# Canada–U.S. Softwood Lumber Trade Revisited: Substitution Bias in the Context of a Spatial Price Equilibrium Framework

**Anthony Mogus, Brad Stennes, G. Cornelis van Kooten**

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**Abstract:** Softwood lumber trade between Canada and the United States has been characterized by various trade restrictions. Many studies have attempted to quantify the effects of such sanctions, modeling softwood lumber as a single, homogenous commodity, although recent research suggests that this may be a misleading assumption because softwood lumber products vary. In this article, we address the problem of "substitution bias" in estimates of the effects of trade restricting policies. A spatial price equilibrium model is used to examine the effects of import duties on Canadian lumber, comparing these with the effects of an export tax and quota. By controlling for substitution bias, our estimates indicate that a larger share of the tariff burden is placed on U.S. consumers, with Canadian producers suffering less injury compared to estimates based on the traditional assumption of a homogenous product. In addition, by comparing the net impact associated with the alternative policy regimes, a policy equivalence is found. Results suggest that the short-run impact of a trade restriction is largely independent of the policy regime incorporated, with the collection of quota rents or tax revenues determining overall winners and losers. FOR. SCI. 52(4):411–421.

**Key Words:** Spatial price equilibrium; trade modeling.

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A FUNDAMENTAL ECONOMIC PREMISE states that free trade maximizes the aggregate welfare of participating regions, because resources are allocated so that regions specialize in the production of goods and services according to their comparative advantages. Yet, moving away from free trade does not imply that all regions, or all sectors within a region, are made worse off. Rather, restrictive trade sanctions alter income distributions, creating both winners and losers, and it is this distributional distinction that usually drives trade policy (Boyd and Krutilla 1987). Perhaps this explains why uncontested free trade in softwood lumber has not occurred between Canada and the U.S. for any significant period in over two decades. Indeed, the softwood lumber trade dispute is the longest lasting trade dispute between Canada and the U.S. and the most significant forest products trade dispute in the world (Zhang 2001, Cashore 1998). In 2003, Canada exported 19.3 bbf of softwood lumber to the U.S. valued at $6.7 billion (2003 Canadian dollars), accounting for roughly 91% of U.S. softwood lumber imports (Council of Forest Industries 2005). Because Canada supplies about 34% of softwood lumber consumed in the U.S., the welfare consequences of distortionary trade policies in lumber are substantial, particularly in terms of its income redistributional effects.

Zhang (2001) estimated the welfare and price impacts associated with the Softwood Lumber Agreement (SLA) using an aggregate price impact (econometric) model to detect a discernible change in both price and quantity. Average price in 1997 U.S. dollars was estimated to increase by some $59/mbf over the first four years of the SLA. He calculated that U.S. producers gained some $7.7 billion while U.S. consumers lost $12.5 billion, for a net loss of $4.7 billion. While Canada gained some $3.1 billion, non-Canadian exporters to the U.S. also gained $626 million. The overall deadweight loss associated with the SLA was estimated to be $1 billion.

Using a two-region partial-equilibrium trade model, van Kooten (2002) estimated the SLA to be comparable to a 6.5% ad valorem tax in terms of its impacts on the U.S. market. During the SLA period, both Canadian producers (capturing quota rents) and American producers (receiving quasi rents) gained significantly at the expense of U.S. consumers. An optimal quota that maximized profits to Canadian producers was derived analytically as the sum of export quota rents and domestic producer surplus, and was estimated to be approximately equivalent to a 15% ad valorem tariff. In the absence of significant "quota busting" from noncovered regions and noncovered products, he recommended that Canadian lumber producers form a cartel to maximize rent capture.

Stennes and Wilson (2005) used a multiple-region, partial-equilibrium trade model to examine the welfare and income distributional effects of a 27% ad valorem tariff, a quota (equivalent to the tariff), and a unit tax on Canadian factors of production (resulting in equivalent U.S. impacts). The tariff and quota resulted in a price wedge of roughly $80/mbf (1995 US$). The unit factor tax caused prices in all

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Acknowledgments: The authors would like to thank two anonymous reviewers and the associate editor for helpful comments and suggestions.

Manuscript received June 27, 2005, accepted December 16, 2005

regions to increase by \$25–28/mbf. Both the tariff and quota caused U.S. producers and Canadian consumers to be better off at the expense of Canadian producers (assuming no rent was collected) and U.S. consumers. The net welfare impact for the U.S. was similar to a unit factor tax, but the policy resulted in higher domestic prices in Canada and other foreign (non-U.S.) markets and accompanying net welfare losses. Net welfare gains and losses at the national level were dictated by which country collected the quota rents or taxes.

The aim of the current article is to provide additional insights into the welfare implications of restrictive trade measures associated with the Canada–U.S. softwood lumber dispute by refining the focus of the spatial price equilibrium (SPE) models traditionally used to study this topic. (A spatial price equilibrium model is the same as a multiple-region, partial equilibrium trade model.) The research is unique in its consideration of the substitutability of softwood lumber across end-uses based on species distinctions. By disaggregating softwood lumber into structural and nonstructural uses, it enables us to consider these unique products separately, thereby avoiding what we refer to as "substitution bias" (Nagubadi et al. 2004). The value of this distinction is considerable, because Canada has insisted that the majority of its lumber exports are not perfect substitutes for all U.S. produced softwood lumber, and that they compete directly only with a subset of U.S. products. The implications of this argument for the softwood lumber dispute are substantial, because the issue of competition is a central element in the conflict. In addition, by not controlling for substitution bias, the welfare inferences of previous studies may be misleading.

Although central to the current study, the literature on substitutability among different softwood lumber products is sparse. Lewandrowski et al. (1994) found that pine lumber produced in the U.S. west was complementary to Douglas-fir lumber produced in the U.S. Pacific Northwest and to southern pine produced in the U.S. South. However, evidence also indicated that, although Douglas-fir and southern pine are not substitutes, Canadian lumber is a substitute for these U.S. lumber species. The species mix and close proximity of Canadian producers to the U.S. market were cited as significant factors in explaining this result.

Nagubadi et al. (2004), in contrast, found that Canadian spruce-pine-fir (SPF) lumber was unrelated to treated southern yellow pine, Douglas-fir, and other species groups that together accounted for approximately 71% of softwood lumber produced in the U.S. Rather, Canadian SPF was determined to be a substitute for both untreated southern yellow pine and structural panel products. Interestingly, these authors found that there was greater competition between structural panel products and untreated southern yellow pine than between Canadian SPF lumber and untreated southern yellow pine.

We proceed in the next section by describing our SPE model, the data that we use, and how we calibrated the model to find a free-trade equilibrium where none exists in practice. We then present results of various scenarios comparing assumptions concerning substitutability between two different uses of lumber—for structural and other purposes. Sensitivity analysis is used to determine the robustness of the results. We conclude by arguing that, by correcting for substitution bias, U.S. consumers and producers could gain while permitting greater imports of lumber from Canada.

## Modeling Structural versus Nonstructural Trade in Softwood Lumber

Previous studies of Canada–U.S. softwood lumber trade have generally made use of the spatial price equilibrium framework. The advantage of this approach is its regional modeling capability. By using transport costs as the source for regional price differentials (Boyd and Krutilla 1987), the SPE framework implicitly assumes that a single, integrated North American lumber market exists. Evidence for this assumption comes from Yin and Baek (2005), who tested the "law of one price" for U.S. lumber markets using cointegration analysis on a comprehensive set of (monthly) lumber data covering most of the 1990s [2]. They found substantial evidence supporting the law of one price hypothesis in terms of the main species groups, grades within those species groups and across geographic regions of the U.S.

Because SPE allows multiple but separate supply and demand regions to be examined distinctly, it provides greater realism and precision compared to more aggregated approaches or econometric models. Importantly for the current study, the SPE model also enables us to distinguish lumber produced from different species, because species are often region specific. Because the standard SPE model in the context of forest products trade is well-known (e.g., van Kooten and Folmer 2004, pp.409–418), we consider only the effect that the distinction between structural and nonstructural lumber has on the model.

Our model consists of 15 regions allocated into net demand or net supply regions. A net excess supply region is defined as producing more lumber than it consumes, whereas a net excess demand region is unable to satisfy domestic consumption from domestic production and must import lumber. Regions are categorized as net supply or net demand based on the production and consumption conditions that prevailed in 2003. (Two regions represent supply and demand for the rest of the world, based on import and export levels among Canada, the U.S., and the rest of the world.)

Along with information on production and consumption, price data and exogenous supply, and demand elasticities are used to derive linear excess supply and excess demand functions for each region. See Table 1 for a list of the model regions and their associated supply and demand elasticities. A description of production, consumption, prices, and transportation data is provided in the Appendix. The respective regional (inverse) excess demand and excess supply functions are as follows:

$$P_i = \alpha_i - \beta_i q_i, \quad \forall i \text{ and } \alpha_i, \quad \beta_i > 0, \tag{1}$$

$$P_j = \mu_j + \delta_j q_j, \quad \forall j \text{ and } \delta_j > 0. \tag{2}$$

Table 1. **Model regions & elasticity estimates used in the SPE model**

| Acronym | Region[a] | Supply Elasticity[b] | Demand Elasticity |
|---|---|---|---|
| BC | British Columbia | 0.529 | −0.17 |
| AB | Alberta | 0.415 | −0.17 |
| ROC | Saskatchewan, Manitoba | 0.415 | −0.17 |
| EC | Ontario, Quebec | 0.57 | −0.17 |
| AC | New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland & Labrador | 0.57 | −0.17 |
| ECD | n.a. | n.a. | −0.17 |
| CAL | California | 0.335 | −0.17 |
| SE | South East US | 0.963 | −0.17 |
| NE | North East US | 0.188 | −0.17 |
| NC | North Central US | 0.848 | −0.17 |
| SC | South Central US | 0.937 | −0.17 |
| MTN | US Mountain | 0.866 | −0.17 |
| PNW | Pacific Northwest | 0.335 | −0.17 |
| RWS | Rest of World Supply | 1.5 | n.a. |
| RWD | Rest of World Demand | n.a. | −0.17 |

[a] Regions are consistent with those used in Stennes and Wilson. 2005 (slightly modified from Haynes. 2003) with the exception of a slight change in ECD.
[b] Supply elasticities are consistent with those used in Stennes and Wilson (2005). One exception is that a supply elasticity of 1.5 was used for the RWS region, as was assumed by Adams (2003).
Sources: Stennes and Wilson (2005), Adams (2003), Adams and Haynes (1996), Latta and Adams (2000) and, Zhang (2001).

The variables $q_i$ and $q_j$ represent the total quantities demanded (by region $i$) and supplied (by region $j$) in the trade market; parameters $\alpha$ and $\mu$ denote the intercept terms for the regional (inverse) excess demand and excess supply functions, respectively; and $\beta$ and $\delta$ represent the corresponding slope coefficients. The objective is to maximize the trade surplus (TS), which equals the sum of the consumer and producer surpluses in the trade market, by allocating lumber from excess supply to excess demand regions, while minimizing total shipment costs [2]. Using linear trade functions, Equations 1 and 2, and including transportation costs, the objective function can be written as

$$\underset{q_{ij}}{\text{Maximize}} \quad \text{TS} = \sum_{i=1}^{M} (\alpha_i q_{ij} + \tfrac{1}{2}\beta_i q_{ij}^2) - \sum_{j=1}^{X} (\mu_j q_{ij} + \tfrac{1}{2}\delta_i q_{ij}^2)$$

$$- \sum_{i=1}^{M} \sum_{j=1}^{X} t_{ij} q_{ij}, \quad \forall i, j, \tag{3}$$

where $q_{ij}$ is the quantity exported by region $j$ to region $i$, $t_{ij}$ is the unit transportation cost from region $j$ to region $i$, and there are $X$ exporting and $M$ importing regions. In addition, the following constraints are imposed, a net supply region cannot export more than it produces:

$$\sum_i q_{ij} \leq q_j \quad \forall j \tag{4}$$

similarly, all demand in a region must be satisfied

$$\sum_j q_{ij} \geq q_i, \quad \forall j, \tag{5}$$

and, non-negativity

$$q_i, q_j, q_{ij} \geq 0. \tag{6}$$

Assuming respective regional domestic supply and demand slopes are positive and negative, TS is strictly concave in $q_i$ and $q_j$, concave in $q_{ij}$, and bounded from above. This assures that a solution exists, and that it is unique in terms of $q_i$ and $q_j$, but not necessarily for $q_{ij}$ (Takayama and Judge 1971, p.142).

## Model Calibration

SPE models are typically calibrated on a free-trade market basis, drawing on regional production, consumption, price, and elasticity data to define domestic supply and demand schedules, which are in turn used to construct regional trade functions. A free-trade market is implicitly characterized by transportation costs representing the natural (and exclusive) source of price differences between regions. Transportation costs include all costs associated with moving lumber between regions, plus transaction costs (e.g., insurance). Once the free-trade market is defined, trade restrictions are imposed and their impacts assessed relative to free trade.

Unfortunately, free trade was absent in the North American softwood lumber market during the period for which the SPE model is calibrated. Specifically, in 2003 a 27.2% ad valorem tariff existed on U.S. softwood lumber imports from Canada, consisting of an 18.79% countervail (CV) duty and an 8.43% anti-dumping duty, with only the latter imposed on lumber from the Atlantic provinces. Thus, production and consumption levels observed in 2003 were influenced by the tariff. It was necessary, therefore, to calibrate the free-trade model so that, when the 27.2% duty was imposed, the outcome replicated the observed state in 2003. The key to achieving this was to establish price–quantity pairs. Optimizing a SPE model yields an array of regional prices, which are centered on representative prices, but differentiated according to transportation costs. In the absence of free trade, it was necessary to incorporate policy-induced price differences as well.

The following steps were taken to determine regional prices: (1) Using representative supply and demand prices, the objective function specified in the SPE model was maximized with reference to the Canadian excess supply curves adjusted to the tariff level. Various composite price indexes were used to generate representative prices (Random Lengths, 2005) (see Appendix). By explicitly creating the price wedges that were present during 2003, this information was captured in the model-generated prices. (2) The model prices were re-entered into the model, and new prices were generated. After several such iterations, the SPE model was able to mimic the production and consumption levels observed in 2003. (3) With regional supply and demand schedules identified, free-trade prices and quantities were determined by removing the embedded price wedges (i.e., using the free-trade excess supply curves in the objective function). (4) One additional step was included to determine prices in nontariff-covered regions through which Canadian exports could flow. This was necessary because optimization approaches imperfectly incorporate discriminatory ad valorem tariffs [3]. What this meant was that the tariff-adjusted excess supply functions for the Canadian regions were applied to all demand regions, rather than exclusively to those in the U.S. To correct for this, the two non-U.S. demand regions (denoted RWD and ECD, see Table 1) were rebated back the tariff equivalent amount from the Canadian excess supply regions (using the cost coefficients for transport). These rebates were adjusted in the price iteration process and subsequently converged after a few iterations.

### *Distinguishing the Markets*

In this study, we differentiate softwood lumber according to structural and nonstructural end uses, with this distinction based on the species from which the lumber originates. (An exception is treated southern yellow pine, which was included on the basis of the additional treatment.) Admittedly this is not an exact demarcation, but it should suffice as a reasonable approximation because many species have typical end-use applications. In general, structural and nonstructural uses are determined by inherent strength and appearance characteristics, respectively. Although species are commonly classified according to these characteristics, there may also be considerable variation within a species. Incorporating species grades (strength and visual properties that largely dictate within-species end uses) to account for this would have been preferred, but this information is not available.

Numerous sources were used to determine which species to allocate to the nonstructural category (Random Lengths 2000, U.S. Department of Agriculture 1999, Canadian Wood Council 2005 [Canadian Species. www.cwc.ca/products/lumber/visually_graded/species.php. August 2005], National Association of Home Builders 2001, Western Wood Products Association 2001, 2005, and Nagubadi et al., 2004). We defined the following species as nonstructural: Cedars (western/inland red, incense, yellow, and Port Orford), redwood, and various pine species (Ponderosa, sugar, white, red and treated southern yellow).

The SPE model was solved sequentially using two distinct markets—an all-softwood lumber market (all-SWL) that included both structural and nonstructural lumber, and a structural softwood lumber market (structural-SWL) that excluded nonstructural lumber. The former could also be referred to as the lumber market as used in previous studies. We contend that using the structural-SWL market is preferred because it is a more accurate representation of a homogenous commodity, which is a requisite condition in SPE analysis. Further, by controlling for substitution bias, we measure the impacts of trade-restricting policies more precisely.

## Model Results

The SPE model precisely simulates the production and consumption patterns observed in 2003 (Table 2). In addition, the volume of trade flowing between Canadian regions and the U.S. (which is the critical element in measuring the impacts of trade restrictions) is accurately reflected in the trade flows generated by the model, as seen in Table 3 [4]. This was achieved with very few flow constraints [5]. The difference between the total volume of Canadian exports to the U.S. generated by the model and actual 2003 exports is equivalent to the volume of lumber imported into Canada from the U.S. and the rest of the world.

The base case for our two model formulations is given in Table 4. These production, consumption, and price figures reflect a paradigm of unconstrained (free) trade between Canada and the U.S., and were used as a basis for comparing the restrictive trade policies.

### *Policy Scenarios and Impacts*

We examine three conventional trade policies that have all at some point characterized softwood lumber trade between Canada and the U.S.:

1. a 27.2% ad valorem import tariff (8.4% for Atlantic Canada (AC) region),
2. a quota restricting Canadian regional exports to the same levels observed with the tariff, and
3. a unit export tax restricting total Canadian exports to the same level observed with the tariff. (The unit export tax imposed on the AC region was roughly one third of that applied to the other Canadian supply regions, which is consistent with the tariff case, and allows polices to be directly compared.)

The price impacts of these trade policies are presented in Table 5 for both markets. As expected, all policies yield similar price impacts in export markets because the total volume of Canadian lumber exported to the U.S. was equated across the three policies. However, the unit export tax resulted in larger Canadian market impacts than the quota or the ad valorem tariff. Moreover, all three policies are clearly effective in creating a substantial price wedge between Canadian and U.S. regions, averaging $74/mbf in the all-SWL market and $70/mbf in the structural-SWL

**Table 2. Production, consumption, and prices in the two model formulations. 2003 with tariffs**

| Region | All SWL | | | Structural SWL | | |
|---|---|---|---|---|---|---|
| | Prod. | Cons. | Prices | Prod. | Cons. | Prices |
| | . . . . . . . (mmbf [1]) . . . . . . . | | US$/mbf | . . . . . . . (mmbf) . . . . . . . | | US$/mbf |
| BC | 15,010 | 1,724 | 257 | 14,122 | 1,614 | 245 |
| AB | 3,195 | 1,579 | 266 | 3,195 | 1,579 | 253 |
| ROC | 686 | 245 | 272 | 686 | 238 | 260 |
| EC | 11,295 | 6,055 | 286 | 10,690 | 5,826 | 274 |
| AC | 2,568 | 635 | 324 | 2,497 | 594 | 309 |
| ECD | 0 | 1,314 | 331 | 0 | 1,063 | 317 |
| *Canada* | *32,754* | *11,552* | | *31,460* | *10,814* | |
| CAL | 2,627 | 6,016 | 384 | 1,502 | 4,757 | 368 |
| SE | 7,116 | 12,228 | 411 | 4,412 | 9,669 | 394 |
| NE | 1,319 | 8,531 | 396 | 716 | 6,746 | 380 |
| NC | 589 | 11,657 | 386 | 455 | 9,217 | 370 |
| SC | 9,794 | 10,220 | 390 | 5,961 | 8,081 | 374 |
| MTN | 3,630 | 5,618 | 380 | 2,851 | 4,442 | 364 |
| PNW | 10,871 | 2,086 | 334 | 9,646 | 1,649 | 318 |
| *US* | *35,497* | *56,355* | | *25,542* | *44,562* | |
| RWS | 1,947 | 0 | 269 | 965 | 0 | 267 |
| RWD | 0 | 2,741 | 359 | 0 | 2,591 | 346 |

[1] The production and consumption are measured in million board feet (mmbf) and the prices in thousand board feet (mbf).

**Table 3. SPE model and actual trade flows to the U.S. in 2003**

| Region | Model Flows | Actual Flows |
|---|---|---|
| | . . . . . . . . . . . . (mmbf) | . . . . . . . . . . . . |
| BC | 10,000 | 10,127 |
| AB | 1,616 | 1,591 |
| ROC | 441 | 453 |
| EC | 5,240 | 5,368 |
| AC | 1,634 | 1,672 |
| *Total* | 18,931 | 19,211 |

market. (This price wedge was determined using the average price differences between Canadian supply regions (excluding AC) and the U.S. demand regions to which they export.) The AC region is an exception, however, because the trade policies cause the price to increase. In this case, the relative advantage of less restrictive policies is translated into an explicit net gain for this region. Regional production and consumption levels adjust in the usual manner in response to the price changes.

Welfare impacts are presented in Table 6 as percent changes from the base case. As with prices, regional welfare changes are comparable across all policies within each market. Relative to free trade, Canada as a whole is clearly worse off. Because all but one Canadian region is a net supplier, the losses in producer surplus largely surpass the modest gain in consumer surplus. Taken as a whole, the U.S. is also significantly worse off with trade sanctions. With all but one U.S. region importing lumber, the losses to consumers largely exceed producer gains. The two countries in aggregate experience a net loss—a deadweight loss due to economic inefficiency associated with the misallocation of production and consumption across regions as a result of moving away from free trade. Estimates of these losses are also given in Table 6. Although the deadweight losses are significant, ranging from roughly $27 million to $63 million in 2003, income redistribution plays a much greater role. Trade restrictions create a price wedge between market price and marginal costs of production that results in a rent. In essence, there is a transfer of surplus from U.S. consumers to those collecting the policy-induced rents [6]. Thus, one country can gain considerably (relative to the free-trade outcome) at the expense of the other depending on what happens with the policy-induced rents. A U.S. duty implies gains to the U.S. in the form of government revenues; an export tax implies that Canada and the Canadian government gain (see below); a quota redistributes rents to Canadian lumber producers.

## *Comparing Results between Markets*

A comparison of the price impacts across policies in the all-SWL and the structural-SWL markets reveals some interesting results. Most notably, in the structural-SWL market, the prices in Canadian supply regions fall by less, whereas the prices in U.S. demand regions increases by more compared to the price changes in the all-SWL market. The explanation for this can be found by examining the price wedge structures in both markets. Using the model with structural lumber, consumption and production dynamics are altered, with Canada's share of total U.S.–Canada production increasing from 48% to 55%. The direct implication of these changes is a partial transfer of the tariff burden from Canadian producers to U.S. consumers. A general case for Canada and the U.S. is illustrated in Figure 1, where "St" and "All" subscripts are used to distinguish the structural-SWL and all-SWL functions. Given an average lumber price of $300/mbf, U.S. consumers would experience a $30.60/mbf price increase if one uses the results of the structural-SWL model, but only a $25.30/mbf price increase under the all-SWL market.

A comparison of welfare impacts in the all-SWL and structural-SWL markets follows intuitively from the price results. Although Table 6 provides some indication as to

**Table 4. Production, consumption, and prices in the two model formulations. 2003 free trade (base case)**

| | All SWL | | | Structural SWL | | |
|---|---|---|---|---|---|---|
| Region | Prod. | Cons. | Prices | Prod. | Cons. | Prices |
| | . . . . . . . (mmbf) . . . . . . . | | US$/mbf | . . . . . . . (mmbf) . . . . . . . | | US$/mbf |
| BC | 16,255 | 1,678 | 298 | 15,121 | 1,578 | 277 |
| AB | 3,408 | 1,536 | 308 | 3,379 | 1,443 | 288 |
| ROC | 732 | 238 | 317 | 726 | 232 | 296 |
| EC | 12,380 | 5,882 | 335 | 11,887 | 5,679 | 314 |
| AC | 2,557 | 636 | 322 | 2,460 | 597 | 301 |
| ECD | 0 | 1,286 | 372 | 0 | 1,044 | 352 |
| *Canada* | *35,332* | *11,256* | | *33,573* | *10,573* | |
| CAL | 2,559 | 6,095 | 355 | 1,455 | 4,831 | 334 |
| SE | 6,621 | 12,378 | 381 | 4,047 | 9,810 | 360 |
| NE | 1,301 | 8,640 | 366 | 704 | 6,848 | 346 |
| NC | 551 | 11,809 | 357 | 420 | 9,361 | 336 |
| SC | 9,097 | 10,352 | 361 | 5,456 | 8,205 | 340 |
| MTN | 3,385 | 5,692 | 350 | 2,621 | 4,512 | 330 |
| PNW | 10,547 | 2,117 | 304 | 9,301 | 1,679 | 284 |
| *US* | *34,061* | *57,083* | | *24,005* | *45,247* | |
| RWS | 1,624 | 0 | 239 | 782 | 0 | 233 |
| RWD | 0 | 2,679 | 406 | 0 | 2,540 | 386 |

**Table 5. Change in price relative to the free trade case (%)**

| | All SWL | | | Structural SWL | | |
|---|---|---|---|---|---|---|
| Region | Tariff | Quota | Export Tax | Tariff | Quota | Export Tax |
| BC | −13.6 | −13.6 | −14.8 | −11.8 | −11.9 | −13.2 |
| AB | −13.8 | −13.8 | −14.3 | −12.1 | −12.1 | −12.7 |
| ROC | −14.0 | −14.0 | −13.9 | −12.4 | −12.4 | −12.3 |
| EC | −14.4 | −14.4 | −13.2 | −12.9 | −12.9 | −11.6 |
| AC | 0.8 | 0.8 | 2.1 | 2.6 | 2.6 | 4.0 |
| ECD | −11.1 | −10.9 | −11.9 | −9.7 | −9.4 | −10.4 |
| CAL | 8.4 | 8.4 | 8.4 | 10.1 | 10.1 | 10.1 |
| SE | 7.8 | 7.8 | 7.8 | 9.4 | 9.4 | 9.4 |
| NE | 8.1 | 8.1 | 8.1 | 9.8 | 9.8 | 9.8 |
| NC | 8.3 | 8.3 | 8.3 | 10.1 | 10.1 | 10.1 |
| SC | 8.2 | 8.2 | 8.2 | 9.9 | 9.9 | 9.9 |
| MTN | 8.5 | 8.5 | 8.5 | 10.3 | 10.3 | 10.3 |
| PNW | 9.7 | 9.7 | 9.7 | 11.9 | 11.9 | 11.9 |
| RWS | 12.4 | 12.4 | 12.4 | 14.5 | 14.5 | 14.5 |
| RWD | −11.6 | −10.0 | −10.9 | −10.4 | −8.6 | −9.5 |

how welfare changes in absolute terms in the two models, it is important to note that these figures are not directly comparable because they represent changes relative to two unique base cases (with the all-SWL model including nonstructural lumber). However, it is worthy to note that the welfare loss to the U.S. is greater in absolute terms in the structural-SWL market even though the welfare losses associated with nonstructural lumber are not captured. Overall, the loss in welfare is greater for U.S. importing regions and less for Canadian supply regions when the structural-SWL market is considered rather than the all-SWL market. The implication is that U.S. policy should be fine-tuned to target only nonstructural lumber from Canada.

Changes in U.S. welfare for a given tariff level are illustrated in Figure 2 in a simple fashion. Rightward movement along the horizontal axis corresponds to an increasing demand-to-supply ratio. Where the curve crosses the horizontal axis, U.S. domestic demand is perfectly satisfied by U.S. domestic supply. An import tariff imposed at this point would have no impact on U.S. welfare. To the right of this intersection, U.S. domestic demand is greater than supply and lumber is imported. With an import tariff imposed in this situation, the U.S. experiences a net loss in welfare, because the loss in consumer surplus more than offsets the gain to U.S. producers. Whereas welfare estimates based on the traditional all-SWL market may have fallen around a point such as A, controlling for substitution bias is associated with a downward movement, perhaps to point B. In this analysis, point A is associated with a 0.9% loss in welfare based on the all-SWL market, whereas point B corresponds to a 1.2% welfare loss obtained from the structural-SWL market.

## *Sensitivity Analysis*

Because supply and demand elasticities play a key role in SPE model estimates, alternate values were examined to

Table 6. Changes in welfare by region from free trade for both all-SWL and structural-SWL formulation (values in thousands of US$)

| | Tariff | | Quota | | Unit Tax | |
|---|---|---|---|---|---|---|
| Region | All SWL | Structural | All SWL | Structural | All SWL | Structural |
| BC | −11.9% | −10.3% | −12.0% | −10.4% | −13.0% | −11.5% |
| AB | −3.8% | −3.5% | −3.8% | −3.5% | −3.9% | −3.7% |
| ROC | −5.7% | −5.1% | −5.7% | −5.1% | −5.7% | −5.1% |
| EC | −3.7% | −3.3% | −3.7% | −3.3% | −3.4% | −3.0% |
| AC | 0.4% | 1.4% | 0.4% | 1.4% | 1.1% | 2.1% |
| ECD | 4.4% | 3.8% | 4.3% | 3.6% | 4.7% | 4.0% |
| *Canada* | −5.1% | −4.5% | −5.2% | −4.5% | −5.2% | −4.6% |
| *CS* | $486 | $377 | $485 | $376 | $471 | $362 |
| *PS* | −$1,368 | −$1,064 | −$1,372 | −$1,068 | −$1,372 | −$1,068 |
| *Net* | −$882 | −$687 | −$886 | −$692 | −$901 | −$706 |
| CAL | −1.3% | −2.0% | −1.3% | −2.0% | −1.3% | −2.0% |
| SE | −1.0% | −1.5% | −1.0% | −1.5% | −1.0% | −1.5% |
| NE | −2.0% | −2.6% | −2.0% | −2.6% | −2.0% | −2.6% |
| NC | −2.4% | −2.9% | −2.4% | −2.9% | −2.4% | −2.9% |
| SC | −0.2% | −0.8% | −0.2% | −0.8% | −0.2% | −0.8% |
| MTN | −0.9% | −1.1% | −0.9% | −1.1% | −0.9% | −1.1% |
| PNW | 5.3% | 6.9% | 5.3% | 6.9% | 5.3% | 6.9% |
| *US* | −0.9% | −1.2% | −0.9% | −1.2% | −0.9% | −1.2% |
| *CS* | −$1,682 | −$1,519 | −$1,681 | −$1,519 | −$1,682 | −$1,520 |
| *PS* | $1,038 | $838 | $1,037 | $838 | $1,038 | $838 |
| *Net* | −$644 | −$681 | −$644 | −$681 | −$644 | −$681 |
| Revenue/Rent | $1,302 | $1,209 | $1,304 | $1,212 | $1,313 | $1,220 |
| ROW | $181 | $132 | $163 | $114 | $173 | $123 |
| Deadweight Loss | −$43 | −$27 | −$63 | −$47 | −$59 | −$44 |

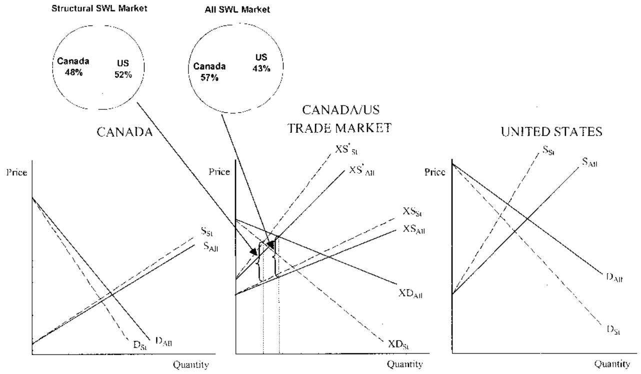

Figure 1. Price wedge structures and shares of the tariff burden.

assess the robustness of our results. Specifically, we consider a demand elasticity of −0.34 (double the original value) and cases where all supply elasticities are doubled. With more price-responsive (elastic) demand, consumers are better able to adjust their spending behavior and hence a smaller amount of consumer surplus is lost. This comes at the expense of producer gains, and is observed irrespective of the trade policy. Conversely, when supply becomes more elastic, producers can react to price signals with more flexibility and hence capture a larger share of the surplus that would have otherwise gone to consumers. Results of the sensitivity analysis for the structural-SWL market are provided in Table 7. Overall, changes in elasticities influence the magnitude of the welfare changes (by less than 10%), but little else.

Because we originally use the same elasticities in both the structural-SWL and all-SWL models, we consider also the case where the demand elasticity for structural lumber is greater than for all lumber. Higher demand elasticities are expected as one disaggregates the product mix (from the "all" to "structural" lumber), because more substitutes are available at the more disaggregated level. When a demand elasticity of −0.34 is assumed for structural-SWL while that for all-SWL remains at −0.17, the differences between the two models are much more modest, with an average lumber

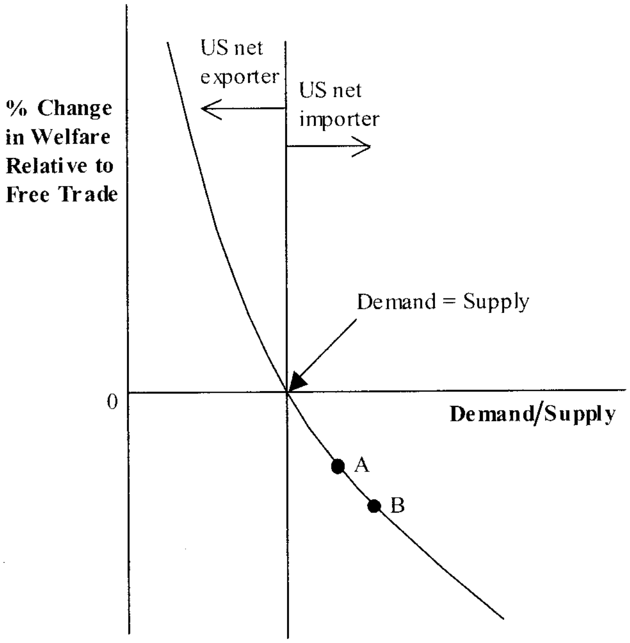

Figure 2. Welfare and the U.S. domestic economy for a given tariff level.

Table 7. Aggregate welfare with alternative supply and demand elasticities (thousands of US$) (structural SWL)

| | Tariff | | | Quota | | | Unit Export Tax | | |
|---|---|---|---|---|---|---|---|---|---|
| | Original Elast. | Double Demand | Double Supply | Original Elast. | Double Demand | Double Supply | Original Elast. | Double Demand | Double Supply |
| CS | 377 | 396 | 361 | 376 | 396 | 360 | 362 | 382 | 345 |
| PS | −1064 | −1141 | −1049 | −1068 | −1149 | −1051 | −1068 | −1147 | −1051 |
| Total | −687 | −745 | −688 | −692 | −753 | −691 | −706 | −765 | −705 |
| CS | −1519 | −1426 | −1588 | −1519 | −1426 | −1588 | −1520 | −1423 | −1591 |
| PS | 838 | 783 | 846 | 838 | 783 | 846 | 838 | 781 | 848 |
| Total | −681 | −643 | −742 | −681 | −643 | −742 | −681 | −641 | −743 |

price increase due to the tariff some $2/mbf lower in this case. It is unlikely, however, that the difference between the demand elasticities will be this great, but it is also clear that one can moderate the impact of substitution bias even further by assuming an even higher elasticity of demand for "structural" versus "all" softwood lumber. This is one caveat on our results.

## Conclusions

When nonstructural softwood lumber, a product that had previously been recognized as complementary rather than competitive with structural-SWL, is removed from the standard spatial price equilibrium framework used to investigate the Canada–U.S. lumber trade dispute, the estimated policy impacts are fundamentally altered: The negative impacts exerted by trade policies on U.S. consumers become more pronounced, although injury to Canadian producers is reduced. In the context of current import duties, the tariff-induced price increase in the U.S. is approximately 21% higher when modeling the structural-SWL market rather than the traditional all-SWL market. By failing to distinguish between end uses of lumber in the determination of countervail duties, an additional $37 million in losses are incurred, exclusive of the direct losses from consuming policy-induced higher-priced nonstructural lumber. In contrast, Canadian prices fall almost 15% less when only structural-SWL is considered, resulting in a reduction of losses by nearly $200 million, though we expect this would be slightly lower if changes in the nonstructural lumber market were also taken into account.

From a supply perspective, restricted trade has promoted growth in U.S. lumber imports from noncovered (or less covered) regions, and noncovered products coming from regions affected by trade sanctions. Since the imposition of the quota in 1996 (and through the subsequent tariff period), U.S. imports of softwood lumber from non-Canadian regions have risen by over two bbf, representing more than a sixfold increase (US Department of Agriculture. 2004–05. [Foreign Agric. Serv. www.fas.usda.gov/ustrade/]. August 2005). In addition, U.S.-bound softwood lumber exports from AC (which was excluded from the SLA quota and exempt from the countervail portion of the current duties) nearly doubled during this same period (Council of Forest Industries 2005). In relation to exempt products, Canadian raw log exports to the U.S. have increased approximately 5½ times since 1996, even with various domestic impediments in place (USDA 2004–05). Moreover, U.S. imports of many value-added products from Canada have experienced significant growth [7].

On the demand side, the persistence of restricted trade has had a direct impact on lumber consumption. The disparity in Canadian and U.S. lumber prices resulting from the price wedge is clearly reflected in consumption statistics. From 1996 to 2003, per capita lumber consumption increased by 71% in Canada, but only by 3% in the U.S. Higher U.S. lumber prices have played a role in both discouraging construction and promoting substitution to nonlumber products. The results of this study highlight this point as U.S. consumers incur even greater losses when we control for the substitution of various types of lumber. Furthermore, it was estimated that U.S. lumber use in wall, floor, and roof framing decreased by 11%, 29%, and 22%, respectively, between 1995 and 1998 (Cintrafor, 2000). The use of engineered wood products (glulam beams, I-joists, etc.) and nonwood products, such as steel and concrete, are increasing at the expense of lumber.

It is unlikely that the structural shifts occurring in U.S. markets for softwood lumber will easily be reversed. Inroads by overseas producers and substitute products have been significant, and their market shares will probably continue to grow. Overall, it is likely that the success that the U.S. Coalition for Fair Lumber Imports has had in lobbying for restrictions on Canadian lumber will be eroded over time as a result of these structural changes, which continue to shrink the potentially exploitable margins.

The latter conclusions are not altogether firm because the spatial price equilibrium model is static. Future research needs to take into account dynamic aspects of supply and demand, because some have suggested that the intertemporal equivalence of trade policies, and the concomitant characteristics of their impacts, can diverge significantly due to underlying structural movements in demand and supply (Adams and Haynes 1981, Schwindt et al. 2004, Stennes and Wilson 2005).

Further research on both demand and supply elasticities and price-quantity equilibriums (e.g., under free trade) is also required, including research on components making up the "all softwood lumber" category. This is needed in the regional SPE modeling framework to construct the trade functions. Although we were able to use recent data on lumber price–quantity pairs and transportation costs among regions, up-to-date elasticity estimates are not available from the literature, with demand elasticity estimates in particular dating back to the early 1990s, nor are such estimates region specific.

Research also needs to examine in greater detail the complementarity and substitutability among various wood and nonwood products used in construction. Although we have demonstrated that distinguishing between structural and nonstructural softwood lumber is important, the extent to which Canadian softwood lumber exports compete with various U.S. lumber products is an issue that requires further study.

## *Endnotes*

[1] Law of one price maintains that, once quality differences and transport and trading costs are taken into account, prices in separate market segments should behave uniformly and consistently over time.

[2] Because this is a partial equilibrium analysis (softwood lumber is examined in isolation of all other goods), the sum of consumer and producer surpluses is not to be considered a measure of aggregate wellbeing (Samuelson 1952).

[3] Nicholson et al. (1994) have shown that it is not possible to directly solve a SPE model with discriminatory ad valorem tariffs (i.e., tariffs on imports that differ by exporting region) using an optimization model because the value of the tariff depends on the endogenously determined supply price. However, a solution may be obtained by using an iterative process, whereby the approximated tariff rate is successively updated after each iteration (Nicholson and Bishop, 2004).

[4] Regional information on actual flows of structural-SWL from Canada to the U.S. was not available. However, the model was able to replicate the total volume of Canadian structural-SWL exports to the U.S., exclusive of the estimated 129 mmbf of structural-SWL brought into Canada.

[5] In the all-SWL market, two minimum-shipment flow constraints were imposed. These lower bounds were (mmbf): 468 from the U.S. to RWD and 300 from AC to ECD. For the structural-SWL market, three lower bounds were imposed: 393 from the U.S. to RWD, 165 from AB to ECD, and 300 from AC to ECD (see Table 1 for definitions). These constraints are needed to recreate a realistic set of flows in the model from the U.S. to the rest of world and internally to domestic markets within Canada, and both are relatively unimportant in terms of trade flows and stay in place for all of the runs.

[6] With respect to the current softwood lumber duties, tariff revenues collected by the U.S. government may be further reallocated to U.S. producers under the highly contentious Byrd amendment.

[7] U.S. imports of various Canadian value-added wood products not covered by the trade restrictions have increased significantly since 1996. For instance, Canadian wood door and frame exports to the U.S. have more than tripled and prefabricated building exports have increased nearly nine times since 1996.

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## Appendix: Data elements

### *Production & Consumption*

Reported data on total softwood lumber production was used in the all-SWL model formulation, though a few figures were estimated (United States Census Bureau 2004, Statistics Canada 2004, 2005a, Spelter and Alderman 2003, Newfoundland and Labrador Department of Finance 2004, Western Wood Products Association 2004, Southern Forest Products Association 2005 [Industry Statistics. www.sfpa.org/Industry_Statistics/default.htm]). In the structural-SWL formulation, the production data were adjusted to exclude production of nonstructural species (as defined in this article). With nonstructural production volumes reported for major nonstructural producing regions, remaining volumes were allocated based on various estimates and assumptions. Non-North American supply was derived from Canada and U.S. overseas imports (USDA 2004-05, Industries Canada 2005 [Trade Data Online, Strategis.gc.ca/sc_mrkti/dst/engdoc/tr_homep.html.]

Consumption in the all-SWL model formulation was determined by allocating (national level) total apparent consumption of all-SWL to the (country) regions, where apparent consumption is defined as domestic production plus imports minus exports. (USDA 2004-05, Statistics Canada 2004b, Western Wood Products Association 2004, U.S. Census Bureau 2005, National Association of Realtors 2005 [Total Sales: Single Family, Apartment Condos and Co-ops. www.realtor.org/Research.nsf/files/REL04Q4S.pdf/$FILE/REL04Q4S.pdf], Canadian Housing And Mortgage Commission. 2004 [Canadian Housing Observer. www.cmhc-schl.gc.ca/en/cahoob/hodata2004/hodata2004_002.cfm], Statistics Canada 2005, [Building permits, non-residential values by type of structure. CANSIM Table 026-00051. cansim2.statcan.ca/directory/Table_Directory.pdf]. Random Lengths 2004, Global Wood 2005 [Industry News & Markets. www.globalwood.org/market1/us-pine-reports.htm], World Forestry Institute 2005 [Information Resources. www.worldforestry.org/wfi/trade-4.htm). In the structural-SWL formulation, apparent consumption of structural-SWL was used in place of all-SWL. Non-North American demand was based on Canada and U.S. overseas exports (USDA 2004-05, Industries Canada 2005 [Trade Data Online, Strategis.gc.ca/sc_mrkti/dst/engdoc/tr_homep.html.]

### *Prices*

Representative prices (Rp), used to anchor the range of endogenous prices, were determined using four lumber composite price indexes: framing lumber, low-grade random dimension lumber, shop and molding lumber, and boards (Random Lengths 2005). The framing lumber index was used as the Rp in the structural-SWL formulation. A nonstructural lumber index was approximated based on the remaining three indexes. The Rp in the all-SWL formulation was determined using an average of the structural and nonstructural lumber indexes, based on respective shares of total production in 2003.

## *Transportation Costs*

Transportation costs are defined between excess supply and excess demand regions. These costs reflect a fixed and a variable component. The fixed segment (equivalent across all supply regions and independent of distance) represents the cost of moving lumber to the rail point within a region. The variable segment signifies the cost of moving lumber between net supply regions and net demand regions in North America (Burlington Northern Santa Fe 2004 [Price Lookup. www.bnsf.com/prices.html], Canadian Northern Railway 2004 [Published Tariff Rates. Price Quote—Price Documents. www.cn.ca/en_index.shtml?ww=1024], Canadian Pacific Railway 2004 [Tariff Publishing System. The Price Line. www8.cpr.ca/inet58/tariffpublishing], CSX Corporation 2004 [The Price Look-up and Price Lists. www.csx.com/index.cfm?fuseaction=pricelist.forest_industrial], Norfolk Southern Corporation 2004 [Paper, Clay, and Forest Products. www.nscorp.com/nscorp/index.jsp], Union Pacific Railroad 2004 [Price and Transit Time Inquiry. c02.my.uprr.com/cdm/price_query.jas]). Container costs were used synonymously with rail costs for movement between North America and the rest of the world (Maersk Sealand 2004 [Rates. www.maersksealand.com/HomePage/appmanager/], P&O Nedlloyd [USA Tariff and Rate Information. www.ponl.com/topic/home_page/language_en/products_and_services/service_information/usa_tariff]). Costs are adjusted to 2003 real U.S. dollars. Transportation costs used in the all SWL formulation are shown in Table A1. The transport cost matrix used in the structural-SWL formulation was similar with the following exceptions: RWS to CAL, MTN, SE, and SC were 178.24, 168.40, 127.01 and 144.47, respectively.

**Table A1. Transportation Costs (2003 $US per thousand board feet)**

| To/From | CAL | MTN | SE | SC | NE | NC | ECD | RWD |
|---|---|---|---|---|---|---|---|---|
| BC | 56.82 | 52.59 | 83.81 | 63.28 | 85.50 | 58.89 | 74.17 | 108.22 |
| AB | 61.82 | 58.08 | 73.20 | 60.02 | 74.89 | 48.27 | 67.07 | 125.74 |
| ROC | 62.79 | 49.44 | 66.42 | 48.95 | 67.51 | 39.96 | n.a. | 133.38 |
| EC | 67.56 | 51.88 | 46.27 | 47.56 | 31.45 | 39.80 | n.a. | 109.28 |
| AC | 99.79 | 83.33 | 63.02 | 66.83 | 44.39 | 59.99 | 53.87 | 109.28 |
| PNW | 54.11 | 48.78 | 76.66 | 56.53 | 80.76 | 52.48 | 81.68 | 114.44 |
| RWS | 127.36 | 169.37 | 157.17 | 158.08 | 127.01 | 153.62 | 149.63 | n.a. |