second, given that softwood lumber production in the U.S. has been rebounding and that Canadian producers seem unable to increase their market share in the U.S. under SLA 2006, it will be hard to demonstrate that the U.S. industry actually suffer an "injury" or "threat to injury" using data in the last 2 years. With no injury or threat of injury, there is simply no trade case in the U.S. Two factors have contributed to this situation. One factor is that Canada does not have the timber supply to threaten the U.S. domestic market share anymore because timber resource endowment in Canada has been curtailed considerably in recent years. The outbreak of mountain pine beetle infestation has wiped out almost a half of British Columbia's merchantable timber stands, around 723 million m^3, between 2005 and 2012 (Natural Resources Canada 2015). Timber harvests in B.C. are expected to be 20% less than before the mountain pine beetle infestation (B.C. Ministry of Forest, Mines and Lands 2010). The other factor is that over the last decade, Canada has been able to establish overseas markets as a viable alternative export destination. In 2014, Canada exported almost 5 bbf of softwood lumber to overseas markets, particularly to China, which was around 45% of the Canadian lumber shipments to the U.S. (Random Lengths 2015). Parajuli et al. (2015) estimated that Canadian lumber shipments to overseas markets reduces the Canadian lumber flows to the U.S. by 16% during the period of 2006–2014.

Finally, partly due to timber resource decline in Canada, some Canadian lumber producers have shifted their lumber production to the U.S. (Taylor 2009; Christensen 2015). West Fraser, one of the largest lumber producers in Canada, now owns 15 sawmills in the U.S. that produced 1.8 bbf of softwood lumber in 2014 and has become the fourth-largest producer in the U.S. (Wood Markets 2015). Although foreign-owned production capacity is supposedly considered as neutral in a trade dispute, the fact is that an increasing Canadian ownership of American sawmills reduces the level of support for the U.S. Lumber Coalition. The forthcoming aggregate trade deals such as Trans-Pacific Partnership (TPP) may be another avenue to curtail the protective behavior by some U.S. lumber producers (Christensen 2015).

This study only covers the U.S. lumber imports from Canada and ignores the imports from other countries, which is about 2%–3% of total U.S. imports. Furthermore, because we estimate only an export supply function, the welfare effects of the agreement in Canada, particularly Canadian consumer surplus, cannot be calculated. Lastly, this study ignores the Canadian overseas lumber exports. A future study could model the U.S. – Canada softwood lumber trade under oligopoly and oligopsony frameworks to capture the influences of all other trade partners on the Canadian lumber shipments to the U.S.

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References

Adams, D.M. 2003. Market and resource impacts of a Canadian lumber tariff. J. For. **101**: 48–52.

Baek, J. 2007. The J-curve effect and the US–Canada forest products trade. J. For. Econ. **13**: 245–258. doi:10.1016/j.jfe.2006.11.001.

Baek, J. 2011. Dynamics of the US–Canada softwood lumber trade: market and welfare effects of the 2006 Softwood Lumber Agreement. The Estey Centre Journal of International Law Trade Policy, **12**(2): 69–81.

Baek, J. 2012. The long-run determinants of U.S. lumber imported from Canada revisited. For. Pol. Econ. **14**: 69–73. doi:10.1016/j.forpol.2011.07.007.

Baek, J., and Yin, R. 2006. U.S.–Canada softwood lumber trade: measuring the market and welfare impacts of restrictions. For. Sci. **52**(4): 390–400.

B.C. Ministry of Forest, Mines and Lands. 2010. The State of British Columbia's Forests. 3rd edition. Forest Practices and Investment Branch, Victoria, BC. Available from https://www.for.gov.bc.ca/hfp/sof/2010/SOF_2010_Web.pdf [accessed 1 June 2015].

BC Timber Sales. 2015. BC timber sales. Available from www.for.gov.bc.ca/bcts/ [accessed 1 July 2015].

Boyd, R., and Krutilla, K. 1987. The welfare impacts of US trade restrictions against the Canadian softwood lumber industry: a spatial equilibrium analysis. Can. J. Econ. **20**(1): 17–35. doi:10.2307/135228.

Buongiorno, J., Chou, J.J., and Stone, R.N. 1979. A monthly model of the United States demand for softwood lumber imports. For. Sci. **25**(4): 641–655.

Buongiorno, J., Chavas, J.-P., and Uusivouri, J. 1988. Exchange rates, Canadian lumber imports and United States prices: a time-series analysis. Can. J. For. Res. **18**(12): 1587–1594. doi:10.1139/x88-242.

Chen, N.-J., Ames, G.C.W., and Hammett, L. 1988. Implications of a tariff on imported Canadian softwood lumber. Can. J. Agric. Econ. **36**: 69–81. doi:10.1111/j.1744-7976.1988.tb03262.x.

Christensen, N. 2015. Branching out: preparing for life without a softwood lumber agreement. Canada West Foundation. Available from http://cwf.ca/publications-1/branching-out-preparing-for-life-without-a-softwood-lumber-agreement [accessed 1 October 2015].

Devadoss, S. 2006. Is there an end to US–Canadian softwood lumber disputes? J. Agric. Appl. Econ. **38**(1): 137–153. doi:10.1017/S1074070800022124.

Devadoss, S., Aguiar, A.H., Shook, S.R., and Araji, J. 2005. A spatial equilibrium analysis of US–Canadian disputes on the world softwood lumber market. Can. J. Agric. Econ. **53**: 177–192. doi:10.1111/j.1744-7976.2005.04024.x.

Elliott, G., Rothenberg, T.J., and Stock, J.H. 1996. Efficient tests for an autoregressive unit root. Econometrica, **64**: 813–836. doi:10.2307/2171846.

Farnia, F., Frayret, J.-M., Beaudry, C., and Lebel, L. 2015. Time-based combinatorial auction for timber allocation and delivery coordination. For. Pol. Econ. **50**: 143–152. doi:10.1016/j.forpol.2014.07.004.

Foreign Affairs, Trade and Development Canada (FATDC). 2006–2015. Softwood lumber exports report (various monthly issues). Trade Controls Bureau. Available from http://www.international.gc.ca/controls-controles/softwood-bois_oeuvre/index.aspx?lang=eng [accessed 1 October 2015].

Giles, D. 2011. Cointegration at the hips. Econometrics Beat: Dave Giles' blog. Available from http://davegiles.blogspot.com/2011/05/cointegrated-at-hips.html [accessed 2 June 2016].

Greene, W. 2011. Econometric analysis. 7th edition. Pearson Education Ltd.

Jennings, S., Adamowicz, W., and Constantino, L. 1991. The Canadian lumber industry and the macroeconomy: a vector autoregression analysis. Can. J. For. Res. **21**(3): 288–299. doi:10.1139/x91-036.

Johansen, S. 1988. Statistical analysis of cointegration vectors. J. Econ. Dynam. Cont. **12**: 231–254. doi:10.1016/0165-1889(88)90041-3.

Johansen, S. 1995. Likelihood based inference in cointegrated vector autoregressive models. Oxford University Press, Oxford, UK.

Johansen, S., Mosconi, R., and Nielsen, R. 2000. Cointegration analysis in the presence of structural breaks in the deterministic trend. Econometrics J. **3**: 216–249. doi:10.1111/1368-423X.00047.

Joyeux, R. 2007. How to deal with structural breaks in practical cointegration analysis? *In* Cointegration for the applied economist. 2nd edition. *Edited by* B. Rao. Palgrave Macmillan, New York. pp. 195–221.

Jung, C., and Doroodian, K. 1994. The law of one price for US softwood lumber: a multivariate cointegration test. For. Sci. **40**(4): 595–600.

Kinnucan, H.W., and Zhang, D. 2004. Incidence of the 1996 Canada–U.S. Softwood Lumber Agreement and the optimal export tax. Can. J. Agric. Econ. **52**: 73–88. doi:10.1111/j.1744-7976.2004.tb00095.x.

Lindsey, B.L., Groombridge, M.A., and Loungani, P. 2000. Nailing the homeowner. The economic impact of trade protection of the softwood lumber industry. Center for Trade Policy Studies Rep. No. 11, CATO Institute, Washington, DC.

Mogus, A., Stennes, B., and van Kooten, G.C. 2006. Canada–US softwood lumber trade revisited: substitution bias in the context of a spatial price equilibrium framework. For. Sci. **52**(4): 411–421.

Myneni, G., Dorfman, J.H., and Ames, G.C.W. 1994. Welfare impacts of the Canada–U.S. softwood lumber trade dispute: beggar thy consumer trade policy. Can. J. Agric. Econ. **42**: 261–271. doi:10.1111/j.1744-7976.1994.tb00023.x.

Nagubadi, R.V., and Zhang, D. 2013. US imports for Canadian softwood lumber in the context of trade dispute: a cointegration approach. For. Sci. **59**(5): 517–523. doi:10.5849/forsci.12-013.

Nagubadi, R.V., Zhang, D., Prestemon, J.P., and Wear, D.N. 2004. Softwood lumber products in the United States: substitutes, complements, or unrelated? For. Sci. **50**(4): 416–426.

Nanang, D.M. 2000. A multivariate cointegration test of the law of one price for Canadian softwood lumber markets. For. Pol. Econ. **1**: 347–355. doi:10.1016/S1389-9341(00)00028-9.

Natural Resources Canada. 2015. Mountain pine beetle (factsheet). Available from www.nrcan.gc.ca/forests/insects-diseases/13397 [accessed 1 October 2015].

Niquidet, K. 2008. Revitalized? An event study of forest policy reform in British Columbia. J. For. Econ. **14**(4): 227–241. doi:10.1016/j.jfe.2007.10.001.

Parajuli, R., and Chang, S.J. 2015. The softwood sawtimber stumpage market in Louisiana: market dynamics, structural break, and vector error correction model. For. Sci. **61**(5): 904–913. doi:10.5849/forsci.14-099.

Parajuli, R., Chang, S.J., and Hill, R.C. 2015. How effective is the United States–Canada Softwood Lumber Agreement 2006? An econometric study. For. Sci. **61**(6): 1041–1049. doi:10.5849/forsci.15-014.

Perron, P. 1989. The great crash, the oil prices shock and the unit root hypothesis. Econometrica, **57**: 1361–1401. doi:10.2307/1913712.

Prestemon, J.P., and Holmes, T.P. 2000. Timber price dynamics following a natural catastrophe. Am. J. Agric. Econ. **82**: 145–160. doi:10.1111/0002-9092.00012.

Random Lengths. 2015. Forest products market, prices, and statistics. Eugene, Oregon.

Shahi, C., Kant, S., and Yang, F. 2006. The law of one price in the North American softwood lumber markets. For. Sci. **52**(4): 353–366.

Softwood Lumber Agreement (SLA). 2006. Softwood Lumber Agreement between the Government of Canada and the Government of the United States of America: legal text. Available from http://www.treaty-accord.gc.ca/text-texte.aspx?id=105072&lang=eng [accessed 1 October 2015].

Song, N., Chang, S.J., and Aguilar, F.X. 2011. U.S. softwood lumber demand and supply estimation using cointegration in dynamic equations. J. For. Econ. **17**: 19–33. doi:10.1016/j.jfe.2010.07.002.

Statistics Canada. 2015. CANSIM — Canadian Socioeconomic Database from Statistics Canada. Available from http://www.statcan.gc.ca/ [accessed 1 October 2015].

Sun, C., and Zhang, D. 2003. The effects of exchange rate volatility on U.S. forest commodities exports. For. Sci. **49**(5): 807–814.

Taylor, R. 2009. B.C. sawmill closures "no surprise". *In* Logging & Sawmilling Journal. Available from http://forestnet.com/LSJissues/nov2013/closures.php [accessed 1 October 2015].

Toppinen, A., and Toivonen, R. 1998. Roundwood market integration in Finland: a multivariate cointegration analysis. J. For. Econ. **4**(3): 241–265.

U.S. Bureau of Labor Statistics (US BLS). 2015. Overview of BLS statistics on inflation and prices. Available from www.bls.gov/bls/inflation.htm [accessed 1 October 2015].

US Census Bureau. 2015. New residential construction, new privately owned housing units started. Available from http://www.census.gov/construction/nrc/historical_data/index.html [accessed 1 October 2015].

USDA Economic Research Service (US ERS). 2015. United States Department of Agriculture, Economic Research Service. Available from http://www.ers.usda.gov/data-products/agricultural-exchange-rate-data-set.aspx [accessed 1 October 2015].

van Kooten, G.C. 2002. Economic analysis of the Canada–United States softwood lumber dispute: playing the quota game. For. Sci. **48**(4): 712–721.

Wear, D.N., and Lee, K.J. 1993. US policy and Canadian lumber: effects of the 1986 memorandum of understanding. For. Sci. **39**(4): 799–815.

Wood Markets. 2015. Canada & U.S. Top 20 Lumber Producers' Annual Ranking: 2014. News release. International Wood Markets Group Inc. BC Canada. Available from https://www.woodmarkets.com/wp-content/uploads/2015/03/15-03-26-Press-Release-Top-20-US-Canada-Lbr-Producers-RT2.pdf [accessed 1 October 2015].

Zhang, D. 2001. Welfare impacts of the 1996 United States–Canada Softwood Lumber (trade) Agreement. Can. J. For. Res. **31**(11): 1958–1967. doi:10.1139/x01-130.

Zhang, D. 2006. Welfare impacts of the 1996 United States–Canada softwood lumber agreement: an update. Can. J. For. Res. **36**(1): 255–261. doi:10.1139/x05-231.

Zhang, D. 2007. The softwood lumber war: politics, economics, and the long US–Canadian trade dispute. RFF Press, DC.

Zivot, E., and Andrews, D.W.K. 1992. Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. J. Bus. Econ. Stat. **10**(3): 251–270. doi:10.1080/07350015.1992.10509904.