Explaining post-pandemic lumber price volatility and its welfare effects

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Abstract: The COVID-19 pandemic led to an unprecedented increase in the U.S. price of softwood lumber by more than 300%. The price increase has been attributed to constraints on supply and increased demand for lumber caused by a pandemic-induced boom in domestic housing construction and, more so, home improvements. However, the volatility in lumber prices after the COVID-19 outbreak remains unexplained. In this paper, we employ a theoretical model to explain the cause of price volatility. We examine why demand and supply functions for lumber might be quite inelastic over the period from March 2020 to April 2022, despite very small shifts in demand. This implies that slight movements in interest rates or changes in the prices of substitutes, for example, can lead to large jumps in prices. Price volatility harms consumers while greatly benefitting lumber producers. Overall, as a result of the pandemic, U.S. producers gained some $5.3 billion, while U.S. consumers lost $7.3 billion per quarter.

Keywords: lumber price volatility, welfare impacts, U.S.-Canada softwood lumber trade

1 Introduction

Since the outbreak of the COVID-19 pandemic, lumber prices have risen sharply but, as importantly, have increased in volatility. Following discussions with industry insiders at the British Columbia (BC) Council of Forest Industries (COFI 2022), and with University of BC forest economists (UBC 2022), several potential issues that contributed to high and fluctuating prices were identified.

- Because of the pandemic, the demand for lumber used in repair and remodeling (R&R) now exceeds the demand for lumber in new construction (see also van Kooten and Schmitz 2022).
- Supply has become more inelastic because of the pandemic as U.S. sawmilling capacity is lagging demand. Most lumber mills are currently operating at full capacity in the U.S. and the industry is only now beginning to increase capacity.
- BC was often considered to be a residual supplier of lumber to the U.S. market in the sense that, when U.S. mills were at or near capacity, BC lumber exports increased to make up for the shortfall in the U.S. This is not happening at the current time.
- Canadian lumber exports, particularly those from BC are negatively impacted by the constraints on railroad capacity. With more petroleum being moved because of restrictions on pipeline construction, and with increased exports of other commodities such as potash moving to market by train, there has been a bottleneck in rail car movements—a supply chain problem. As a result, BC sawmills have not always been able to operate at full capacity even when plenty of logs are available in "storage;" yet, BC mills have laid off people because the mills cannot get lumber to market.

The increase in lumber prices has not yet made its way to the price of timber in the forest—log prices have remained relatively flat but have recently begun to increase (COFI 2022).

This study explores the factors that have contributed to the rapid increase in lumber prices and, in particular, to the associated volatility in prices from March 2020 to April 2022. We also examine the welfare impacts that these developments have had on producers and consumers in the United State and Canada: which parties have gained, and which have experienced a loss as a result of the rising and volatile prices? In doing so, we employ standard welfare economics theory (Just, Hueth, and Schmitz 2004) and extend the previous analysis by van Kooten and Schmitz (2022), who found that, as a result of the pandemic, U.S. producers gained up to 8 billion per quarter, while consumers suffered heavy losses.

One reason that the demand for lumber for R&R has been strong relates to the COVID-19 crisis: As a result of lockdowns, more people spent time working from home, which has led to an increased prioritization for home

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improvements projects and more expensive renovations (Alderman 2020). Low interest rates that were below rates of inflation exacerbated demand for greater housing attributes, despite increasing lumber prices (which also stoked inflationary concerns). Low interest rates also led to a booming construction market that increased demand for lumber, but perhaps to a lesser extent than expected as a large proportion of housing starts were for condominiums; along with higher lumber prices. This put a damper on the use of lumber in construction and thereby created greater demand for concrete, steel and aluminum instead.

The U.S. lumber price increased from $278.50 per thousand board-feet (mbf) in April 2020, approximately when the COVID-19 pandemic began, to $965.30/mbf in March 2022, having peaked to more than $1500/mbf in April 2021. The composite framing construction price of lumber, which under the 2006–2016 softwood lumber agreement between Canada and the U.S., was used to trigger export taxes whenever the price exceeded $355/mbf (van Kooten, Nelson, and Mokhtarzadeh 2021). This price index increased from $408/mbf in March 2020 to $1265/mbf in March 2022. The time paths of both price series are plotted in Figure 1. Not surprisingly, higher lumber prices were considered a harbinger of the rising inflation in the U.S. and elsewhere.

As previously noted, the Canadian response to higher lumber prices has been limited, partly as a result of Canada's tenure system which at times has constrained the amount of timber that forest companies can harvest within certain periods, but more recently as a result of transportation bottlenecks. Therefore, Canadian lumber production is less sensitive to price movements than production in the U.S. Further, the supply chain problems noted previously have negatively impacted Canada's ability to export lumber; while export shipments have risen, more lumber has been shipped by rail where bottlenecks are more pronounced (see Figure 2). As a result, lumber production and exports to the U.S. have declined somewhat as opposed to increasing in response to increases in the price of lumber. This is evident in Figure 3. Canada's monthly production of softwood lumber declined from 4.84 million cubic meters (m^3) (2.05 million bf)[1] in March 2020 to 4.29 million m^3 (1.82 million bf) in February 2022, while production in BC fell from 1.85 to 1.66 million m^3 during the same period. The implication for trade is important because BC accounts for about half of the country's lumber exports, most of which have been to the U.S.

Lumber prices have been highly volatile over the period 2016 to 2022, and volatility could well continue for a time based on recent past behavior. However, if the volatility is related to the COVID-19 pandemic, an examination of trends does not provide an adequate explanation for such volatility. Rather, it is necessary to have an economic model to explain why the pandemic might have led to volatile lumber prices. Although we discussed potential causes of volatile prices above, we provide a more complete model in the next section.

1 The measure mbf is used to denote thousand board feet. To avoid confusion, we spell out 'million bf' to represent mbf × 1000.

2 Theoretical Model of Price Volatility in Canada-U.S. Lumber Markets

Both the lumber demand and supply functions in Canada and the United States are thought to be highly inelastic, with supply less responsive to supply shifters (e.g., log and other input prices, prices of lumber substitutes such as aluminum studs) than demand to similar shifters (primarily prices of lumber substitutes and interest rates). However, log prices have not increased as a result of higher lumber prices, although demand for lumber does appear to be negatively impacted by higher interest rates. Carbon taxes will shift lumber demand outward because lumber is considered a carbon-neutral input in construction compared to concrete because the production of cement emits large amounts of CO_2. Likewise, European subsidies for wood pellets used in the generation of electricity will also increase demand for lumber (see Johnston and van Kooten 2015, 2016).

In Figure 4, we provide a model of Canada-U.S. trade to explain the observed volatility in softwood lumber prices since March 2020. The respective softwood lumber demand functions for Canada and the United States are denoted by D_C and D_U, while supply functions are denoted by S_C and S_U. Since Canada is a net exporter, the Canadian excess supply function (ES_C) needs to be added to the U.S. domestic supply function to give the total supply S_T. Assuming no shipping and handling costs, the equilibrium price P^0 is determined by the intersection of S_T and D_U at point e—this is the price facing domestic consumers in both Canada and the U.S.[2] At P^0, Canadians consume q_d

2 For simplicity and without hindering our explanation, we ignore shipping and handling costs. These would vary considerably in any event, and not just across the U.S.-Canada border as trade occurs among regions in the U.S. as well as among regions in Canada and those to the south. The price index used in the Softwood Lumber Agreement (2006–2016) and provided in Figure 1 is a single price that is also used in our analysis.

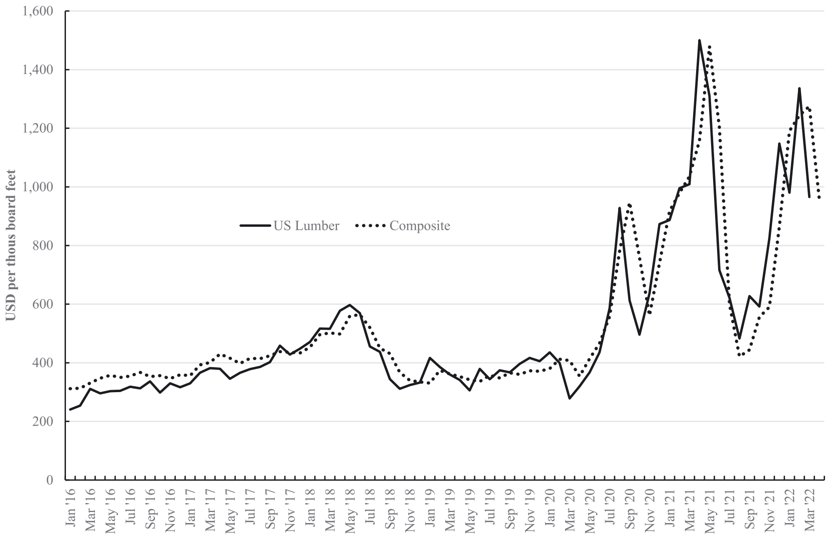

Figure 1: Monthly prices of lumber sold in the U.S. and the composite framing price index in USD, January 2016 through April 2022. Source: Statista (2022) and Random Lengths (various issues).

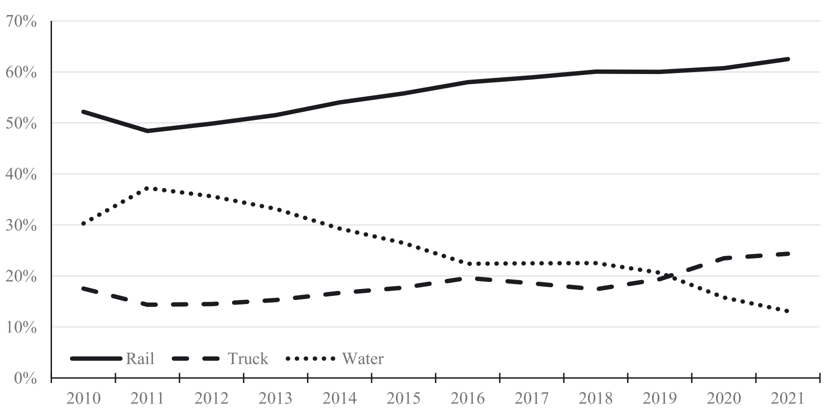

Figure 2: Canadian lumber exports to the United States by mode of transportation, 2010–2021.

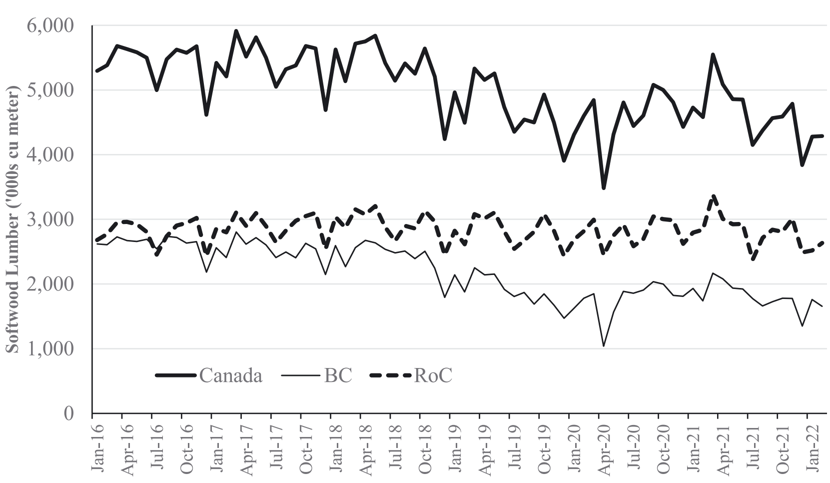

Figure 3: Monthly softwood lumber production ('000 s m^3), BC, rest of Canada, and Total Canada, January 2016 through February 2022. Source: BC council of forest Industries (2022)

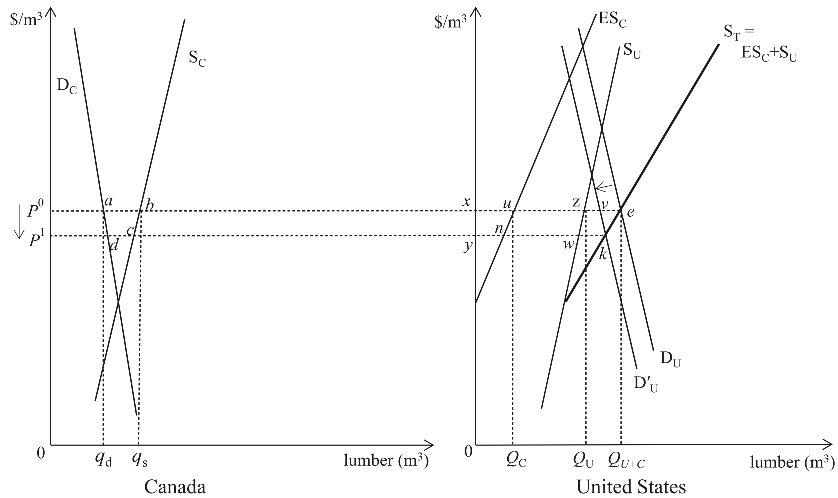

Figure 4: Theoretical model explaining demand driven price volatility.

lumber, while Canada produces an amount q_s; the U.S. produces Q_U and consumes Q_{U+C}, with Q_C ($=q_s - q_d$) imported from Canada.

Suppose that the demand for lumber in the U.S. domestic market falls slightly due to an increase in interest rates—the U.S. demand function shifts from D_U to D'_U (as indicated by the arrow) and the market clearing equilibrium shifts from point *e* to point *k*. There is a very small reduction in U.S. consumption as a result of the shift from equilibrium *e* to *k*, with an accompanying but almost insignificant increase in Canadian consumption going from point *a* to *d*. Both Canadian and American lumber producers slide down their supply functions, although the actual reduction in each country's production is tiny. Yet, compared to the changes in production and consumption, there is a significant decrease in price from P^0 to P^1 (as indicated by the arrow in the right-side panel). Conversely, if the shift in U.S. domestic demand is from D'_U to D_U, there would be small increase in overall production and consumption, although consumption in Canada would fall by an insignificant amount.

We can also examine the welfare implications of a shift in U.S. demand from D_U to D'_U. In Canada, consumers would gain an area bounded by (P^0P^1da) and producers would lose a surplus given by area (P^0P^1cb); overall, the net loss in Canadian wellbeing is given by area (*adcb*) which is equal to area (*xynu*) in the right-side diagram. American consumers would gain area (*xykv*), with U.S. producers losing quasi-rent equal to area (*xywz*). The redistribution of income caused by shifts in a rather inelastic demand function when supply is rather stable and inelastic is quite large.

3 Measuring Price Variability and Welfare Effects

We begin with the most recently available price and production data for Canada and the U.S. In Figure 5, we plot U.S. and Canadian production of softwood lumber, and the composite price for the pandemic period. As we employ abductive reasoning, we can employ linear demand and supply functions (Takemura 2020). Notice that lumber production by both Canada and the United States was rather constant throughout the pandemic period, although it began with an initial dip and recovery at the beginning of the period. In contrast, prices were unstable after the first two pandemic months, rising rapidly and then exhibiting erratic behavior.

To implement the theoretical model provided in the previous section, and to examine the welfare impacts of shifts in demand and the subsequent effects on prices, we employ Figures 6 and 7, respectively, for Canada and the United States, and the data found in Table 1. These figures are simplified versions of the country-level supply and demand shifts described in Figure 4. As indicated in Figure 6, it is clear that there was an outward shift in the domestic demand for Canadian softwood lumber. However, there did not appear to be an inward shift of the domestic supply function; rather, the data indicate that manufacturers were able to increase the supply of lumber by 7.7%, probably by relying on their inventory of logs to produce additional lumber. Nonetheless, it is clear that the supply of lumber function is quite inelastic.

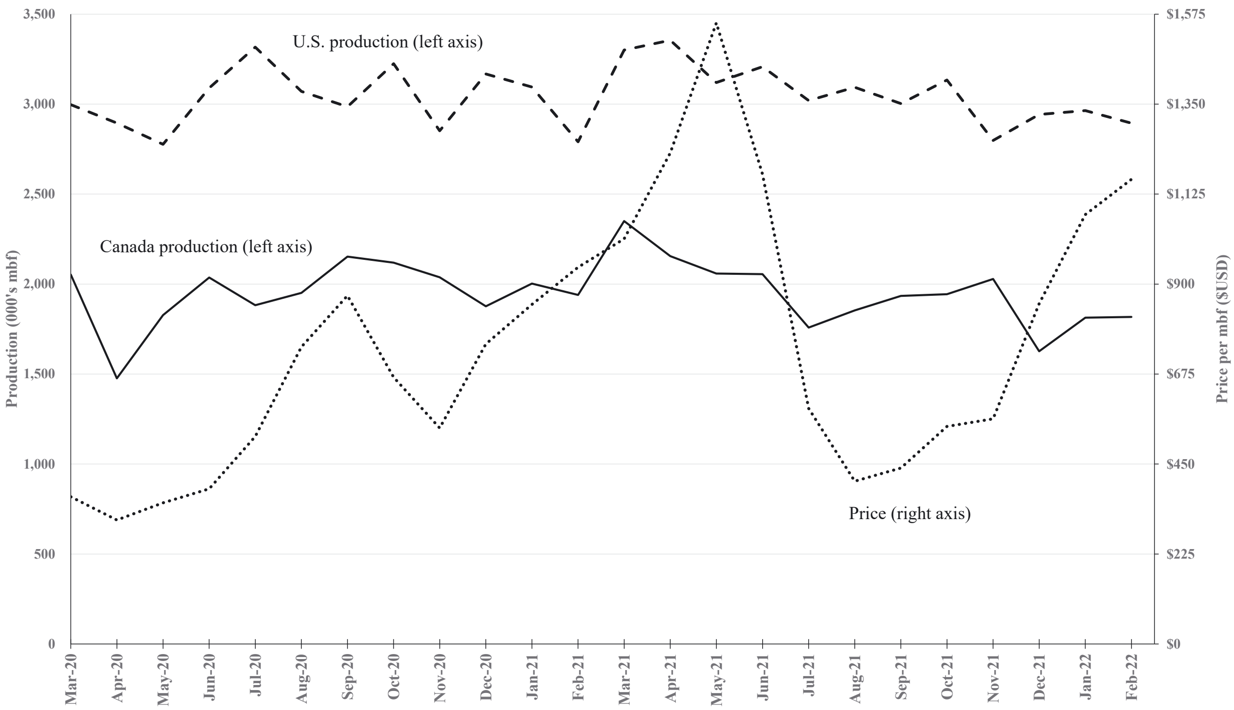

Figure 5: Monthly price and production of softwood lumber in Canada and the U.S., March 2020 through February 2022. Source: BC council of forest Industries (2022), Madison's Lumber Reporter (2020, 2021, 2022).

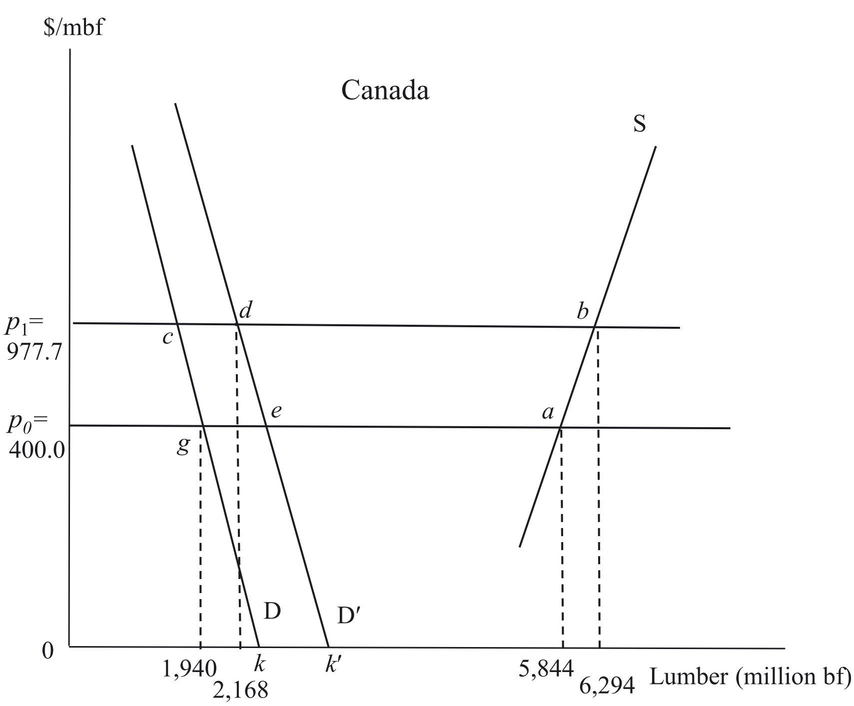

Figure 6: Diagrammatical representation of the price and quantity changes in Canada due to COVID-19.

The change in the welfare of Canadian lumber processors is determined by the area bounded by the points (p_1p_0ab) in Figure 6. This measures the quasi-rent or producer surplus that accrues to processors, which they then set against fixed investments, but only if the price that processors pay for logs remains constant. If the price of logs in the upstream market increases because processors bid higher prices for stumpage, some of the benefits we have identified would accrue to

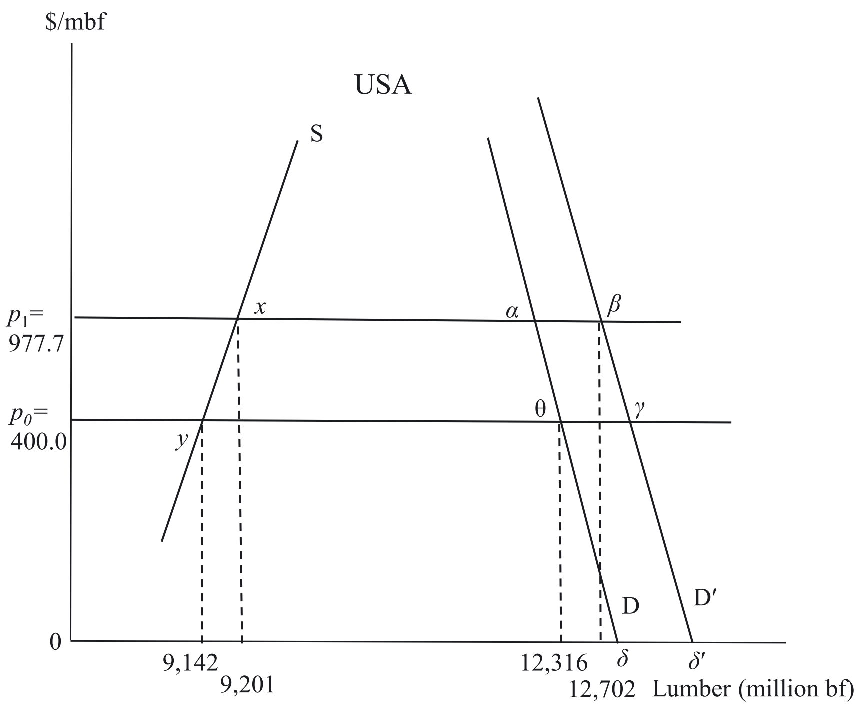

Figure 7: Diagrammatical representation of the price and quantity changes in the United States due to COVID-19.

Table 1: Changes in consumption, production, exports and prices, softwood lumber, 1st Q 2020, 1st Q 2021, and January – February 2022, millions of board feet ('000 s mbf).

	2020	2021	2022		2020	2021	2022
Production				**Exports**			
U.S. total	9142	9201	5858	Canada to U.S.	3072	3430	3127
				Canada total	3755	4240	3591
British Columbia	2253	2474	1447	U.S. to Canada	161	387	348
Rest of Canada	3591	3820	2183	U.S. total	1775	1119	921
Canada total	5844	6294	3630				
				Consumption			
				U.S.	12,316	12,702	
Price (US$/mbf)	$400	$977	$1118	Canada	1940	2168	

Source: BC Council of Forest Industries (2022), and Madison's Lumber Reporter (2020, 2021, 2022) monthly reports.

landowners. In that case, the correct measure of benefits would require knowledge of the changes (elasticities of supply and demand) in the upstream log market.

For American producers of US soft-wood lumber, the situation is like to that of Canada (Figures 4 and 7), except that the U.S. is a net importer of lumber. The domestic supply function, S, could not possibly have shifted inward, although it is clearly quite inelastic. Again, there is a Covid-induced shift in demand for lumber due to the increase in construction and R&R activity. In Figure 7, the difference between domestic supply and demand is met with imports of $y\theta$ from Canada prior to the pandemic and $x\beta$ once COVID-19 lockdowns were in place.

3.1 Welfare Impacts

Using data from Table 1, we examine the welfare impacts of shifts in demand and the subsequent effects on prices. U.S. softwood lumber consumption increased by only 3.1% from 1st Q 2020 to 1st Q 2021, while Canadian consumption rose by 11.8%. U.S. lumber production went up by 0.6% over that period, while Canadian production increased by 7.7%. On a relative basis, Canadian changes were larger than those in the U.S.

Consider first the welfare effects in Canada. If we assume that log prices do not change, then Canadian lumber producers would gain a surplus of some $3506 million

(= 5844 × 577.7 + ½ × 577.7 × [6294–5844]), one-third of which is earned in export markets. Overall, Canadian softwood lumber producers gained some $3.5 billion in the 1st Quarter of 2021 compared to 2020.

Now consider the change in the wellbeing of Canadian consumers of lumber. The domestic demand functions for lumber constitute derived demands as softwood lumber is employed in construction, furniture making and other downstream uses.[3] Assume that the price is at $400/mbf at the time that there is an outward shift in domestic demand. This results in a gain in surplus given by (*gkk′e*) in Figure 6. Then, when the price of lumber increases to $977.7/mbf, there is a loss of surplus equal to (p_1p_Oed).[4] The overall welfare change is given by ($gkk'e - p_1p_Oed$), which can result in a net gain or loss depending on the elasticities of the derived domestic demand functions. If we assume where $\varepsilon_d = -0.2$, then consumers would lose $1175 million dollars.

Turning to the pandemic-induced welfare effects of a small shift in demand on U.S. producers and consumers, we find that, based on the model described by Figure 7, U.S. lumber producers would gain (p_1p_Oyx), or $5298 million per quarter, if log prices remained constant (as noted previously). That is, U.S. producers may have gained some $5.3 billion despite the fact that imports of lumber from Canada accounted for 27% of U.S. domestic consumption. If this situation were to prevail for the entire year, U.S. lumber manufacturers would gain some $21.2 billion in added surplus.

The price volatility that results from the COVID-19 induced shift in demand harms U.S. consumers the most. Like Canada, the domestic demand function is composed of derived demands for various uses. We again assume that price is at $400/mbf at the time of the outward demand shift. The results in a surplus given by ($\theta\delta\delta'\gamma$) in Figure 7. The shift in price to $977.7/mbf once again creates a loss in surplus given by ($p_1p_O\gamma\beta$). The overall change in welfare for the U.S. if we assume $\varepsilon_d = -0.2$ is given by ($\theta\delta\delta'\gamma - p_1p_O\gamma\beta$) which results in a loss to U.S. consumers of $7301 million dollars per quarter.

The overall welfare effects of the pandemic on the Canadian and the U.S. lumber markets are provided in Table 2. To calculate these values, we derived the Canadian excess supply function as found in Figure 4. Again, the pre-pandemic price, p_O, is given by the average lumber price in January to March, 2020—a price of $400 per mbf. The pre-pandemic quantity, q_O, is given by the total net imports by the U.S. from Canada across the same time period, which is 2977 million board feet.[5] The post-pandemic price, p_2, is given by the average lumber price in January to March 2021, which equates to $978 per mbf. The post-pandemic quantity (net imports) is assumed to remain at its previous level of q_O. Net imports in the first three months of 2021 were 10% higher than those in the same three months of the previous year. These differences are negligible compared to the 145% increase in price. The small supply response (price inelastic lumber supply curve) is largely due to quantity constraints (e.g., pandemic-induced labor shortage, Canada's AAC constraints, monopoly power in the U.S., etc.).

3.2 Price Volatility

As noted above, lumber prices have been volatile throughout the last two years. To analyze the effects that shifts in demand have on the price of lumber, we again consider the simplified diagrammatical models of supply and demand in Figures 6 and 7. Looking at U.S. and Canadian markets separately, we impose a 15% increase in demand from pre-pandemic levels for Canada, and a 5% increase in demand for the U.S, which result in similar induced prices ($1137/mbf and $1132/mbf, respectively). These small changes in the quantity demanded in each country give rise to large changes in prices in each of the respective domestic markets. A summary of the welfare impacts from these demand shifts can be found in Table 3.

To arrive at the welfare changes found in Table 3 and without loss of generality, we simply examine shifts in the demand for lumber in each of the Canadian and American markets separately, ignoring the impact this might have on imports and exports. For example, even a 15% increase in

Table 2: Welfare effects from an outward shift in demand for lumber due to COVID-19, $ millions.

Change in welfare	Canada	United States	Total
Producer surplus	3506	5298	8804
Consumer surplus	−1175	−7301	−8476

Source: Authors' calculations.

3 It is unclear whether R&R constitutes a final demand for lumber as opposed to a derived demand.

4 Consumer surplus measures are path dependent in this case. Compared to the areas identified in the text, one could first increase the price, measure the loss in consumer surplus by area (p_1p_Ogc), and then measure a gain in surplus given by the area between D and D′ at the higher price, namely area (*ckk′d*), so the overall change in consumer surplus equals ($ckk'd - p_1p_Ogc$).

5 It is difficult to find consistent export and import data, with data from Random Lengths (various issues) used here. See also discussion that follows (Section 3).

Table 3: Welfare effects from various shifts in demand for lumber, $ millions.

Country	Assumed change in quantity demanded	Producer surplus	Consumer surplus[a]	Total[a]
Canada	15%	4521	−1566	2955
	−5%	−1453	0.227	−1453
United States	5%	8,496	−12,118	−3622
	−1%	−1689	1584	−105

[a]Given path dependency in calculating consumer surplus, the change in Canadian and U.S. consumer surpluses are given in the text by areas ($gkk'e - P_1P_0ed$) and ($\theta\delta\delta'\gamma - P_1P_0\gamma\beta$). An alternative measure is given by areas ($ckk'd - P_1P_0gc$) and ($\alpha\beta\delta\delta' - P_1P_0\theta\alpha$), respectively. Source: Authors' calculations.

the demand for lumber by Canadians is relatively small compared to the North American market for lumber.

Consider first the Canadian lumber market. Keeping the same assumption of a base domestic demand of 1940 million bf prior to the COVID-19 shift, and 2168 million bf after, the increase in demand is 11.8%, and the corresponding price of $977.7/mbf represents a 144% increase. Broken down further, this implies that a 1% increase in domestic demand leads to a subsequent increase in price of 12.3%. Using these values to form a basis for increasing demand, a shift of 15% in demand (to 2231 million bf) raises domestic prices to $1137.3/mbf. Due to the large increase in price, Canadian lumber producers gain a surplus equivalent to $4520 million dollars, an increase of $1.01 billion dollars when compared to the model in Figure 6. That is, Canadian producers gain an additional $4.5 billion dollars because of a 15% increase in domestic demand (compared to pre-pandemic levels).

Now consider the change in the welfare of Canadian consumers of lumber. The outward shift in demand first results in a gain in surplus, although the rise in price creates a loss. The overall change in welfare is a net loss to consumers of $1566 million dollars, an increase in loss of $391,000 when compared to Figure 6. That is, Canadian consumers would lose $1.5 billion dollars as a result of the shift in demand.

In the U.S. market, the relationship between shifts in demand and increases in price is stronger than in Canada. Using the same pre-pandemic price and quantity values, the shift in demand from 12,316 million bf to 12,702 million bf (Figure 7) equates to a 3% increase in demand but a corresponding 144% increase in price. Compared to Canada, the shift in demand is 275% smaller and results in the same increase in price. Broken down, for a 1% increase in demand there is an increase in price of 46%. Due to this increased responsiveness to demand changes, a smaller increase (5% in the U.S. vs 15% in Canada) was used. The 5% increase resulted in a new quantity demanded of 12,931 million bf and corresponding price of $1321.63 for the U.S. market. The increase in price results in large quasi-rents for U.S. producers. The additional surplus from the increase in demand is $8496 million in the model. Yet, U.S. consumers of lumber once again experience large losses due to the change in price. The loss in consumer surplus in the model amounts to $12,118 million.

Alternatively, the sensitivity to demand changes could result in a reversal of the surplus distribution if there was a slight decrease in demand. Using a pre-pandemic price of $400/mbf, if demand in the U.S. dropped by 1% the resulting price decrease would be 46% (as stated previously), resulting in a price of $215.70/mbf. The decrease in price reverses the distribution of surplus from the previous two scenarios. U.S. lumber producers lose $1.69 billion, and consumers gain $1.58 billion. In Canada, the reduced sensitivity allows for a slightly larger decrease of 5% to result in a similar price for $154.22/mbf. The resulting surplus is a loss of $1.45 billion dollars for producers, and a gain to consumers of $0.23 million. These large price fluctuations demonstrate the large impact that small changes in demand have on the U.S. and Canadian lumber markets.

4 Conclusions

Much has been made of the increase in lumber prices resulting from pandemic-induced lockdowns. This has increased the demand for lumber, both because of increased repair and remodeling (or do-it-yourself) demand as buyers shifted expenditures from restricted activities, but also as a result of highly inelastic supply and increased demand for other commodities that employ lumber as an input, such as housing. In this study, we employed an economic model that could account for price variability to examine the potential welfare impacts of these shifts. We find that very small shifts in lumber demand could result in large changes in lumber prices, as witnessed over the period since March 2020. As a result, producers tended to experience very large surpluses, while consumers generally saw a reduction in surplus. As noted by van Kooten, Schmitz, and Kennedy (2021), Schmitz and Chigini (2020), and Schmitz (2021), consumers tended to lose as a result of price volatility.

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