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Resilience of U.S. Rail Intermodal Freight during the Covid-19 Pandemic

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ABSTRACT

The rapid onset of the COVID-19 pandemic in March 2020 marked a challenging time for the US and its freight industry. Manufacturing slowed, consumer purchasing patterns changed, and for many, shopping moved online. The freight industry suffered a sharp decline in shipments, followed by a surprisingly quick rebound. The industry had to adapt quickly to meet fast-changing demand and supply patterns upended by global supply chain disruptions. This paper uses U.S. intermodal activity data, supported by in-depth interviews with leaders of railroads, intermodal carriers, equipment manufacturers, car leasing companies, shippers, and e-commerce players to characterize and assess how the rail industry met the challenge of this demand whiplash and other performance impediments. What emerges is a rich picture of the multi-actor intermodal supply chain, the impacts of COVID-19 on it, the performance of the logistics system in general, and railroads in particular during the pandemic. Industry interviews revealed that a handful of choke points, many of which were outside the rail industry, complicated supply chain responses to COVID-19. The paper shows how the rail industry was an essential component of pandemic resilience, demonstrating a high level of adaptability to meet consumer and business demands. Through the use of depth interviews it reveals the complexity of the intermodal supply chain, and it accurately foretells the subsequent disruptions that continued to plague that supply chain long after the initial impacts of the pandemic.

1. Introduction

Railroads have been an essential part of the United States economy for 170 years, helping to grow the nation by supporting settlement and economic growth from coast to coast. The rail industry has always been in a state of change, ranging from adopting new power sources to changing product mixes to innovations in operating strategies to integration with other transportation modes. The industry has responded to and facilitated market trends, with focus shifting from passengers to freight, from products to bulk commodities, from mostly domestic flows to a central role in international trade, and from break bulk shipments to supporting retail marketing patterns.

Nimbleness of the rail industry in the face of market volatility has advanced in part because of the regulatory relaxation that came with the Staggers Act of 1980, which freed the industry from rate regulations and anticompetitive measures, giving railroads the flexibility to adapt services and to price at levels that allowed them to earn their cost of capital. The industry has continued to innovate, fulfilling the mandate for Positive Train Control (PTC) to assure system safety and support improvements in operating efficiencies. The Class I railroads operating in the U.S. have moved to a variety of forms of Precision Scheduled Railroading (PSR), blocking trains to permit origin to destination moves with fewer stops, and reducing needs to re-sort trains in intermediate yards. This increased average train speeds and reduced dwell times in yards (Leonard, 2021), boosting reliability and efficiency, releasing some resources in the process, and lowering operating ratios (ratios of operating costs to revenues) in response to investor priorities.

This paper explores the impacts of the COVID-19 pandemic on U.S. rail IM service and the resilience of that service in terms of its ability to...
respond to and rebound from pandemic-induced disruptions. It identifies bottlenecks in the IM supply chain and explores their causes. It addresses the prospects for IM rail as the pandemic recedes, considering likely changes in domestic and global supply chain patterns and emerging developments in e-commerce and the supply chains that support it.

The paper provides data-supported insights into the critical role rail freight played in the nation’s essential supply chains in the face of the pandemic-induced disruption and post-pandemic economic rebound. A key aspect of this role is the contribution of rail to the success of e-commerce, supporting on-demand delivery in the context of competition from trucking and air freight. The findings of this study may help position the rail industry to support emerging trends in sourcing, manufacturing, and consumer purchasing.

The multi-method approach used here combines analysis of private and government-provided data describing IM freight and railroad activities during the pandemic period, and in-depth interviews with 20 leaders in the railroad, trucking, and consumer sales sectors. These interviews were essential for providing insights into what was happening in the supply chains from the perspective of a cross-section of industry leaders – key managers in IM freight. While objective data used was descriptive in terms of patterns of IM flows by mode, to understand causality it was important to query senior managers who had direct visibility of elements the supply chain, as providers and consumers of services. The 20 leaders were selected to provide this broad overview of the COVID-19 experience.

Each of these leaders was interviewed on a pre-scheduled video call using a structured questionnaire. Four members of the research team were on each call to assure that the views of the respondent(s) were accurately captured, to follow up on answers to assure depth of the interviews, and to take notes. In addition, all calls were recorded and a transcript was created. Two independent sets of written notes were prepared and compared. These written and audio records informed the co-authors as they extracted and interpreted the results of the interviews. Where necessary, one of the co-authors re-contacted interviewees to clarify the responses.

In this paper, the information received in these interviews is distributed throughout the text, rather than separated, to provide an integrated, multi-dimensional picture of the impacts of COVID on rail IM. The authors’ interpretations and opinions are offered separately in the conclusions.

Based on these sources, the paper describes the state of commerce and IM freight as the COVID-19 pandemic began and through its first year; performance obstacles encountered through the IM supply chain; the likely dynamics of IM supply chain performance as indicated by first year experiences; near term expectations and opportunities for railroads; and public policy issues of importance to the future of rail freight.

2. PRE-COVID TRENDS IN THE RAIL INDUSTRY

In the years shortly before COVID-19 hit, energy shipments by rail were declining; coal has been experiencing a long-term decline - coal’s share of U.S. electricity generation fell by half, from 48% to 19% between 2008 and 2020 (U.S. Energy Information Administration, 2021). This was driven primarily by the ready availability of less costly (and cleaner) natural gas. Shipments of petroleum fuels were reduced by the global oversupply of petroleum, which undercut the prices of domestically-produced shale oils and hit the economic viability of fracking.

Since the opening of Panama Canal Neopanamax locks in 2016, which incentivized investments in east and Gulf coast ports and harbors to accommodate larger container ships, there has been some diversion of Asian imports headed for Midwest and eastern U.S. destinations from west coast (WC) to east and Gulf coast ports. This was supported by the economies of larger container ships, and by some shift in sourcing from China to Southeast Asia in search of lower production costs, which made the Suez Canal route to east coast (EC) of North America more competitive. An additional factor has been ongoing congestion and labor uncertainties in southern California (SoCal) ports, which led retailers and manufacturers to diversify the use of inbound ports to assure supply chain resilience.

The shift to EC ports favored truck-to-destination container movements, rather than IM rail, because haul lengths to markets are shorter in the eastern U.S. Still, WC, and particularly SoCal ports, continued to have a strong draw for containerized imports because of time and cost advantages to both the WC and Midwestern U.S. markets.

The heavy-and-slow bulk product markets – energy, building, and waste materials, and agricultural products – are where rail has its greatest competitive advantage, except in the Mississippi Valley, where barge is also important. Before and during the pandemic, agricultural exports experienced volatility because of trade conflicts between the U.S. and China, Canada, and Mexico.

The growth of lucrative U.S. IM traffic – trailers and containers carried on specialized cars for the longest legs of trips from ports or manufacturers to inland distribution centers – had been underway for several decades when the pandemic struck. Before the pandemic, IM represented just over half of the railroad market in terms of carload and IM unit volumes (see Fig. 1). IM cargo is primarily a mix of imports and manufactured goods headed for distribution centers and consumers, or component parts destined for assembly plants. The Internet brought online purchasing, e-commerce, into the market, and imported goods purchased online became a growing component of IM traffic.

In the years prior to COVID-19, the U.S. Class I railroads introduced versions of PSR, which resulted in fewer, longer, and more direct trains operating on more predictable schedules. This improved service quality – speed and reliability – in key markets, reduced or eliminated service in smaller origin-destination markets, and allowed railroads to sideline or repurpose unneeded power and infrastructure (notably classification hump yards), and to realign workforces to match services. PSR has allowed the industry to focus on reducing operating, enhancing support from investors. PSR has also allowed the railroads to position themselves more directly for IM traffic, which, in response to customer demands, is driven by speed and reliability.

3. COVID-19 IMPACTS AND REBOUND: THE ROLE OF INTERMODAL FREIGHT

The first quarter of 2020 saw rail volumes drop quickly for most commodities as a result of COVID-19 (see Fig. 2, showing percentage change since 2018), mirroring the change in industrial production. Precipitating forces were a sudden drop in employment and shutdowns in manufacturing because of plummeting demand, worker illness, and the need to assure workplace safety. Plant closures affected both inbound and outbound freight – e.g., plastics for auto manufacturing and finished vehicles – both major products moving by rail.

The surprise was the rebound, coming quickly starting in the beginning of the second quarter of 2020 and continuing into the first quarter of 2021, and reaching the levels of the spring of 2019 by the end of 2020. Industry leaders interviewed for this study expressed unanimous surprise with the rapidity of the rebound in demand for some products, a marked difference from the slow multi-year rebound of the Great Recession of 2007–2009. COVID-19 led to a quick shift in consumer demand from services to products, energizing purchasing of

2 Representing four class I railroads, one container port, three large national retailers, two rail car leasing pools, two national chassis pools, two large trucking firms, and one rail car manufacturer.

3 Some container freight is bulk agricultural products headed for export terminals.
Fig. 1. Proportion of rail freight by commodity in the U.S. (carloads/intermodal units 2007–2021) (Association of American Railroads, 2021).

Fig. 2. Percentage change in U.S. rail freight and industrial production (2018–2021) (Board of Governors of the Federal Reserve System (US), 2021).
products for in-home use and home improvement, and particularly boosting e-commerce shopping as consumers found that many needs could be met without leaving home. As a consequence, demand for IM shipments exploded – the word used by many of those interviewed.

This is clear in Fig. 3, which shows changes in weekly IM rail freight movements along with changes in personal consumption expenditures in durable goods. Here the rebound came faster than that for all rail freight, and by the start of 2021, IM activity matched the peak of 2018, a banner year for the industry.

The shift to IM was accelerated by capacity constraints in the trucking market, attributable to persistent driver shortages amplified by the spread of COVID-19. Manifestations in the trucking industry included both tender rejections (refusals of service) on rates contracted in advance and surcharges for shipments that exceeded contracted levels, as shown in Fig. 4, where the index (i.e. tender rejection percentage) rose from average of 5% pre-pandemic to above 25%, and Fig. 3, showing reduced truck tonnage. This pattern of reduced availability of long-haul truck capacity was also reported in the industry interviews. Together these sources suggest that IM rail service played a critical role in the nation’s supply chains during the pandemic, providing much-needed capacity to keep essential goods flowing.

The IM market, particularly the growing share coming from e-commerce, is important for the railroads, not simply for the cargo volumes but also for its high revenue potential. That potential comes with a challenge because of customer demands for high performance levels: short travel times and especially predictability and reliability of on-time delivery of consumer products and manufacturing inputs. Interviews with industry leaders suggested that on-time delivery reliability dominated price in the choice of shipment options, particularly in the e-commerce market.

3.1. Performance of the U.S. Intermodal Market during COVID-19

While there were (and continued to be) reports of gaps in IM supply chain performance, in the form of delayed deliveries at the network (door-to-door, or port-to-door) level, no data could be found that supported significant performance failures on the rail segments. Of course, it is important to recognize that, except for the very largest shippers, most IM customers do not have direct visibility over rail performance – except when there is a serious breakdown – because they work primarily with motor or marine carriers, or third-party logistics companies, which establish longer-term arrangements with rail carriers. In fact, small and medium size shippers may not even be aware that there is a rail segment in their container moves as long as shipments arrive on time.

3.2. How Intermodal Freight Works: A Complex System with many Moving Parts

Delivering end-to-end IM freight services – moving boxes from ports or factories to assembly plants, distribution centers, retail stores, and customers – clearly a centerpiece of the U.S. logistics system, is a complex process. To identify where performance gaps may be occurring, it is important to understand the full complexity of IM supply chains. This process is conceptualized in Fig. 5, which shows flow of inbound freight among the key actors and signals the dependence of the efficiency of the overall process on the performance of every link in the chain.

Efficient IM requires the collaboration and coordination of ocean carriers; ports and port operators; drayage companies and shortline railroads in and around ports; long-haul trucking, especially in the eastern U.S.; Class I railroads; chassis owners and pool operators; inland terminal operators, warehouses, and distribution centers. Behind the scenes are rail car leasing companies and manufacturers. And, of course, the shippers, product manufacturers, and assemblers, wholesalers, and retailers. The graphic also shows that mobile resources, containers and chassis, must be recycled to keep the process moving. For example, some products in 40-ft marine containers may be transloaded to 53-ft domestic containers near inbound ports so international containers can be returned more quickly to their origins to be refilled; chassis used to move containers from ports to trains, and from trains to warehouses or customers, must return to ports or inland terminals for reuse; and domestic containers need to get back to their origins.

Results of the interviews conducted for this research highlighted the potential for disconnects and delays throughout the process, specifically at the network nodes – terminals and interchange points. Integrated carriers, i.e., those firms controlling all of the end-to-end resources – chassis, containers, tractors and drivers, holding long term rail contracts – may be better equipped to assure the success of this multi-step IM logistics. When the demand peaks unexpectedly, as was the case when the COVID-19 rebound began, some capacity and performance issues can be expected; that they were not worse than experienced is a credit to the nimbleness and resilience of this complex system.

3.3. Sources of Delay in the Intermodal Process as a Result of COVID-19

Leadership interviews were the primary source of information about the locations and causes of delays in the IM supply chain. Almost all of these delays were at the nodes of the IM supply chain network, and all are choke points under normal operations. COVID-19, its impacts on both labor availability and shipment demand, exacerbated these bottlenecks.

3.3.1. Delays at Ports and Inland Storage

Ports, particularly the busiest container ports in the country, Los Angeles and Long Beach (the southern California or “SoCal” ports), are major points of congestion on the IM network (United States Department of Transportation, 2019). The WC ports have a long history of both market dominance and congestion, the latter due to the sheer volume of container moves, but also because of a history of labor strife. A number of regulatory and pricing schemes have been applied to reduce port congestion, with varied success (Kingston, 2021; Mongelluzzo, 2019; Mongelluzzo, Szakonyi, & Ashe, 2021).

When COVID-19 hit, loaded inbound container volumes dropped precipitously, first reflecting manufacturing shutdowns in China, and later the dip in U.S. economic activity (Fig. 6). Both data and industry interviews showed that by July 2020, adjustments in the U.S. economy began to pull more products through the Asian supply chain; October showed an almost 30% increase in containers coming through the Port of Los Angeles compared with the same month in 2019. Similar increases were reported in EC ports (Szakonyi, 2020a), and demands for drayage around ports were pressing capacity limits in mid-2020 (Berman, 2021).

Multiple factors contributed to this uptick in IM freight demand – PPE purchases, consumer shifts to buying material goods instead of experiences (theaters, restaurants), store stock and purchasing for the holiday season, and inventory restocking that was deferred from spring and summer because of the pandemic. On top of this peak in inbound container flows, COVID-19 hit both port workers and truck drivers – over 600 cases were reported in the Port of Los Angeles between December 2020 and February 2021 (Mongelluzzo, 2021; Paris, 2021), and 800 tested positive or were in quarantine by the end of February.

As of February 2021, containers were still not moving off the WC docks fast enough, and that has continued through the spring of 2021 and beyond (Losottii, 2021). Early in the pandemic, some retailers were refusing to take boxes from the ports – sales were off and unloading labor was in short supply, and as a result, port storage was filling up (Szakonyi, 2020b). Retailer acceptance of cargo has remained slow, apparently a result of the entire supply chain backing up and the SoCal ports remained heavily congested as import containers stacked up, filling

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4 Chassis are the trailer frames necessary for moving containers over the road and inside ports.
available storage space to 95% of capacity and above. As on-dock storage reaches capacity, container throughput slows, and inbound ships spend more time in berths, at anchor, and slow-steaming to delay port arrival. Limited labor and lift capacity appear to be ongoing factors, but an important cause as reported in interviews seems to be the slow rate of recipients retrieving inbound boxes—using the WC ports as remote warehouses. As in all queuing systems, as the ratio of demand to capacity, or saturation ratio increases, queue lengths and delays start to grow exponentially.

These delays were not limited to WC ports. In July of 2021, the Union
Pacific Railroad and BNSF Railway temporarily stopped accepting cargo from the WC Ports destined for Chicago hubs to allow inland box pick-up to catch up (Ashe, 2021; Stephens, 2021). This reflects the inability or unwillingness of beneficial cargo owners to move freight quickly enough out of container yards, perhaps a manifestation of both retailers and manufacturers carrying larger inventory cushions to reduce the chance of stockouts, and/or a shortage of storage capacity and labor at the final destination.

As many as 54 vessels were anchored off the SoCal ports awaiting berths in February 2021 (Louttit, 2021), leading some marine carriers to divert ships to other WC ports—Oakland, Seattle, and Tacoma. Some carriers have redirected or canceled sailings, and the Federal Maritime Commission was asked to investigate the problem (LaRocco, 2021; Tirschwell, 2021).

Port congestion and COVID-19-related supply chain problems led some shippers to pursue a four-corner strategy, dividing inbound shipments between SoCal, the Pacific Northwest, and two EC ports, Savannah or Charleston and the Port of New York, to reduce risks of delays. Some container owners were reported to be reluctant to ship boxes to EC ports because of slow return cycles compared to WC ports, further congesting WC ports.

This four-corner trend continues to be reported but the impacts seem limited. The draw of SoCal ports remains strong for a variety of reasons, including proximity to large WC markets and the high level of efficiency of rail for moving IM shipments to the U.S. interior. It is difficult for both carriers and shippers to move away from established logistics patterns supported by extensive private and public infrastructure, concentration of labor, long-term contracts, and deep organizational experience.

Assuring the right amount of warehouse and distribution center space in the right places is not a trivial optimization problem. The warehouse development cycle takes time, and there is often local opposition to the siting of new distribution centers because of concerns about rail and truck traffic impacts, a push-back that conflicts with economic development agencies looking to grow jobs. Furthermore, the volatility of retail, and particularly the variety of fulfillment strategies, increasingly requires flexibility in reconfiguring logistics chains,
including the ability to lease/invest in distribution centers on a short term horizon.

3.3.2. Transload Facilities

Near-shore transload facilities can be additional choke points on the overall IM logistics network, while providing shippers additional flexibility in adjusting cargo destinations in near-real-time in response to changing market demands. About a third of inbound international containers, 20- and 40-ft boxes, are transloaded to 53-ft domestic containers at or near the ports for transport by IM rail or long-haul truck. Only the smaller (40-ft) boxes are accommodated on many container ships, while the domestic containers can be swapped for the internationals at a ratio of 2 for 3, amplifying inland shipping capacity. The remaining two-thirds of inbound marine containers are split about evenly between rail to smaller cities and truck to destinations in SoCal.

3.3.3. Equipment Shortages: Boxes, Chassis, but not Rail Cars

Beyond WC ports operating at capacity, some IM delays were attributed by leaders interviewed to lack of equipment availability – domestic containers (boxes) and chassis for moving boxes over the road. Some retailers reported that their boxes sometimes missed scheduled outbound trains at ports, apparently because of slowed in-port box drayage and loading. Some manufacturers and retailers were reported to be slow to unload inbound containers because of local labor shortages as well to hold them for short-term use for local plant or store inventories. As noted, boxes and chassis are typically not provided by the rail carrier, but arranged by the marine carrier, the shipper, or their agents, through a complex web of shared pools and leased equipment.

Chassis shortages were reported at inbound ports and rail ramps as both carriers and customers held on to chassis to meet short term needs. Labor shortages for chassis maintenance were also reported, at least partly due to the pandemic. There are mixed reports from those interviewed as to whether the chassis maintenance issue has been resolved, with variation across regions and time. In the cases of both boxes and chassis, capacity problems seemed to be driven by resource allocation factors rather than by an insufficiency of equipment - an allocation process that is typically managed by third parties outside the control of the rail carriers themselves.

None of the industry leaders interviewed reported shortages of rail cars in total or by type; shortages, or misallocations, were focused primarily on chassis and to a lesser extent containers.

3.4. Meeting Supply Chain Needs of Retailers through Intermodal Freight

Rail is price-competitive with truckload moves for IM freight, especially in long haul markets, where the time and money costs of transloading and lifts on and off trains can be offset by the efficiency of long, double-stack blocked (or unit) trains (i.e. moving as a full train between major terminals without additional processing at classification yards). However, pressures coming from customer demand for quick delivery to support online sales, in the face of shipment delays during the peak of the pandemic, were reported by those interviewed to have led to some diversion from IM rail to direct, long-haul trucking at higher cost. As noted, most of the delays were occurring at the ports, rather than on the rail network itself, and trucks were substituted to make up time. It is not clear how common this diversion tactic has been during the rebound, but paying premium transport prices to meet spiking retail sales, or to produce a delivery line from shutting down, is not uncommon in the global logistics system. One current manifestation is the rapid increase in international air cargo shipments to distribute critical resources to fight the pandemic, as well as to deliver high-value consumer products: from January through December 2020, air cargo rates from Asia to the U.S. increased 66%, and another 36% through November 2021 (U.S. Bureau of Labor Statistics, 2021a; U.S. Bureau of Labor Statistics, 2021b).

The diversion from IM to direct trucking is an indication of the value of timely fulfillment in some markets, as well as the purchasing power of some retailers. It is a factor that can impact volumes on the rail leg of IM but which may be out of the direct control of the railroads themselves if delays are concentrated in ports.

Based on interviews of industry leaders, the largest IM shippers were able to get the capacity and service that they demanded from carriers because of their leverage in the marketplace. These large retailers were reported to keep multiple carriers and paths in their supply chains to assure some level of competition for price control, as well as to provide greater resilience through redundant paths for inbound freight. But even middle size shippers reported reasonable satisfaction with IM performance, accepting and adapting to some uncertainties in arrival of inbound freight, and adjusting their supply chains in response. Smaller shippers may have been able to gain some service advantage by working through 3PLs and logistics support firms which have the capacity to procure freight capacity to the advantage of their customers.

Most import shippers work with long-haul trucking or marine carriers as well as freight forwarders/brokers to procure door-to-door services. These integrating carriers assemble the IM moves, arranging all steps of pick up, long-haul water and rail, and destination drayage, including procuring boxes and chassis as needed. Some retail and manufacturing customers reported becoming aware that their shipment was moving by rail only in the event of major delays. This suggests that from the standpoint of the beneficial cargo owner, IM can deliver service levels comparable to, and competitive with, door-to-door long-haul trucking – making it essentially indistinguishable from an end user's perspective, except for the reduced cost stemming from the efficiency of the rail move.

3.5. Bouncing Back and Rail Employment Factors

Monthly Class I railroad employment as reported to the Surface Transportation Board (STB) has been in a modest decline in recent years, probably due to adjustments as a result of the implementation of PSR (Stephens, 2019; Ziobro, 2020), as well as market trends (Fig. 7). In March 2020, the shrinkage accelerated sharply, with the loss concentrated in Train and Engine (T & E) personnel, suggesting service reductions connected with demand shrinkage attributable to COVID-19. The bottom of the employment swing occurred in June 2020, a decline of 18% of total employment, and 28% of train and engine workers, year over year. T & E employment dropped 18% just between March and June of 2020. Table 1 shows that railroad T&E employment dropped faster than it rebounded. This may have been because demand did not come back so rapidly, but volume data do not support this. The slower rebound may have been because it is easier to furlough employees than to bring them back online: furloughing requires only one or a few decisions by employers; returning to work requires decisions by both employers and employees. For some workers, federally-boosted unemployment compensation rates may have been too attractive for them to return quickly to work; some may have taken other jobs or have been constrained by family obligations created by the pandemic. Some industry observers interviewed (not railroaders) speculated that a nimble rail service restoration might have been impeded because of PSR-driven cutbacks in personnel and power that were too close to the bone. In the manufacturing sector, it was reported that some firms that aggressively laid off workers when the pandemic hit found it difficult to restart production when the rebound became apparent (Tita & Hufford, 2021).

The significance of this view – that the rail industry might have been quicker to bring back capacity – and its underlying cause is uncertain, but it is clear that the railroads were able to bounce back strongly as shipment demand rebounded, and in particular were able to provide capacity for IM movements when trucking struggled to deliver it. It seems likely that at least some manufacturing and retail shippers will build extra resilience into their supply chains as a result of lessons learned from COVID-19. These experiences may inform future railroad planning, as well.
Research in Transportation Business & Management 43 (2022) 100791

4. E-Commerce, Omnichannel Retailing and the Role of Intermodal

Online shopping – e-commerce – has been a growing component of retail sales for more than a decade (U.S. Census Bureau, 2021a). Growth has been accelerating, and the lockdowns of COVID-19 induced both a change in purchasing patterns – from experiences to goods – and a rapid shift to online purchasing as many retail outlets were closed and consumers avoided in-store shopping. Fig. 8 shows the trend in e-commerce share from January 2019 through the third quarter of 2020. This highlights the very rapid jump coming into the second quarter of 2020, the effect of the pandemic. At the COVID-driven peak in the second quarter of 2020, e-commerce was 16.1% of all retail. This dropped to 14.0% in the fourth quarter of 2020, as some purchasing moved back to retail stores.

Department of Commerce figures include expenditures related to gasoline and fuels at gas stations, car dealers, and restaurants and bars, which are not normally purchased online. If these items are excluded, the online share of total retail sales becomes 21.3% in 2020, up from 15.8% in 2019 and 14.3% in 2018 (Ali & Young, 2021).

E-commerce is clearly here to stay and is expected to grow. The natural experiment of COVID-19 has shown many shoppers that this form of purchasing and the delivery (and return) experience is convenient beyond the restrictions of the pandemic. It adds to the portfolio of buying options within omnichannel retailing as described by Chopra (Chopra, 2018), where merchants offer products through in-store purchases, online buying with direct delivery, and online shopping and store pickup, with the latter often being quicker and less costly. The commitment to omnichannel sales is exemplified by reports from interviews that some national retail chains have been modifying the physical arrangement of stores to provide warehouse space for both direct-to-customer deliveries and in-store pickup. The retail stores of these merchants are becoming omnichannel outlets.

The rail component of e-commerce freight is IM traffic, inbound freight from ports or manufacturing centers to inland distribution centers, and it is reflected in the rapid growth of IM shipments during the pandemic. The rail advantage is the capacity and cost efficiency that it brings to e-commerce in competition with direct truckload freight. However, IM is also complementary to trucking from the standpoint of both carriers and shippers. In the face of tight capacity in the trucking sector, leadership interviews suggested that carriers and shippers saw rail IM as a way to pick up the slack. Shippers saw IM as an insurance policy that can provide considerable capacity at a reasonable cost. For e-commerce and omnichannel retailers in particular, IM is a critical link in the import supply chain.

Will the trend to e-commerce continue? Consumers were buying more physical products during the pandemic, but as the virus is brought under control, a more normal purchasing balance between experiences and goods can be expected – Fig. 9 suggests this was beginning at the end of 2020. Still, the trend in online processes, accelerated and tested under COVID-19, is likely to continue and grow. The result may not be more goods purchased, but more goods purchased in different ways. E-commerce brings advantages to retailers as well as shoppers. A strong e-commerce channel can add resilience to sellers in the face of disruptions. It can deliver certain goods to customers at lower costs. And it is now possible for smaller retailers to benefit from online markets by selling...
through vendors that can provide shell, wrap-around services, from web portals to payment management to warehousing and inbound and outbound shipping (e.g., Shopify, Amazon, and UPS) (Chopra, 2021).

5. The Aftermath and Challenges for the Future

A post-pandemic economic recovery is underway in the U.S., though not equally distributed across society, geographic regions, or economic sectors, nor has it been a monotonic recovery, as COVID-19 continues to return in waves. Consumer purchasing trends are returning to a different normal, with more in-store shopping than at the peak of the pandemic, but with a continued growth in online buying and associated expectations for quick delivery that is comparable to in-store buying.

The intermodal supply chain has continued to experience significant congestion and growing delays caused by bottlenecks at ports and inland terminals, driven by shortages of chassis, containers, labor, and storage capacity, trends that were clearly presaged by the interviews conducted for this research. The bottlenecks are primarily at the nodes, the terminals and warehouses, where intermodal transfer rates are not keeping up with the arrival rate of inbound freight.

Labor shortages have continued to impede trucking, but all sectors in the supply chain have struggled to meet the need for workers as the job market across the U.S. has tightened. This is raising pressure to modify employment criteria (e.g., to permit hiring 18-year-olds as interstate drivers, and to soften drug testing rules), and to accelerate automation efforts.

At the same time, product demand has been increasing because of restocking and holiday shopping, creating a perfect storm in the supply chain.

Some major shippers have responded to bottlenecks on the maritime side by chartering their own vessels (Paris & Nassauer, 2021) and diverting cargo to less congested ports, e.g., Seattle, Oakland, and east coast ports such as Savannah, Norfolk, Baltimore, and New York. Those diversion ports are becoming congested as well, struggling with insufficient storage space for inbound containers and adding pop-up, off-site storage in response (Lopez, 2021). The Port of Los Angeles has shifted to 24 h operations, but landside terminals receiving containers from the port have not done the same, and thus the overnight capacity has been underutilized (Putzger, 2021).

The complex, multi-player IM supply chain is likely to make the path to a new equilibrium extend at least through 2022. The future may see more domestic and near-shore sourcing and manufacturing, as well as larger inventory cushions. At the center of the U.S. supply chain are the railroads, which will need to continue to build their own resilience based on lessons from the pandemic – assuring sufficient personnel, power, and terminal storage to deliver essential capacity, anticipating quick changes in demand, collaborating to build the capacity of supply chain partners on whom overall system performance depends, and continuing to deploy the technologies necessary to track and manage their performance.

The pandemic has served to emphasize that terminal throughput rates and storage capacities are critical to IM performance, and thus are important to all involved in the supply chain. The need is for both capacity growth and more efficient allocation and utilization of resources to get the best use out of all IM assets. This may suggest the opportunity and value for the rail industry to engage in terminal and warehouse planning and development through actions ranging from collaboration to advocacy to direct investment.

6. Conclusion

The pandemic has demonstrated the critical need for resilience of the freight industry, manufacturers, and retailers – the ability to adjust quickly and efficiently to changing levels and patterns of supply and demand. All of the players in the U.S. IM logistics system face pressures to perform, and, in the long run, their response should result in a...

![e-Commerce Retail Sales as a Percent of Total Sales](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAB1AAAAcCAYAAACtBvP2AAAAAElFTkSuQmCC)

**Fig. 8.** e-commerce as a share of total retail sales in the U.S. (2018–2020) (U.S. Census Bureau, 2021a).
stronger and more resilient IM supply chain.

A vibrant and adaptable multimodal freight transportation system is a cornerstone of an effective and competitive economy. Rail, trucks, barges, and air carriers each have their own specialized roles in this system. COVID-19 has demonstrated criticality and vulnerability of performance at the nodes of the network, the ports, terminals and warehouses. All parts of the system must perform effectively for the system to work effectively. In the United States, the rail network is at the core of that freight system, serving as the prime mover of bulk materials for construction, agriculture, manufacturing, and energy, and, in the IM market, functioning as the lynchpin for highly efficient, reliable long distance movement of products that support manufacturing and personal consumption.

The disruptions of COVID-19 produced a significant impact on the U.S. freight system in 2020, 2021, and continuing into 2022, both as the effects of the pandemic came into play and especially in the rapid rebound in demand for certain products as stay-at-home purchasing patterns developed. This whipsaw effect forced the industry to play catch up with services offered and the resources needed to deliver them.

While the industry did that successfully, continued congestion in the supply chain is a warning that this chain is only as strong as its weakest links. The lessons learned provide useful guidance for mapping the future of the rail industry and the entire U.S. logistics system, suggesting places where terminal capacity increases are warranted, where better coordination among collaborators is essential, and where allocation and utilization policies for equipment and other resources could be adjusted to improve overall freight system performance. Such actions and investments will help deliver the freight system resilience needed for the next major disruption.

**Author contributions**

All authors contributed to all aspects of the study from developing methodology, to analysis and interpretation of results, and manuscript preparation. All authors reviewed the results and approved the submission of the manuscript.

**Disclaimer**

The content of this paper is the sole responsibility of the authors and does not necessarily reflect the positions or policies of the Association of American Railroads or any of the organizations represented by those interviewed for this work.

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\(^5\) Schofer, J., H. Mahmassani, M. Ng, and B. Johnson. The U.S. Railroads and COVID-19: Keeping Supply Chains Moving. Northwestern University Transportation Center, 2021.

\(^6\) Names of interviewed industrial leaders are listed in the aforementioned report.
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