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economics

Potential Effects of US Protectionism and Trade Wars on the Global Forest Sector

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The study estimated the potential impact of prohibitive import barriers in the United States, and of countervailing measures abroad on the economic welfare of consumers and producers in the forest sector of the United States and the rest of the world. To that end, a global forest products model was used to compare the current state of the world, first with a world without imports in the United States, and then without US imports or exports. With prohibitive US protection and no foreign response, the welfare of US producers increased, but by less than the losses of US consumers, while in the rest of the world the producers lost more than the consumers gained. With countervailing measures abroad against US exports, the welfare of US consumers increased, but by less than what US producers lost, and in the rest of the world the consumers' welfare decreased more than was gained by producers. In sum, a trade war initiated by prohibitive US protectionist policies would decrease the total welfare (producers' and consumers' surplus) of most countries involved.

Keywords: economics, forest products, international trade, welfare, free trade, protectionism

Policy implications

Protectionist trade policies by the US government are unlikely to benefit its forest sector. Even without foreign retaliation, imposition of prohibitive trade barriers on US forest product imports would hurt US consumers of forest products more than it would benefit its producers, leading to a net welfare loss. A trade war, with countervailing measures against US exports, would further decrease welfare in the United States and abroad.

In 2015 the United States traded $49 billion worth of forest products (FAO 2016), a commerce that could be vulnerable to recent changes in trade policies. In contrast to past measures designed to liberate trade, current political movements in the United States appear to favor strong policies akin to mercantilism aimed at protecting domestic industries.

After decades of successful bilateral and multilateral trade negotiations, the US government had, in early 2017, withdrawn from the Trans-Pacific Partnership (TPP), opened renegotiations for the North American Free Trade Agreement (NAFTA), and was considering targeted policies (i.e., countervailing and anti-dumping duties) in place of the recently expired Canada-US Softwood Lumber Agreement (SLA).

These measures, all aimed at limiting US imports, could, even if they were successful, trigger countervailing actions abroad against US exports. Accordingly, this study sought to quantify the effect of such trade wars for the forest products industry, and to determine winners and losers, among producers and consumers in the United States and abroad.

The dismantling of trade agreements, and pursuit of protectionist policies, contrasts with the claim of much classical and neo-classical economic theory. Starting with the sweeping "laissez faire" arguments in the seminal *Wealth of Nations* of Adam Smith ([1776] 1986), followed by David Ricardo's *Principles of Economics* (1951) in favor of free trade, the theory contends that countries should specialize in the production of goods for which they have comparative advantage, and that this will benefit all trading countries. Samuelson (1962) reasons that specialization, and unrestricted trade, leads to improved economic welfare in the context of perfect competition. This reasoning is confirmed and refined by including

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factor endowments like forest resources in Heckscher-Ohlin type models to explain the positive contribution of free trade (Feenstra 2004, p. 31–63).

Nevertheless, protectionism can be defended in view of the unequal distributional effects that may result from free trade. Samuelson and Stolper (1941) show how in this context suppliers of the relatively abundant factors gain, while those of a relatively scarce factor lose. Still, they claim, trade will lead to higher aggregate economic welfare, constituting a potential Pareto improvement; the winners could compensate the losers, and still be better off. But this redistribution rarely occurs, and as a result, even Samuelson (1964) admits that protectionist measures may be justified in some places and times, and Keynes (1936) recognizes the benefits of mercantilist policies aimed at stimulating domestic production.

In the forest economics literature, there is little support for protectionist policies. Gallaway et al. (1999) estimate that the active anti-dumping and countervailing duties in the United States reduced the economic welfare of its wood and lumber industry by $38 million in 1993 ($63 million in 2017 dollars). According to Johnston and Buongiorno (2017), Brexit will have a negative impact on users of wood products in the United Kingdom. More studies consider the welfare enhancement associated with a move away from protectionism, through countervailing duties and tariffs, toward free trade. For example, the possibility of removing the Canadian-U.S. Softwood Lumber Agreement is examined by van Kooten and Johnston (2014), Johnston and van Kooten (2017), and Parajuli and Zhang (2016). Prestemon and Buongiomo (1996) and Prestemon (1997) investigate the effects of NAFTA, while Turner et al. (2005) deal with the Free Trade Area of the Americas. Consistent with neo-classical economic theory, the thrust of the findings is that trade liberalization among groups of countries leads to improved overall economic welfare, but with unequal distribution of benefits and some costs (Buongiorno et al. 2017). For example, while the United States has since withdrawn from the TPP, Buongiorno and Zhu (2016) find that the treaty would have increased domestic economic welfare in the United States, but with welfare losses in Asia. Others find similar mixed effects of the removal of trade restrictions like the log export ban in Russia (van Kooten and Johnston 2014), and in Pacific Rim countries (Perez-Garcia et al. 1997).

Continuing these past studies, and in light of the current political movements in favor of mercantilist and protectionist policies, in the United States and in Europe, the objective of this study was to estimate the impact of prohibitive barriers on US imports of forest products, and of countervailing measures abroad against US exports, on the economic welfare of consumers and producers in the forest sector of the United States and of the rest of the world.

The paper is organized as follows. The next section outlines the theoretical framework based on the neo-classical description of international trade. Next, we describe the numerical methods of a partial-equilibrium model of the global forest sector, followed by a description of the scenarios to simulate the effect of prohibitive US protectionist policies, and retaliatory responses by the rest of the world. The results suggest that prohibitive US import barriers alone raised the welfare of US producers, but by less than the consumers' losses. Meanwhile, producers in the rest of the world lost more than the consumers gained. With countervailing measures abroad against US exports, the welfare of US consumers increased, but by less than producers' losses, and in the rest of the world the consumers' welfare decreased more than was gained by producers. In sum, a trade war initiated by prohibitive US protectionism would decrease the total welfare of most countries involved.

Methods

Theory

The theoretical framework underlying the analysis assumed competitive global markets in the forest sector. Figure 1 symbolizes the essence of the theory with one commodity and two regions: the United States and the rest of the world. The United States is assumed to be the importer of the commodity, and the figure represents the changes in the global market equilibrium resulting from a trade barrier, such as a prohibitive import tariff imposed by the

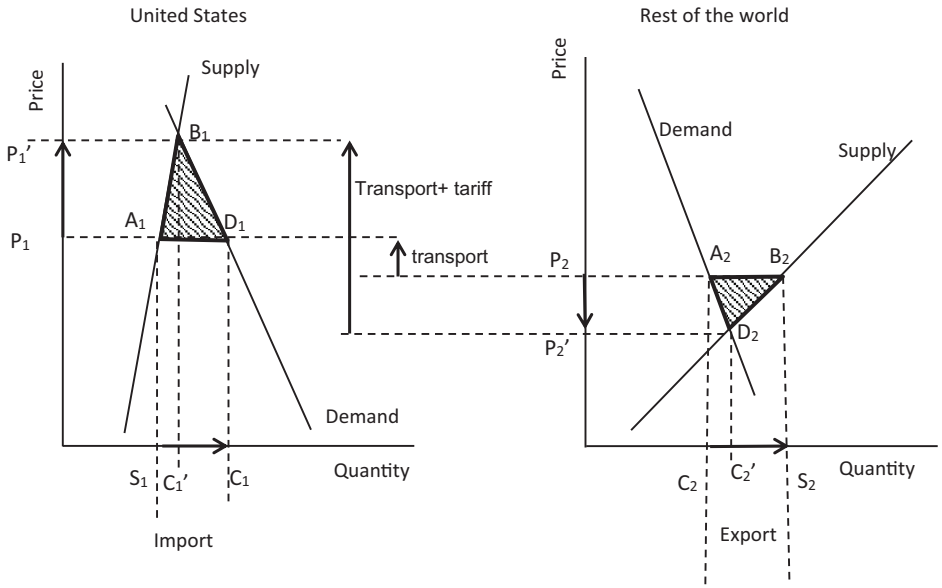

Figure 1. Effect of a prohibitive US import tariff on the production, consumption, and price of one commodity, in the United States and in the rest of the world. The dashed areas show the loss in social welfare, sum of changes of consumers' and producers' surplus, due to the tariff eliminating US imports.

United States. Without the tariff, the equilibrium price is P_1 in the United States and P_2 in the rest of the world, the difference between the two being the transport cost (including pre-existing tariff). At those prices and cost, the US consumption is C_1 and the production is S_1, while the consumption and production in the rest of the world are respectively C_2 and S_2. The resulting excess demand (import) in the United States, C_1-S_1, is equal to the excess supply (export) of the rest of the world, S_2-C_2.

With a prohibitive import tariff in the United States, the US price rises to P_1' where domestic demand is just equal to domestic supply at a reduced consumption but higher production, C_1'. Meanwhile, the price in the rest of the world decreases to P_2', and consumption equates production at a higher consumption but lower production level, C_2', with zero export. The higher price and production in the United States increases the producer surplus, the value of the product minus its cost of production, by the area P_1, P_1', B_1, A_1. Meanwhile, the consumer surplus, the value of the product minus the cost to consumers, decreases by the area P_1, P_1', B_1, D_1, in accord with the decrease in consumption and the higher price.

The net result for the United States is a decrease in "social welfare" (Samuelson 1952), defined as the consumer surplus plus producer surplus, equal to the area of the triangle A_1, B_1, D_1. The corresponding change in the rest of the world is a decrease in producer surplus induced by the lower price and production, equal to the area P_2, B_2, D_2, P_2', and an increase in consumer surplus due to the decrease in price and increase in consumption equal to the area P_2, A_2, D_2, P_2'. The net result is a decrease in the social welfare of the rest of the world equal to the area inside A_2, B_2, D_2.

In sum, the imposition of a prohibitive tariff in the United States decreases the world social welfare by decreasing it both within the United States and abroad. By switching the labels "United States" and "Rest of the World," Figure 1 also illustrates the effect of countervailing measures in the rest of the world that would negate US exports and again reduce social welfare in the two regions. This result concerning the direction of the effects is independent of the elasticities of supply and demand, as long as demands (supplies) are negative (positive) functions of prices. To estimate the magnitude of the effects and their distribution, between consumers and producers, and among countries, requires a more detailed empirical model of the global forest sector.

The Global Forest Products Model (GFPM)

The GFPM (Buongiorno et al. 2003)[1] is an empirical implementation of a spatial and dynamic version of the theory sketched in Figure 1. It is meant to simulate the workings of the global forest sector, covering changes in forest stock and forest area, production of raw materials, manufacturing of materials into products, and demand for end products. The geographic unit is the country, of which 180 are represented in the current GFPM version (2017). Demand, production, imports, exports, and prices are predicted for 14 product groups that cover raw materials (fuelwood, industrial roundwood, other fiber, wastepaper), intermediate products (mechanical pulp, chemical pulp), and end products (fuelwood, sawn wood, veneer and plywood, particleboard, fiberboard, newsprint, printing and writing paper, and other paper and paperboard). The demand for end products and the supply of raw materials are represented by econometric equations, while the manufacturing of raw materials into intermediate and end products is represented by activity analysis: input-output coefficients and attendant manufacturing costs.

In dynamic applications, the GFPM calculates in each projected year the spatial competitive equilibrium of the global forest sector. This is done by solving a series of recursive quadratic programming problems that maximizes the total social surplus (the value of the end products to consumers minus the cost of production and the international transport costs) in each projected year. In the present application, however, the GFPM was used in comparative-statics mode, with and without constraints on US imports and exports. Following Samuelson (1952), the equilibrium in a given year was obtained by maximizing the sum of the consumers' and producers' surplus for all products and countries:

$$\max\left(\sum_{i,k}\int_0^{D_{i,k}} P_{ik}(D_{ik})dD_{ik} - \sum_{i,k}\int_0^{D_{i,k}} P_{ik}(S_{ik})dS_{ik} - \sum_{i,k}\int_0^{D_{i,k}} m_{ik}(Y_{ik})dD_{ik} - \sum_{i,j,k} c_{ijk}T_{ijk}\right) \quad (1)$$

where i and j refer to countries, k to products, P is the price, D is the end-product demand, S the raw material supply, Y the manufactured quantity at marginal cost m, and T is the quantity transported at cost c, including tariff and taxes. Thus, the first integral measures the value of the end products to consumers, the second and the third the cost of production, and the last part is the transport cost. The optimization was done subject to the following demand-supply equilibrium constraint for each country and product:

$$\sum_j T_{jik} + S_{ik} + Y_{ik} = D_{ik} + \sum_n a_{ikn}Y_{in} + \sum_j T_{ijk} \qquad \forall i,k \quad (2)$$

where a_{ikn} was the input of product k per unit of product n. The left part of the equation was the sum of the imports, domestic supply, and manufactured quantity of a product in a country, while the right part was the sum of the domestic demand for the end products, the demand for input in manufacturing other products, and the exports to other countries. The primal solution of this constrained optimization gave the quantities consumed, produced, and traded, while the dual solution gave the equilibrium prices by product and country.

For this study, the model was recalibrated for the base year 2013 (average of the years 2012, 2013, and 2014) with the procedure described in Buongiorno et al. (2003) to obtain input-output coefficients, and manufacturing and transport costs. The data on production, imports, exports, and prices were from the FAOSTAT database (FAO 2016). The elasticities of wood supply were obtained from Turner et al. (2006), and the demand elasticities of the end products are in Buongiorno (2015). According to the calibration procedure, the GFPM solution for 2013 closely replicated the observations for the same year on production, consumption, price, and net trade.

After finding the equilibrium solutions for a specific trade scenario, the data were used to compute the consumer surplus for all end products (fuelwood, sawn wood, panels, paper, and paperboard) by summing the area under the demand curves up to the consumed quantity and subtracting the cost of the products at the equilibrium price. The producer surplus of the suppliers of raw materials (roundwood, wastepaper, other fiber pulp) was computed

by subtracting the cost of production, the area under the supply curves up to the quantity produced, from the producer revenues: the equilibrium price times the quantity produced. The producer surplus in manufacturing, the transformation of raw materials and intermediate products (wood pulp) into end products, was computed by first estimating the value added, the value of production minus the cost of raw material and intermediate products, and then subtracting the cost of other inputs (m in equation [1]) from the value added. The final social welfare was the total consumer surplus minus the producer surplus (of raw material suppliers and manufacturers).

US Trade Policies

In the first scenario, the consequences of high protectionist measures, such as a prohibitive import tariff, in the United States were simulated by constraining to zero the United States import activities in equation [1] above. Then, in the second scenario, the effects of countervailing measures abroad were represented by adding constraints eliminating also US exports of forest products.

The magnitude of the effects depended on the importance of the United States in the world trade of forest products. Table 1 shows the amounts of US imports and exports in absolute value and their share of world imports and exports. Within solid wood products, the United States imported more than 20 million m^3 of sawn wood, nearly 17% of world imports. Veneer and plywood and particleboard imports were lower in absolute amount, but still represented 11% to 16% of world imports. In the pulp and paper categories, the largest US imports were in chemical pulp and printing and writing paper, amounting to about 5 million metric tons each and respectively 10% and 12% of world imports. Although less than half this amount in absolute value, US newsprint imports accounted for more than 17% of global imports.

On the export side, the main US exports were in pulp and paper. Exports of wastepaper in particular were near 19 million metric tons (t) and 34% of world exports. This was followed by exports of other paper and paperboard that approached 9 million tons, representing 17% of global exports. Chemical pulp was also an important US export, exceeding 7 million tons and nearly 14% of world exports. Within solid wood products, industrial roundwood was the major US export, amounting to 20 million m^3 and more than 10% of world exports.

In summary, US imports and exports of forest products are a substantial part of their world trade. Thus, prohibitive protectionist measures in the United States, and countervailing actions abroad, should have a significant effect on global trade, prices, and thus production and consumption in the United States and the rest of the world. However, the changes due to such a trade war would not be equal to the observed quantities exported or imported (Table 1), due to expected price changes and attendant responses of demand and supply.

Results

The consequences of prohibitive barriers on US imports of forest products, and countervailing measures abroad, were obtained with the GFPM calibrated for the year 2013 so that its solution reproduced closely the production, consumption, trade, and prices observed in that year. The GFPM was then solved for the year 2013 under two scenarios, first with the US imports constrained to zero, and then with both US imports and exports (Table 1) constrained to zero. The difference between the GFPM solutions with or without US trade activities gave a measure of potential effects of US protectionism and of foreign countervailing measures on the global forest sector, compared to its state with the current trade regime.

Consequences for Consumers' Welfare

Table 2 summarizes the effects of the two scenarios on the economic welfare of consumers of wood products in the United States, the rest of the world, and selected countries. The effects were the changes in consumer surplus, measured by the changes of the areas under the demand curves of the nine GFPM end products: fuelwood, industrial roundwood used in the round (such as poles, piling, posts), sawn wood, veneer and plywood, particleboard, fiberboard, newsprint, printing and writing paper, other paper, and paperboard.

With US prohibitive trade barriers only, without reaction abroad, the consumer welfare in the United States decreased by $\$1.6 \times 10^9$ or 0.7%, in accord with a general increase in the US prices of end products (Table 3), accompanied by a decrease in consumption. In contrast, the consumer surplus increased in all other regions and countries, but only by $\$655 \times 10^6$ in total, or less than 0.05%. The largest welfare gain in absolute value was in Asia, mainly in China, followed by the European Union, but in all cases the change did not exceed 0.1%. This rise in welfare outside the United States occurred

Table 1. US share of world imports and exports of forest products in 2013.

Product	Imports			Exports		
	US (1,000 m^3)	World (1,000 m^3)	US share (%)	US (1,000 m^3)	World (1,000 m^3)	US share (%)
Industrial roundwood	1,153	194,962	0.6	20,041	199,256	10.1
Sawn wood	20,513	121,809	16.8	6,595	125,522	5.3
Veneer and plywood	3,104	27,173	11.4	1,028	30,661	3.4
Particleboard	4,051	25,657	15.8	564	25,942	2.2
Fiberboard	1,664	21,293	7.8	827	22,634	3.7
	(1,000 t)	(1,000 t)	(%)	(1,000 t)	(1,000 t)	(%)
Mechanical pulp	39	882	4.4	29	656	4.4
Chemical pulp	5,303	51,646	10.3	7,272	52,948	13.7
Other fiber pulp	11	411	2.7	82	398	20.6
Wastepaper	811	56,665	1.4	18,894	55,787	33.9
Newsprint	2,116	12,327	17.2	799	12,599	6.3
Printing and writing paper	4,925	41,348	11.9	2,326	44,409	5.2
Other paper and paperboard	2,726	52,629	5.2	8,996	53,711	16.7

in conjunction with a small decrease in the world prices of end products (Table 3), which led to higher consumption.

These welfare effects on consumers were reversed with countervailing measures abroad that negated US exports. In that scenario, the welfare of US consumers of wood products increased by $695x10^6$ (0.3%) in conjunction with the lower US prices of printing and writing paper and of other paper and paperboard induced by the 24% and 43% decrease in the price of other fiber pulp and wastepaper (Table 3) along with the elimination of the large US exports of wastepaper in this scenario (Table 1). Meanwhile, the welfare of other countries decreased by $3.7 x10^9$ in accordance with the higher world price of most products in this scenario (Table 3) and the attendant lower consumption outside the United States. The largest decrease in consumer welfare was in Asia, exceeding $2.2x10^9$, of which $1.3x10^9$ was in China. Europe experienced a decline in consumer welfare of $1.0x10^9$, most of it within the European Union, and especially in Germany.

Table 2. Changes in consumers' welfare in the forest sector, with prohibitive US import barriers, and with countervailing measures abroad negating US exports.

Region	With prohibitive US import barriers		With countervailing measures abroad	
	10^6	%	10^6	%
United States	–1567	–0.7	695	0.3
Rest of the world	655	0.0	–3,698	–0.3
AFRICA	**23**	**0.0**	**–78**	**0.0**
Egypt	5	0.0	–21	–0.2
Nigeria	2	0.0	–5	0.0
South Africa	4	0.0	–24	–0.3
N/C AMERICA	**29**	**0.0**	–171	–0.3
Canada	22	0.1	–60	–0.2
Mexico	6	0.0	–88	–0.4
S AMERICA	**36**	**0.0**	**–186**	**–0.2**
Argentina	4	0.1	–21	–0.3
Brazil	19	0.0	–111	–0.2
Chile	5	0.0	–15	–0.1
ASIA	**373**	**0.0**	**–2,203**	**–0.3**
China	217	0.1	–1,290	–0.3
India	18	0.0	–131	–0.1
Indonesia	10	0.0	–75	–0.3
Japan	59	0.1	–288	–0.4
Korea, Rep.	7	0.0	–106	–0.5
Malaysia	6	0.1	–35	–0.4
OCEANIA	**12**	**0.1**	**–48**	**–0.2**
Australia	9	0.1	–38	–0.3
New Zealand	3	0.1	–9	–0.2
EUROPE	**181**	**0.1**	**–1,013**	**–0.3**
EU-28	**150**	**0.1**	**–890**	**-0.3**
Austria	5	0.0	–26	-0.2
Finland	2	0.0	–15	-0.2
France	17	0.1	–97	-0.3
Germany	38	0.1	–215	-0.4
Italy	12	0.0	–12	-0.4
Russian Fed.	20	0.1	–74	-0.2
Spain	4	0.0	–81	-0.7
Sweden	7	0.1	–22	-0.2
United Kingdom	20	0.1	–99	-0.3

Consequences for the Producers' Welfare

Table 4 summarizes the effects of the two scenarios on the welfare of producers in the forest sector, including the suppliers of raw materials: roundwood, other fibers, and wastepaper, the manufacturers of intermediate products: mechanical and chemical pulp, and the producers of end products: sawn wood, veneer and plywood, particleboard, fiberboard, newsprint, printing and writing paper, and other paper and paperboard.

The effect of the United States' prohibitive barriers on imports of wood products, without foreign retaliation, was to raise the welfare (producer surplus) of US producers by $1.5x10^9$ or 6.3% (Table 4), along with the increase in the price of most wood products in the United States (Table 3), and the attendant increase in production. Concurrently, the producers' welfare in the rest of the world was reduced by $847 x10^6$ or 0.5%, in accord with the lower world prices (Table 3) and less production. The largest losses in producers' surplus were in Asia and in Europe, and the specific countries with the largest absolute losses were China, Canada, and Russia, in that order.

Symmetric effects were observed with countervailing measures abroad against US exports. The producers' welfare in the United States decreased by $1.6x10^9$ (6.7%), while it increased by $2.8x10^9$ (1.5%) in the rest of the world (Table 4). In Asia in particular, the producer surplus was $1.2x10^9$ higher with this scenario, of which $782x10^6$ was in China alone, and in Europe it was $972x10^6$ higher, mostly due to the increase in the European Union and in Germany in particular. The decrease of producers' welfare in the United States was due in large part to the decrease in the price of wastepaper (Table 3), of which the US exports large quantities (Table 1). This lower fiber price induced in turn a lower price of printing and writing and other paper and paperboard, products of high value also exported in large amounts by the United States. The rise in producers' welfare in the rest of the world stemmed from the price increase for most products (Table 3) and attendant increases in production.

Table 3. Change in forest product prices in the United States and the world, with prohibitive US import barriers, and with countervailing measures abroad negating US exports.

Product	With prohibitive US import barriers		With countervailing measures abroad	
	US (%)	World (%)	US (%)	World (%)
Industrial roundwood	3.4	–0.3	2.9	0.1
Sawn wood	3.0	–0.3	2.6	0.1
Veneer & plywood	2.6	–0.2	2.4	–0.1
Particleboard	2.8	–0.3	2.6	–0.2
Fiberboard	1.7	–0.1	1.6	0.0
Mechanical pulp	2.7	–0.2	2.5	0.1
Chemical pulp	1.5	–0.1	1.2	0.3
Other fiber pulp	0.1	0.1	–23.8	0.4
Wastepaper	–0.6	–0.6	–43.3	11.2
Newsprint	1.5	–0.4	1.2	1.6
Printing & writing paper	1.5	–0.3	–1.2	0.9
Other paper and paperboard	0.1	0.1	–3.2	1.2

Table 4. Change in producers' welfare in the forest sector, with prohibitive US import barriers, and with countervailing measures abroad negating US exports.

Region	With prohibitive US import barriers		With countervailing measures abroad	
	10^6	%	10^6	%
United States	1,462	6.3	–1,552	–6.7
Rest of the world	–847	–0.5	2,770	1.5
AFRICA	**–31**	**–0.2**	**114**	**0.6**
Egypt	–1	–0.1	8	1.4
Nigeria	–2	–0.1	2	0.1
South Africa	–3	–0.3	25	2.1
N/C AMERICA	–71	–0.6	241	2.1
Canada	–60	–0.7	173	2.1
Mexico	–1	–0.1	42	2.5
S AMERICA	**–48**	**–0.3**	**197**	**1.3**
Argentina	–4	–0.5	14	1.6
Brazil	–27	–0.3	137	1.5
Chile	–11	–0.5	22	1.0
ASIA	**–447**	**–0.5**	**1,156**	**1.2**
China	–160	–0.3	782	1.3
India	–8	–0.1	64	0.5
Indonesia	–24	–0.5	66	1.4
Japan	–40	–1.0	–48	–1.2
Korea, Rep.	–4	–0.2	–34	–2.4
Malaysia	–11	–0.9	19	1.6
OCEANIA	**–27**	**–0.8**	**91**	**2.8**
Australia	–9	–0.6	12	0.8
New Zealand	–10	–0.8	18	1.4
EUROPE	**–222**	**–0.5**	**972**	**2.4**
EU-28	**–155**	**–0.5**	**833**	**2.8**
Austria	–11	–1.0	34	3.0
Finland	–21	–0.7	102	3.4
France	–16	–0.6	–8	–0.3
Germany	–35	–0.7	174	3.5
Italy	–6	–0.5	121	10.5
Russian Fed.	–47	–0.6	108	1.3
Spain	–3	–0.2	71	4.0
Sweden	–21	–0.5	128	3.4
United Kingdom	5	0.3	–2	–0.1

Table 5. Change in total economic welfare in the forest sector, with prohibitive US import barriers, and with countervailing measures abroad negating US exports.

Region	With prohibitive US import barriers		With countervailing measures abroad	
	10^6	SD	10^6	SD
United States	–105	16.3	–857	10.6
Rest of the world	–192	9.7	–928	15.1
AFRICA	**–8**	**2.7**	**36**	**2.3**
Egypt	4	0.0	–13	0.3
Nigeria	0	0.2	–4	0.2
South Africa	0	0.2	1	0.3
N/C AMERICA	**–42**	5.5	70	1.0
Canada	–38	6.0	113	2.1
Mexico	5	0.1	–45	0.7
S AMERICA	**–12**	**2.3**	**10**	**2.7**
Argentina	0	0.3	–7	0.1
Brazil	–8	1.2	26	1.9
Chile	–6	0.6	8	0.4
ASIA	**–74**	**4.4**	**–1,047**	**11.2**
China	57	1.6	–508	6.7
India	9	0.2	–67	0.7
Indonesia	–14	0.6	–9	0.8
Japan	19	1.5	–336	3.3
Korea, Rep.	3	0.4	–141	1.3
Malaysia	–6	0.3	–16	0.4
OCEANIA	**–15**	**1.1**	**43**	**1.1**
Australia	0	0.7	–26	0.5
New Zealand	–8	0.3	9	0.5
EUROPE	**–41**	**7.5**	**–41**	**6.1**
EU-28	**–5**	**4.9**	**–57**	**5.5**
Austria	–7	0.7	8	0.2
Finland	–19	0.5	87	1.4
France	2	0.6	–104	0.9
Germany	3	1.6	–41	1.6
Italy	6	0.4	9	0.7
Russian Fed.	–27	2.5	35	1.0
Spain	1	0.3	–10	0.6
Sweden	–14	0.7	106	1.7
United Kingdom	25	0.4	–101	1.3

SD = Standard deviation due to uncertain demand elasticities.

Consequences for Total Sector Welfare and Sensitivity Analysis

Table 5 summarizes the total (consumers' and producers') gains or losses in different countries and regions according to the two scenarios. For the United States, instating prohibitive import barriers without incurring a trade war decreased the sector welfare by $105x10^6, or less than 0.1% as the gains of producers (Table 4) fell short of consumers' losses (Table 2). But retaliatory measures abroad that also eliminated exports reduced further the US sector welfare losses to a total of $857x10^6 (–0.4%) due to producers' welfare losses (Table 4) that far exceeded the gains of consumers (Table 2).

For the total rest of the world, the effects had the same sign as in the United States (Table 5). A unilateral US import ban, without foreign response, decreased the total welfare of the sector abroad by approximately double the decrease in the United States, in absolute value, due to producers' losses exceeding consumers' gains. Retaliation against imports from the United States lowered the sector welfare in the rest of the world by amounts of the same order of magnitude as in the United States, but due to gains in producers' surplus (Table 4) inferior to the losses of consumers (Table 2). However, there were variations between countries; for example, China's welfare increased, by a small amount, with the US protectionist policy, although the welfare of the rest of the world decreased as a whole.

The main effects of the US policy and of the response by the rest of the world were in countries that heavily import from or export to the United States. This is summarized in Table 5, where the total welfare losses due to the US import ban with the rest of the world retaliation were especially high in China, Japan, and Korea (major importers from the United States), while the largest gains were in Canada (major exporter to the United States).

To evaluate the sensitivity of the results to changes in major parameter assumptions, Table 5 presents the standard deviation of total sector welfare calculated for low, medium, and high price elasticities of demand. The low and high were equal to the medium plus or minus one standard error of the mean elasticity (Buongiorno 2015). The coefficient of variation (ratio of the standard deviation to mean absolute value) of the welfare change with US import barriers was 15.5% for the United States and 9.7% for the rest of the world, while the welfare change with countervailing measures abroad was 1.2% for the United States and 1.6% for the rest of the world.

Discussion and Conclusion

In contrast with past liberal, free-market trade policies leading to international trade agreements such as the North American Free Trade Agreement, the proposed Trans-Atlantic Trade and Investment Partnership, and the now defunct Trans-Pacific Partnership, the current political atmosphere in the United States appears to favor protectionist-mercantilist attitudes in trade policy.

Table 6. Change in US economic welfare in the forest sector associated with selected trade policies.

Policy	Consumers (10^6)[a]	Producers (10^6)	Total (10^6)	Source
Trans Pacific Partnership	647	–208	438	Buongiorno & Zhu (2016)
US antidumping and countervailing duties			–62	Gallaway et al. (1999)
Memorandum of understanding (1986–1991)	–1,880	1,286	–594	Wear & Lee (1993)
Softwood lumber agreement 1996	–1,667	970	–698	Zhang (2006)
Softwood lumber agreement 2006[b]	–103	168	17	van Kooten & Johnston (2014)
Softwood lumber agreement 2006	–851	604	–247	Parajuli & Zhang (2016)
Trans-Atlantic Trade and Investment Partnership	771 to 15,030	–1 to 140	770 to 15,170	Buongiorno et al. (2014)

[a]All values converted to 2010 $US using the US Producer Price Index.
[b]Figure includes consumer surplus, producer surplus, and scarcity rents.

Accordingly, the objective of this paper was to attempt to quantify the consequences for the global forest sector of potential trade wars beginning with prohibitive trade barriers on US imports followed by retaliatory measures abroad that would neutralize US exports. The analysis was done with a global forest products model that simulated the consumption, production, trade, and prices in the forest sector in 2013. A comparative-statics procedure was followed, contrasting this observed situation in 2013 with one in which the United States did not import and then could not export due to countervailing measures abroad.

The results showed that US producers gained economic welfare from protectionist policies aimed at prohibiting imports, leading to higher prices and expanded domestic production. However, US consumers of wood products experienced a loss that more than offset the producers' gains. This is consistent with neoclassical economic theory and previous studies of trade policies in the forest sector (Table 6). In the particular case of the softwood lumber trade between the United States and Canada, Wear and Lee (1993), Zhang (2006), Parajuli and Zhang (2016), and van Kooten and Johnston (2014) report net welfare losses in the United States due to the limits on Canadian imports. Symmetrically, trade liberalization such as that considered in the Trans-Atlantic Trade and Investment Partnership (Buongiorno et al. 2014), and the Transpacific Partnership (Buongiorno and Zhu 2016), lead to positive total welfare effects in the United States, despite hurting producers.

The results also suggest that the magnitude of the welfare effects for many countries is small, which highlights the importance of taking a comprehensive market approach to policy analysis in the forest sector. Perez-Garcia et al. (2005) argue that evaluating the gains and losses of policy in the forest sector is challenging since wood markets are intertwined among products, and internationally connected through bilateral trade of inputs and final products. Consider, for example, the literature evaluating the welfare implications of US-Canada softwood lumber dispute—Wear and Lee (1993), Zhang (2006), and Parajuli and Zhang (2016) report large net welfare losses in the United States due to the limits on Canadian imports, driven largely through reduced consumer surplus in the US lumber market. Meanwhile, van Kooten and Johnston (2014) argue that these same welfare losses are mitigated, by gains in the US producer surplus in the upstream log market, as well as the consequences associated with changes in bilateral trade flows. The present results support this interpretation.

Less studied in the past, the real possibility of countervailing measures abroad led to a very different distribution of economic benefits than that intended by protectionism. Much of the literature assessing the impact of trade policies on the forest sector, such as the North American Free Trade Agreement (Prestemon and Buongiomo 1996, Prestemon 1997), and the Canada-US Softwood Lumber Agreement (van Kooten and Johnston 2014, Johnston and van Kooten 2017, Parajuli and Zhang 2016), draws conclusions on a one-way imposition of trade barriers. Yet trade wars may drive much of the final outcomes. The present study found that while US producers of forest products gained from prohibitive import barriers, they lost more from countervailing measures that curtailed exports. And US consumers who lost from the elimination of US imports benefited instead, though by a lesser amount, from countervailing foreign measures against US exports. In the rest of the world, consumers gained from the canceling of US imports, but lost approximately six times as much with a countervailing cut of US exports. Meanwhile, producers outside the United States who experienced a decrease in producer surplus with prohibitive US protectionism gained more than three times as much with retaliation against US exports.

Regarding the softwood lumber trade dispute between the United States and Canada, the results of this study imply that a pure unilateral policy, even without a Canadian response (unlikely in the present political context; see Erlanger and Hirschfeld Davis 2017) would benefit US producers, but hurt more US consumers, leading to a net welfare loss. In the more likely scenario with a Canadian retaliation within the forest sector or/and in other sectors, the result would be a net welfare loss in both countries. Making more specific predictions for the case of the softwood lumber would require some model refinements. In particular, sawn wood would need to be split between coniferous and nonconiferous, and bilateral trade flows such as imports of the United States from Canada would need to be recognized explicitly. Furthermore, the proposed US tariffs vary across Canadian provinces and even by firms, ranging from 3 to 24%, a level of detail that does not exist in the current GFPM database.

However, for the total forest sector and the broad global community, the results of this study suggest that total welfare (producers' and consumers' surplus) was reduced both in the United States and abroad, with prohibitive US import barriers alone as well as with foreign retaliation. That is, trade wars are costly for the country that starts them and retaliatory measures worsen the welfare of most countries involved. This implies that potential Pareto improvements exist whereby the winners in a free trade world could compensate the losers and still be better off. The fact that we continue to observe protectionist policies within the forest sector implies that they are motivated, in part, to benefit specific industries but not necessarily the larger economy.

In sum, pursuant to the results of this study, protectionist trade policies by the US government are unlikely to benefit its forest sector. Even without foreign retaliation, imposition of prohibitive trade barriers on US forest product imports hurt US consumers

of forest products more than it benefited producers, leading to a net welfare loss. A trade war, with countervailing measures against US exports, further decreased welfare in the United States and abroad. Yet, the United States has a long history of government intervention aimed at protecting its domestic forest product industries, exemplified in the softwood lumber dispute with Canada. Historically, negotiations have flirted with a trade war, with both countries invoking tribunals under the auspices of the World Trade Organization and NAFTA. More recently, interests to renegotiate NAFTA coupled with the imposition of tariffs averaging 27% on Canadian softwood lumber imports to the United States (Government of Canada 2017) have been met with threats of retaliatory trade measures from Canada. With the shifts in US economic policy toward protectionism, it would appear that strong barriers to imports, and associated trade wars, are not necessarily a relic of the past.

Endnote

1. The current 2017 version of the GFPM, including the software, documentation, and database, is available freely for research purposes at: labs.russell.wisc.edu/buongiorno/welcome/gfpm/

Literature Cited

Buongiorno, J. 2015. Income and time dependence of forest product demand elasticities and implications for forecasting. *Silva Fenn*. 49(5):1395.

Buongiorno, J., C.M.T. Johnston, and S. Zhu. 2017. An assessment of gains and losses from international trade in the forest sector. *Forest Policy Econ.* 80(2017):209–2017.

Buongiorno, J., P. Rougieux, A. Barkaoui, S. Zhou, and P. Harou. 2014. Potential impact of a transatlantic trade and investment partnership on the global forest sector. *J. Forest Econ.* 20(2014):252–266.

Buongiorno, J., and S. Zhu. 2016. Potential effects of a Trans-Pacific Partnership on forest industries. *Forest Policy Econ.* 81(2017):97–104. http://dx.doi.org/10.1016/j.forpol.2016.08.001

Buongiorno, J., S. Zhu, D. Zhang, J. Turner, and D. Tomberlin, 2003. *The Global Forest Products Model, structure, estimation, and applications*. Academic Press, Elsevier, San Diego.

FAO. 2016. FAOSTAT Forestry Database. Food and Agriculture Organization of the United Nations. Available online at http://faostat.fao.org/site/626/default.aspx#ancor; last accessed Oct. 31, 2016.

Erlanger, S., and J. Hirschfeld Davis. 2017. Once dominant, the United States finds itself isolated at G-20. *New York Times*, July 7. Available online at https://www.nytimes.com/2017/07/07/world/europe/trump-g-20-trade-climate.html?emc=eta1.

Feenstra, R.C. 2004. The Heckscher–Ohlin model. P. 31–63 in *Advanced international trade: Theory and evidence,* Princeton University Press, Princeton, NJ.

Gallaway, M.P., B.A. Blonigen, and J.E. Flynn. 1999. Welfare costs of the U.S. antidumping and countervailing duty laws. *J. Int. Econ*. 49(2):211–244.

Government of Canada. 2017. http://www.international.gc.ca/controls-controles/softwood-bois_oeuvre/index.aspx?lang=eng.

Johnston, C.M.T., and J. Buongiorno. 2017. Impact of Brexit on the forest products industry of the United Kingdom and the rest of the world. *Forestry*. 90(1):47–57.

Johnston, C.M.T., and G.C. van Kooten. 2017. Inefficiencies of the Canada–U.S. softwood lumber dispute: A calibrated mixed complementary approach. *Forest Policy Econ.* 74(2017):71–80.

Keynes, J.M. 1936. Notes on mercantilism, the usury laws, stamped money and the theories of under-consumption. Chapter 23 in *The general theory of employment, interest, and money*, Palgrave Macmillan, London. http://cas.umkc.edu/economics/people/facultypages/kregel/courses/econ645/winter2011/generaltheory.pdf.

Parajuli, R., and D. Zhang. 2016. Welfare impacts of the 2006 United States-Canada Softwood Lumber Agreement. *Can. J. For. Res.* 46(7):950–958.

Perez-Garcia, J., B. Lippke, and J. Baker. 1997. Trade barriers in the Pacific forest sector: Who wins and who loses. *Contemp. Econ. Policy* 15(1):87–103.

Perez-Garcia, J., J.K. Barr, and J. Daniels. 2005. Washington's sawmilling sector analysis: Capacity utilization rates and timber outlook. *CINTRAFOR Working Paper 99*. University of Washington, College of Forest Resources, Seattle.

Prestemon, J. 1997. The effects of NAFTA expansion on US forestry product exports. *J. Forestry.* 95(7):26–32.

Prestemon, J., and J. Buongiomo. 1996. Effects of the North American Free Trade Agreement on Mexico's imports of forest products from the United States and Canada. *Can. J. For. Res*. 26:794–809.

Ricardo, D. 1951. On foreign trade. In *The works and correspondence of David Ricardo* (vol. 1), Sraffa, P. and M.H. Dobb (eds.), Cambridge University Press, Cambridge.

Samuelson, P.A. 1952. Spatial price equilibrium and linear programming. *Am. Econ. Rev*. 42(3):283–303.

Samuelson, P.A. 1962. The gains from international trade once again. *Econ. J.* 72(288):820–829.

Samuelson, P.A. 1964. Theoretical notes on trade problems. *Rev. Econ. Stat.* 46(2):145–154.

Samuelson, P.A., and W.F. Stolper. 1941. Protection and real wages. *Rev. Econ. Stud.* 9(1):58–73.

Smith, A. [1776] 1986. *The wealth of nations*. Penguin Books, London.

Turner, J., J. Buongiorno, and S. Zhu. 2005. Effects of the Free Trade Area of the Americas on forest resources. *Agric. Resour. Econ. Rev.* 34(1):104–118. doi.org/10.1017/S106828050000160X.

Turner, J.A., J. Buongiorno, and S. Zhu. 2006. An economic model of international wood supply, forest stock and forest area change. *Scand. J. For. Res.* 21(2006):73–86. doi:10.1080/02827580500478506.

van Kooten, G.C., and C.M.T. Johnston. 2014. Global impacts of Russian log export restrictions and the Canada–U.S. lumber dispute: Modeling trade in logs and lumber. *Forest Policy Econ.* 39(2014):54–66.

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

Zhang, D. 2006. Welfare impacts of the 1996 United States–Canada Softwood Lumber Agreement: An update. *Can. J. For. Res.* 36(1):255–261.