SUPER DISRUPTIONS AND SUPPLY CHAIN CRISES: THE CASE OF LUMBER IN THE UNITED STATES DURING THE COVID-19 PANDEMIC

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ABSTRACT

The coronavirus (COVID-19) pandemic of 2020-2021 wreaked havoc on supply chains around the world. The forest products industry and, specifically, the lumber industry have been no exception with the price of lumber rising in the United States to levels not seen since the housing boom of the post-World War II period. The rise has also affected downstream industries such as the creation of single and multi-family housing and transportation products such as pallets. This study examined empirical evidence to determine if the lumber industry crisis qualified as a super disruption versus an instantaneous disruption by examining the four criteria of impact, scope, recovery, and timing. The study found that the lumber industry met all four of these characteristics as they relate to a super disruption or a supply chain crisis. An outline is then presented to develop a responsive and dynamic supply chain management business model that attempts to integrate resilience and adaption at different stages of an outbreak or crisis.

***Keywords**: COVID-19 pandemic, Housing Supply, Instantaneous Disruptions, Logistics, Lumber, Operational Risks, Ripple Effects, Super Disruptions, Supply Chain Crises, Supply Chain Resilience*

INTRODUCTION

The COVID-19 pandemic has created a disequilibrium in supply and demand, causing many product shortages from semiconductor chips to chlorine, medical supplies, and even toilet paper. Almost 94% of the Fortune 1000 indicated disruptions in their supply chains (Sherman, 2020). Also

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affected was the lumber industry. The forest products industry is particularly complex given all the partners within the many layers of transactions as well as the diversity of products in the end market, including lumber.

A typical supply chain for forest products consists of the owner of the timber, the buyer, the logger, and the mill. Potential buyers of timber purchase trees from the timber owner who may be directly involved in the sale or may use a consulting forester. A sale can consist of a per unit basis or a lump sum process. The purchasers then contract loggers to harvest the trees. Timber is processed into logs that are then segregated based on the end products created. Logs are then transported by truck to a mill where value-added softwood products are made for structural framing (e.g., beams, rafters, headers, and joists) as well as manufactured products used within residential construction such as doors, windows, trusses, and cabinets. Softwood is also used for pallets, fences, porches, decks, garages, and landscape walls. Builders of such products do not, in general, purchase from sawmills, but, instead, use an intermediary such as a lumber yard.

Between April 2020 and April 2021, the surge in the price of lumber increased the cost of an average new single-family home by $35,872 and the price of an average new multi-family home increased by $12,966 with the average monthly rent for a new apartment rising by $119 (Emrath, 2021). During this time period, this represented a 184% increase in product costs for single-family and 190% for multi-family builder's lumber costs (Emrath, 2012). This resulted in the largest rise in lumber prices since the U.S. housing boom that followed after World War II (Miller, 2021). Though the COVID-19 pandemic caused a significant increase in the price of softwood products, there was a background of concurrent issues that converged to contribute to the surge. These included 2017 Canadian lumber tariffs imposed during the Trump administration and the closing of thirty large sawmills as a result of a recession and housing downturn created by the subprime mortgage crisis between 2007 and 2010 (Mitchell, 2021).

CRITERIA FOR A SUPER DISRUPTION

Ivanov (2021) argues that *resilience* is a vital and central determinant in the administration of supply chain management. He defines resilience to be "a firm's capability to withstand, adapt, and recover from disruptions" in order to achieve continuity of operations to meet target performance and customer demands. Figure 1 indicates four major differentials that have been developed to distinguish aspects of resilience between instantaneous and supper disruptions in supply chains (Choi, 2020; Ivanov, 2021). The disruption of the lumber industry meets all four of the indicated criteria for a super disruption (supply chain crisis) in that the disrupted state was long-term and marked by a gradual degradation affecting a broad scope of supply and demand factors. Unlike an instantaneous disruption, the lumber industry experienced a recovery process within the presence of a continuing disruption that experienced simultaneous and sequential openings and closures involving suppliers, distributors, and market venues.

Figure 1: Instantaneous Supply Chain Disruptions and Super Disruptions/Supply Chain Crises

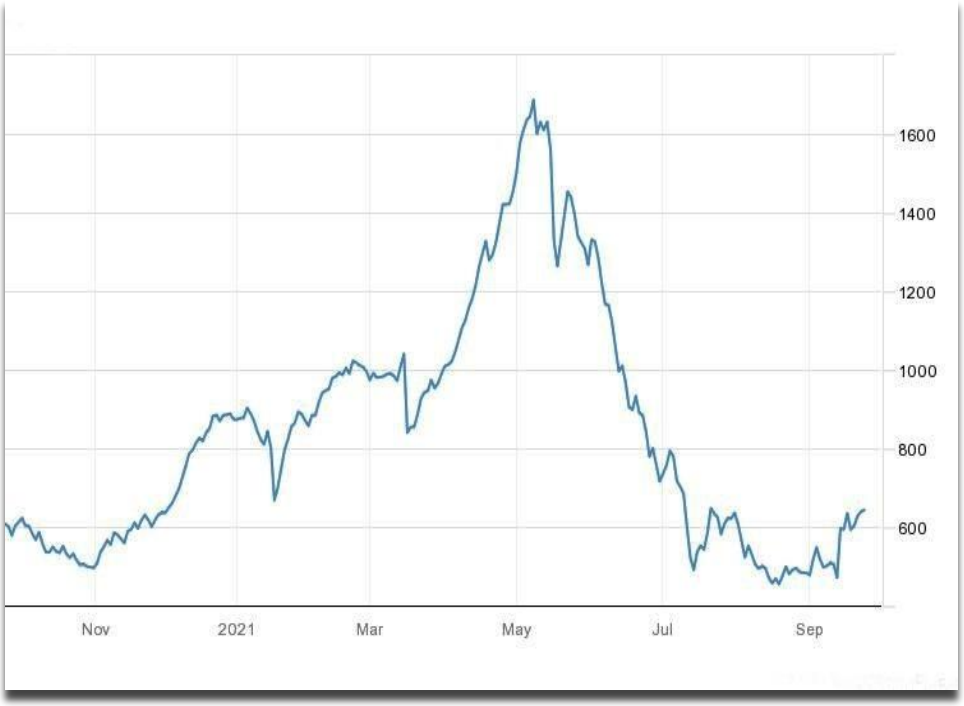
Criteria	Instantaneous disruption (e.g., an earthquake or fire)	Super disruption/supply chain crises (e.g., a pandemic)
Impact	Instant impact	Long-lasting impact with hardly predictable scaling
Scope	Single supply chain echelon (with possible propagations)	Simultaneous disruptions in supply, demand, and logistics
Recovery	Begins when disruption is over	Is performed in the presence of a disruption and its unpredictable scaling
Timing	A single disruptive event	Simultaneous and/or sequential openings and closures of suppliers, facilities, and markets

Adapted from: Ivanov, D. (2021) *Introduction to supply chain resilience: Management, modelling, technology.* Cham, Switzerland: Springer.

IMPACT

Far from having an instant impact, the price of lumber per thousand board feet grew from $336 on May 7 of 2020 to a peak of $1,711 approximately one year after, for an increase of 409% (Random Lengths, 2021; Trading economics, 2021). Proper scalability to adjust logistical services and to costs became difficult due to unpredictability of volume as to the supply base of processed timber. Forecasting load and scheduling appropriate capacity became diminished. This was exacerbated

Figure 2: Rise of the Price of Lumber During the COVID-19 Pandemic



Source: Trading economics.com/commodity/lumber.

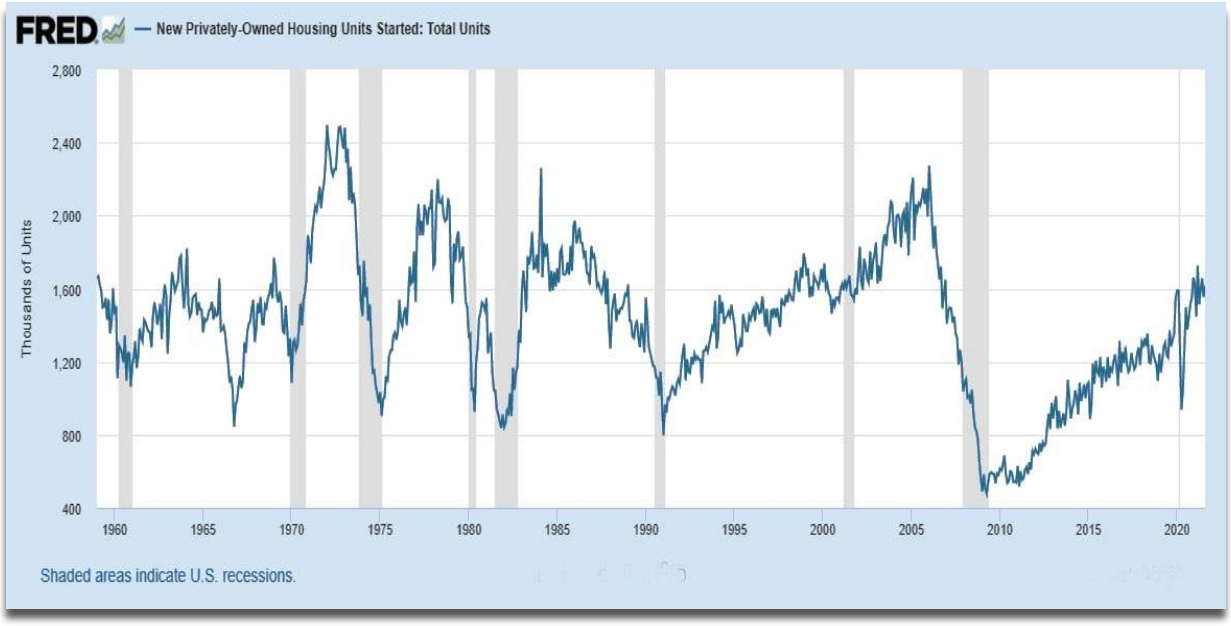
by increased demand for new home furnishings (primarily for office space) and remodeling (do-it-yourself) products for many who transferred to remote working in their homes. This was financed, in part, by federal government stimulus checks as well as federal government supplements to unemployment compensation.

SCOPE

Consistent with the scope of a super disruption, the forest products industry experienced logistical disruptions throughout its supply chain, affecting supply, demand, and market venues. Prior to the pandemic, the housing industry had misread market conditions and, therefore, reduced sawmill production and unloaded inventory in fear of a pending housing crash. Thirty mills closed, causing a reduction of over two thousand jobs between May of 2019 and May of 2020, just as the pandemic was starting to grow (Mitchell, 2021). Health concerns about mill workers resulted in shift reductions and shutdowns, beginning in March of 2020. The reduction in logs being shipped to sawmills saw a shortage in truck drivers, thus increasing transportation costs and the price of end products.

The dramatic increases in the prices for framing lumber and structural paneling resulted in a significant drop in housing starts. The $35,872 increase in the cost of an average new home was believed to have priced about 5.5 million households in the U.S. out of the housing market, meaning that these households could no longer qualify for a mortgage to purchase the average new home (National Association of Homebuilders, 2021b).

Figure 3: New Privately-Owned Housing Starts from 1960 to 2021

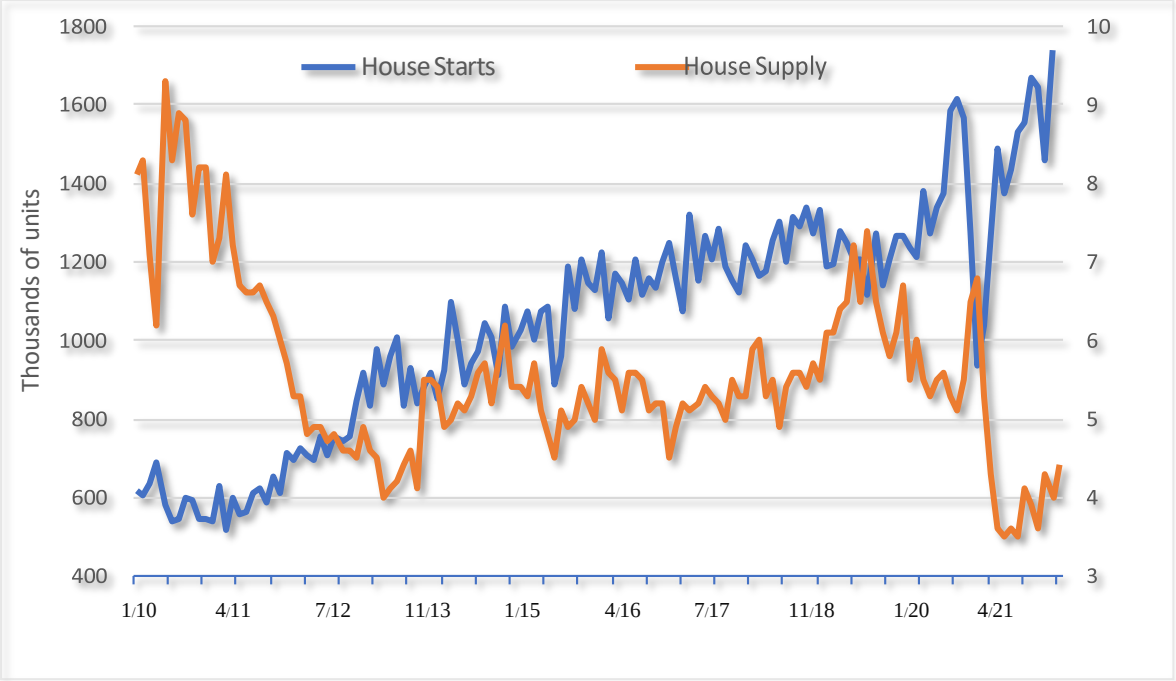


Source: Federal Reserve Economic Data (2021b)

As Figure 3 indicates, housing starts consistently experienced downturns during recessionary periods. However, in the first quarter of 2020, an aberrant decline occurred due to the general economic shutdown caused by the pandemic. The second quarter of that year saw an expansion of housing starts. However, as indicated in Figure 4, the expansion was met with a depletion in housing supply with a gap that has narrowed but continued into the third quarter of 2021.

Characteristic within the scope of the long existence of a super disruption is the phenomenon of the *ripple effect*. The ripple effect "refers to structural dynamics and describes a downstream propagation of the downscaling in demand fulfillment in the supply chain as a result of severe disruption" (Dolgui et al. 2020). Instead of remaining localized or within one segment of the supply chain, a cascading downward affected the entire supply chain, causing delivery delays, loss of market share, and precautionary steps to prevent lower revenues. Haren and Simchi-Levi (2020) cited two examples of ripple effects from the pandemic. The first involved Fiat Chrysler Automobiles ceasing their production of vehicles in Serbia due to the halt of parts coming from China. The second was Hyundai suspending their production automobiles in Korea due to a similar, severe disruption in spare parts coming from China.

Figure 4: Housing Starts and Housing Supply from 2010 to 2021



Adapted from Zhang, X., & Stottlemyer, A. (2021). *Lumber and timber price trends analysis during the COVID-19 pandemic.*

An example of a precautionary measure in the lumber industry, resulting from a ripple effect, was the inclusion of price escalation clauses by builders in sales and construction contracts (see Figure

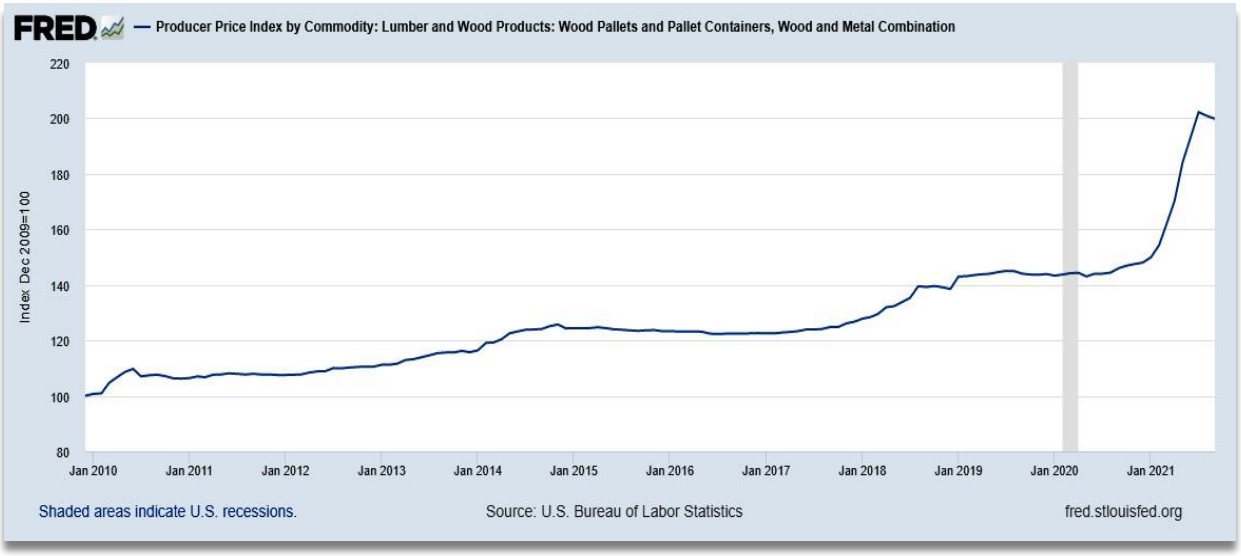
5). According to a survey conducted by the National Association of Home Builders (2021a), 47% of builders included such clauses which, in essence, allows for adjustments in wages, fees, and other payment to account to fluctuations in the cost of raw materials like lumber. Any burden of price increases for material and labor cost are passed on from the builder to the purchaser of the home.

Another example of a ripple effect in the related downstream industries of forest products involved pallets. Wooden shipping pallets are used as the base of a *unit load* which is a fundamental and standard means to ship products with the utilization of forklifts and jacks. Approximately one billion are produced in the United States on an annual basis with an estimated two billion in usage at any given time (Murray, 2021). A pallet is usually 90% wood with the rest consisting of metal, plastic, or cardboard. In 2021, about 94% of transporting businesses used wooden pallets (Michel, 2021). Pandemic-triggered shift reductions, shutdowns and lockdowns substantially reduced production, causing the price of a wooden pallet to nearly double from $9 to $15 (Mitchell, 2021; Murray, 2021) and to continue rising into the third quarter of 2021. The pallet price boom, in turn, increased the prices for all transported products, including fertilizer and farm products.

Figure 5: Methods by Which Builders Dealt with the Recent Increases in Lumber Prices During the COVID-19 Pandemic (Represented by Percent of Respondents of an April, 2021NAHB Survey)

Adapted from: National Association of Home Builders (2021a)

Figure 6: Producer Price Index by Commodity. Lumber and Wood Products: Wood Pallets and Pallet Containers, Wood and Metal Combination



Source: Federal Reserve Economic Data (2021a)

RECOVERY AND TIMING

Unlike the recovery phenomenon of an instantaneous disruption (e.g., an earthquake), which begins when the disruption is over, the recovery pertaining to a super disruption occurs within the presence of the actual disruption despite the unpredictable scaling of the lasting crisis. This recovery manifests itself as an attempt to couple a supply chain with the dynamics of the disruption.

In the case of the lumber industry, the U.S. government dropped tariff rates on Canadian lumber from 20% to 9% in December of 2020, during the middle of the crisis (NAHB, 2020). Also, all three thousand sawmills in the country became fully operational by the end of that year. As a consequence of these actions, the price differential between timber and lumber prices narrowed. However, complexity of the downstream industries of forest products will delay full recovery into 2022 because of a shortage of truck drivers, shipping containers, and vehicle chassis.

The lumber crisis, far from being a single disruptive event, consisted of simultaneous disruptions that affected suppliers, facilities, and end markets. Much of the epidemic outbreak propagations consisted of ripples within supply chain echelons due to shift reductions and lockdowns. The ripple effect is a very strong catalyst for stress within supply chains with disruptive propagations that threaten the collapse of any supply chain or the creation of a prolonged recovery (Dolgui et al. 2018). The lumber industry's specific vulnerability to ripple effects warrants the need for a multi-faceted exploration with regard to preparedness adaption, and recovery.

CONCLUSION

The COVID-19 pandemic wreaked havoc on the lumber industry's supply chain as it did on many others. The industry's weaknesses reveal the need for a focus on viability within a responsive and dynamic model that integrates resilience and adaption at different stages of an outbreak or crisis. A dynamic model would seek the interaction and engagement of external and internal resources, including human labor, a flexible manufacturing process, a transportation network, suppliers, and an effective communications structure. Quiroz et al. (2020) suggest several focuses for the development of an effective operations and supply chain management business model to deal with epidemic outbreaks and pandemics:

1. *Preparedness focus* that pre-allocates resources, incorporates distribution planning, and practices product diversification and substitution.
2. *Adaption focus* that seeks to re-allocate supply and demand as well as providing flexible production technologies to accommodate societal needs during a pandemic (e.g., masks, disinfectant spray, and ventilators,).
3. *Ripple effect focus* that attempts to control disruption propagations through modeling of potential pandemic scenarios and the consequences of supply chain structural dynamics.
4. *Recovery focus* that attempts to integrate the recovery of capacities, the workforce, and logistical infrastructures while also forecasting pandemic propagations and ramping-up the decision-making process.

Dealing with uncertainty, risk, and disruption regarding a supply chain is always a challenge, even in the most stable of times. Therefore, an interrelated and correlated model that incorporates preparedness, response, and recovery to restore normal operations, fulfillment continuity, and target performance is vital to designing resilience as a central determinate in the management of a supply chain. Along with resilience is the importance of maintaining regular communications with suppliers and clients to ensure a consistently operational and effective business.

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