NRC Research Press

ARTICLE

Projected effects of US tariffs on Canadian softwood lumber and newsprint imports: a cobweb model

Joseph Buongiorno

Abstract: Starting from the cobweb theorem, a model of demand, supply, multilateral trade, and prices was formulated for the softwood lumber and newsprint markets in Canada, the United States (US), and the rest of the world. Parameters were estimated with panel data from multiple years and countries. The model was used to project the effects of US tariffs on softwood lumber and newsprint imports from Canada. To assess the uncertainty of the projections, multiple replications were performed by repeated sampling from the parameters' statistical distributions. The results suggested that the initial shock of the tariffs dampened out and took 3 to 4 years to stabilize. In the long run, other things being equal, a 20.83% US tariff on softwood lumber imports from Canada decreased US imports from Canada by 4.7% to 8.0% and raised the US price by 0.3% to 2.3% and the US production by 0.9% to 1.7%, with 95% probability, while it lowered the Canadian price by 0.7% to 3.0% and Canadian production by 1.1% to 2.4%. A 28.69% US tariff on newsprint imports from Canada decreased US imports from Canada by 3.2% to 7.0% and raised the US price by 1.4% to 3.3% and the US production by 2.9 to 6.3%, while it lowered the Canadian price by 0.8% to 1.9% and the Canadian production by 1.6% to 3.5%.

Key words: trade policy, market model, cobweb, softwood lumber, newsprint, demand, supply, price, forest products, forecasting.

Résumé : À partir du théorème de la toile d'araignée, un modèle de demande, d'approvisionnement, de commerce multilatéral et de prix a été élaboré pour les marchés du bois d'œuvre résineux et du papier journal au Canada, aux États-Unis et dans le reste du monde. Les paramètres ont été estimés à partir des données recueillies au moyen d'un panel sur plusieurs années et pour plusieurs pays. Le modèle a été utilisé pour projeter les effets des droits de douane américains sur le bois d'œuvre résineux et le papier journal importés du Canada. Pour évaluer l'incertitude des projections, des répétitions multiples ont été faites par le biais d'un échantillonnage répété à partir de la distribution statistique des paramètres. Les résultats indiquent que le choc initial des tarifs douaniers s'atténue et prend 3 à 4 ans pour se stabiliser. À long terme, les autres choses étant égales, un tarif douanier américain de 20,83 % sur le bois d'œuvre résineux importé du Canada diminue les importations des États-Unis en provenance du Canada de 4,7 à 8,0 %, augmente le prix américain de 0,3 à 2,3 % et la production américaine de 0,9 et 1,7 % selon une probabilité de 95 %, tandis qu'il y a une diminution du prix au Canada de 0,7 à 3,0 % et de la production au Canada de 1,1 à 2,4 %. Un tarif douanier américain de 28,69 % sur les importations de papier journal du Canada diminue les importations des États-Unis en provenance du Canada de 3,2 à 7,0 %, augmente le prix américain de 1,4 à 3,3 % et la production américain de 2,9 à 6,3 %, tandis qu'il y a une diminution du prix au Canada de 0,8 à 1,9 % et de la production au Canada de 1,6 à 3,5 %. [Traduit par la Rédaction]

Mots-clés : politique commerciale, modèle de marché, toile d'araignée, bois d'œuvre résineux, papier journal, demande, approvisionnement, prix, produits forestiers, prévisions.

Introduction

The markets for softwood lumber and newsprint in Canada and the United States (US) are closely connected. Consequently, the recent intent of the US government to heavily tax Canadian imports has received considerable attention. In November of 2017, the U.S. Department of Commerce recommended combined countervailing and antidumping duties averaging 20.83% on softwood lumber shipments to the US (Random Lengths 2017). For newsprint, in March of 2018, the U.S. Department of Commerce imposed preliminary duties that averaged 28.69%, 6.53% in countervailing duties and 22.16% for antidumping (The Canadian Press 2018).

The objective of this paper was to evaluate the effects on production, consumption, trade, and prices of these proposed US tariffs in both countries and in the rest of the world (ROW). The trade in softwood lumber has been the subject of many disputes and temporary agreements between the two countries, due in part to claims by US producers that the Canadian softwood lumber industry was subsidized by its government through cheap stumpage prices on crown lands (Baek 2011; Devadoss 2006; Zhang 2007). Consequently, there have been several studies of the "softwood lumber wars" (Wear and Lee 1993; Parajuli et al. 2016; Ochuodho et al. 2016). In particular, Johnston and Parajuli (2017) examined, among other trade policies, the effects of recent tariff proposals on Canadian softwood lumber imports, finding, for example, that a 26.75% tariff reduces Canada's market share in the US by nearly 5%. The newsprint trade, less controversial in the past, may also be appreciably affected by the proposed high tariffs, with the attendant market disruptions that are discussed in this paper.

Canada and the US in world markets

Softwood lumber

Based on the data of the Food and Agriculture Organization of the United Nations (FAO 2017*a*), in 2015, the world production of

Received 16 April 2018. Accepted 29 August 2018.

J. Buongiorno.* Department of Forest and Wildlife Ecology, University of Wisconsin–Madison, Madison, WI 53706, USA.
Email for correspondence: jbuongio@wisc.edu.
*Present address: Russell Labs, 1630 Linden Drive, Madison, WI 53706,USA.

Table 1. Softwood lumber and newsprint production, consumption, import, export, and price in Canada, the United States, and the rest of the world (ROW) in 2015 (FAO 2017*a*).

Activity	Unit	Canada	United States	ROW	World
Softwood lumber					
Production	10^3 m^3	45 360	54 335	221 743	321 438
Consumption	10^3 m^3	15 088	74 959	231 391	321 438
Import	10^3 m^3	700	23 360	17 320	41 380
Export	10^3 m^3	30 272	2 736	8 372	41 380
Price	\$·m^{-3}	206[a]	225[b]	225[b]	
Newsprint					
Production	10^3 t	3 521	1 658	19 678	24 857
Consumption	10^3 t	269	3 230	21 358	24 857
Import	10^3 t	60	1 976	1 784	3 820
Export	10^3 t	3 312	404	104	3 820
Price	\$·t^{-1}	510[a]	554[b]	554[b]	

[a]Unit value of world export.
[b]Unit value of world import.

softwood lumber (coniferous sawnwood in FAO's terminology) was approximately 321 million m^3, worth \$66.2 × 10^9 at world prices (Table 1). Of this global output, 17% was produced in the US and 14% was produced in Canada. However, the US consumed 23% of the global production, while Canada consumed only 5%. Correspondingly, the US imported 56% of the 41.4 million m^3 of global softwood lumber exports, while Canada exported 73% of them.

Table 2 shows in more detail the trade flows of softwood lumber between Canada, the US, and the ROW. Of the 30.2 million m^3 exported by Canada, approximately half went to the US and half went to the ROW. Furthermore, the US imported 95% of the 8.4 million m^3 exported by the ROW. These data suggest that a study of the relation between the US and Canada, including the effect of a US tariff on Canadian imports, should also consider the ROW. The ROW competes with Canada in supplying the US, and the ROW is an alternative to the US market for Canadian softwood lumber (see also Devadoss et al. (2005) and Johnston and Parajuli (2017)).

Newsprint

For newsprint, the global production in 2015 was approximately 24.9 million tonnes, worth \$12.7 × 10^9 at world prices (Table 1). Of this, 14% was produced in Canada and 7% was produced in the US. In contrast, the US consumed 13% of the world production, while Canada consumed only 1% of it.

Of the 3.8 million tonnes of world trade, the US imported 52% and the ROW imported 47%, while 87% of world exports came from Canada. As shown in the newsprint direction of trade (Table 2), 57% of the Canadian total exports of 3.3 million tonnes went to the US. The US also imported and exported smaller amounts to and from the ROW. Nevertheless, as the ROW was a major destination of Canadian exports, it could play a role in determining the ultimate impact of a US tariff on newsprint imports from Canada.

Methods

Model structure

The underlying concept was the cobweb theorem (Ezekiel 1938; Pashigian 2008; Waugh 1964). In one of its simplest forms, this model sets consumption as a function of lagged price, production equal to consumption, and price as a function of production. An exogenous shock such as a rise in demand leads to dampened fluctuations of quantity and price that with suitable parameters converge to a new equilibrium.

This basic recursive structure was extended here to deal with multilateral trade and to distinguish between domestic and import demand. Specifically, the relation between consumption, production, trade, and prices of a commodity in a particular year, other things being equal, was described by the following general equations:

Table 2. Direction of trade of softwood lumber and newsprint in Canada, the United States, and the rest of the world (ROW) in 2015 (FAO 2017*a*).

		Exporters			
Importers	Unit	Canada	United States	ROW	World
Softwood lumber					
Canada	10^3 m^3	0	261	439	700
United States	10^3 m^3	15 427	0	7 933	23 360
ROW	10^3 m^3	14 845	2 475	0	17 320
World	10^3 m^3	30 272	2 736	8 372	41 380
Newsprint					
Canada	10^3 t		60	0	60
United States	10^3 t	1 872		104	1 976
ROW	10^3 t	1 440	344		1 784
World	10^3 t	3 312	404	104	3 820

$$C_{it} = \alpha_i P_{i,t-1}^{\beta_i} \quad \forall i \tag{1}$$

$$T_{ijt} = \gamma_{ij}[(1 + \tau_{ijt})P_{i,t-1}]^{\delta_{ij}} \quad \forall ij \tag{2}$$

$$I_{jt} = \sum_i T_{ijt} \quad \forall j \tag{3}$$

$$X_{it} = \sum_j T_{ijt} \quad \forall i \tag{4}$$

$$Q_{it} = C_{it} + X_{it} - I_{it} \quad \forall i \tag{5}$$

$$P_{it} = \mu_i Q_{it}^{\varphi_i} \quad \forall i \tag{6}$$

where subscript i refers to a region and t refers to a time period. Equation 1 expresses the domestic demand: apparent consumption in a region and period (C_{it}) is a function of the price in the region lagged one period ($P_{i,t-1}$) with a region-dependent elasticity (β_i) and a calibration constant (α_i) (see below).

Similarly, eq. 2 describes the demand for imports of region j from region i as a function of the lagged product price in the export region ($P_{i,t-1}$) augmented by the eventual ad valorem tax rate (τ_{ijt}) of the importing region j on the commodity coming from region i in year t. The parameter δ_{ij} is the elasticity with respect to the import price, and γ_{ij} is a calibration constant.

Equations 3 and 4 express total imports (I_{jt}) and exports (X_{it}) of each region as the sums of imports from different origins or exports to different destinations (T_{ijt}).

Equation 5 states that production in a region (Q_{it}) is the sum of domestic consumption and net trade (exports minus imports).

Lastly, according to the inverse supply eq. 6, the price (marginal cost) in a region is a function of the production in the region, with elasticity φ_i and a calibration constant μ_i.

Calibration constants

The calibration constants α_i and γ_{ij} in eqs. 1 and 2 account for the variables that determined domestic and import demand, respectively, in the base year before the tariff, in addition to the price. Similarly, the constant μ_i in eq. 6 reflects all of the factors that affected the price in the base year, apart from production.

Thus, given a set of elasticities, β_i, δ_{ij}, and φ_i, and the base year observations C_{i0}, Q_{i0}, T_{ij0}, and P_{i0}, the calibration constants are such that the equations replicate the base year observations. For example, given eq. 6, the calibration constant μ_i for a particular region is

Table 3. Parameters of domestic demand, import demand, and price equations for softwood lumber and newsprint.

	Variable	Coefficient	SE	*t* statistic	Method	Observations	Countries
Softwood lumber							
Domestic demand	$\ln(P_{i,t-1})$	−0.25	0.04	−6.21***	FE	2117	128
	$\ln(Y_{i,t})$	0.24	0.05	4.41***			
Import demand	$\ln(P'_{i,t-1})$	−0.38	0.05	−7.35***	FE	2290	132
	$\ln(Y_{i,t})$	1.12	0.08	14.06***			
Price	$\ln(Q_{i,t})$	1.11	0.50	2.22**	2SLS & FE	2306	130
	Year (*t*)	0.01	0.002	2.87**			
Newsprint							
Domestic demand	$\ln(P_{i,t-1})$	−0.22	0.04	−5.79***	FE	2673	145
	$\ln(Y_{i,t})$	0.36	0.02	18.93***			
Import demand	$\ln(P'_{i,t-1})$	−0.22	0.05	−4.66***	FE	3312	167
	$\ln(Y_{i,t})$	0.27	0.03	8.04***			
Price	$\ln(Q_{i,t})$	0.52	0.04	12.58***	2SLS & FE	2856	150
	Year (*t*)	−0.02	0.001	−19.17***			

Note: *P*, real price; *Y*, real gross domestic product; *Q*, production; *t*, year; SE, standard error; FE, fixed effects; 2SLS, two-stage least square. Significance level: **, 5%; ***, 1%.

$$\mu_i = P_{i0}Q_{i0}^{-\tau_i} \qquad \forall i \tag{7}$$

The calibration constants α_i and γ_{ij} in eqs. 1 and 2 assume a market equilibrium in the base year so that $P_{i0} = P_{i,-1}$.

Model replications

In this application, the model is used to project the consequences for all of the variables of introducing an ad valorem tariff τ_{ijt} beginning in the base year, $t = 0$, other things being held constant. Each simulation was carried out for a sufficient length of time to ensure convergence to a post-tariff equilibrium.

In view of the uncertainty of the parameters and their potential differences across countries and trade flows, 20 replications were performed, each conditional on a different set of elasticities and attendant calibration constants. Given the mean and standard error (SE) of the elasticities (see below), in each replication, elasticities were drawn randomly from their distribution. For example, an observation of the price elasticity of demand for a product in a particular country was obtained from

$$\beta_i = F^{-1}(r|\hat{\beta}, s_{\hat{\beta}}) \tag{8}$$

where F^{-1} is the inverse normal cumulative density function, r is a uniformly distributed random number in the [0,1] interval, $\hat{\beta}$ is the econometric estimate of the mean elasticity, and $s_{\hat{\beta}}$ is its SE.

Average elasticities and standard errors

The average elasticities $\hat{\beta}$, $\hat{\delta}$, and $\hat{\varphi}$ and their SEs were estimated with pooled cross-section and time series data. The data consisted of annual observations from multiple years and countries. The following functional form is used for domestic demand:

$$\ln(C_{it}) = \beta \ln(P_{i,t-1}) + \rho \ln(Y_{it}) + \theta_i + \varepsilon_{it} \tag{9}$$

where the domestic price ($P_{i,t-1}$) is estimated as the average of the unit value of imports and exports, weighted by the quantity imported and exported, and Y_{it} is the gross domestic product (GDP). Both price and GDP are in constant $US of 2010. ρ is the elasticity with respect to GDP, θ_i is a country-specific fixed effect, and ε_{it} is a random effect varying by year and country.

For the import demand eq. 2, the average price elasticity is estimated with a similar functional form:

$$\ln(I_{it}) = \delta \ln(P'_{i,t-1}) + \rho \ln(Y_{it}) + \theta_i + \varepsilon_{it} \tag{10}$$

where price $P'_{i,t-1}$ was the unit value of imports in constant $US of 2010. The functional form for the price eq. 6 is

$$\ln(P_{it}) = \varphi \ln(Q_{it}) + \gamma t + \theta_i + \varepsilon_{it} \tag{11}$$

where γ refers to a time trend. Given the panel data, exogenous GDP, and predetermined lagged price, eqs. 8 and 9 were estimated by ordinary least squares with fixed effects (Wooldridge 2006, p. 485). In view of the endogenous explanatory variable (Q_{it}) in eq. 11, the parameters were estimated by two-stage least squares (Wooldridge 2006, pp. 526–529) with fixed effects. In the first stage, Y_{it}, year (t), and fixed effects (θ_i) were used as instruments to predict production ($\hat{Q}_{it}$), which in the second stage replaced the independent variable Q_{it} in eq. 11.

Data

The data used in estimating the parameters of the domestic and import demand (eqs. 9 and 10) and the price (eq. 11) were panel data of time series pooled across multiple countries (Supplementary data[1]). The data came from the FAOSTAT Forestry Statistics data base (FAO 2017*b*) and from the World Development Indicators data base (World Bank 2017). They covered all of the countries and years for which data were available from 1992 to 2014. Apparent annual consumption (C_{it}) was estimated as production plus imports minus exports. Domestic price (P_{it}) was approximated by the weighted average of the unit value of imports and exports, import and export quantities serving as weights, deflated to constant (2010) $US, using the US GDP deflator (World Bank 2017). The import price (P'_{it}) was the unit value of imports, also expressed in constant $US. The real gross domestic product (Y_{it}) in constant $US of 2010 was taken directly from World Bank (2017). Due to missing data, the number of observations varied from 2117 for coniferous sawnwood domestic demand to 3312 for newsprint import demand (Table 3).

Results

Demand and price equations

The results of estimation of the average demand and supply equations for softwood lumber are in Table 3. For the domestic demand, the average price elasticity was −0.25 (SE of 0.04). The

[1]Supplementary data are available with the article through the journal Web site at http://nrcresearchpress.com/doi/suppl/10.1139/cjfr-2018-0153.

demand for import was more elastic (−0.38, SE of 0.05). Both demand elasticities were significantly different from zero at least at the 99% confidence level. The elasticity of price with respect to output was 1.11 (SE of 0.50), statistically significant at least at the 95% confidence level.

For newsprint (Table 3), the price elasticity was practically the same for the domestic demand and the demand for imports, −0.22 with SEs of 0.04 and 0.05, respectively. The elasticity of the price with respect to output was 0.52 (SE of 0.04). All three parameters were statistically significant at least at the 99% confidence level.

Adjustment dynamics

Figure 1 illustrates how the variables in the model described by eqs. 1–6 adjusted over time in response to a US tariff on Canadian imports of softwood lumber and newsprint. Specifically, Figure 1 shows the path of the price in Canada, the US, and the ROW resulting from a 20.83% tariff on US imports of softwood lumber from Canada and a 28.69% tariff on US imports of newsprint for Canada.

The data in Fig. 1 were obtained with the average values of the supply, demand, and price elasticities in Table 3. The initial conditions ($t = 0$) were as in Tables 1 and 2, and the tariff rates were $\tau_{ijt} = 0.2083$ for softwood lumber and $\tau_{ijt} = 0.2869$ for newsprint for $t = 1, 2, \ldots$ In the first year following the imposition of the tariff, the price of softwood lumber increased in the US while it decreased in Canada. It then fluctuated with damped oscillations and converged to a new price, higher than the pre-tariff price for the US and lower for Canada, in approximately 3 to 4 years. The adjustment was slightly more rapid for the price of newsprint than for that of softwood lumber. For the ROW, the US tariff had hardly any effect on the price level. In accord with this price behavior, damped oscillations and convergence also occurred for the other variables such as production, consumption, imports, and exports.

Long-term effects of the softwood lumber tariff

Table 4 summarizes the consequences of the introduction of a 20.83% US tariff on imports of softwood lumber from Canada for production, consumption, imports, exports, and prices in Canada, the US, and the ROW. The results were for 20 replications of the projections, each with a random set of elasticities obtained with equations analog to eq. 8 (with the mean and standard errors in Table 3) continued until the variables converged to equilibrium.

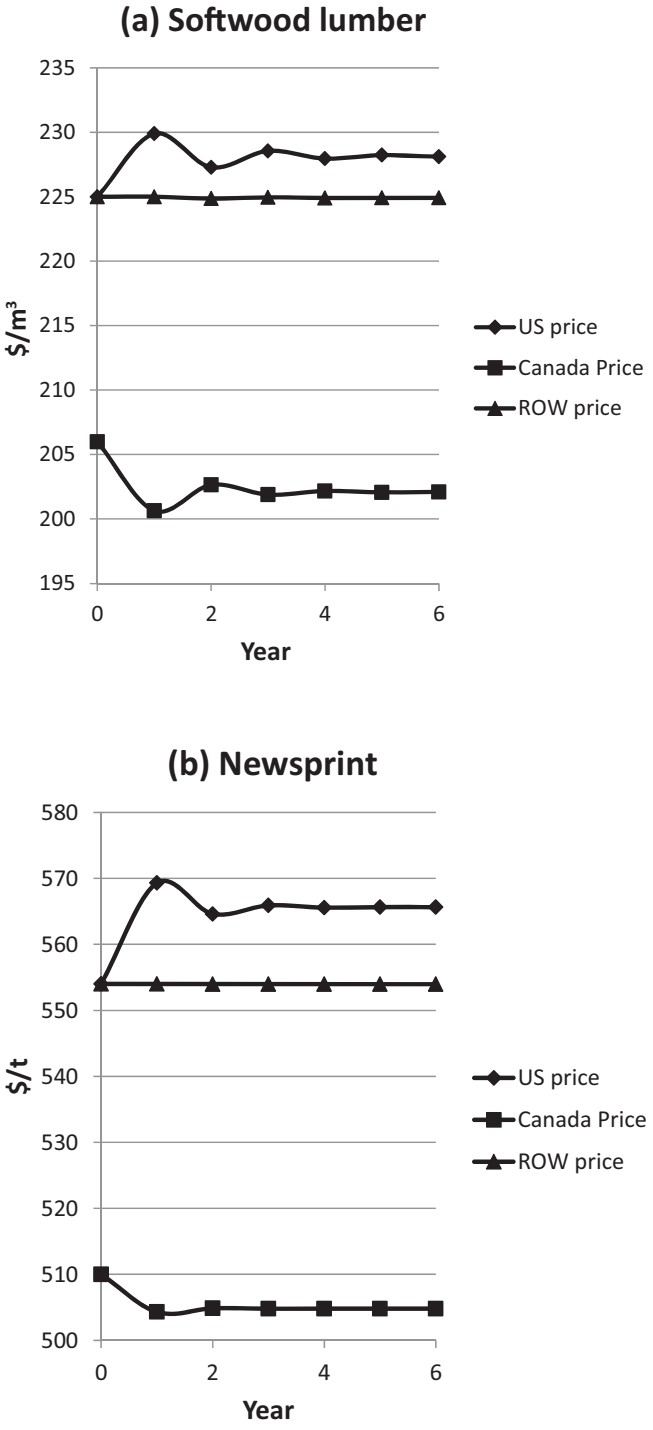
The statistics in Table 4 are for the changes between the initial conditions (Tables 1 and 2) and the equilibrium after the introduction of the 20.83% US tariff. The average, standard deviation (SD), maximum, and minimum were computed over 20 replications. The 95% lower and upper bounds were equal to the average ± 1.96 SD.

According to these 95% confidence bounds, the main tariff effect was to decrease US imports by 0.7 to 1.2 million m^3 (3.1% to 5.3%). Accordingly, Canadian exports also decreased but by relatively less (2.0% to 3.8%) due to an increase in imports by the ROW of 0.2% to 0.9%. Production in Canada decreased but by somewhat less than exports due mostly to an increase in domestic consumption in accord with a 0.7% to 3.0% lower price.

In contrast, the price in the US was 0.3% to 2.3% higher due to the tariff. This correlated with an increase in US production of 0.5 to 1 million m^3 (0.9% to 1.7%) and a decrease in consumption of 0.1% to 0.6%. The tariff impact in the ROW was generally small, except for the higher imports noted above and the corresponding lower production in accord with a slightly lower price.

Table 5 shows more detail on the changes in trade flows due to a 20.83% US tariff on Canadian softwood lumber imports. The main relative change was the decrease of 4.7% to 8% of the Canadian exports to the US. In a partial offset, with a lower price in Canada, Canadian exports to the ROW increased by 0.3% to 1.2%, while US exports to the ROW and Canada decreased by 0.1% to 0.9% in accord with the price increase in the US.

Fig. 1. Projected response of softwood lumber and newsprint prices in the United States, Canada, and the rest of the world (ROW) following US tariffs on Canadian imports of (*a*) 20.83% for softwood lumber and (*b*) 28.69% for newsprint. Figures were obtained with average values of model parameters.



Long-term effects of the newsprint tariff

As shown in Table 6, a 28.69% US tariff on newsprint imports from Canada affected mostly Canada and the US. The 20 replications with randomly selected parameters showed hardly any change in production, consumption, trade, and price in the ROW.

Table 4. Projected effects of a 20.83% US tariff on softwood lumber imports from Canada.

Item	Unit	Average	SD	Minimum	Maximum	Lower 95%	Upper 95%
Canada							
Production	10^3 m^3	**–794**	**151**	**–1156**	**–541**	**–1090**	**–498**
	%	–1.7	0.3	–2.5	–1.2	–2.4	–1.1
Consumption	10^3 m^3	**77**	**23**	**33**	**125**	**32**	**123**
	%	0.5	0.1	0.2	0.8	0.2	0.8
Export total	10^3 m^3	**–872**	**139**	**–1199**	**–636**	**–1145**	**–599**
	%	–2.9	0.5	–4.0	–2.1	–3.8	–2.0
Import total	10^3 m^3	**–1**	**1**	**–3**	**0**	**–2**	**0**
	%	–0.2	0.1	–0.4	0.0	–0.3	0.0
Price	\$·m^{-3}	**–4**	**1**	**–6**	**–2**	**–6**	**–1**
	%	–1.9	0.6	–2.9	–0.8	–3.0	–0.7
US							
Production	10^3 m^3	**723**	**116**	**508**	**894**	**496**	**950**
	%	1.3	0.2	0.9	1.6	0.9	1.7
Consumption	10^3 m^3	**–240**	**97**	**–450**	**–41**	**–429**	**–51**
	%	–0.3	0.1	–0.6	–0.1	–0.6	–0.1
Export total	10^3 m^3	**–14**	**6**	**–25**	**–2**	**–25**	**–3**
	%	–0.5	0.2	–0.9	–0.1	–0.9	–0.1
Import total	10^3 m^3	**–977**	**130**	**–1275**	**–784**	**–1232**	**–722**
	%	–4.2	0.6	–5.5	–3.4	–5.3	–3.1
Price	\$·m^{-3}	**3**	**1**	**1**	**6**	**1**	**5**
	%	1.3	0.5	0.3	2.5	0.3	2.3
ROW							
Production	10^3 m^3	**–74**	**30**	**–150**	**–24**	**–133**	**–14**
	%	0.0	0.0	–0.1	0.0	–0.1	0.0
Consumption	10^3 m^3	**18**	**8**	**5**	**33**	**3**	**34**
	%	0.0	0.0	0.0	0.0	0.0	0.0
Export total	10^3 m^3	**1**	**0**	**0**	**2**	**0**	**2**
	%	0.0	0.0	0.0	0.0	0.0	0.0
Import total	10^3 m^3	**93**	**34**	**29**	**164**	**26**	**161**
	%	0.5	0.2	0.2	0.9	0.2	0.9
Price	\$·m^{-3}	**–0.1**	**0.0**	**–0.1**	**0.0**	**–0.1**	**0.0**
	%	0.0	0.0	–0.1	0.0	–0.1	0.0

Note: Average, standard deviation (SD), minimum, and maximum were computed over 20 replications, each with parameters selected randomly from their distribution. Lower 95% and Upper 95% = Average ± 1.96 SD. ROW, rest of the world.

Table 5. Projected effects on softwood lumber direction of trade of a 20.83% US tariff on softwood lumber imports from Canada.

Exporter	Importer	Unit	Average	SD	Minimum	Maximum	Lower 95%	Upper 95%
US	Canada	10^3 m^3	**–1**	**1**	**–3**	**0**	**–2**	**0**
		%	–0.5	0.2	–1.1	–0.1	–0.9	–0.1
	ROW	10^3 m^3	**–12**	**5**	**–23**	**–2**	**–23**	**–2**
		%	–0.5	0.2	–0.9	–0.1	–0.9	–0.1
Canada	US	10^3 m^3	**–978**	**130**	**–1276**	**–784**	**–1233**	**–723**
		%	–6.3	0.8	–8.3	–5.1	–8.0	–4.7
	ROW	10^3 m^3	**106**	**35**	**41**	**181**	**38**	**174**
		%	0.7	0.2	0.3	1.2	0.3	1.2
ROW	US	10^3 m^3	**1**	**0**	**0**	**2**	**0**	**2**
		%	0.0	0.0	0.0	0.0	0.0	0.0
	Canada	10^3 m^3	**0**	**0**	**0**	**0**	**0**	**0**
		%	0.0	0.0	0.0	0.0	0.0	0.0

Note: Average, standard deviation (SD), minimum, and maximum were computed over 20 replications, each with parameters selected randomly from their distribution. Lower 95% and Upper 95% = Average ± 1.96 SD. ROW, rest of the world.

The largest relative change was in US imports that, according to the 95% confidence bounds, decreased by 60 000 to 130 000 t (3.0% to 6.6%). Accordingly, US production increased by 48 000 to 105 000 t (2.9% to 6.3%) and the US price increased by 1.4% to 3.3%. Symmetrically, the Canadian newsprint exports were 57 000 to 124 000 t (1.7% to 3.8%) lower with the tariff, reducing production by an almost equal amount and the price by 0.8% to 1.9%. The direction of trade results (Table 7) showed that the only economically significant change due to the tariff was the 60 000 to 131 000 t (3.2% to 7.0%) lower exports from Canada to the US.

Summary and conclusion

The objective of this study was to project some of the effects of potential US tariffs on imports of softwood lumber and newsprint from Canada. To this end, we formulated a cobweb-type model of demand, supply, multilateral trade, and price for Canada, the US, and the ROW. The parameters of the model consisted of elasticities of domestic demand and import demand and of price elasticities with respect to production.

The mean and SEs of the parameters were estimated from pooled cross-section and time series data. For softwood lumber,

Table 6. Projected effects of a 28.69% US tariff on newsprint imports from Canada.

Item	Unit	Average	SD	Minimum	Maximum	Lower 95%	Upper 95%
Canada							
Production	10^3 t	**–90**	**17**	**–135**	**–58**	**–123**	**–56**
	%	–2.5	0.5	–3.8	–1.6	–3.5	–1.6
Consumption	10^3 t	**1**	**0**	**1**	**2**	**0**	**1**
	%	0.3	0.1	0.2	0.6	0.1	0.5
Export total	10^3 t	**–91**	**17**	**–137**	**–59**	**–124**	**–57**
	%	–2.7	0.5	–4.1	–1.8	–3.8	–1.7
Import total	10^3 t	**0**	**0**	**–1**	**0**	**–1**	**0**
	%	–0.5	0.2	–0.9	–0.2	–0.8	–0.2
Price	$\$\cdot t^{-1}$	**–7**	**1**	**–11**	**–5**	**–10**	**–4**
	%	–1.4	0.3	–2.1	–0.9	–1.9	–0.8
US							
Production	10^3 t	**77**	**14**	**47**	**116**	**48**	**105**
	%	4.6	0.9	2.8	7.0	2.9	6.3
Consumption	10^3 t	**–16**	**4**	**–25**	**–7**	**–25**	**–8**
	%	–0.5	0.1	–0.8	–0.2	–0.8	–0.3
Export total	10^3 t	**–2**	**0**	**–3**	**–1**	**–3**	**–1**
	%	–0.5	0.1	–0.7	–0.2	–0.7	–0.3
Import total	10^3 t	**–95**	**18**	**–144**	**–61**	**–131**	**–60**
	%	–4.8	0.9	–7.3	–3.1	–6.6	–3.0
Price	$\$\cdot t^{-1}$	**13**	**3**	**8**	**20**	**7**	**18**
	%	2.3	0.5	1.4	3.6	1.4	3.3
ROW							
Production	10^3 t	**–2**	**1**	**–4**	**–1**	**–5**	**0**
	%	0.0	0.0	0.0	0.0	0.0	0.0
Consumption	10^3 t	**0**	**0**	**0**	**1**	**0**	**1**
	%	0.0	0.0	0.0	0.0	0.0	0.0
Export total	10^3 t	**0**	**0**	**0**	**0**	**0**	**0**
	%	0.0	0.0	0.0	0.0	0.0	0.0
Import total	10^3 t	**3**	**1**	**1**	**5**	**0**	**5**
	%	0.2	0.1	0.0	0.3	0.0	0.3
Price	$\$\cdot t^{-1}$	**0.0**	**0.0**	**–0.1**	**0.0**	**–0.1**	**0.0**
	%	0.0	0.0	0.0	0.0	0.0	0.0

Note: Average, standard deviation (SD), minimum, and maximum were computed over 20 replications, each with parameters selected randomly from their distribution. Lower 95% and Upper 95% = Average ± 1.96 SD. ROW, rest of the world.

Table 7. Projected effects on newsprint direction of trade of a 28.69% US tariff on newsprint imports from Canada.

Exporter	Importer	Unit	Average	SD	Minimum	Maximum	Lower 95%	Upper 95%
US	Canada	10^3 t	**0**	**0**	**–1**	**0**	**–1**	**0**
		%	–0.5	0.2	–0.9	–0.2	–0.8	–0.2
	ROW	10^3 t	**–2**	**0**	**–2**	**–1**	**–3**	**–1**
		%	–0.5	0.1	–0.7	–0.2	–0.7	–0.3
Canada	US	10^3 t	**–95**	**18**	**–144**	**–61**	**–131**	**–60**
		%	–5.1	1.0	–7.7	–3.2	–7.0	–3.2
	ROW	10^3 t	**4**	**2**	**2**	**7**	**1**	**8**
		%	0.3	0.1	0.1	0.5	0.1	0.5
ROW	US	10^3 t	**0**	**0**	**0**	**0**	**0**	**0**
		%	0.0	0.0	0.0	0.0	0.0	0.0
	Canada	10^3 t	**0**	**0**	**0**	**0**	**0**	**0**
		%	n/a	n/a	n/a	n/a	n/a	n/a

Note: Average, standard deviation (SD), minimum, and maximum were computed over 20 replications, each with parameters selected randomly from their distribution. Lower 95% and Upper 95% = Average ± 1.96 SD; n/a, division by zero. ROW, rest of the world.

domestic and import demands were inelastic with respect to price, and the domestic price was elastic with respect to production. For newsprint, the domestic and import demands were inelastic with respect to price, and the domestic price was inelastic with respect to production.

To reflect the uncertainty of the model parameters across countries and trade flows, repeated projections were carried out with different parameter sets drawn randomly from their distributions. The model was used to obtain 95% confidence intervals of the effects of combined ad valorem antidumping and countervailing duties of 20.83% on US softwood lumber imports from Canada and of 28.69% on newsprint imports, other things being equal.

The results showed that the production, consumption, trade, and prices responded to the tariff shocks with damped oscillations that stabilized over 3 to 4 years. The main long-run effect was on Canadian exports to the US, which decreased by 4.7% to 8.0% for softwood lumber and by 3.2% to 7% for newsprint. The tariff on newsprint decreased Canada's exports to the US less than the lower tariff on softwood lumber because the elasticity of US import demand was lower for newsprint, with the same SE. Accordingly, production of softwood lumber decreased by 1.1% to 2.4% in Canada while it increased by 0.9% to 1.7% in the US. This in turn raised the price of softwood lumber by 1.4% to 3.3% in the US while lowering it by 0.8% to 1.9% in Canada. To a limited extent,

the effect of the US softwood lumber tariff on Canada was compensated by Canadian exports to the ROW, which increased by 0.3% to 1.2%.

For newsprint, the Canadian production was 1.6% to 3.5% lower due to the tariff, while the US production was 2.9% to 6.3% higher, and correspondingly, the US price was 1.4% to 3.3% higher while it was 0.8% to 1.9% lower in Canada. The ROW played a negligible role in the market adjustments to the US tariff on newsprint.

The methods used to obtain these results attempted to take into account the uncertainty due to the model parameters. Zhang and Parajuli (2016) also point out the sensitivity of policy impact estimates to data selection in empirical analysis. In particular, the approach in this paper assumed that numerous policy changes such as the repeated softwood lumber agreements between the US and Canada were included in the multicountry residual shocks of eqs. 9–11. Furthermore, there was an added uncertainty stemming from a priori theoretical choices and model structures. Even though the econometric results suggested that the cobweb theorem adopted and extended in this paper, assuming in particular a lagged relation between consumption and price, was consistent with existing data, it is only one among many possible alternative theories.

For example, Johnston and Parajuli (2017) studied the effect of tariff levels on US softwood lumber imports from Canada with comparative statics in an optimization mixed-complementary model taking into account the ROW. Their findings corroborate those in this paper in terms of the direction of the effects, but they differ in magnitude. For instance, a tariff of 20% decreases Canadian exports to the US by approximately 3.5 million m^3 (Johnston and Parajuli 2017, fig. 3) compared with the 0.7 to 1.2 million m^3 projected in the present study (Table 5). Furthermore, since January of 2018, after the tariff was imposed, the framing lumber composite price has increased by 25% per month except for April (Random Lengths 2018). Although these are short-term changes, due in large part to the shortage of railroad cars during that period (Skerritt 2018), they are much larger than the long-term projection of the price impact of the tariff alone (0.3% to 2.3%) found in the present study.

These differences illustrate that much remains to be done to fully understand and, especially, quantify the effects of a policy in very complex markets. Meanwhile, decision makers should use the results from these studies with prudence, with some confidence that they give the correct indication of the direction of the effects of policies and a rough approximation of the magnitude, which may still be enough for practical purposes.

Acknowledgements

The research leading to this paper was supported in part by USDA Forest Service Joint Venture Agreement 17-JV-11330143-087, in cooperation with Project Leader Jeff Prestemon. In addition, the helpful comments of the Associate Editor and two reviewers are gratefully acknowledged.

References

Baek, J. 2011. Dynamics of the U.S.–Canada softwood lumber trade: market and welfare effects of the 2006 softwood lumber agreement. J. Int. Law Trade Policy, **12**(2): 69–81.

Devadoss, S. 2006. Is there an end to U.S.–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 U.S.–Canadian disputes on the world softwood lumber market. Can. J. Agric. Econ. **53**: 177–192. doi:10.1111/j.1744-7976.2005.04024.x.

Ezekiel, M. 1938. The cobweb theorem. Q. J. Econ. **52**(2): 255–280. doi:10.2307/1881734.

Food and Agriculture Organization of the United Nations (FAO). 2017*a*. Forest products yearbook, 2015. Food and Agriculture Organization of the United Nations, Rome.

Food and Agriculture Organization of the United Nations (FAO). 2017*b*. FAO forestry statistics data base [online]. Food and Agriculture Organization of the United Nations, Rome. Available from http://www.fao.org/faostat/en/#data/FO [accessed 15 August 2017].

Johnston, C.M.T., and Parajuli, R. 2017. What's next in the U.S.–Canada softwood lumber dispute? An economic analysis of restrictive trade policy measures. For. Policy Econ. **85**(1): 135–146. doi:10.1016/j.forpol.2017.09.011.

Ochuodho, T.O., Lantz, V.A., and Olale, E. 2016. A computable general equilibrium analysis of the United States–Canada 2006 softwood lumber agreement. For. Sci. **62**(6): 679–689. doi:10.5849/forsci.15-093.

Parajuli, R., Sarangi, S., Chang, S.J., and Hill, R.C. 2016. The United States–Canada softwood lumber trade: an actual versus optimal export tax. For. Policy Econ. **73**: 112–119. doi:10.1016/j.forpol.2016.08.009.

Pashigian, B.P. 2008. Cobweb theorem. *In* The new Palgrave dictionary of economics. Palgrave Macmillan, London.

Random Lengths. 2017. U.S.–Canada trade dispute timeline [online]. Available from http://www.randomlengths.com/US-Canada-Timeline/ [accessed 10 April 2018].

Random Lengths. 2018. Random Lengths framing lumber composite price [online]. Available from http://www.randomlengths.com/in-depth/monthly-composite-prices/ [accessed 27 August 2018].

Skerritt, J. 2018. Canada's rail crunch adds to soaring cost of lumber [online]. Bloomberg News, 27 April. Available from https://www.ttnews.com/articles/canadas-rail-crunch-adds-soaring-cost-lumber [accessed 15 August 2018].

The Canadian Press. 2018. The United States imposes more anti-dumping duties on Canadian newsprint [online]. CBC, 13 March. Available from http://www.cbc.ca/news/politics/us-duties-newsprint-1.4575237 [accessed 10 April 2018].

Waugh, F.V. 1964. Cobweb models. J. Farm Econ. **46**(4): 732–750. doi:10.2307/1236509.

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.

Wooldridge, J.M. 2006. Introductory econometrics: a modern approach. Thomson South-Western Inc.

World Bank. 2017. World development indicators data base [online]. Available from http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators [accessed 1 June 2017].

Zhang, D. 2007. The softwood lumber war: politics, economics and the long U.S.–Canadian trade dispute. Routledge, Washington, D.C.

Zhang, D., and Parajuli, R. 2016. Policy impacts estimates are sensitive to data selection in empirical analysis: evidence from the United States–Canada softwood lumber trade dispute. Can. J. For. Res. **46**(11): 1343–1347. doi:10.1139/cjfr-2016-0168.