Mountain pine beetle, global markets, and the British Columbia forest economy

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Abstract: A number of near-term timber supply shocks are projected to impact global forest product markets, particularly mountain pine beetle induced timber reductions, a Russian log export tax, and timber supply increases from plantation forests in the Southern Hemisphere and Sweden. We examined their effect on a number of global jurisdictions using a dynamic global forest products trade model that separates British Columbia (BC) into coastal and interior forest sectors. The results suggest that global increases in plantation timber would have negligible effects on BC log and lumber markets, that the Russian tax would have minor effects on this market, and that the beetle-induced timber supply drop would moderately increase BC prices (primarily log prices). In the United States South, lumber and log prices could rise as a result of the mountain pine beetle, while other shocks will have a negligible impact on prices. Yet, lumber production will fall because log prices will increase substantially more than lumber prices. Japan could be impacted much more than other regions by the Russian tax on log exports. In the absence of export taxes, a beetle-induced timber shortage would cause lumber production in Japan to rise (as Japan can access nearby Russian logs), while the export tax would reduce lumber production because log prices rise disproportionately more than in other regions.

Résumé : Plusieurs chocs d'offre de bois d'œuvre à très court terme pourraient avoir un impact sur les marchés mondiaux de produits forestiers, particulièrement des réductions de l'offre de bois d'œuvre causées par le dendroctone du pin ponderosa, une taxe à l'exportation des grumes en provenance de Russie et des augmentations de l'offre de bois d'œuvre provenant de plantations dans l'hémisphère Sud et en Suède. Nous avons étudié leur effet sur plusieurs juridictions dans le monde à l'aide d'un modèle dynamique du commerce des produits forestiers à l'échelle mondiale qui scinde la Colombie-Britannique en secteurs forestiers côtier et intérieur. Les résultats indiquent qu'une augmentation mondiale de l'offre de bois d'œuvre provenant des plantations aurait des effets négligeables sur les marchés du bois d'œuvre et des grumes de la Colombie-Britannique, que les effets de la taxe russe seraient mineurs et que la diminution de l'offre de bois d'œuvre causée par le dendroctone augmenterait de façon modérée les prix en Colombie-Britannique (grumes non transformées). Le prix des grumes et du bois d'œuvre pourrait augmenter dans le sud des États-Unis à cause du dendroctone du pin ponderosa tandis que les autres chocs auront un impact négligeable sur les prix. Par contre, la production de bois d'œuvre va diminuer parce que le prix des grumes augmente beaucoup plus que les prix du bois d'œuvre. La taxe russe sur les grumes destinées à l'exportation pourrait avoir un impact beaucoup plus important au Japon que dans les autres régions. En l'absence de taxe à l'exportation, une pénurie de bois d'œuvre causée par le dendroctone pourrait entraîner une augmentation de la production de bois d'œuvre au Japon (étant donné que le Japon peut avoir accès aux grumes provenant de la Russie qui est située à proximité) tandis que la taxe à l'exportation réduit la production de bois d'œuvre parce que le prix des grumes augmente de façon plus disproportionnée que dans les autres régions.

[Traduit par la Rédaction]

Introduction

Some near-term timber supply shocks are projected to impact global forest product markets, and these could change the structure of the forest sector in British Columbia (BC). In this paper, we project the potential marginal (or partial) effects of some of the key supply-side factors on prices and output in the BC forest sector and other selected global jurisdictions. British Columbia Ministry of Forest and Range (2007) has projected the BC provincial timber supply to drop by approximately 25% (from the 2006 level) when salvage harvesting ends. Although future timber supplies are highly uncertain, this reduction in output has been used previously to analyze the impact on the BC economy (e.g., Wright 2007). However, such studies have not considered changes in forest product prices as a result of the supply shock, which could potentially mitigate economic decline. In the near future, several emerging global factors can also be expected to impact the prices of BC forest products: (*i*) the decline in timber supply caused by the mountain pine beetle; (*ii*) the ramping up of a log export tax by the Russian Federation, which is expected to reach 80% in 2009; and (*iii*) the growth of timber supply from plantation forests in Chile, New Zealand, Australia, and Sweden. This study projects the impacts of these events on lumber and sawlog

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prices and output over time, using a dynamic global spatial price equilibrium model.

British Columbia Ministry of Forests and Range (2007) forecasts that as a result of the mountain pine beetle outbreak, the annual allowable cut will be reduced by approximately 12×10^6 m^3 below pre-outbreak levels beginning in 2009. Because of increased salvage harvests, the 2006 harvest was 8.7×10^6 m^3 above the pre-outbreak annual allowable cut, which indicates an expected drop of approximately 20×10^6 m^3. The drop below the current (2006) harvest will amount to approximately 20% of BC, 4.5% of North America, and 1.5% of global timber supplies. As a result, it will impact global log and lumber prices.

The timber stock principally affected by mountain pine beetle is in the interior region of BC. Although the beetle is now increasingly present in parts of Alberta, we only model the BC supply effects in this paper. While the majority of people living in the BC interior communities are dependent on the forest industry, the interior forest industry is also important to the economy of the entire province. The BC forest industry directly generates 8% of the provincial gross domestic product but is responsible for 32% of the province's economic base if indirect effects are taken into account (Wright 2007). The impact of a 20% decline in forestry output would then be substantial, but so would a 5% increase in the price of forest products. Of secondary importance, however, price increases may mitigate the effects of timber supply reductions.

The government of the Russian Federation is committed to increasing export taxes on raw logs, which will reach 80% in 2009. Hamilton (2008) reports that Chinese and Japanese sawmills are dependent upon log exports from Russia and have found it difficult to purchase economical fibre since the log export tax was raised to 25% on 1 April 2008. He further reports that a BC forest company has received inquiries from Japanese companies seeking to replace their Russian supply of logs. One analyst suggested that the Asian market will be prosperous for BC forest companies for 5–6 years after the imposition of the 80% export tax (Roberts 2007).

Several world regions have recently exhibited rapid timber supply growth. Food and Agricultural Organization data, for example, indicate that the supply of industrial roundwood increased by 53% in Australia, 160% in New Zealand, and 205% in Chile during the 15 years between 1990 and 2004. This increased supply is largely due to the growth of plantation-style forestry in regions with inherently good growing conditions. Thus, Sedjo (1999) reports that timber yields are 18–30 $m^3 \cdot ha^{-1} \cdot year^{-1}$ in Chile compared with only 1.5–5.3 $m^3 \cdot ha^{-1} \cdot year^{-1}$ in BC. The supply of fibre from the emerging forest export regions makes the global market for forest products more competitive and could potentially push down prices in BC.

In this paper, a dynamic partial equilibrium trade model was used to examine the effects of a decrease in BC timber supply brought about by the mountain pine beetle disturbance, an increase in Russian log export taxes, and enhanced timber output from regions with plantation forests. The data used in the model come from the Global Forest Products Model (GFPM) (Buongiorno et al. 2003) and other sources (discussed below in Computational methods). The main focus is on the BC forest industry, although partial results are also provided for selected regions. The model predicts that for both the interior and coastal regions of the province, the BC timber supply decrease and the Russian log export tax will cause lumber prices to rise, whereas the growing world timber supply will have a minimal effect. The reduced BC timber supply will cause an in increase in sawlog prices in both BC regions, whereas the Russian log export tax will have a substantial effect on log prices on the BC coast only. A growing global timber supply will have negligible effects on log prices in BC. The effect on other North American regions will be similar to that on BC, with some exceptions; however, Japan will be affected disproportionately more, especially by the log export tax and because of its proximity to Russia and its reliance on Russian logs.

Computational methods

Our computational model is an extended version of a softwood lumber trade model (spatial equilibrium model) developed by the Canadian Forest Service (CFS) (Stennes and Wilson 2005; Mogus et al. 2006) and is patterned on the model used by Boyd and Krutilla (1987). The purpose of the CFS spatial equilibrium trade model is to analyze US–Canada softwood lumber trade; it includes six Canadian and seven US regions plus two regions to represent the rest-of-the-world demand and supply. BC is treated as a single region in this model. However, in this paper, we extend the CFS model by dividing BC into two regions (BC coast and BC interior), increasing the number of regions outside North America, adding a log sector, and making the model dynamic.

It was necessary to model the interior and coastal regions of BC as unique regions to properly study the effects of various forest-sector events on the BC forest industry. The two regions of the province have rather distinctive industries and it would potentially be misleading to treat them otherwise. Because we were also interested in the impacts of a Russian log export tax and an increased supply from plantation forests, the trade model needed to be extended to include a log sector. It also necessitated the inclusion of Russia, Japan, Chile, New Zealand, Australia, Finland, and Sweden as separate regions. However, a lack of data regarding bilateral trade in logs required us to reduce the number of separate Canadian and US regions from 13 to 8 (see Appendix A). Finally, the model was made dynamic using a method similar to that employed in the GFPM (Buongiorno et al. 2003), as described below.[2]

[2] The GFPM is widely used to analyze forest policies at the global level (e.g., Turner et al. 2005; Prestemon et al. 2006). It is a country-level model that provides only imports and exports of products, and not bilateral trade flows or tariffs and (or) export taxes that target some countries and (or) regions but not others (as was true for the Canada–US Softwood Lumber Agreement). Our model is a bilateral, regional trade model with 19 regions (that do not correspond to countries) and two products (logs and lumber). In contrast, the GFPM has as many regions as there are countries for which data are available and has upwards of 17 products, with both the number of countries and number of products varying, depending on the policy to be analyzed.

Much of the data for our model comes from the GFPM (Zhu et al. 2007) although bilateral trade information comes from other sources (see Appendix A). Further, the data that would enable us to calibrate the two BC regions separately for all products included in the GFPM are not available, therefore, detail in the product diversity dimension was dropped. Without such detail it was necessary to assume that the fraction of timber supply for lumber and other products is constant over time, and our model ignored the fraction not used for lumber production.

The computational strategy is based on the work of Samuelson (1952) and Takayama and Judge (1971). The model computes the prices and quantities that maximize total surplus in the market, and these are equivalent to competitive prices and quantities. Total surplus is measured as total consumption benefits minus production costs, transportation costs, and import and (or) export taxes and tariffs. Demand-and-cost curves are assumed to be continuous linear functions so that their integrals are quadratic and so that quadratic programming can be used to compute equilibrium.[3] Data on price and income elasticity, tariffs, and transportation costs, as well as other data are stored in Excel.

As in the GFPM, an updating procedure that connects periods is used to make the model dynamic. This is done because shocks are exogenously imposed at different times, which precludes the use of a true dynamic optimization procedure. The first-period results are computed and then used to update the input parameters for the second period, with the procedure repeated for subsequent periods. The program maximizes total surplus, which is subject to constraints on total harvest and manufacturing capacity, in each period. The total harvest constraint is constant over time except for the regions whose total harvest is assumed to grow exogenously, which occurs in the scenarios of "growth of global timber supply" and "all factors" (described below). Manufacturing capacity is assumed to grow by no more than 10% per year to prevent the possibility of a sharp and unrealistic jump in some region's lumber production from dominating the results.

The model is written in Matlab with calls to the CPLEX solver in General Algebraic Modeling System (GAMS) (GAMS Development Corporation 2001). Matlab retrieves data from Excel, passes required information to GAMS during each individual period in the model, recovers and saves the optimized solution in each period, updates the prices and quantities for the next period, and upon reaching the end of the time horizon, passes the results back to Excel.[4]

Often models like ours assume that demand curves shift upwards over time as national incomes grow. Contrariwise, we assumed that demand curves are constant over time to more easily distinguish between effects. It is likely that growing incomes in the future will cause prices to exhibit some growth trend, which could potentially overwhelm the changes brought about by the disturbances, especially the changes caused by beetle-induced timber supply reductions. The disturbances of interest in this study should cause deviations from income and population growth trends. To examine these deviations in isolation, we kept demand constant over time.[5]

We employed the following notation:

Lumber demand / lumber supply: y_{D_i} / y_{S_i}
Sawlog demand / sawlog supply: x_{D_i} / x_{S_i}
Lumber demand: $p_{y_i}(y_{D_i}) = a_i + b_i y_{D_i}$
Lumber manufacturing cost: $c_{y_i}(y_{S_i}) = c_i y_{S_i}$
Sawlog cost: $c_{x_i}(x_{S_i}) = c_i x_{S_i}$
Recovery factor: ϕ_i
Sawlogs / total harvest: γ_i
Maximum harvest: h_i
Interregion flow: $X_{i,j}$ / $Y_{i,j}$
Ratio of lumber to log transport costs: $\pi/4$
Ratio of lumber to log tariffs: $\Omega_{x_{i,j}}/Y_{y_{i,j}}$

There are 19 regions in the model, denoted by i (or j). (We used x to denote sawlogs and y to refer to lumber.) Interregion trade flows, transportation costs, and tariffs constitute 19 × 19 matrices. The rows of the matrices represent the export regions and columns the import regions. For example, the (12,13)th element of $X_{i,j}$ represents the export of logs from region 12 to region 13; the (15,15)th element of $Y_{i,j}$ represents the lumber produced and consumed in region 15. The (i,j) elements of $\Omega_{y_{i,j}}$ are the total import tariffs charged by region j on lumber exported from region i. The elements of $T_{i,j}$ are lumber transportation costs from region i to region j. To determine the transport costs for logs, we inflated the lumber transportation costs, $T_{i,j}$, by $4/\pi$ to get equivalent log transportation costs.[6]

The programming objective function is formulated as

$$\mathrm{Max} \sum_i [a_i y_{D_i} - 1/2(b_i y_{D_i}^2 + c_i y_{S_i}^2 + C_{S_i}^2 x_{S_i})] - \sum_i \sum_j \{X_{i,j}[(4/\pi)T_{i,j} + \Omega_{x_{i,j}}] + Y_{i,j}[T_{i,j} + \Omega_{y_{i,j}}]\}$$

The model constraints are as follows (with a brief description included on the left):

Sawlogs in i ≤ fixed fraction of harvest in i: $x_{S_i} \leq \gamma \cdot h_i$
Supply from i to all ≤ sawlogs produced in i: $\sum_j X_{i,j} \leq x_{S_i}$
Lumber produced in i ≤ sawlogs × recovery in i: $y_{S_i} \leq \phi \cdot x_{D_i}$
Lumber production in i ≤ capacity of i: $y_{S_i} \leq \bar{y}_i$

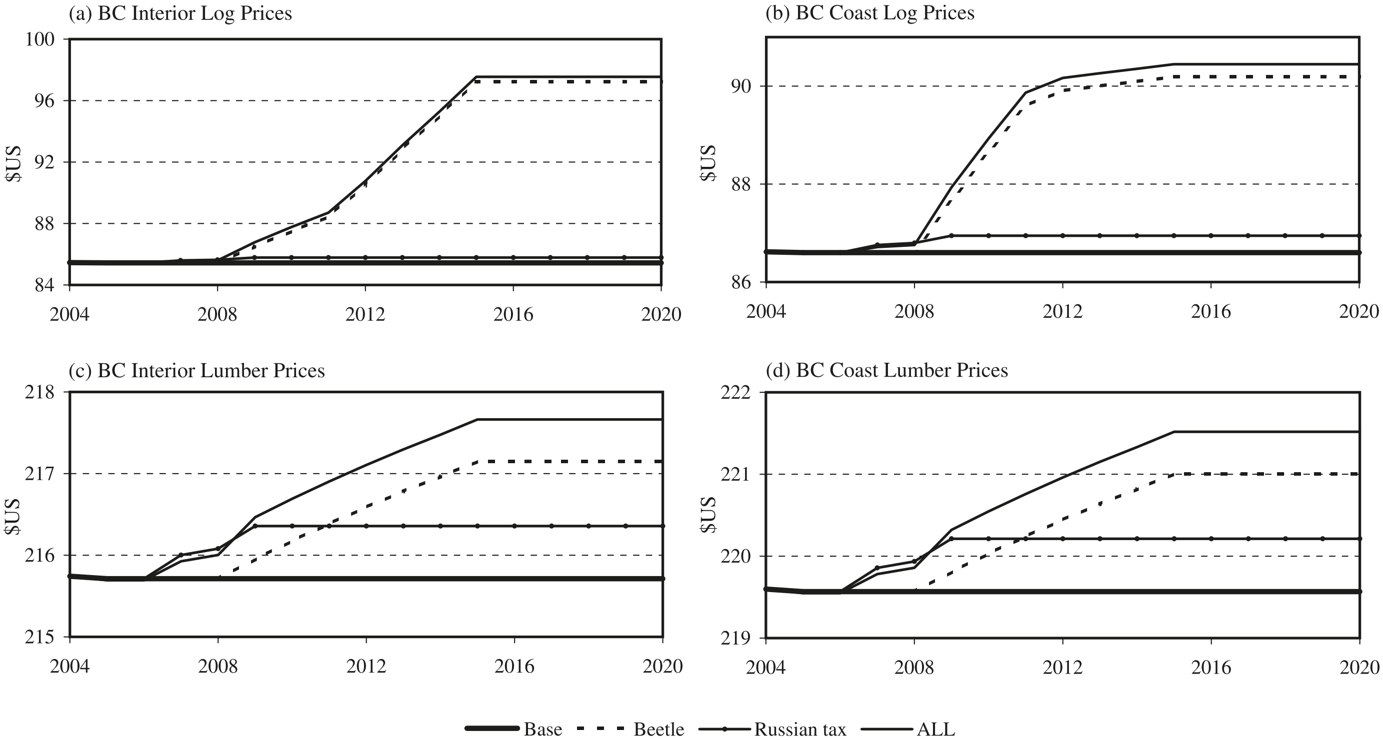
[3] Linearity is the most common assumption in these types of models for two reasons: (1) given no guidance regarding functional forms, economists often use linear supply and demand for policy analysis; and (2) linear functions can easily be constructed from information about price elasticity and a single point on the curve.

[4] The processes and various computer codes are available from the authors upon request. The user can easily substitute basic data in Excel and run the Matlab program to determine the sensitivity to assumptions about elasticities, transportation costs, and so on.

[5] There is a provision in the model to include growth in demand caused by potential growth in population and per capita gross domestic product.

[6] The area of the largest circle that fits into a square with side r is $\pi(r/2)^2$. Then the ratio of the area of the circle to the square is $\pi/4$. Thus, to account for the space between logs, one needs to multiply the lumber transportation cost by $4/\pi$ to obtain the cost of transporting logs.

Fig. 1. British Columbia log and lumber prices under various scenarios.



Supply from i to all ≤ lumber production in i: $\sum_j Y_{i,j} \leq y_{S_i}$

Region i lumber demand ≤ supply from all regions: $y_{D_j} \leq \sum_i Y_{i,j}$

Exogenous changes in the parameters were used to simulate five scenarios:

1. Base case: all parameters as in 2004.
2. Beetle-induced timber shortage: all parameters as in 2004, but BC interior maximum harvest declines by 6% from the previous period for the period 2009 to 2015, so it is approximately 34% below 2008 levels by 2015 (comparable to the provincial-level reductions of 25% discussed in the Introduction). This decline reflects some ability to salvage harvest pine-beetle killed timber.
3. Russian tax: all parameters as in 2004, but Russian log export tax rises from 6.5% in 2004 to 20% in 2007, 25% in 2008, and 80% in 2009, and thereafter.
4. Growth in global timber supply: all parameters as in 2004, but maximum harvests in Chile grow by 2.9% per year, in New Zealand by 3.1%, in Sweden by 3.2%, and in Australia by 0.9% (see Sedjo 1999).
5. All factors: all of the above.

Because the set of results is large and dynamic in nature, they are presented graphically. This allows for easy comparison of the scenarios.

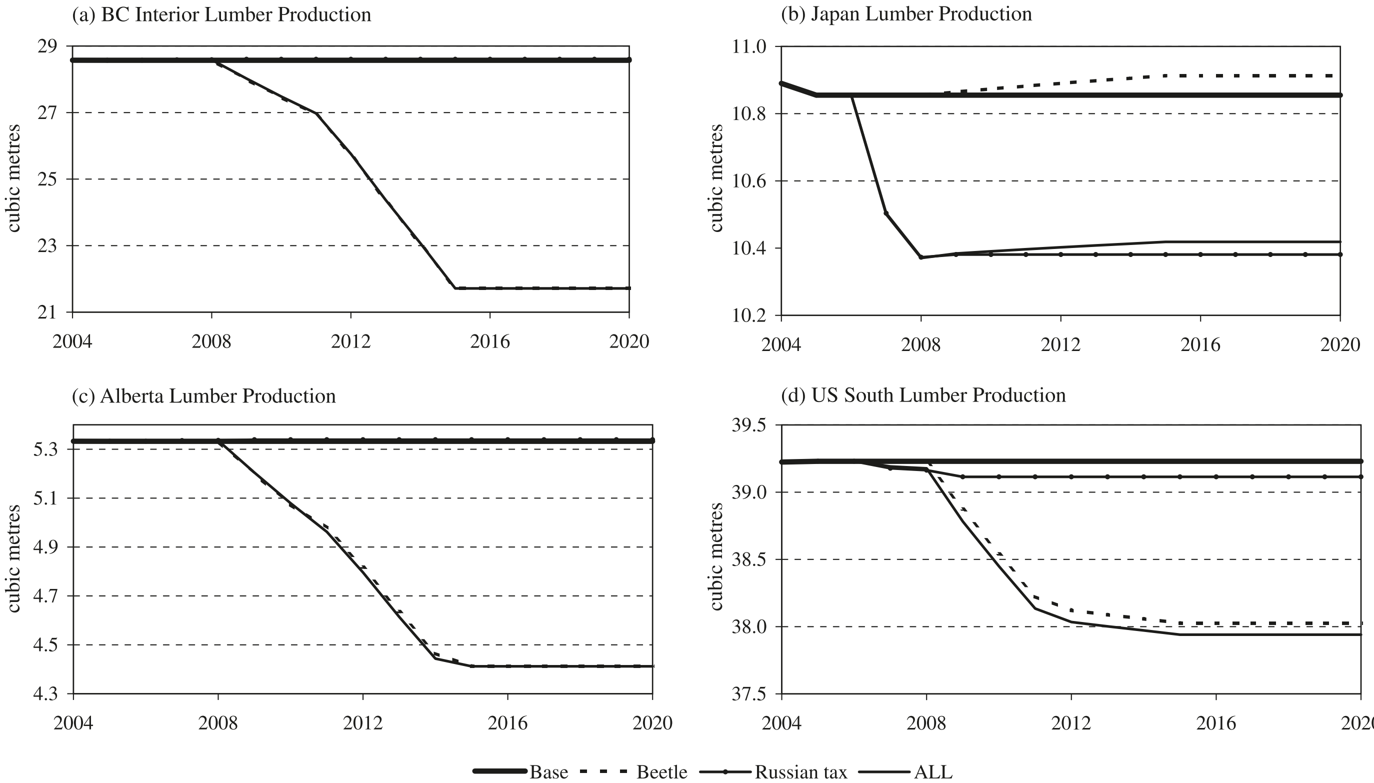
Finally, the model is calibrated as described in Stennes and Wilson (2005) and Mogus et al. (2006). Indeed, a model of this type is automatically calibrated to the base year prices, quantities and trade flows if these and prior information on the supply and demand elasticities are used to construct the demand and supply functions, as is the case here.

Results

As the focus region of our analysis was BC, we present a comprehensive set of model results for BC and selected results for Japan, the US South, and Alberta, as these aid our understanding of the BC results. We do not provide results for the "growth in global timber supply" scenario, as this scenario is difficult to distinguish from either the base case or Russian tax scenarios in graphs for the regions for which we provide results. The effect of increased timber harvests in Chile, New Zealand, Sweden, and Australia can be deduced from the "all factors" scenarios. Further, although the simulations are to 2029, we present results only for 2004–2020.

Figure 1 depicts the prices of sawlogs and lumber in the BC interior and BC coast under each of the four scenarios. For the BC interior, log prices under the base case and beetle-induced timber shortage scenarios show a rise from just over $\$85{\cdot}m^{-3}$ in 2004 to just under \$98 in 2015 and thereafter. As noted, the effects of the Russian tax and global timber supply growth are almost indistinguishable from the base case, with the former causing a \$0.35 rise in the price of sawlogs and the latter a \$0.01 decrease (Fig. 1*a*). The beetle-induced shortage will have a smaller effect on the price of lumber (Fig. 1*c*) than on the price of logs (Fig. 1*a*), as lumber prices will increase by about $\$1.50{\cdot}m^{-3}$. However, the Russian tax will affect lumber prices more than log prices, increasing lumber prices by about $\$0.65{\cdot}m^{-3}$. The global growth in timber supply (not shown) has a minimal effect on the BC interior lumber price, while the total effect from the all-factors scenario will see

Fig. 2. Lumber production in the British Columbia (BC) interior, Japan, Alberta, and the US South under various scenarios.



a $\$2{\cdot}m^{-3}$ increase by 2015. Lumber production results for the BC interior (Fig. 2*a*) will be unaffected by all but the beetle-induced shortage scenario, in which case lumber production will decline in parallel with the exogenous timber supply decrease.

For the BC coast region, the beetle-induced timber shortage will have the largest impact on sawlog price, increasing it by about $\$3.50{\cdot}m^{-3}$ (Fig. 1*b*). The Russian export tax will cause the coast sawlog price to rise by $\$0.35{\cdot}m^{-3}$, similar to its effect on the interior price. The beetle-induced timber shortage will cause a $\$1.50{\cdot}m^{-3}$ increase in the price of lumber, while the Russian export tax will cause a $\$0.65{\cdot}m^{-3}$ increase (Fig. 1*d*). Under the global growth scenario, neither the log nor lumber prices in the coast region will deviate meaningfully from the base case (not shown).

Although not provided here, model results indicate that BC coast lumber production will fall from 2009 to 2011 as a result of the beetle-induced timber shortage. This will occur because some coastal logs will be diverted to the interior to replace those lost from the decrease in interior harvests. The Russian tax will cause a slight increase in BC coast lumber production, while the effect of global growth will have a negligible impact.

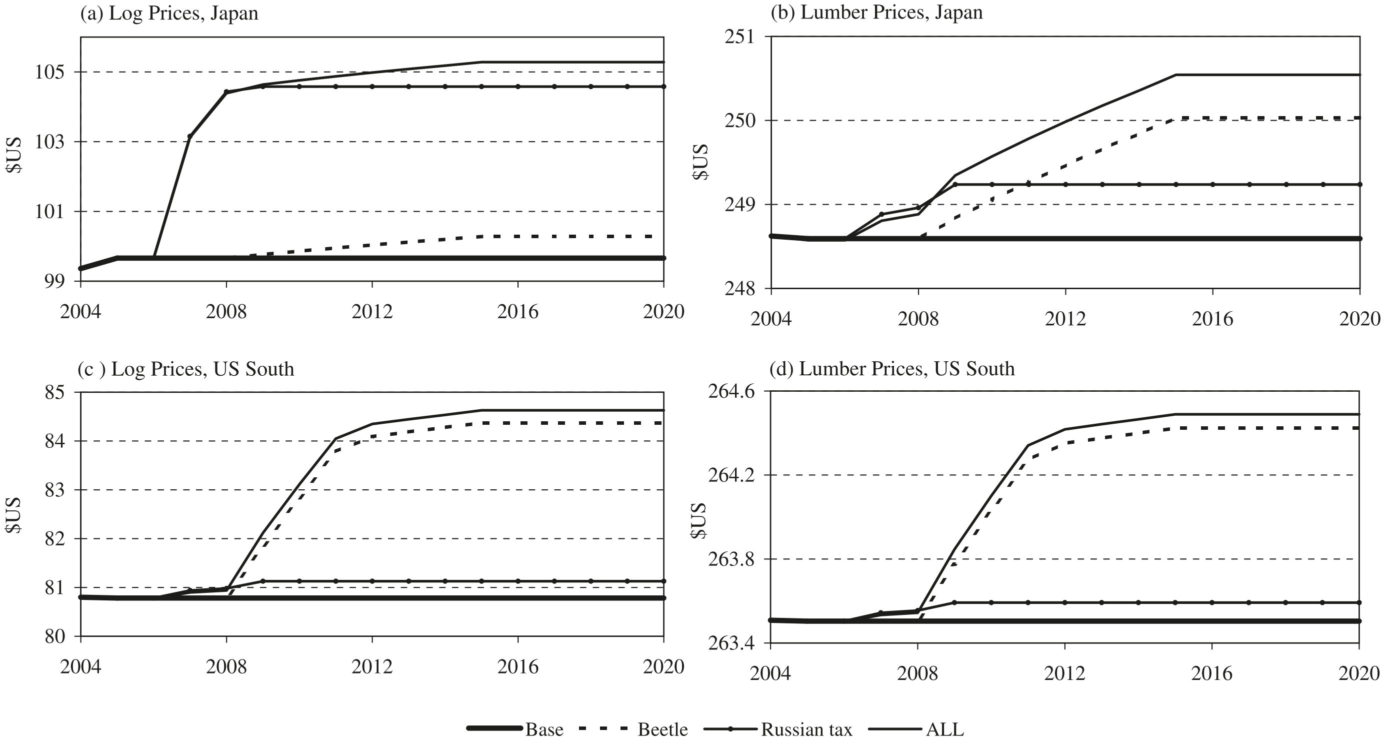
The production of lumber in Alberta is predicted to decline as result of the beetle-induced timber shortage because some logs will be diverted to the BC interior (Fig. 2*c*), as in the case of the BC coast. This result implies that the otherwise idle mills in the BC interior are efficient enough, in comparison with the least efficient mills in surrounding regions, that the cost of transporting logs to them is recouped when lumber is manufactured there.

In the US South, lumber production will fall in all cases, with the greatest decline caused by the pine beetle infestation in the BC interior (Fig. 2*d*). This is surprising because lumber prices in the US South will actually increase but only by about $\$0.10{\cdot}m^{-3}$ in the case of the Russian log export tax, by about $\$1{\cdot}m^{-3}$ in the all-factors scenario, and by a little less than $\$1{\cdot}m^{-3}$ in the beetle-induced timber shortage scenario (Fig. 3*d*). The decline in lumber production is related solely to the increase in the price of sawlogs (Fig. 3*c*) — log prices will increase by upwards of 5% compared with a lumber price increase of less than 0.5%.

The situation in Japan is similar in some respects to that of the US South in that log prices will increase by much more in relative terms than lumber prices (compare Figs. 3*a* and 3*b*). The effects of the Russian tax and the beetle-induced shortage on Japanese sawlog prices are both meaningful, but in contrast to the BC regions, the Russian export tax will have a far bigger impact on prices than the timber shortage will. The Russian export tax will cause a $\$5{\cdot}m^{-3}$ increase in the price of logs compared with a $\$0.60{\cdot}m^{-3}$ increase due to the timber shortage. This is not surprising since BC logs are of secondary importance in Japan compared with Russian logs. In contrast, the effects of the timber supply shocks on Japanese lumber prices will be very comparable to their effects on lumber prices in BC, e.g., the beetle-induced timber shortage will have the biggest impact on price (Fig. 3*b*). This is perhaps indicative of a more prevalent global market for lumber than logs. Indeed, the decline in timber supply caused by the pine beetle actually leads to a slight increase in Japanese lumber production compared with the base case (Fig. 2*b*).

Compared with the other regions, Japan will be hurt disproportionately more by the Russian tax on log exports, as

Fig. 3. Log and lumber prices for Japan and the US South under various scenarios.



seen by the large hike in log prices faced by Japanese mills as a result of the tax (Fig. 3*a*) and by the subsequent drop in lumber production by nearly 500 000 m^3 (Fig. 2*b*). Japan relies to a much larger extent than North America or the Southern Hemisphere on log imports from Russia. With the exception of Asia (as represented by Japan) and some Scandinavian countries (especially Finland), other regions do not import Russian logs. In most cases, distances are too large and this is reflected in our model. Nonetheless, the export tax will have some impact on other regions through the prices of both logs and lumber.

Discussion and conclusions

In general, the results show that the projected decline in the BC timber supply and the Russian log export tax will cause the prices of sawlogs and lumber to increase in BC, whereas an expected growth in the world's timber supply will not substantially affect BC prices. The effect on prices as a result of a drop in the BC interior timber supply due to the mountain pine beetle infestation will be greater than the effect of the Russian sawlog export tax. In terms of lumber prices, the effect of the reduction in timber supply will be roughly double the effect of the Russian tax; in terms of sawlog prices, the effect of the Russian tax will be smaller than that of the decline in timber supply.

Earlier we suggested that price increases could potentially mitigate some of the effect of a 20% decrease in timber supply. The results of this study indicate that the net increase in the price of lumber from all of the factors analyzed will be about \$2·m^{-3}, or less than 1%. This is unlikely to mitigate the effect of the timber supply decrease on the lumber manufacturing sector. The net increase in the price of sawlogs in the BC interior will be more than \$12·m^{-3}, or about 13%. This indicates that there is some potential for mitigation of losses to timber resource owners (primarily the provincial government) from declining timber sales.

Our results also suggest that the timber supply reduction in the BC interior will impact forest product prices globally. Indeed, the Japanese results show that the price of lumber in that country will be impacted more by the supply decrease than by the Russian sawlog tax. This is not the case for North American regions outside BC, where the Russian export tax will have a negligible effect on lumber prices and a small effect of perhaps 5% on log prices. However, the US South will see a small reduction in lumber production because of the Russian tax, while a jurisdiction like Alberta will be essentially unaffected.

Future research will need to expand the model to include more forest products, as other forest product sectors use coproducts from sawmills and are thereby affected by reduced timber supplies. As a result of work by Mogus et al. (2006), the model may need to examine different species of logs. This would require much more detailed data for the BC interior and coast. To our knowledge such data do not exist, but if they were available this would be a good extension of the research. Another extension is to experiment with different scenarios regarding the BC timber supply decrease. We have used a baseline scenario in this study; in reality, however, there is uncertainty regarding how long salvage harvesting will be able to continue.

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Appendix A

Data and sources

The data used to calibrate the relations in the model came from a variety of sources. The lumber consumption and production data are found in Tables A1 and A2, respectively, while information about log supply is provided in Table A3. Transportation cost data are provided in Table A4.

All data on Price Elasticity of Lumber Demand, Base Lumber Price, Recovery Rate, Base Manufacturing Cost, and Elasticity of SawLog Supply are from the GFPM (available from http://forest.wisc.edu/facstaff/Buongiorno/book/GFPM.htm). For the US and Canadian regions, those series are assumed to be uniform throughout the country. All other non-Canadian and non-US data are also borrowed from the GFPM. Canadian regional harvest data are from the Canadian Compendium for Forest Statistics (National Forestry Database 2007) and from CANSIM II Table 303 0009 (available from Statistics Canada at http://cansim2.statcan.gc.ca/cgi-win/cnsmcgi.pgm?Lang=E&CII_DDSect=301&CII_Blurb=DIRBLURBS&ResultTemplate=CII/CII_Dir&RootDir=CII/). US Regional data are from the United States Census Bureau (2007). Additional information is available from FAOSTAT (2008) and, for BC, from PriceWaterhouseCoopers (2004).

Transport costs come from two sources: one for shipping by land and the other by sea; calculation was required. For some regions, calculations involved only land or sea shipping, but often a combination of the two was used. For example, shipping from Alberta to Japan includes shipping first by land to BC, then by sea to Japan. Ground shipping costs were calculated based on the method used by Mogus et al. (2006), in which a loading cost and a per kilometre cost are calculated for each cubic metre shipped. For sea shipping, container shipping costs compiled by Rodrigue (2005) between the major continents are used. Per cubic metre costs of shipping between continents are based on the cost of shipping a container and the volume of a container. This data set is especially useful as the transport costs reflect direction-based cost differences caused by trade imbalances.

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Table A1. Lumber consumption.

Region	Price elasticity	Base lumber price ($·m^3)	Base lumber consumption (m^3)
Japan (JAP)	–0.16	258.06	21 805 000
US North (USN)	–0.16	253.00	47 643 916
US South (USS)	–0.16	253.00	52 976 336
US West (USW)	–0.16	253.00	32 377 312
BC interior (BCI)	–0.16	228.00	976 700
BC coast (BCC)	–0.16	228.00	3 093 000
Alberta (ALTA)	–0.16	228.00	3 726 204
Atlantic Canada (AC)	–0.16	228.00	1 497 892
Rest of Canada (ROC)	–0.16	228.00	14 868 000
New Zealand (NZ)	–0.16	228.00	2 581 000
Australia (AUS)	–0.16	265.65	3 549 000
Chile (CHL)	–0.21	228.00	5 496 438
Sweden (SWE)	–0.16	228.00	5 696 830
Finland (FIN)	–0.16	228.00	5 592 708
Russia (RUS)	–0.14	228.00	6 567 000
Rest of Europe (REUR)	–0.17	205.61	82 097 521
Rest of Latin America (RLAT)	–0.56	244.57	15 155 919
Rest of Asia (ROA)	–0.21	276.43	33 329 328
Rest of world (ROW)	–0.20	249.21	7 776 053

Table A2. Lumber production data.

Region	Lumber recovery factor	Base manufacturing cost ($/m^3)	Base lumber production (m^3)
Japan	0.806	152.66	13 263 000
US North	0.674	146.12	4 503 087
US South	0.674	146.12	39 904 808
US West	0.674	146.20	40 653 552
BC interior	0.607	88.12	33 591 000
BC coast	0.607	88.12	6 288 300
Alberta	0.607	88.12	7 812 200
Atlantic Canada	0.607	88.12	5 562 900
Rest of Canada	0.607	88.12	29 519 200
New Zealand	0.714	127.20	4 406 000
Australia	0.752	169.89	5 351 000
Chile	0.618	111.55	7 754 000
Sweden	0.495	54.58	16 740 000
Finland	0.613	88.06	13 460 000
Russia	0.602	108.31	18 770 000
Rest of Europe	0.670	134.77	72 436 007
Rest of Latin America	0.517	93.53	14 159 800
Rest of Asia	0.730	167.46	25 633 671
Rest of world	0.560	118.97	3 640 811

Table A3. Log supply data.

Region	Elasticity of log supply	Sawlog to harvest ratio	Base sawlog consumption (m^3)	Base harvest (m^3)
Japan	0.80	0.31	16 455 335	13 167 000
US North	1.60	0.34	6 681 138	19 255 000
US South	1.60	0.34	59 205 947	184 229 000
US West	1.60	0.34	60 316 843	81 495 000
BC interior	0.80	0.95	55 339 374	58 063 000
BC coast	0.80	0.53	10 359 638	25 911 000
Alberta	0.80	0.51	12 870 181	14 252 000
Atlantic Canada	0.80	0.51	9 164 580	15 990 000
Rest of Canada	0.80	0.51	48 631 301	54 417 000
New Zealand	0.80	0.46	6 170 868	14 802 000
Australia	0.80	0.45	7 115 691	19 614 000
Chile	1.40	0.48	12 546 926	26 103 000
Sweden	1.53	0.45	33 818 182	57 800 000
Finland	1.50	0.32	21 957 586	43 225 000
Russia	1.31	0.50	31 179 402	101 000 000
Rest of Europe	1.36	0.45	108 113 443	184 561 976
Rest of Latin America	1.40	0.45	27 388 395	54 605 645
Rest of Asia	1.40	0.45	35 114 618	74 946 418
Rest of world	1.40	0.45	6 501 448	12 276 400

Table A4. Transportation cost per cubic metre.

Region	NZ	AUS	CHL	SWE	FIN	RUS	REUR	RLAT	ROA	ROW	JAP	USN	USS	USW	BCI	BCC	ALTA	AC	ROC
JAP	42.88	37.97	83.56	52.67	52.67	52.67	52.67	89.87	10.17	71.49	0.00	94.65	86.60	72.07	60.03	56.45	63.61	100.15	89.71
USN	68.86	77.56	40.05	23.88	23.88	23.88	23.88	37.29	63.02	60.94	63.02	0.00	22.83	38.94	35.46	38.59	32.32	9.84	5.96
USS	57.83	67.02	36.35	23.88	23.88	23.88	23.88	38.27	46.89	67.20	46.89	22.83	0.00	22.07	29.86	31.58	28.15	32.08	20.96
USW	50.90	58.54	43.65	45.95	45.95	45.95	45.95	48.06	24.82	77.87	24.82	38.94	22.07	0.00	18.40	17.49	19.32	46.87	34.61
BCI	56.59	62.26	50.61	59.34	59.34	59.34	59.34	53.60	28.68	78.13	28.32	35.46	29.86	18.40	0.00	5.27	5.27	40.42	30.11
BCC	55.08	60.63	51.19	62.47	62.47	62.47	62.47	50.60	24.82	79.76	24.82	38.59	31.58	17.49	9.64	0.00	12.84	43.70	33.26
ALTA	58.10	63.89	50.03	56.20	56.20	56.20	56.20	51.32	32.53	76.50	31.98	32.32	28.15	19.32	6.64	9.84	0.00	37.14	26.95
AC	73.39	81.57	42.26	33.72	33.72	33.72	33.72	37.71	64.37	58.28	68.52	9.84	32.08	46.87	40.42	43.70	37.14	0.00	12.88
ROC	67.36	75.50	41.82	29.84	29.84	29.84	29.84	39.71	54.92	63.56	58.08	5.96	20.96	34.61	30.11	33.26	26.95	12.88	0.00
NZ	0.00	10.45	46.89	82.51	80.81	78.59	88.94	58.31	50.48	57.10	42.88	68.86	57.83	50.90	56.59	55.08	58.10	73.39	67.36
AUS	10.45	0.00	55.03	75.66	73.74	70.33	82.43	64.79	43.41	53.41	37.97	77.56	67.02	58.54	62.26	60.63	63.89	81.57	75.50
CHL	46.89	55.03	0.00	63.47	65.39	68.53	56.63	92.45	12.55	38.52	83.56	40.05	36.35	43.65	50.61	51.19	50.03	42.26	41.82
SWE	82.51	75.66	63.47	0.00	4.02	11.33	13.13	52.99	22.15	50.29	22.15	43.18	43.18	65.25	78.64	81.77	75.50	43.18	49.14
FIN	80.81	73.74	65.39	4.02	0.00	8.38	16.55	54.83	22.15	50.83	22.15	43.18	43.18	65.25	78.64	81.77	75.50	43.18	49.14
RUS	78.59	70.33	68.53	11.33	8.38	0.00	22.52	54.83	22.15	49.16	22.15	43.18	43.18	65.25	78.64	81.77	75.50	43.18	49.14
REUR	88.94	82.43	56.63	13.13	16.55	22.52	0.00	57.24	22.15	46.90	22.15	43.18	43.18	65.25	78.64	81.77	75.50	43.18	49.14
RLAT	58.31	64.79	92.45	52.99	54.83	57.24	46.06	0.00	85.35	30.77	89.87	37.29	38.27	48.06	52.46	53.60	51.32	37.71	39.71
ROA	50.48	43.41	92.45	52.67	52.67	52.67	52.67	85.35	0.00	62.84	10.17	94.65	78.52	56.45	60.03	56.45	63.61	100.15	89.71
ROW	57.10	53.41	38.52	50.29	50.83	49.16	46.90	30.77	62.84	0.00	71.49	60.94	67.20	77.87	78.13	79.76	76.50	58.28	63.56

Note: The definitions for region abbreviations are available in Table A1.