Covid-19 and Softwood Lumber Price Movements

by

Rebecca Zanello
BSc in Agriculture, University of Alberta, 2020

An Extended Essay Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTER OF ARTS
in the Department of Economics

We accept this extended essay as conforming
to the required standard

Dr. G.C. van Kooten Supervisor (Department of Economics)

Dr. Peter Kennedy, Member (Department of Economics)

Table Of Contents

ABSTRACT

The Covid-19 pandemic led to unprecedented changes in the U.S. price of softwood lumber by more than 300% between 2020 and 2022 (van Kooten and Schmitz, 2022). The increased volatility of lumber prices after the Covid-19 outbreak remains unexplained. This essay examines why demand and supply functions for lumber might be quite inelastic, with even small shifts in demand resulting in large jumps in prices. We also find that price volatility harms consumers while greatly benefitting lumber producers. Overall, we find that U.S. producers gained some $5.3 billion, while U.S. consumers lost $7.3 billion per quarter as a result of the pandemic. Separately, we also employ an event model to estimate the impact of Covid and other key events on the price of softwood lumber. The econometric model serves to provide evidence that the price volatility of softwood lumber is not completely random, and we can instead attribute part of the variation to recent regional and global events. We find that while Covid did result in a price jump (van Kooten and Schmitz, 2022), it was smaller than a rainfall event that restricted exports from Canada, while import duties and other trade action had no discernible impact on U.S. lumber prices.

1. INTRODUCTION

Since the outbreak of the Covid-19 pandemic, lumber prices have risen sharply but, as importantly, have increased in volatility. Several potential issues that contributed to high and fluctuating prices were identified by van Kooten et al. (2022). Because of the pandemic, the demand for lumber used in repair and remodeling (R&R) now exceeds the demand for lumber in new construction. Softwood lumber supply has become more inelastic because of the pandemic as U.S. sawmill 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 was not happening during Covid (van Kooten and Schmitz, 2022).

Canadian lumber exports are negatively impacted by constraints on railroad capacity, particularly those from BC. With more petroleum being moved by rail 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', with BC mills having laid off employees because the mills cannot get lumber to market. However, 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).

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 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. High lumber prices also reduced demand. This put a damper on the use of lumber in construction and thereby created greater demand for other building materials (mainly concrete, steel and aluminum).

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, reaching a peak in April of 2021 at more than $1,500/mbf. 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) increased from $408/mbf in March 2020 to $1,265/mbf in March 2022. The time paths of both price series are plotted in Figure 1, with the addition of housing starts. Housing starts have been found to be a driver of U.S. demand for Canadian lumber; following the logic that an increase in real domestic income and economic activity leads to a rise in lumber imports to meet the demand for additional housing and construction (Baek, 2012). As showing in Figure 1, housing starts fell dramatically beginning in 2005, but the impact on prices was insignificant compared to the impact of the pandemic. 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. Forest management in Canada is currently done so under the Sustainable Forest Management (SFM) criteria. It aims to support economic, environmental, and social values of forests as a "3-legged stool of sustainability" (Rotherham and Armson, 2016).

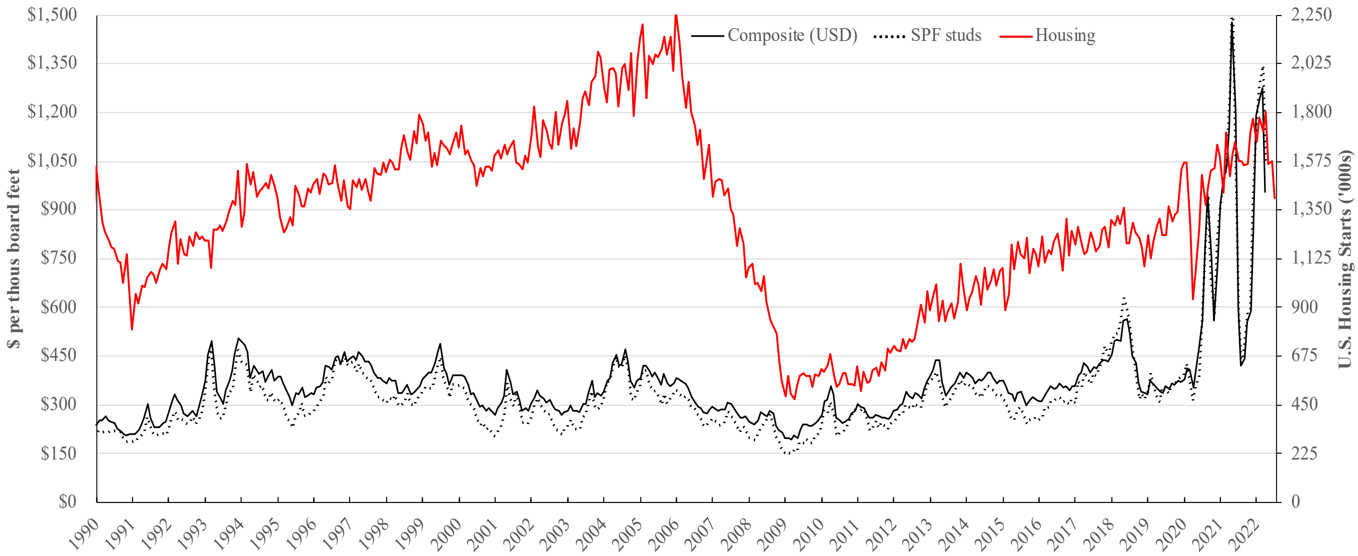

Figure 1. Monthly Prices of Lumber Sold in the U.S. and the Composite Framing Price Index in USD, January 2016 through April 2022. Source: Statista (2022) and Random Lengths (various issues).

There are around 40 different kinds of forest tenure in Canada, and a vast majority of the annual allowable cut (AAC) is represented by long term leases of 20-25 years (Haley and Nelson, 2007). The tenure system has at times constrained the amount of timber that forest companies can harvest within certain periods. More recently the supply of softwood lumber has been limited as a result of transportation bottlenecks as previously noted. 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.

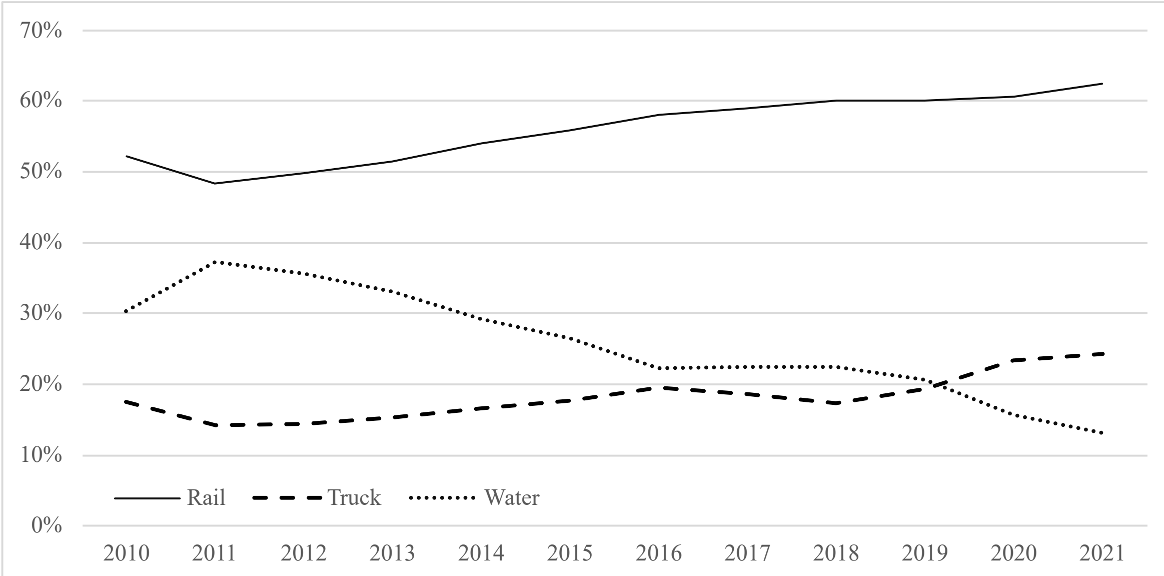

Figure 2. Canadian Lumber Exports to the United States by Mode of Transportation, 2010-2021. Source: Statistics Canada (2022)

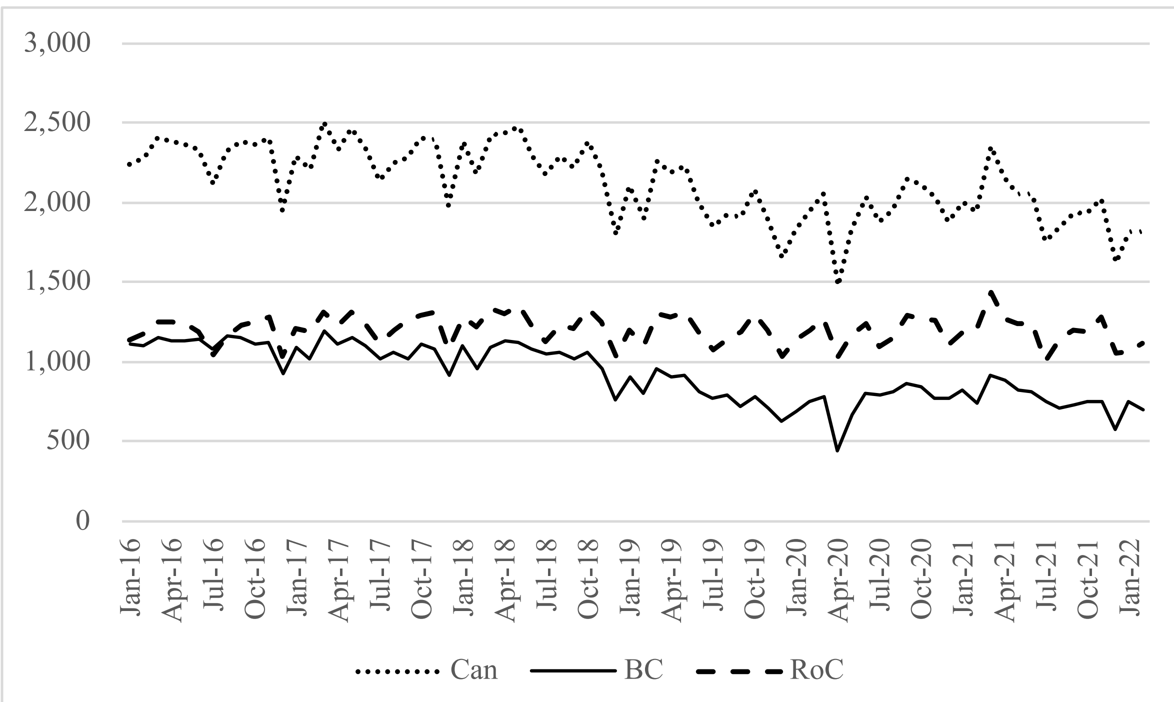

Figure 3. Monthly Softwood Lumber Production (‘000s m3), BC, Rest of Canada, and Total Canada, January 2016 through February 2022. Source: BC Council of Forest Industries (2022)

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 million m^3 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 already discussed potential causes of volatile prices, this essay aims to provide information on both the potential factors that have contributed to the significant changes in softwood lumber prices, and the subsequent social surplus changes associated with the price volatility.

In section 2 of this essay, we employ event analysis to determine whether certain events, including the pandemic, could explain erratic prices. Although the price variation seen over the pandemic months could be completely random (see Zanello et al., 2023), we argue that this is an unsatisfying explanation. Overall, we find that the Covid-19 pandemic had a large statistically significant impact on softwood lumber prices, and surprising also identified an even larger impact of the Pacific Northwest Flood (PNF). In section 3, we move into an analysis of the impacts of Covid-19 on consumer and producer surplus in both the United States and Canada. We aim to identify which parties benefitted, and those who lost as a result of the price instability during the pandemic.

[1] The measure mbf is used to denote thousand board feet. To avoid confusion, we spell out 'million bf' to represent mbf×1000. Also 1 mbf = 2.36 m^3.

2. COVID-19 PRICE MOVEMENTS REGRESSION ANALYSIS[2]

2.1 Summary

In this section, we employ an econometric modelling approach to examine the potential factors impacting the large variation of softwood lumber prices resulting from the Covid-19 pandemic—which demonstrated that Covid-19 could account for price variability. Overall, we found that the Covid-19 pandemic had a large statistically significant impact on softwood lumber prices, as witnessed over the period since March 2020. Additionally, we found that the Pacific Northwest Floods had an even greater statistically significant impact (although likely shorter lived) on softwood lumber prices following the pandemic, which offers an explanation as to the lack of a return to pre-pandemic prices in the periods following the end of the pandemic.

2.2 Methodology

The base econometric model that we use in the event analysis looks at pricing data from the Composite Framing Index (CFI) over time, with significant effects partitioned as dummy variables to analyze their impact on lumber prices. We have based on our on the Composite Framing Index as it was used as a threshold price for determining the tariff in resolving some of the softwood lumber disputes between Canada and the U.S. The same econometric model using the Spruce-Pine-Fir Index is available in Appendix A. To provide a more robust analysis of the effects of Covid-19 on lumber prices, we employ roughly 41 years of data. This allows for additional analysis of other significant events in the softwood lumber industry, including those with respect to the softwood lumber dispute between Canada and the U.S. Over 50% of the softwood lumber

---

[2] This section is based on joint work published as: Zanello, R., Shi, Y., Zeinolebadi, A., van Kooten, G.C. (2023). Covid-19 and the Mystery of Lumber Price Movements. *Forests*, *14*(1), 152; https://doi.org/10.3390/f14010152. My direct contributions included data collection, analysis, as well as the development and application of the econometric model. The writing reflects joint work with my coauthors, but I have rewritten many aspects for this essay.

produced in Canada is exported to the United States, which highlights the importance of including the effects of the softwood lumber dispute, and subsequent Softwood Lumber Agreements (SLA), in our econometric models. For more detailed information regarding the softwood lumber disputes and subsequent agreements, see van Kooten et al. (2021).

One of the main points of contention between Canada and the U.S., and the subject of a 2020 World Trade Organization (WTO) dispute panel, is the implementation of Countervailing duties (CVD) and Antidumping (AD) duties by the United States. CVD are placed by an importing country (in this case the U.S.) when a government feels that the exporting country is subsidizing production and depressing prices (WTO, n.d.). Therefore, the CVD acts as an import tax. Generally, AD duties are put in place by importing countries to prevent exporters from selling a product at a lower price than they would normally charge in domestic markets (WTO, n.d.). As seen in Table 1 and Figure 4, during the four decades after 1981 the United States imposed an AD duty or CVD, or both, on Canadian softwood lumber. Through data collection from various sources (Global Affairs Canada, 2022; Zhang, 2007), we have included a variable that represents the value of both CVD and AD duties over the 41-year period in our econometric analysis. A more detailed analysis of the parties involved in the dispute will be provided in section 2.2

Table 1. Historical AD and CVD rates between Canada and the United States.

Year[a]	Average of AD or CVD (%)
1987 – 1991	15.00
1992	9.92
1993 – 1994	6.51
2001	25.60
2002	22.42
2003	13.92
2004 – 2005	10.81
2006	11.86
2007 – 2009	15.00
2010	14.09
2011	15.00
2012	11.25
2013	6.67
2015	8.57
2017	22.85
2018 – 2020	20.23
2021	19.84
2022	17.91

[a]Years without an AD or CVD were removed. Source: Global Affiars Canada (2022), and Zhang (2007).

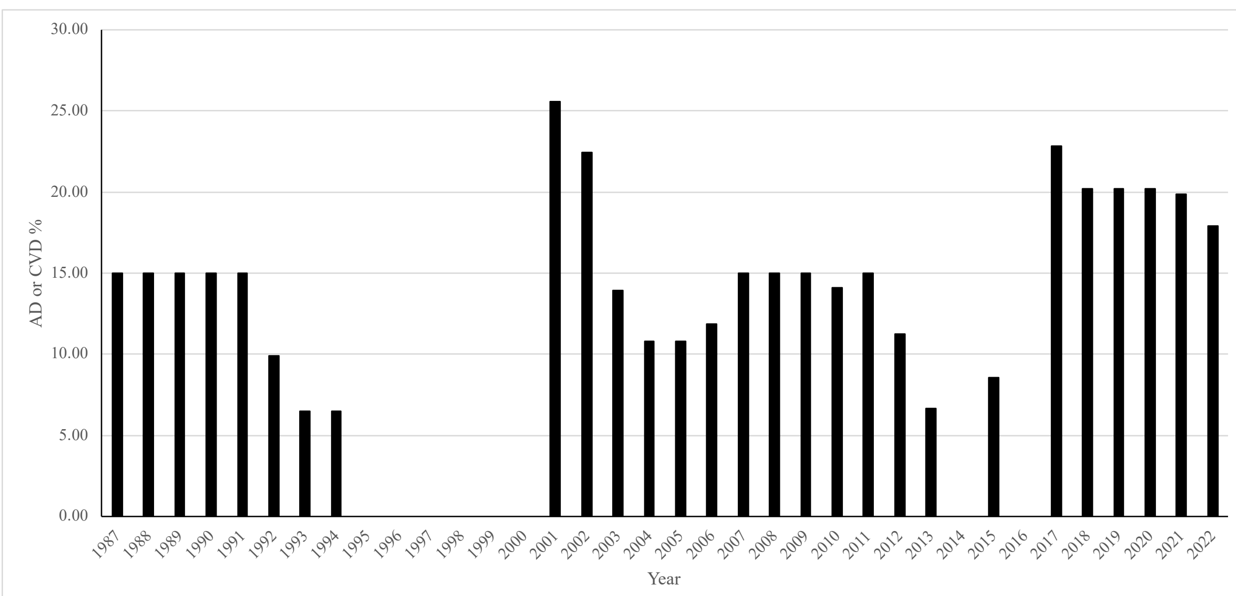

Figure 4. Historical Antidumping and Countervailing Duties on Canadian Softwood Lumber by the United States. Source: Global Affiars Canada (2022), and Zhang (2007).

An additional event of interest that we consider is an Atmospheric River event that occurred during November 2021, which was formally known as the Pacific Northwest Floods (PNF). The rainfall began as a “Pineapple Express” storm system, and the resulting floods caused an estimated $675 million in insured damage (IBC, 2022). The series of atmospheric rivers began on 13 November 2021 and led to tragic loss of life, mudslides, and the flooding of homes, businesses, and farms. The effects of the PNF were also felt heavily in the transportation sector of British Columbia. Beginning November 15, a series of road and rail closures stuck BC as a result of the PNF. On November 15, Highway 1 near the Sumas River was closed due to a flood warning; this was followed by the closure of several sections of Highway 3 and 99 (Lai et al., 2022). Further, on December 9 sections of Highways 16, 29, and 97 were closed due to severe weather and deteriorating road conditions (pavement cracking). Simultaneously, during the period of November 14 – December 4 the Canadian National Railway (CNR), and the Canadian Pacific Railway (CP) closed their services due to 58 outages (Lai et al., 2022). See Figure 4 below for a map of the effected Highways and Railways effected by the PNF.

This bottleneck extended into the softwood lumber industry as trains and commercial trucks were unable to bring lumber from the interior to shipping points on the coast. Based on information from the Council of Forest Industries (COFI, 2022), it was estimated that the impact from transportation constraints continued throughout the winter until June 2022. In the next section, we develop four econometric models to test whether the Covid-19 pandemic and other global and local events had a significant effect on the price of softwood lumber, and our results are provided in Section 2.4.

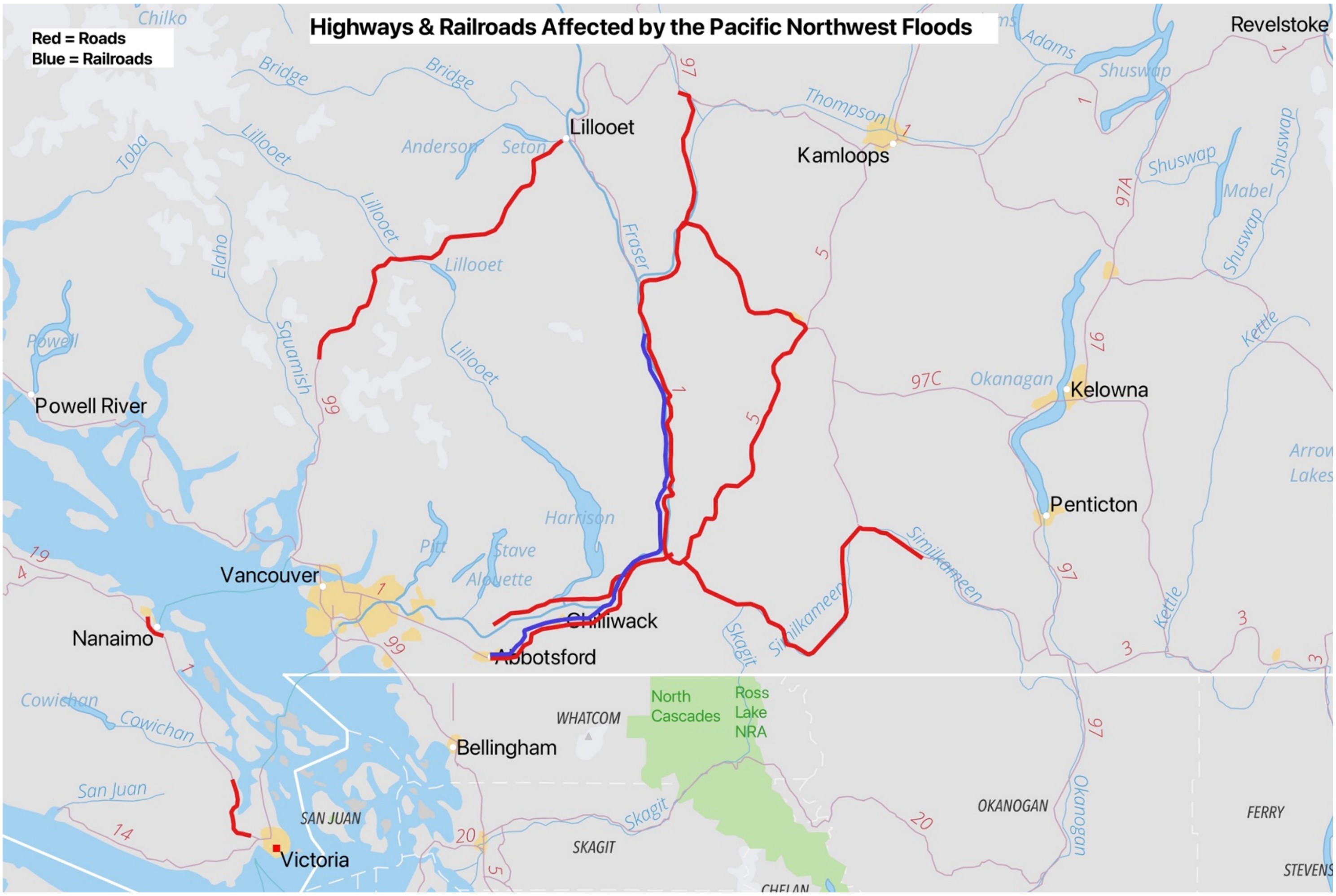

Figure 4. Highways and Railways affected by the PNF. Source: Government of British Columbia (2021)

2.3 Price Impact Model Specification

In this section, we explore the design and variable specification of our price impact model. Similar to Zhang (2001, 2006), we employ four highly aggregated reduced-form econometric price models that include factors influencing lumber supply, the Canada-US exchange rate, as well as various policy variables. Our first two models include monthly data for the period between January 1, 1981, and October 31, 2022. The first model is specified as:

$$P_t = \alpha_0 + \alpha_1 Covid_t + \alpha_2 PNF_t + \sum_{i=3}^{n} \alpha_i X_{it} + \varepsilon_t, \varepsilon_t \sim n.i.d.(0, \sigma^2) \quad (4)$$

where P_t indicates the monthly price of the composite softwood lumber index (Random Lengths, various issues). $Covid_t$ and PNF_t were used to represent the Covid-19 pandemic, and the PNF respectively; and X_{it} represents the subsequent control variables described in Table 2.

Our second model is identical to the first apart from $ADCVD_t$, a variable constructed to represent an average of the actual value of the AD duty plus CVD placed on Canadian softwood lumber by the United States. The implementation of AD and CVD policies is a point of contention between Canada and the U.S., as noted in the previous section. Our rationale for including regressions run with and without $ADCVD_t$ is motivated by the lack of clear and consistent data on the monthly rates of AD and CVD tariffs over time. The data we collected and report for this variable have been gathered from a variety of sources, as no single source has kept track of this information over time. Additionally, four major companies—Canfor Corporation, Resolute Forest Products, West Fraser Mills, and J.D. Irving—had varying rates of CVD and AD imposed on them because of their size and influence within the softwood lumber industry. In addition, a single rate was set for all other companies, which is a function (often a weighted average) of the rates imposed on the large companies and is used for the construction of this variable. Because of the innate uncertainty and variation due to the nature the of AD and CVD rates, we chose to present the regression output for both time periods with and without this variable. The second model is given below:

$$P_t = \beta_0 + \beta_1 Covid_t + \beta_2 PNF_t + \beta_3 ADCVD_t + \sum_{i=4}^{n} \beta_i X_{it} + \varepsilon_t, \varepsilon_t \sim n.i.d.(0, \sigma^2) \qquad (5)$$

Our second pair of models includes the addition of Average Hourly Wages from those employed in the Forestry and Lumber Industries as defined by Statistics Canada (2022). These data are only available from Statistics Canada for the months of January 2001 to October 2022 (Table 14100306), and therefore we have included this data in separate regressions. As a result, aside from the condensed time period, the third and fourth regressions are identical to Equations (4) and (5) respectively with the addition of W_t contained in X_{it}. A detailed description of the variables included in each of the four models can be found in Table 2.

Table 2. 1981–2022 variables, their descriptions, and sources.

Variable	Description	Unit	Source	Model 1	Model 2	Model 3	Model 4
P_t	Composite Lumber Price	$CAD	Random Lengths	X	X	X	X
$Exch_t$	$CAD to $USD Exchange Rate	C$/US$	FRED Economic Data	X	X	X	X
HS_t	New Privately Owned Housing Units Started in the United States	1000s	FRED Economic Data	X	X	X	X
$ADCVD_t^a$	Anti-Dumping and Countervailing Duty Rates by the USA on Canadian Softwood Lumber	%	Various sources		X		X
W_t	Average Hourly Wage of Canadian's Employed in Forestry and Logging	$CAD	Statistics Canada			X	X
PRE_t	Pre – Softwood Lumber Agreements	0 or 1	Jan 1981 – Dec 1986	X	X		
MOU_t	Memorandum of Understanding	0 or 1	Jan 1987 – Sep 1991	X	X		
$L2_t$	Period in between MOU and TRQ	0 or 1	Jan 1992 – Dec1993	X	X		
TRQ_t	Tariff Rate Quota Periods	0 or 1	Apr 1996 – Mar 2005	X	X	X[b]	X[b]
$SLA06_t$	Softwood Lumber Agreement of 2006	0 or 1	Oct 2006 – Dec 2015	X	X	X	X
$POST_t$	Post Softwood Lumber Agreement of 2006	0 or 1	Jan 2017 – Jul 2022	X	X	X	X
FC_t	Great Financial Crisis	0 or 1	Dec 2007 – Jun 2009	X	X	X	X
$Covid_t$	Covid-19 Pandemic	0 or 1	Jan 2020 – Jan 2022	X	X	X	X

[a] The $ADCVD_t$ has been created by the authors using data from Global Affiars Canada (2022), and Zhang (2007) which was only included in the second regression.
[b] In Models 3 and 4, the period for TRQ_t was limited to Jan 2001 – Mar 2005

Our main variable of interest is $Covid_t$ as we expect that the Covid-19 pandemic caused lumber prices to rise significantly (van Kooten et al., 2021). Based on our initial data exploration, there is a sharp increase in both the raw lumber price and the variation of price following the Covid-19 pandemic. By incorporating the event regressors, we expect to be able to attribute more of this variation in price to the pandemic, and not simply just a random walk. Although our variable of interest is the Covid-19 pandemic, we also expect positive coefficients on the other event variables in the model. Similar to the results found by Zhang (2006), for example, we expect HS_t and W_t to have positive coefficients, as increases in the number of housing starts can be attributed to an increase in demand, and an increase in wage rates can reduce supply and thus increase price. Additionally, we expect the coefficients on $Exch_t$ to be negative as demonstrated by Adams et al. (1986), and Zhang (2006), and we expect the coefficients on PNF_t to be positive as an interruption in the supply chain amounts to a suppression of supply which then drives up prices.

2.4 Results

The estimation results are provided in Table 3a for the CFI Index. The first and third columns of the table provide results for models without the $ADCVD_t$ variable, while the second and fourth provide the results when it is included. As seen in the table, the majority of the events that we identified are positive and highly statistically significant; most importantly, the central variable of interest in this essay, $Covid_t$, is statistically significant in all regressions—the Covid-19 pandemic had a positive impact on softwood lumber prices. When the entire dataset from 1981–2022 was employed in the regression, the price of softwood lumber increased by 42.1% at the 1% significance level during the pandemic months. With the addition of the $ADCVD_t$ variable, the significance of $Covid_t$ does not change, although there is a slight reduction in the price impact (38.5%). Additionally, when using the condensed dataset (from 2001–2022), the significance of

$Covid_t$ remains, but its impact is reduced somewhat further (32.7% at the $p < 0.01$ significance level). Now with the addition of the $ADCVD_t$ variable, the coefficient estimate is slightly higher at 33.1%.

The significant effect that the Covid-19 pandemic had on lumber prices is not a surprise, but the extent of the price impact relative to the effect that other past events had on price presents an interesting contrast. Considering our full regression model without $ADCVD_t$ (col 1 in Table 2), the Covid-19 pandemic price impact was 12 percentage points higher than that of the Great Financial Crisis of 2008 (42.1% vs. 30.1%). With the inclusion of $ADCVD_t$ (col 2), the impact is even more pronounced at 20 percentage points (38.5% vs. 18.5%). Across all four regressions $Covid_t$ remains extremely significant, with estimated price impacts ranging from 32% to 42%. Clearly, the pandemic had a sizeable impact on the softwood lumber industry.

Although our main variable of interest was Covid-19, we also identified a surprising and interesting significant event—the supply chain disruption caused by the November 2021 Atmospheric River (Pacific Northwest Floods). We found that the PNF had a large and statistically significant impact on softwood lumber prices. Looking first at our extended dataset from 1981–2022, the PNF had an 87.0% impact on price (holding all else constant); when the $ADCVD_t$ variable is included as a regressor, the positive impact is only slightly reduced to 81.1%.

In the model where only the data from 2001–2022 are employed in the regression, the PNF event remains statistically significant ($p < 0.01$), with its impact respectively ranging from 60.3% to 55.7% depending on whether or not the $ADCVD_t$ variable is included. The severity of this natural disaster on the softwood lumber prices was roughly 2.5 times higher than the impact of Covid-19 pandemic, even though the PNF event lasted only about one-third as long as the pandemic. Both events indicate that disruptions to the lumber supply chain can lead to significant impacts on industry prices.

Table 3a. Explaining North American Lumber Price Movements: Dependent Variable Logarithm of Composite Framing Index (CFI).

Regressor	(1981)	(1981)	(2001)	(2001)
$Exch_t$	0.647***	0.486***	0.438***	0.435***
	(0.079)	(0.066)	(0.095)	(0.087)
HS_t	0.0002***	0.0002***	0.0003***	0.0002***
	(0.00003)	(0.00002)	(0.00004)	(0.00004)
$ADCVD_t$		-0.013***		-0.008***
		(0.001)		(0.002)
PRE_t	-0.522***	-0.586***		
	(0.030)	(0.025)		
MOU_t	-0.349***	-0.223***		
	(0.032)	(0.028)		
$L2_t$	-0.014	0.040		
	(0.041)	(0.034)		
W_t			0.028***	0.018***
			(0.004)	(0.005)
TRQ_t	0.003	0.066***	0.081	0.108**
	(0.030)	(0.025)	(0.051)	(0.046)
$SLA06_t$	-0.031	-0.002	0.045	0.010
	(0.035)	(0.029)	(0.063)	(0.058)
$POST_t$	0.216***	0.436***	0.201***	0.324***
	(0.035)	(0.033)	(0.065)	(0.064)
FC_t	-0.263***	-0.170***	-0.146***	-0.133***
	(0.040)	(0.033)	(0.043)	(0.039)
$Covid_t$	0.351***	0.326***	0.283***	0.286***
	(0.041)	(0.033)	(0.040)	(0.036)
PNF_t	0.626***	0.594***	0.443***	0.472***
	(0.061)	(0.050)	(0.065)	(0.059)
Constant	4.983***	5.220***	4.345***	4.755***
	(0.107)	(0.089)	(0.154)	(0.164)
Observations	501	501	255	255

Note: *p<0.10, **p<0.05, ***p<0.01

Finally, differences between models representing the two distinct time periods can be partially understood by looking at the overall variance in price between the two time frames. As indicated in Figure 5, the variation in price during the Covid-19 pandemic and the subsequent PNF is more pronounced visually when we view the data as part of a longer time frame. Upon comparing the price data of the shorter time frame (2001–2022), the change in variation, although still obvious, is less than when using the longer time frame (1981–2022). This is not surprising given the greater number of events after 2001 (five) compared to before 2001 (three), with one event common to both time frames (see Table 3a).

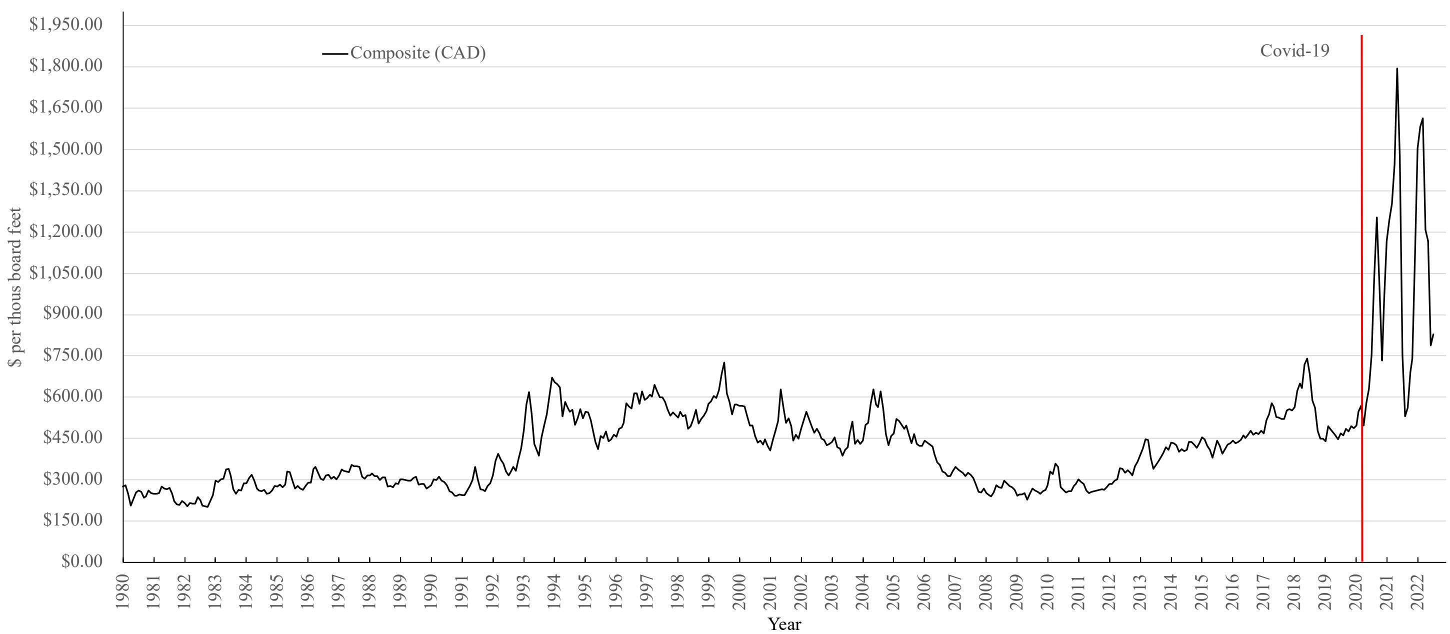

Figure 5. Composite framing price index in CAD January 1980 through July 2022
Source: Statista (2022) and Random Lengths (various issues).

Further, in our initial regression analysis the dates of $Covid_t$ and PNF_t coincided between the months of November 2021 to January 2021. In an effort to view these events from another angle, we have also undertaken the same regression analysis but with alternate dates for the Covid-19 pandemic (March 2020 – October 2021, inclusive), and the addition of the variable PxC_t which runs from November 2021 to June of 2022, to represent both the PNF and pandemic jointly. The alternative classification allows for a more distinct analysis of the Covid-19 pandemic (without the effects of the PNF overlap), and a separate period in which the effects of both the PNF and the pandemic can be considered. The full results of this alternate regression are shown in Appendix A (Table A2 for the CFI and Table A3 for the SPF Index).

While the results for the unchanged variables differ slightly from our original regression, we will highlight the changes to our two main variables of interest $Covid_t$ and PxC_t. Beginning with the effects from Covid-19 we now observe a more pronounced effect of the pandemic on softwood lumber prices. As seen below in Table 3b, the resulting differences vary largely from our original regression but have remained statistically significant at the 1% level. Further, as we saw in our previous results, the impact of the PNF was surprisingly large and this pattern continues with the introduction of our mixed variable PxC_t. PxC_t differs greatly from our original regression with percentage point increases ranging from 17.1 to 31.0. This combination variable serves to provide an estimate of the combined effects of both events on softwood lumber prices, rather than their individual impacts as presented in Table 3a. We feel this alternate regression highlights a possible alternative classification of the pandemic and PNF and serves as an interesting point of comparison.

Table 3b. Associated Price Effects – Alternate Time Period Comparison (%)

Regression	Regressor	(1981)	(1981)	(2001)	(2001)
Original	$Covid_t$	40.2	38.5	32.7	33.1
Adjusted Dates	$Covid_t^a$	54.0	50.4	40.1	40.6
Percentage Point Change		13.8	11.9	7.4	7.5
Original	PNF_t	87.0	81.1	55.7	60.3
Adjusted Dates	PxC_t^b	118.0	104.2	72.8	79.9
Percentage Point Change		31.0	23.1	17.1	19.6

[a] $Covid_t$ adjusted dates are from March 2020 to October 2021 inclusive.
[b] PxC_t adjusted dates are from November 2021 to June 2022 inclusive.

3. LUMBER PRICE VOLATILITY AND WELFARE EFFECTS[3]

3.1 Summary

This section examines the welfare impacts that the Covid-19 pandemic had on producers and consumers in the United States 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 et al., 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. 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.

3.2 Background

As described in detail by van Kooten et al. (2021), there has been close to four decades of softwood lumber disputes between Canada and the U.S., leading to various CVD, AD duties and softwood

[3] This section is based on joint work published as: van Kooten, G.C., Zanello, R., Schmitz, A. (2022). Explaining Post-Pandemic Lumber Price Volatility and its Welfare Effects. Journal of Agriculture & Food Industrial Organization (18). DOI: 10.1515/jafio-2022-0018. ISBN: 1542-0485. My direct contributions included data collection, as well as development and application of the welfare model. The writing reflects joint work with my coauthors, but I have rewritten many aspects for this essay.

lumber agreements (SLA). For our welfare analysis, we identify four groups in the next section who are impacted by price volatility: U.S. producers and consumers, and Canadian producers and consumers. This section provides a brief summary of the opinions and stances of the various groups surrounding softwood market structure, and subsequent trade disputes (prior to the pandemic).

Beginning with U.S. producers, the main lobbying body driving the dispute is the Coalition for Fair Lumber Trade (CFLT). The CFLT advocates that Canadian provincial governments are providing subsidies to lumber producers through the tenure system, which enables forest companies to access timber on public lands at fixed, long-term stumpage rates that do not reflect market conditions. They claim that lumber producers in Canada benefit from stumpage rates that are set below market values, thus the creation of the AD and CVD (Yin and Baek, 2004). Specifically in BC, the CFLT argue that the provinces stumpage target rate creates a non-market-based system, and that the target rates set by the province do not accurately reflect market values. The central argument implemented by the CFLT is that the price of exported lumber from Canada is subsidized below production costs, thus leading to distortions of the U.S. market, and threatening the success of U.S. lumber producers, timber landowners, and mills (U.S. Lumber Coalition, n.d.).

Opposite the CFLT, two Canadian associations have formed in order to combat the dispute. The B.C. Lumber Trade Council (BCLTC) and the Free Trade Lumber Council (FTLC). These groups counter the CFLT arguments stating that stumpage rates do not equate to a subsidy, and that it is unreasonable to compare stumpage rates across countries. They argue that the increased lumber exports to the U.S. are not due to the subsidies but are instead stemming from a competitive advantage from the exchange rate, and U.S. consumer preference. The relatively low Canadian dollar makes its inexpensive to import lumber from Canada into the U.S. to meet the excess demand (as seen in Figure 6). Furthermore, Canadian lumber is seen as having higher availability and superior quality by American consumers (Yin and Baek, 2022).

The final group to be considered are the consumers on both sides of the border. In the U.S. The National Lumber and Building Material Dealers Association (NLBMDA) oppose the restrictions on U.S. softwood lumber trade with Canada. They argue that the disputes and subsequent CVD and AD rates cause increased price volatility, and higher prices for construction (Yin and Baek, 2022). They also support Canadian lumber producers and insist that the provincial governments are not subsidizing timber production. An additional organization that has been backing the NLBMDA is the American Consumers for Affordable Homes group (ACAH). This group is comprised of 14 national organizations, made up of consumers, homebuilders, and retailers (making up 95% domestic consumption in softwood lumber) (Yin and Baek, 2022). As seen in the following section, U.S. consumers are often one of the largest losing parties as a result of higher prices. Canadian consumers face minimal effects from the softwood lumber trade disputes, as the prices of Canadian lumber (sold in Canada) are not heavily dependent on imports from elsewhere, or exports to the United States.

3.3 Theoretical Model of Price Volatility[4]

Both the lumber demand and supply functions in Canada and the United States are thought to be quite inelastic, with supply less responsive to supply shifters (e.g., log and other input prices, prices of lumber substitutes such as aluminium studs) than demand to similar shifters (primarily prices of lumber substitutes, 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

[4] In this section, we model volatility as the effect from a one-time demand variation (due to Covid-19 or some other cause as discussed in section 3.6). To capture the full effects of price volatility on agent surplus requires more advanced consumer choice models that incorporate the costs of defensive action, and the impact of volatility that lasts over more than one period. This type of analysis goes beyond the models in this essay.

used in the generation of electricity will also increase demand for lumber (see Johnston and van Kooten 2015, 2016).

In Figure 6, we provide a model of Canada-U.S. trade to explain the observed volatility in softwood lumber prices since March 2020.[5] 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 *k*—this is the price facing domestic consumers in both Canada and the U.S.[6] At P^0, Canadians consume q_d 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 increases slightly due to a decline 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 *k* to point *e*. There is a very small increase in U.S. consumption as a result of the shift from equilibrium *k* to *e*, with an accompanying but almost insignificant decrease in Canadian consumption going from point *d* to *a*. Both Canadian and American lumber producers slide up 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 increase 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

[5] The framework for the models in this section demonstrating excess supply and demand as well as welfare measures in vertical chains are developed from the concepts presented in van Kooten (2021, Chapter 4).

[6] 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.

decrease in overall production and consumption, although consumption in Canada would increase by an insignificant amount.

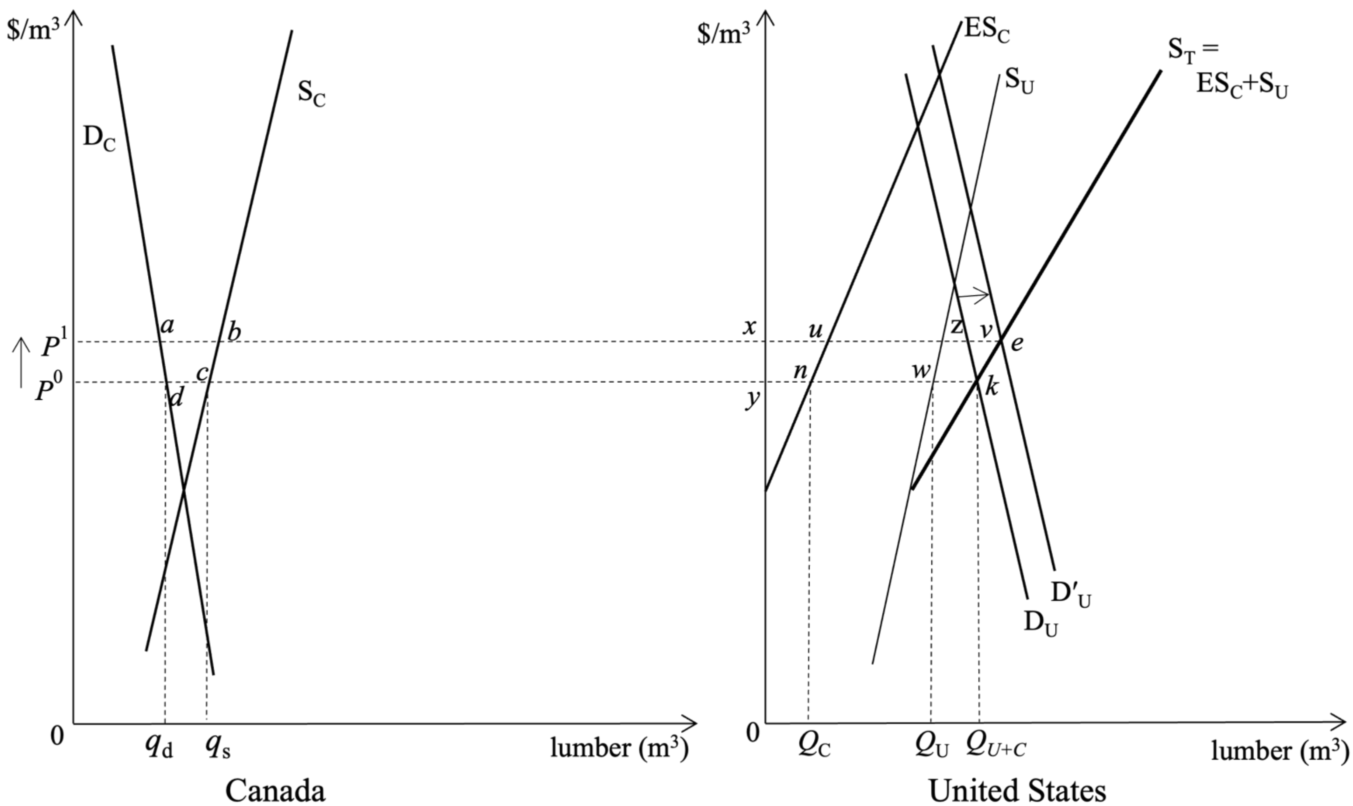

Figure 6: Theoretical Model Explaining Demand Driven Price Volatility

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

3.4 Measuring Price Variability and Welfare Effects

We begin with the most recently available price and production data for Canada and the United States. In Figure 7, 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 simple linear demand and supply functions to represent the market (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 behaviour.

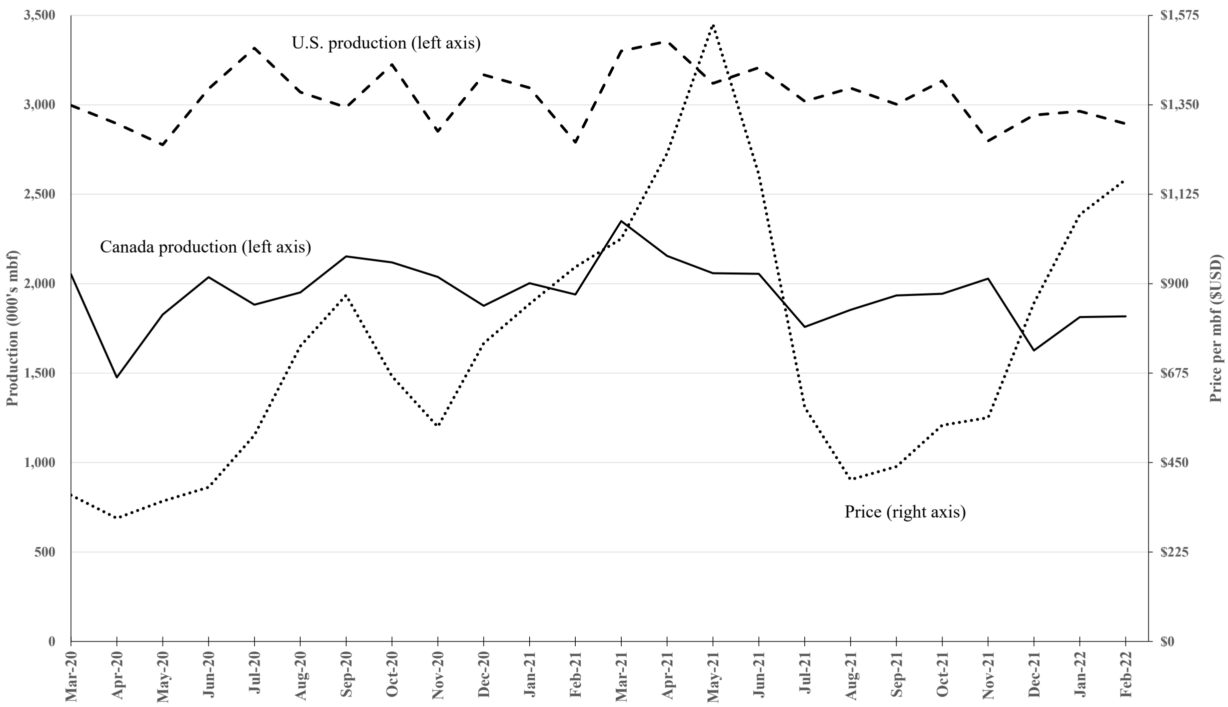

Figure 7: Monthly Price and Production of Softwood Lumber in Canada and the U.S., March 2020 through February 2022.
Source: BC Council of Forest Industries (2022), Madison's Lumber Reporter (2020, 2021, 2022)

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 8 and 9, respectively, for Canada and the United States, and the data found in Table 4. These figures are simplified versions of the country-level supply and demand shifts described in Figure 6. As indicated in Figure 8, 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.

Table 4: Changes in Consumption, Production, Exports and Prices, Softwood Lumber, 1st Q 2020, 1st Q 2021, and January – February 2022, Millions of Board Feet ('000s mbf)

	2020	2021	2022		2020	2021	2022
Production				**Exports**			
U.S. Total	9,142	9,201	5,858	Canada to U.S.	3,072	3,430	3,127
				Canada Total	3,755	4,240	3,591
British Columbia	2,253	2,474	1,447	U.S. to Canada	161	387	348
Rest of Canada	3,591	3,820	2,183	U.S. Total	1,775	1,119	921
Canada Total	5,844	6,294	3,630				
				Consumption			
				U.S.	12,316	12,702	
Price (US$/mbf)	$400	$977	$1,118	Canada	1,940	2,168	

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

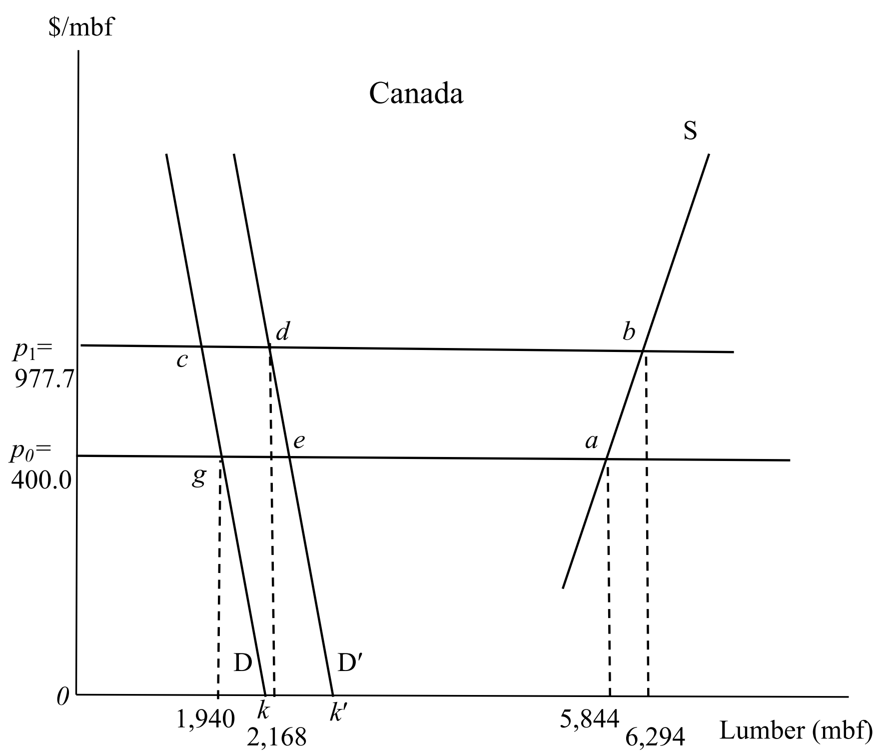

Figure 8: Diagrammatical Representation of the Price and Quantity Changes in Canada due to Covid-19

The change in the welfare of Canadian lumber processors is determined by the area bounded by the points (p_1p_0ab) in Figure 8. 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 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 U.S. softwood lumber, the situation is like to that of Canada (Figures 6 and 8), 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 9, 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.

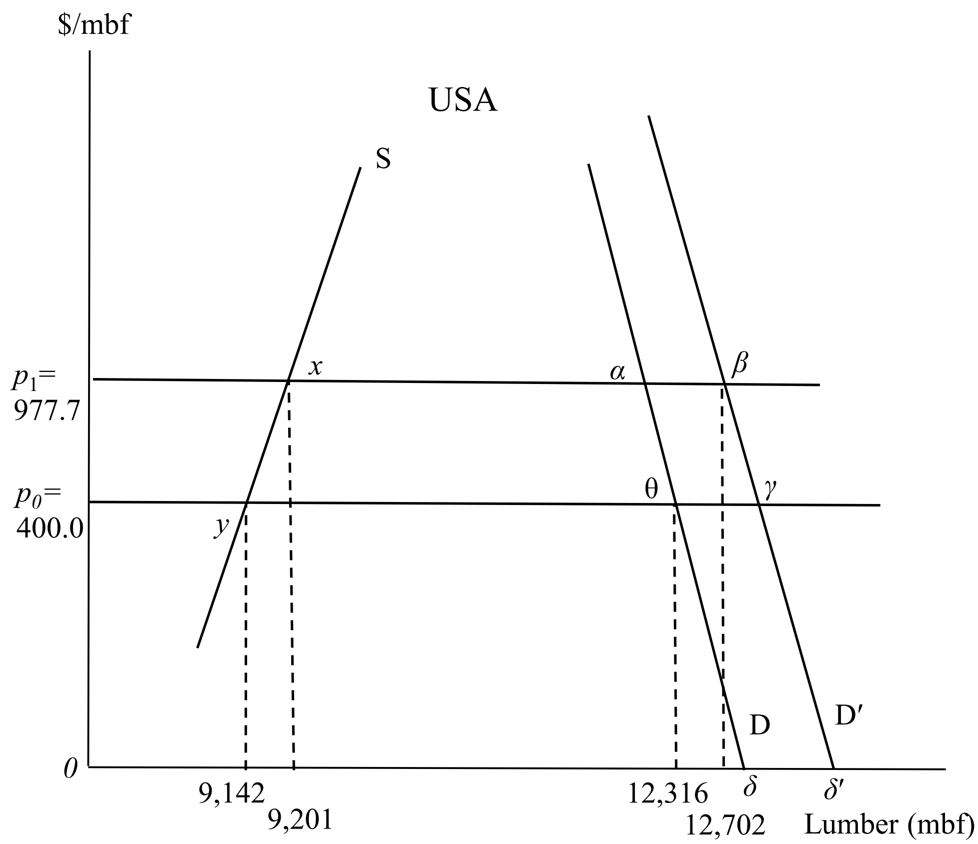

Figure 9: Diagrammatical Representation of the Price and Quantity Changes in the United States due to Covid-19

3.5 Welfare Impacts

Using data from Table 4, 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 1stQ 2020 to 1stQ 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 $3,506 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 surplus 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.[7] 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 8. Then, when the price of lumber increases to \$977.7/mbf, there is a loss of surplus equal to (p_1p_0ed).[8] The overall welfare change is given by ($gkk'e - p_1p_0ed$), 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 \$1,175 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 9, U.S. lumber producers would gain (p_1p_0yx), or \$5,298 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 9. The shift in price to \$977.7/mbf once again creates a loss in surplus given by ($p_1p_0\gamma\beta$). The overall change in welfare for the U.S. if we

---

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

[8] 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_0gc), 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 ($ckk'd - p_1p_0gc$).

assume $\varepsilon_d = -0.2$ is given by ($\theta\delta\delta'\gamma - p_1 p_0 \gamma\beta$) which results in a loss to U.S. consumers of $7,301 million dollars per quarter.

The overall welfare effects of the pandemic on the Canadian and the U.S. lumber markets are provided in Table 5. To calculate these values, we derived the Canadian excess supply function as found in Figure 6. Again, the pre-pandemic price, p_0, is given by the average lumber price in January to March, 2020—a price of $400 per mbf. The pre-pandemic quantity, q_0, is given by the total net imports by the U.S. from Canada across the same time period, which is 2,977 million board feet.[9] The post-pandemic price, p_1, 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_0. 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.).

Table 5: Welfare Effects from an Outward Shift in Demand for Lumber due to Covid-19, $ millions

Change in welfare	Canada	United States	Total
Producer surplus	$3,506	$5,298	$8,804
Consumer surplus	–$1,175	–$7,301	–$8,476

Source: Authors' calculations

3.6 Price Volatility

As noted above, lumber prices have been volatile throughout the last two years. To analyse 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 8 and 9. Looking at U.S. and Canadian

[9] 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).

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 ($1,137/mbf and $1,132/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 6.

To arrive at the welfare changes found in Table 6 and without loss of generality, we simply examine shifts in the demand for lumber in each of the Canadian and American markets separately. We ignore the impact this might have on imports and exports, as the overall effects of the demand shifts are small compared to the entire lumber market. For example, even a 15% increase in the demand for lumber by Canadians is relatively small compared to the North American market for lumber.

Table 6. 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%	4,521	–1,566	2,955
	–5%	–1,453	0.227	–1,453
United States	5%	8,496	–12,118	–3,622
	–1%	–1,689	1,584	–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.

Consider first the Canadian lumber market. Keeping the same assumption of a base domestic demand of 1,940 million bf prior to the Covid-19 shift, and 2,168 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 2,231 million bf) raises domestic prices to $1,137.3/mbf. Due to the large increase in price, Canadian lumber producers gain a surplus equivalent to $4,520 million dollars, an increase of $1.01 billion dollars when compared to the model in Figure 7. 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 surplus 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 $1,566 million dollars, an increase in loss of $391,000 when compared to Figure 8. 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 9) 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 $1,321.63 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 $8,496 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 & DISCUSSION

In this essay, we explored the impact of the Covid-19 pandemic on the softwood lumber industry. The increase in price volatility during the pandemic period was unprecedented and warranted exploration into the extent to which the pandemic was an underlying driver of volatility and the potential income distributional impacts of the price changes. In section 2, we employed an econometric model incorporating event analysis to ascertain the effects of Covid-19 on lumber price variation, as well as other local and global events. Aside from the statistically significant impact of the pandemic, we also concluded that the PNF had an even greater impact on lumber prices following the pandemic. An explanation for why the price of lumber rose as a result of the November 2021 flooding event is relatively straightforward—there was a disruption in the supply chain that shifted the supply curve inwards while demand remained unchanged. The reason why the Covid-19 pandemic resulted in an increase in lumber prices requires a much more nuanced explanation as the underlying factors are unclear. Although an inward shift of the supply function and/or an outward shift in the demand are involved, it is not clear why this would be the case. An inward shift in supply could be the result of a pandemic-induced reduction in labour, while but demand might have declined as it did in many retail sectors. Identification of such effects would be necessary for economists to determine the welfare impacts of the pandemic.

Previous research by van Kooten and Schmitz (2022) postulated that there was actually an increase in the demand for lumber; with more people working from home and desiring more space, there was an increase in demand for lumber by the repair and remodelling, and the housing sectors. On the supply side of lumber, van Kooten et al. (2022) argued that lumber producers already faced rail transport and sawmill capacity constraints. These constraints were then exacerbated by the Covid-19 pandemic leading to a substantial increase in price. In both cases, the price increases had significant effects on producer and consumer surpluses in Canada and the U.S., as shown in section 3 where we employed an economic model that could account for price variability to examine the potential welfare impacts of these shifts. As noted by van Kooten, Schmitz, and Kennedy (2019), Schmitz and Chigini (2020), and Schmitz (2021), consumers tended to lose as a result of price volatility. Our results follow this logic, as we find that American consumers tend to experience the biggest negative impact as a result of the pandemic.

The research in this essay was limited by data availability—if more data had been available on individual factors affecting softwood lumber our regression analysis could provide more precise results. However, the pandemic is a recent event and future research may be able to present panel data to compare the pandemic effects across countries, or more detailed regressors to shake out price effects further. Additionally, we have uncovered the importance of an intact supply chain on the softwood lumber industry. The PNF led to significant damages to the lumber routes to the coast, and additional research is needed on the effect of supply chain issues on lumber exports. In conclusion, this essay provided novel analysis on both the impact of Covid-19 on softwood lumber prices, and the distributional effects of the Covid-19 induced price variability on producer and consumer surpluses in Canada and the United States.

5. APPENDIX A

Table A1. Explaining North American Lumber Price Movements: Dependent Variable Logarithm of Spruce-Pine-Fir (SPF) Price Index

Regressor	(1981)	(1981)	(2001)	(2001)
$Exch_t$	0.444^{***}	0.246^{***}	0.131	0.133
	(0.093)	(0.080)	(0.119)	(0.113)
HS_t	0.0002^{***}	0.0002^{***}	0.0003^{***}	0.0003^{***}
	(0.00003)	(0.00003)	(0.0001)	(0.0001)
$ADCVD_t$		-0.014^{***}		-0.007^{***}
		(0.001)		(0.002)
PRE_t	-0.478^{***}	-0.546^{***}		
	(0.035)	(0.030)		
MOU_t	-0.327^{***}	-0.191^{***}		
	(0.037)	(0.034)		
$L2_t$	0.007	0.055		
	(0.048)	(0.041)		
W_t			0.033^{***}	0.024^{***}
			(0.006)	(0.006)
TRQ_t	0.086^{**}	0.152^{***}	0.173^{***}	0.195^{***}
	(0.035)	(0.030)	(0.063)	(0.061)
$SLA06_t$	-0.016	0.011	0.043	0.010
	(0.041)	(0.035)	(0.079)	(0.076)
$POST_t$	0.380^{***}	0.622^{***}	0.352^{***}	0.457^{***}
	(0.041)	(0.039)	(0.081)	(0.084)
FC_t	-0.335^{***}	-0.233^{***}	-0.192^{***}	-0.182^{***}
	(0.046)	(0.040)	(0.054)	(0.051)
$Covid_t$	0.345^{***}	0.321^{***}	0.267^{***}	0.268^{***}
	(0.048)	(0.040)	(0.050)	(0.048)
PNF_t	0.659^{***}	0.614^{***}	0.427^{***}	0.463^{***}
	(0.071)	(0.060)	(0.080)	(0.077)
Constant	5.059^{***}	5.343^{***}	4.403^{***}	4.770^{***}
	(0.125)	(0.108)	(0.192)	(0.214)
Observations	501	501	255	255

Note: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$

Table A2. Explaining North American Lumber Price Movements: Dependent Variable Logarithm of Composite Framing Index (CFI) – Covid-19 and PNF Adjusted Dates.

Regressor	(1981)	(1981)	(2001)	(2001)
$Exch_t$	0.647***	0.486***	0.438***	0.435***
	(0.079)	(0.066)	(0.095)	(0.087)
HS_t	0.0002***	0.0002***	0.0003***	0.0002***
	(0.00003)	(0.00002)	(0.00004)	(0.00004)
$ADCVD_t$		-0.013***		-0.008***
		(0.001)		(0.002)
PRE_t	-0.522***	-0.586***		
	(0.030)	(0.025)		
MOU_t	-0.351***	-0.225***		
	(0.032)	(0.028)		
$L2_t$	-0.016	0.038		
	(0.041)	(0.034)		
W_t			0.028***	0.018***
			(0.004)	(0.005)
TRQ_t	0.003	0.065***	0.080	0.106**
	(0.030)	(0.025)	(0.050)	(0.046)
$SLA06_t$	-0.034	-0.005	0.041	0.005
	(0.035)	(0.029)	(0.062)	(0.058)
$POST_t$	0.202***	0.421***	0.190***	0.312***
	(0.035)	(0.033)	(0.064)	(0.064)
FC_t	-0.264***	-0.171***	-0.146***	-0.134***
	(0.040)	(0.034)	(0.043)	(0.039)
$Covid_t$	0.432***	0.408***	0.337***	0.341***
	(0.043)	(0.036)	(0.042)	(0.039)
PxC_t	0.779***	0.714***	0.547***	0.587***
	(0.062)	(0.052)	(0.067)	(0.062)
Constant	4.987***	5.219***	4.357***	4.767***
	(0.106)	(0.089)	(0.153)	(0.164)
Observations	501	501	255	255

Note: *p<0.10, **p<0.05, ***p<0.01

[a] $Covid_t$ adjusted dates are from March 2020 to October 2021 inclusive.

[b] PxC_t adjusted dates are from November 2021 to June 2022 inclusive.

Table A3. Explaining North American Lumber Price Movements: Dependent Variable Logarithm of Spruce-Pine-Fir (SPF) Price Index – Covid-19 and PNF Adjusted Dates.

Regressor	(1981)	(1981)	(2001)	(2001)
$Exch_t$	0.447***	0.252***	0.135	0.139
	(0.092)	(0.079)	(0.119)	(0.115)
HS_t	0.0002***	0.0002***	0.0003***	0.0003***
	(0.00003)	(0.00003)	(0.0001)	(0.0001)
$ADCVD_t$		-0.014***		-0.008***
		(0.001)		(0.002)
PRE_t	-0.479***	-0.547***		
	(0.034)	(0.030)		
MOU_t	-0.329***	-0.194***		
	(0.037)	(0.033)		
$L2_t$	0.005	0.053		
	(0.047)	(0.040)		
W_t			0.033***	0.023***
			(0.006)	(0.006)
TRQ_t	0.085**	0.151***	0.171***	0.192***
	(0.035)	(0.030)	(0.063)	(0.062)
$SLA06_t$	-0.020	0.008	0.036	0.0005
	(0.040)	(0.035)	(0.079)	(0.077)
$POST_t$	0.361***	0.602***	0.335***	0.443***
	(0.041)	(0.040)	(0.082)	(0.086)
FC_t	-0.335***	-0.234***	-0.194***	-0.184***
	(0.046)	(0.040)	(0.054)	(0.052)
$Covid_t^a$	0.449***	0.419***	0.332***	0.343***
	(0.050)	(0.043)	(0.053)	(0.052)
PxC_t^b	0.828***	0.767***	0.577***	0.616***
	(0.072)	(0.062)	(0.085)	(0.082)
Constant	5.065***	5.342***	4.417***	4.797***
	(0.123)	(0.107)	(0.193)	(0.218)
Observations	501	501	255	255

Note: *p<0.10, **p<0.05, ***p<0.01

[a] $Covid_t$ adjusted dates are from March 2020 to October 2021 inclusive.

[b] PxC_t adjusted dates are from November 2021 to June 2022 inclusive.

6. REFERENCES

Adams, D.M.; McCarl, B.A.; Homayounfarrokh, L. 1986. The role of exchange rates in Canadian—United States lumber trade. *For. Sci.* 1986, *32*, 973–988. https://doi.org/10.1093/forestscience/32.4.973.

Alderman, D. 2020. *United States Forest Products Annual Market Review and Prospects, 2015-2021. October. Madison: Forest Products Laboratory.* Available at: https://unece.org/fileadmin/DAM/timber/country-info/statements/usa2020.pdf (accessed May 19, 2022).

Baek, J. 2012. The long-run determinants of U.S. lumber imported from Canada revisited. *Forest Policy and Economics, 14(1), 69–73*. https://doi.org/10.1016/j.forpol.2011.07.007.

COFI (BC Council of Forest Industries). 2022. Personal communication. May 16 and September 2022.

Federal Reserve Bank of St. Louis (FRED). 2022. U*.S. Census Bureau and U.S. Department of Housing and Urban Development, New Privately-Owned Housing Units Started: Total Units [HOUST]*. Available at: https://fred.stlouisfed.org/series/HOUST (accessed 29 November, 2022).

Global Affairs Canada. 2022. *Softwood Lumber.* Available at: https://www.international.gc.ca/controls-controles/softwood-bois_oeuvre/index.aspx?lang=eng (accessed 25 November, 2022).

Government of British Columbia. 2021. 2021 B.C. Highway Flood Recovery Projects. Government of British Columbia. Available at: https://www2.gov.bc.ca/gov/content/transportation-projects/bc-highway-flood-recovery (accessed 16 February, 2023).

Insurance Bureau of Canada (IBC). 2022. *Insured Losses of 2021 Floods Now $675 Million.* Available at: http://www.ibc.ca/bc/resources/media-centre/media-releases/insured-losses-from-2021-floods-in-bc-now-675-million (accessed 11 November, 2022).

Johnston, C. M. T., and G. C. van Kooten. 2016. Global Trade Impacts of Increasing Europe's Bioenergy Demand. *Journal of Forest Economics 23: 27-44.* https://doi.org/10.1016/j.jfe.2015.11.001.

Johnston, C. M. T., and G. C. van Kooten. 2015. "Back to the Past: Burning Wood to Save the Globe." *Ecological Economics 120 (December): 185-193.* https://doi.org/10.1016/j.ecolecon.2015.10.008.

Just, R. E., D. L. Hueth, and A. Schmitz. 2004. The Welfare Economics of Public Policy. A Practical Approach to Project and Policy Evaluation. Cheltenham, UK: Edward Elgar.

Lai, C., Lui, X., Su, W., Zheng, A. 2022. Causes and Effects of the November 2021 Pacific Northwestern Floods in British Columbia. *Highlights in Science, Engineering and Technology, 17 (1).* https://doi.org/10.54097/hset.v17i.2462.

Madison's Lumber Reporter. 2020. *North American Softwood Lumber Production, Sawmill Capacity Utilization, WWPA: March 2020 – December 2020*. Available at: https://madisonsreport.com/2020/08/14/north-america-softwood-lumber-production-sawmill-capacity-utilization-wwpa-may-2020/ (accessed May 23, 2022).

Madison's Lumber Reporter. 2021. *North American Softwood Lumber Production, Sawmill Capacity Utilization, WWPA: January 2021 – December 2021*. Available at: https://madisonsreport.com/2021/08/16/north-america-softwood-lumber-production-sawmill-capacity-utilization-wwpa-may-2021/ (accessed May 23, 2022).

Madison's Lumber Reporter. 2022. *North American Softwood Lumber Production, Sawmill Capacity Utilization, WWPA: January 2022 – February 2022*. Available at: https://madisonsreport.com/2022/05/20/north-america-softwood-lumber-production-sawmill-capacity-utilization-wwpa-february-2022/ (accessed May 23, 2022).

Haley, D., & Nelson, H. 2007. Has the time come to rethink Canada's Crown forest tenure systems? *Forestry Chronicle, 83(5), 630–641*. https://doi.org/10.5558/tfc83630-5

Random Lengths. Various Issues. *Forest Product Market Prices and Statistics Yearbook*. Published by J. P. Anderson, N. West, A. Fitzgerald, and D. Guzman. Eugene: Random Lengths Publications Ltd.

Rotherham, T., & Armson, K. A. 2016. The Evolution of Forest Management in Canada: Management Paradigms and Forest Tenure Systems. *Forestry Chronicle, 92(4), 388–393*. https://doi.org/10.5558/tfc2016-071.

Statista. 2022. *Monthly Price of Lumber in the United States from January 2019 to March 2022*. Available at: https://www.statista.com/statistics/1239728/monthly-lumber-price-usa/ (accessed May 16, 2022).

Statistics Canada. 2022. *Table 14100205: Average Hourly Earnings for Employees Paid by the Hour, by Industry. Monthly, Unadjusted for Seasonality*. Available at: http://dc.chass.utoronto.ca.ezproxy.library.uvic.ca/cansimdim/English/ (accessed 25 November, 2022).

Takemura, R. 2020. Economic Reasoning with Demand and Supply Graphs. *Mathematical Social Sciences 103: 25-35*. https://doi.org/10.1016/j.mathsocsci.2019.11.001.

U.S. Lumber Coalition. n.d. *Canadian Subsidies and Dumping*. Available at: https://uslumbercoalition.org/issues/canadian-subsidies-dumping/ (accessed 20 January, 2023).

van Kooten, G. C. 2021. Applied Welfare Economics, Trade, and Agricultural Policy Analysis. University of Toronto Press. https://doi.org/10.3138/9781487533236.

van Kooten, G.C.; Schmitz, A. 2022. Covid-19 Impacts on U.S. Lumber Markets. *For. Policy Econ.* 2022, *135*, 102665. https://doi.org/10.1016/j.forpol.2021.102665.

van Kooten, G. C., Schmitz, A., & Kennedy, P. L. 2019. Is Commodity Storage an Option for Enhancing Food Security in Developing Countries? *Journal of Agricultural & Food Industrial Organization, 18(1)*. https://doi.org/10.1515/jafio-2019-0054.

van Kooten, G.C.; Nelson, H.; Mokhtarzadeh, F. 2021. Canada-U.S. Softwood Lumber Dispute: Background. Chapter 2 in International Trade in Forest Products: Lumber Trade Disputes, Models and Examples; van Kooten, G.C., Voss, L., Eds.; CAB International: Wallingford, UK; pp. 10–26.

van Kooten, G.C.; Zanello, R.; Schmitz, A. 2022. Explaining Post-Pandemic Lumber Price Volatility and its Welfare Effects. *J. Agric. Food Ind. Organ. 18.* https://doi.org/10.1515/jafio-2022-0018.

Yin, R., & Baek, J. 2004. The US–Canada softwood lumber trade dispute: what we know and what we need to know. *Forest Policy and Economics, 6(2), 129–143.* https://doi.org/10.1016/S1389-9341(02)00104-1.

World Trade Organization (WTO). n.d. *Anti-Dumping, Subsidies, Safeguards: Contingencies, etc.* Available at: https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm8_e.htm (accessed 25 November, 2022).

Zanello, R., Shi, Y., Zeinolebadi, A., & Kooten, G. C. van. 2023. COVID-19 and the Mystery of Lumber Price Movements. *Forests, 14(1), 152*. https://doi.org/10.3390/f14010152.

Zhang, D. 2007. The Softwood Lumber War: Politics, Economics, and the Long U.S.-Canadian Trade Dispute, 1st ed. Routledge: London, UK.

Zhang, D. 2001. Welfare impacts of the 1996 United States—Canada Softwood Lumber (trade) Agreement. *Can. J. For. Res. 31, 1958–1967*. https://doi.org/10.1139/cjfr-31-11-1958.

Zhang, D. 2006. Welfare impacts of the 1996 United States—Canada softwood lumber agreement: An update. *Can. J. For. Res. 36, 255–261.* https://doi.org/10.1139/x05-231.