MARITIME TRANSPORTATION RESEARCH AND EDUCATION CENTER
TIER 1 UNIVERSITY TRANSPORTATION CENTER
U.S. DEPARTMENT OF TRANSPORTATION

Shipping Container Chassis in the U.S.
December 2017 to December 2019

Dr. Bethany Stich
University of New Orleans
368 Milneburg Hall; 2000 Lakeshore Drive New Orleans LA 70148
Tel: 662-312-0048; email: bstich@uno.edu

Peter Webb
University of New Orleans
368 Milneburg Hall; 2000 Lakeshore Drive New Orleans LA 70148
Tel: 901-596-9576; Fax: 504-280-6272; email: pwebb@uno.edu

James Amdal
368 Milneburg Hall; 2000 Lakeshore Drive New Orleans LA 70148
Tel: 504-280-6873; email: jamdal@uno.edu

FINAL RESEARCH REPORT
Prepared for:
Maritime Transportation Research and Education Center

University of Arkansas
4190 Bell Engineering Center
Fayetteville, AR 72701
479-575-6021

ACKNOWLEDGEMENT

This material is based upon work supported by the U.S. Department of Transportation under Grant Award Number 69A3551747130. The work was conducted through the Maritime Transportation Research and Education Center at the University of Arkansas.

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the U.S. Department of Transportation's University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

TABLE OF CONTENTS

TABLE OF FIGURES

PROJECT DESCRIPTION

The University of New Orleans Transportation Institute (UNOTI) examined the issues surrounding the current state of international chassis utilization in the United States (U.S.). The international chassis system in the U.S. is unique compared to global chassis utilization where the motor carriers, the freight customers, or off-site terminals provide chassis. However in the U.S., the divestment of international chassis by ocean carriers, which began in 2009, resulted in three major international chassis leasing companies linked to the foreign carriers. These lessors are the American shippers' predominant provider of international chassis. The extra cost associated with the lack of international chassis lessor competition profits the foreign ocean carrier lines while raising costs for domestic consumers. This situation is compounded by the fact that Direct Chassis Leasing International (DCLI) acquired the domestic fleet of one of the other two major international chassis lessors, TRAC Intermodal in January of 2018. Since then DCLI has also been investing in data analytics to improve chassis repositioning to meet demand. This means that chassis are located where they are needed rather than idling. The company has also added 11,000 more pieces to its chassis pools (DCLI 2018), further consolidating the chassis provision and limiting competition.

The lack of true market competition in chassis pricing, where truckers would be able to choose based upon a combination of cost and availability, has led to artificially high rates for motor carriers as well as unnecessary congestion at marine terminals. Truckers, in many cases, have to make extra turns at port facilities to secure a chassis linked by a major provider to a foreign ocean carrier in order to complete a container acquisition. Thereby, shipper stakeholders want the ocean carriers to be fully separate from the international chassis link of the supply chain (Federal Maritime Commission Bureau of Trade Analysis, 2015). The control of the leasing options by the ocean carriers means that many truckers are locked into using the international chassis leased by whichever intermodal equipment provider (IEP) is "legacy-linked" to the ocean carrier for whom they are making any given leg of their journey. There is no choice for these truckers (Mongelluzzo 2017c). Generally, a motor carrier with permission to pick up a container from one ocean carrier would not have permission to use another ocean carrier's chassis to do so, despite complete physical interchangeability.

Presently, from a national perspective, there is no overarching management solution to chassis pooling or chassis ownership. It is the legacy of contracts controlled by the ocean carriers which has led to ever-more vigorous calls for open choice of chassis on the part of truckers. Open choice refers to motor carriers and truckers being free to choose their own chassis based on market rates and convenience rather than following legacy contracts (Connors, 2017). Despite this problematic situation, chassis is not at the forefront of the freight trade or academic literature.

This report is an effort to expose the challenges associated with this unique U.S. chassis provision. First, we outline key chassis regulations, focusing on those associated with the Ocean Carriers Equipment Managers Association (OCEMA), a U.S. association of 15 main ocean carriers who oversee the operational safety of U.S. intermodal ocean freight transportation. Second, we discuss the anti-trust issues related to the chassis legacy contracts. Third, we consider the topic of environmental sustainability as it relates to the current chassis dilemma. Fourth, we examine the subject of chassis regarding disaster resilience. Fifth, we review the

concerns of time and money involved with chassis as it presently operates in the U.S. Finally, the operations of chassis globally and in the U.S. are compared. To understand how this situation came into being, it is necessary first to understand the history of containerized shipping.

METHODOLOGICAL APPROACH

As an exploratory study, this research uses primarily secondary source analysis. Exploratory research is conducted for a problem or issue that has not yet been comprehensively studied. The goals of this method are to establish priorities, define terms and/or operations and procedures and determine the best research design, key stakeholders, data collection methods and appropriate units of analysis.

Johnson (2014) notes, "Technological advances have led to vast amounts of data that has been collected, compiled, and archived, and that is now easily accessible for research. As a result, utilizing existing data for research is becoming more prevalent, and therefore secondary data analysis. While secondary analysis is flexible and can be utilized in several ways, it is also an empirical exercise and a systematic method with procedural and evaluative steps, just as in collecting and evaluating primary data" (p. 619). The main source of our information was *The Journal of Commerce*. Relevant federal regulations were also accessed, as well as prior Transportation Research Board chassis research. Additionally, the director of the Port of Houston and the owner of a New Orleans-based motor carrier were interviewed. A chassis-oriented tour of the port operations surrounding chassis use at the Port of New Orleans was conducted.

The significance of this study, therefore, is that it calls attention to a vital and understudied area of freight logistics. Furthermore, this study identifies significant problems associated with the current chassis system. In accordance with the goals of exploratory research, an extensive literature review was conducted to determine the current state of chassis utilization in the U.S. and, then, determine the key issues associated with this system of provisions; recommendations for addressing these issues are provided and future research needs are identified.

LITERATURE REVIEW

Historical Context

Shipping containers are large, rectangular metal boxes in which cargo is transported by sea, rail, truck, and, rarely, air. When used for international shipping, they come in standard lengths of 20, 40, and 45 feet. This is known as containerized shipping. Prior to the advent of containerized shipping, cargo was shipped by a method known as breakbulk. In this method, large gangs of dockworkers known as stevedores and longshoremen loaded and unloaded cargo from ships. Stevedores usually owned the equipment for this unloading, and it was they who directly employed the longshoremen. This was the process whether the cargo was shipped in smaller boxes, crates, sacks, bales, etc.

Prior to the advent of containerization, break bulk cargo was loaded, lashed, unlashed and unloaded from a ship one piece at a time. This was a time-consuming process at best. The cargos were also subject to theft and/or vandalism. Malcolm McLean revolutionized international shipping in 1956 by inventing a standardized method to transport cargo. Today roughly 90% of the world's trade in non-bulk goods utilizes containers for transport (George 2013). Since its nascent beginning in 1956, over the decades containerization has grown to become the industry norm in international trade and transport. It offered a degree of standardization that allowed for intermodalism: the use of a standard storage unit (the container) to be used on a train, a truck (with chassis), or on various sized vessels: from small coastal ships to the mammoth container vessels of today. It also slashed the costs associated with international transport to a fraction of its former (pre-containerization) era.

It took some time for containerized shipping to really take hold of the shipping industry, but by the 1970s this method was rapidly revolutionizing it (Levinson 2008). Ships loaded high with containers (container ships) sailed up to the docks of ports, where the importing containers were unloaded by cranes, and the exporting containers waiting at the docks were simultaneously loaded onto the same ships. This new technology significantly impacted the labor forces of the stevedores and longshoremen. For example, according to one director of the Port of New Orleans, over the roughly twenty-year period from 1967 to 1986, the tonnage at the Port tripled, while the longshore labor force declined by a factor of 60% (Port director one 2017). Global seaborne container trade is believed to account for approximately 60% of all world seaborne trade, which was valued at around 12 trillion U.S. dollars in 2017. Containerized shipping links trading partners between the water, rail, and air modes as well as on-time distribution points and retail outlets.

Containers are how freight moves seamlessly from one mode to another and this system depends upon intermodal drayage. Drayage is the movement of freight via truck. Intermodal drayage refers to the movement of containers between ports and rail terminals, and an inland destination. Drayage typically includes either delivering an export container to the port or picking up an import container. It "is a hub-and-spoke system with the ports and rail terminals as the hubs and drayage providing the spokes" (Cambridge Systematics, Inc. et al. 2011). According to the U.S. Customs and Border Protection, it "…processed … more than 28.5 million imported cargo containers at U.S. ports of entry [in FY 2017]" (U.S. Customs and Border Protection 2018).

The crucial transportation modes involved in getting shipping containers to or from an inland distribution hub or a port are rail or truck. Rail is important particularly for inland distribution hubs that are located remotely from ports or inland waterways. But for both distribution hubs and ports, trucks carry 64% of the tons and 69% of the value of freight moved in the U.S. By 2045, it is projected that trucks will move essentially the same percentage of the expected 25 trillion total tons of freight. Nowhere is the importance of trucking more obvious than in relation to North American Free Trade Agreement (NAFTA) freight flows. From August 2015 to August 2017, trucks carried 64.7% of U.S. NAFTA freight. That amounts to $31.9 billion of the $52.0 billion of total imports (61.4%) and $31.1 billion of the $45.4 billion of total exports (68.5%) (Bureau of Transportation Statistics 2017). Without a chassis, a truck is just a cab with wheels.

A chassis is defined as a special type of truck trailer/undercarriage developed specifically to facilitate roadway-based transportation of domestic and marine shipping containers. Chassis have a skeleton structure consisting of a frame, multiple axles (2 to 3) and several locking mechanisms (known as twist locks) to facilitate locking of the container on the container chassis. Chassis are designed specifically to be the primary means of transport of shipping containers by truck between various shipping facilities, including ports and rail terminals.

For the purposes of this report, only international chassis are discussed (unless otherwise specified), which is the standardized chassis designed to be readily interchangeable for use with the internationally uniform 20', 40' and 45' shipping containers. These international chassis are known variously as marine chassis, ocean carrier chassis, ocean liner chassis, and ocean container chassis. Other kinds of chassis include: domestic chassis, which are designed for use with 48' and 53' length domestic shipping containers; and triaxle chassis, a chassis used in hauling 20' or 40' containers with three axles and a center that slides out, allowing for either size of container. This allows for better weight distribution and allows the hauling of heavier containers.

Trucking is key to shipping, and chassis are key to trucking. Therefore, the international chassis is, in turn, "…the linchpin of today's international commerce" (Lane 2015). Traditionally, ocean carriers (the companies which own and operate the container ships) provided international chassis in the U.S. as part of their pricing package (Tioga Group, Incorporated 2011). That is, the cost of the chassis was included in the price the ocean carrier charged the domestic trucking companies for bringing the containers to, or taking them from, the ocean vessels. However, recent recession-related shifts in international chassis management are creating gridlock at key transportation hubs, financially rewarding international ocean carriers while overburdening domestic motor carriers (trucking companies), and artificially inflating the cost of transport.

Due to the 2008 recession, international ocean carriers decided to divest themselves of their chassis to save money. This process started in 2009, and in 2010 Maersk was the first ocean carrier which stopped offering chassis (Connors 2017). Most other ocean carriers did the same thing over the next three years (ibid). The chassis were sold to chassis leasing companies or intermodal equipment providers, also known as IEPs. A chassis leasing company owns a fleet of chassis, and leases them to shipping companies, which then rent them to their various motor carriers. Collectively, the chassis leasing companies are known as chassis lessors. These lessors wanted guarantees that all the chassis they had purchased from the ocean carriers would be used.

Exclusive contracts were put in place between the chassis lessors and the ocean carriers to ensure this (Connors 2017). Renewal of these contracts has led to a legacy of exclusivity, whereby, in many cases, the ocean carriers are mandating the use of which chassis lessors can be used by the truckers, even though the ocean carriers themselves no longer own the chassis. That is why these contracts are called legacy contracts. The three main chassis lessors are TRAC Intermodal, Flexi Van Leasing, and Direct Chassis Link (DCLI).

- TRAC Intermodal: Princeton, NJ. TRAC Intermodal's international chassis fleet consists of 180,000 chassis (Morley 2017a).

- Flexi Van Leasing: Kenilworth, NJ. Flexi Van's Fleet consists of 177,000 Chassis at 600 marine locations comprising nine pools and 60 depots (ibid).

- DCLI: Charlotte, NC. DCLI's fleet consists of 136,000 chassis. Now that it has acquired TRAC intermodal's domestic chassis fleet as of January 2018, DCLI owns, leases, or manages approximately 136,000 international chassis, as well as approximately 80,000 other chassis, for a total chassis fleet of over 216,000. Additionally, the company manages over 86,000 domestic intermodal containers for third parties, via its REZ-1 asset management platform (ibid, DCLI 2017).

Generally, a motor carrier with permission to pick up a container from one ocean carrier would not have permission to use another's chassis, despite complete interchangeability.

Chassis Pooling

To ameliorate the situation of multiple truck turns, as well as to coordinate equipment (storage and movement), regulatory compliance, and improve supply chain efficiencies, ports began *"*pooling*"* chassis. In pooling, chassis lessors negotiate an agreement whereby all lessor-owned international chassis are made available at terminals that are doing business with those lessors. At the port of Los Angeles-Long Beach (LA-LB), this took the form of a port-wide "pool of pools," in which the three largest international chassis lessors (TRAC Intermodal, Flexi Van Leasing, and DCLI) have arranged for truckers to now "…pick up and drop off chassis at any of the terminals served by the three chassis pools," instead of having to split the operation into two separate trips (Stich, et. al. 2019; Mongelluzzo 2015a). This allowed truckers using TRAC, DCLI and Flexi Van chassis the full interchange of international chassis between the pools formerly managed separately within the port's jurisdiction. The following is a list of the most important chassis pools:

- LA-LB (pool of pools). Participants include TRAC Intermodal, Direct Chassis Link Inc. (DCLI), and Flexi-Van Leasing. The total chassis pool is 100,000 and has been operational since May 2015. The pool incorporates fourteen (14) major marine terminals and four (4) major rail facilities with seventeen (17) start/stop locations (Stich, et. al. 2019). Currently, LA-LB is beginning to experiment with off terminal chassis yards, which frees up terminal space for cargo handling and facilitating cargo processing at the terminals. This is especially beneficial for large ports like LA-LB and NY-NJ. It ultimately calls for a multiplicity of neutral chassis pools to accommodate all the off-terminal facilities (Mongelluzo 2018).

- The Port of New York-New Jersey (NY-NJ) tried to form a port-wide gray pool but the arrangement fell apart when Direct Chassis Link could not find a place to locate its part of the chassis pool (Morley 2017b), as well as the labor issues associated with maintenance and repair (M&R) (Mongelluzzo 2017c).

- The Port of Houston Authority (POHA) decided not to pursue chassis pooling given the complicated issues between the ocean carriers and unionized domestic labor. Private sector interests (motor carriers primarily) declined to pursue this option as well (Stich, et. al. 2019; Amdal 2017).

- Ports in the southeast belong to regional pools in which a truck driver can pick up and drop off the international chassis at the same terminal in any port within the regional pool (Hutchins 2015). For example, in Memphis a cooperative pool (CO-OP pool) that incorporates 15,000 chassis from 11 major motor carriers has been put in place. Some, such as James Newsome of South Carolina Ports, have proposed a national chassis pool (Tirschwell 2017a). In New Orleans, Gulf Consolidated Chassis Pool (GCCP) provides a list of common chassis facilities which include the Port of New Orleans, Ports America, and Burlington Northern Santa Fe, Norfolk Southern, and Union Pacific. Recently, the North American Chassis Pool Cooperative (NACPC) teamed up with Flexi-Van to offer an open choice pool at NY-NJ (Journal of Commerce 2018; North American Chassis Pool Cooperative (NACPC) 2018).

- The primary chassis pool for the southern Atlantic ports has until very recently been the South Atlantic Chassis Pool (SACP) of Consolidated Chassis Management (CCM). In a challenge to this, however, the ports of Georgia and South Carolina port authorities have devised a new Southern States Chassis Pool (SSCP). It would incorporate "... marine terminals, inland intermodal terminals... Depots in Georgia, South Carolina, Alabama, Florida, North Carolina, Tennessee… [The option to join has been] offered to the ports of Jacksonville, Florida and Wilmington, North Carolina. Rail ramps have been offered for Birmingham, Alabama and Nashville, Tennessee and inland ports in Georgia and South Carolina; [Memphis has not been invited to join]"(Ashe 2018f). The SSCP would be a gray/neutral pool encompassing all the member ports and terminals. The SSCP would be increasing the number of available chassis by as much as 12,000, from a current total of 53,000 chassis in the SACP to about 60,000 to 65,000, all to be premium chassis (LED lights, radial tires, antilock brakes), to accommodate post-Panamax ships. It will be starting August 2, 2018, pending Federal Maritime Commission (FMC) approval, and is supported by the Beneficial Cargo Owners (BCOs) and the NACPC, which would run the pool as a non-profit (Ashe 2018f).

However, the SACP and the International Institute of Container Lessors (IICL) have challenged the SSCP, claiming it violates the Shipping Act of 1984, referring to the proposed pool as "...a price-setting agreement between two competing ports and a third party that would regulate the supply of and the price at which chassis, that are neither owned, nor leased by the Member Ports, are to be supplied to users of the chassis... "(Ashe 2018g). The IICL takes issue with the ports of Savannah and Georgia extending chassis management authority to intermodal terminal pools

covered under the SACP. The IICL also maintains that it is adequately meeting the need for increasing the chassis supply, and for premium chassis (Ashe 2018g).

Secondary Data Analysis

Chassis Logistics

"The overall cost of driver and tractor time spent in marine container terminals is estimated at over $1 billion annually. The cost of obtaining international chassis at stacked terminals, as opposed to arriving with an international chassis, is estimated at upwards of $2-4 million... Congestion in the container yard is estimated to cost motor carriers about $37-47 million annually… Extra drayage associated with empty containers, bare chassis, or bobtail tractors (truck tractors with no chassis attached) costs about $11.5 million annually" (Tioga Group, Incorporated 2011:37 adjusted for inflation to 2017). If it takes about "…2.5 drayage trip legs for each container moved… due to the need for tractor-only moves and empty container repositioning" (Tioga Group, Incorporated 2011:1), then American truckers made almost 66 million truck trip legs in FY 2015." A trip leg is the movement of a truck tractor in intermodal drayage. It can be dropping off an empty container, loading or unloading a full container, or hooking/unhooking a chassis. Trip legs take time for truckers to complete, and as the saying goes, "Time is money."

Other costs include gate queuing (trucks waiting in line to get into the marine terminal), gate processing delays, exceptions and troubled tickets (instances where a truck is flagged because of repair issues with the chassis), and congestion on highways and streets. In situations where there are few main international chassis leasing companies, the cost of leasing from them could be as high as $20 per day, as opposed to $12-$15.50 per day when using a leasing company controlled by domestic motor carriers (Mongelluzzo 2017c). Ultimately, this results in higher prices for American consumers. If motor carriers had more freedom to choose their chassis lessors, or to own and use their own chassis, the cost of imported goods would be reduced, benefitting the U.S., not foreign ocean carrier lines. It is the legacy contracts which are the sticking point in the process.

For example, if a trucker picks up a Maersk ocean liner container, the trucker must use an international chassis leased by a Maersk legacy-linked IEP for that portion of their trip. Then, if they drop off the Maersk container to pick up a container from American President Lines (APL), they must first go and collect an international chassis from a different IEP legacy-linked to APL. The truckers who must do this are not compensated for these extra moves or turns. Most truckers are paid by the turn, not the hour.

Nationally, there is no overarching solution to chassis pooling or ownership. The legacy of contract control by the ocean carriers has led to calls for open choice for truckers. That is, motor carriers and truckers being free to choose their own chassis based on market rates and convenience rather than following legacy contracts (Connors 2017). Recently, the NACPC teamed up with Flexi-Van to offer an open choice pool at NY-NJ (North American Chassis Pool Cooperative (NACPC) 2018). NACPC was organized by motor carriers and provides premium chassis pools consisting of high-end chassis with radial tires and LED lights. Although chassis

pooling has proven to be an imperfect solution, it was the first large scale attempt to mitigate a major choke-point for truckers (Bonney 2014).

KEY ISSUES

Key Chassis Regulations

Containers and chassis are governed by international and national law. The first instance of international chassis regulation was the Customs Convention of 1972, which was declared on December 6, 1975. Oversight is provided by the World Customs Organization (WCO). Shortly thereafter the International Maritime Organization (IMO), an agency of the United Nations which oversees the safety of global shipping, declared the International Convention for Safe Containers on September 6, 1977 with a two-fold purpose:

- To maintain a high standard of safety in the transport and handling of containers
- To facilitate the international transport of containers by providing uniform international safety regulations applicable to all forms of surface transport (Stich, et. al. 2019).

The International Organization for Standardization's International Standards for freight containers and chassis has adopted 30 international standards for all manner of containers: air, surface, intermodal; containers on-board vessels, tank containers, platform and platform-based containers (The Institute of International Container Lessors 2017).

The Uniform Intermodal Interchange & Facilities Access Agreement is the standard contract governing the interchange of intermodal equipment between ocean carriers, railroads, equipment leasing companies and intermodal trucking companies. It covers facility access, equipment interchange procedures, equipment usage rules, liability and insurance requirements, administrative processes, and dispute resolution (Tioga Group, Incorporated 2011). At the terminal the driver will go through the terminal operators' sub processes, including:

- Verifying the identity of the driver and motor carrier
- Verifying the transaction is legitimate (inbound and outbound)
- Checking the condition of equipment (inbound and outbound) and issuing an Equipment Interchange Report (EIR)
- Performing the exchange of container and chassis with the container yard (Stich, et. al. 2019).

Regarding roadability (the safe usage of chassis on the roads) legislation was passed in 2009 with oversight provided by the U.S. Federal Motor Carrier Safety Administration (FMCSA). This established a regulatory requirement for safe operation, inspection, repair and maintenance of intermodal chassis in the U.S. Requirements include:

- Single IEP for each chassis (December 2009)
- IEP establishment of inspection, maintenance, repair, and recordkeeping program (December 2009)
- Standardized audit trail of driver Roadability Component Defect (RCD) reports
- Standardized audit trail of Driver Vehicle Inspection Reports (DVIR)
- Application of a U.S. Department of Transportation (USDOT) number to all chassis (December 2010)

"The key effect is to hold IEPs responsible for maintaining chassis to FMCSA standards and establish a corresponding audit trail… The burden has thus been placed disproportionately on the drivers and motor carriers, who must either find a good chassis or wait to have one fixed" (Tioga Group, Incorporated 2011:68). These regulations and the resulting audit trail were created to ensure that IEPs maintain international chassis on schedule and repair defects noted by drivers, establishing a shared safety responsibility among intermodal equipment providers, motor carriers and drivers (Rodrigue 2012). Given that the average age of an international chassis in the U.S. is 19 years, this legislation was notable for maintaining safety and roadability (Stich, et. al. 2019).

The terms under which chassis are provided is governed by the Ocean Carriers Equipment Management Association (OCEMA), a U.S. association of 15 main ocean carriers who oversee the operational safety of U.S. intermodal ocean freight transportation. It is licensed by the FMC, the federal body charged with oversight of international ocean freight in the U.S. (Stich, et. al. 2019).

The terms of chassis provision outlined by OCEMA are paraphrased as follows:

- Individual ocean carriers can coordinate the formation of chassis pools and the upkeep of the chassis (although this is now the purview of separate chassis leasing companies).
- Chassis can be exchanged among individual ocean carriers (although technically they chose to divest themselves of them) and among marine terminal operators and all other parties involved in the shipping process, i.e., "…rail terminal operators, container yard operators, rental companies, shippers, inland carriers, and logistics providers…"
- Individual ocean carriers can form, own, and operate chassis pools or pool-owning companies (although no ocean carriers technically own any of the pool companies anymore). The pools can be managed by carrier-formed chassis leasing companies or neutral parties (gray pools).
- The ocean carriers collectively delegate inspection and maintenance and repair (M&R) of chassis and compliance with state and federal chassis-related law (Ocean Carrier Equipment Management Association 2017:9, 10).

Note that OCEMA is no longer in de facto compliance with its own terms of chassis provision.

U.S. Federal chassis regulations are related to roadability. The original legislation was the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005. Specifically, the legislation states in "Section 4118. ROADABILITY…a requirement to identify intermodal equipment providers (chassis lessors) responsible for the inspection and maintenance of intermodal equipment (chassis) that is interchanged or intended for interchange to motor carriers in intermodal transportation" and "a requirement that an intermodal equipment provider…systematically inspect, repair, and maintain, or cause to be systematically inspected, repaired, and maintained…" the intermodal equipment (Rep Don Young (R) Alaska 2005). The ILA and the ILWU have been in frequent conflict with chassis lessors at union terminals to make sure that the unions are the ones doing chassis maintenance and repair (M&R) (Bonney 2012; Mongelluzzo 2015b).

Antitrust Issues

Chassis Lessors

The deregulation of the 1980s, specifically with an eye towards loosening antitrust legislation, ultimately yielded the three dominant chassis leasing companies, Flexi Van, DCLI, and TRAC Intermodal (Magnier 1988). Part of the leasing companies' evolution was the Federal Maritime Commission (FMC)-scrutinized formation of Consolidated Chassis Management (CCM) in 2012. This chassis consortium consisted of 20 ocean carriers who "managed" but no longer technically owned their chassis, facilitating the use of these chassis in pools so that truckers could use them interchangeably at marine terminals (Bonney 2012). In 2014, the Department of Justice's antitrust division ruled that the Ports of LA-LB international chassis providers could share their international chassis, roughly 100,000, in a gray pool. This ruling set the precedent for the creation of additional chassis pools (Stich, et. al. 2019).

Ocean Carriers

In April of 2017, the major ocean carriers consolidated into three ocean carrier shipping alliances with Vessel Sharing Agreements (VSAs). These three alliances are:

- The **Ocean Alliance**: CMA CGM (Compagnie Maritime d Affretement Compagnie Generale Maritime), COSCO (China Ocean Shipping Company), OOCL (Orient Overseas Container Line Ltd.), APL (American President Lines) and Evergreen (APL is now owned by CMA CGM)
- The Transport High Efficiency Alliance (THE) **THE Alliance**: NYK Group (Nippon Yusen Kabushiki Kaisha Line and NYK Ro Ro [Roll on/Roll off, referring to vessels designed for wheeled cargo such as cars to roll directly aboard]), MOL (Mitsui O.S.K. Lines), O.S.K. (Osaka Shosen Kaisha), "K" Line (Kawasaki Kisen Kaisha, Ltd.), Hapag Lloyd, UASC (United Arab Shipping Company Co.) and Yang Ming (UASC has merged with Hapag Lloyd); and
- The **2M Alliance**: Maersk Line and MSC (Mediterranean Shipping Company), with HMM (Hyundai Merchant Marine Co., Ltd.) and Hamburg Sud (Hamburg Sud is now owned by Maersk Line). HMM is not officially in the alliance, but they have slot purchases and exchanges with MSC as well as Maersk (American Export Lines 2017).

These three alliances now account for "…nearly 80% of global container trade and roughly 90% of container capacity on major trade routes. The main trade lane that is highly affected by this change and the main reason for the new alliances is the North America-Asia a.k.a. "East-West" trade lane between the Far East and North America which will represent 96% of East-West trade" (American Export Lines 2017). As may be expected, this level of consolidation has brought about concerns expressed by the FMC of antitrust violations by the alliances, or, more specifically, abuses by them of antitrust immunity provisions (Bonney 2016a). Under 46 U.S.C. §§ 40307(a)(1), (2), "Exemption from antitrust laws":

- The ocean carriers may act in concert if doing so doesn't negatively impact U.S. commerce.
- The ocean carriers may act in concert when moving in foreign nations during trade with the U.S.
- The ocean carriers may act in concert during marine terminal operations which take place outside the U.S.

- The ocean carriers may act in concert according to any agreements made before the 1984 amendments to the Shipping Act of 1916 (United States Congress 2014:46).

This relates to chassis, for example, in the case of THE Alliance wanting to purchase chassis and containers as an alliance per se, rather than these purchases being made by individual ocean carriers. The chassis lessors interpret federal regulations as prohibiting this, saying that "…section 10(c)(4) of the Shipping Act of 1984 makes it illegal for ocean carriers to collectively discuss the cost of services with truck, rail, or air carriers that are not regulated by the FMC" (Stich, et. al. 2019; Bonney 2016b).

This means that a group of ocean carriers cannot negotiate chassis rates or services with non-ocean shipping companies, unless by doing so they do not violate existing anti-trust laws. This prohibition holds as long it does not affect the total charge of "moving freight from beginning to end" by a group of ocean carriers (Mediterranean Shipping Company 2018b; United States Congress 1999).

This section of the Act can be interpreted such that chassis ownership by the new ocean carrier alliances is off limits, unless the ocean carriers' antitrust exemptions are extended. Such an extension is strongly opposed by the FMC as well as the U.S. Justice Department, to the extent of subpoenaing some of the heads of the alliances' members, even though the ocean carrier alliances have made attempts to remove the appearance of collusion from their VSAs (Bonney 2016a; Hutchins 2017a; Journal of Commerce 2016). American shipping companies and chassis lessors are in fear of the ocean carrier alliances' collective buying power, and this concern has been taken seriously by Congress, which is moving to give the FMC more enforcement power (Bonney 2016b; Hutchins 2017b, 2017c).

Chassis and the Environment

The present chassis supply system hampers environmentally sustainable freight transportation, by contributing to avoidable congestion and the resulting emissions. To better understand this, a working definition of sustainability is in order. "The term 'sustainability' represents a pattern of human activity that aims to use the planet's resources in a manner that meets the needs of the world's population now and in the future, while achieving a balance between environmental conservation, economic development, and livability (including consideration of social equity and justice)" (Stich, et. al. 2019; Federal Highway Administration 2017). When related to transportation, sustainability entails a discussion of the harm caused by vehicle emissions.

Emissions

Freight diesel is a main generator of particulate matter (PM), oxides of nitrogen (NO_x), which generate ozone, and greenhouse gas (GHG) emissions, particularly carbon dioxide (CO_2). PM and NO_x can cause respiratory failure, cancer, and early death in children and older adults. Freight accounts for 29% of all transportation-related GHG emissions, and 68% of that number is due to freight trucking (Federal Highway Administration 2017). Aside from PM, NO_x, and CO_2, diesel freight trucking also releases Hydrofluorocarbons (HFC), Nitrous oxide (N_2O) and Methane (CH_4) (Federal Highway Administration 2017). All these materials are hazardous to human health, and CH_4 is another major GHG. Diesel freight trucking, then, is a contributor to

climate change. It makes sense to seek ways both to reduce freight trucking emissions and to limit the amount of freight trucking activity to the greatest possible extent.

Chassis and Inefficiency

Chassis, however, remains a sticking point in optimizing sustainability at American ports and intermodal terminals. Inefficiencies within the current chassis provision regime lead to excess truck moves, thereby producing more emissions, as well as increasing those from congestion-related idling.

Chassis and Disaster Resilience

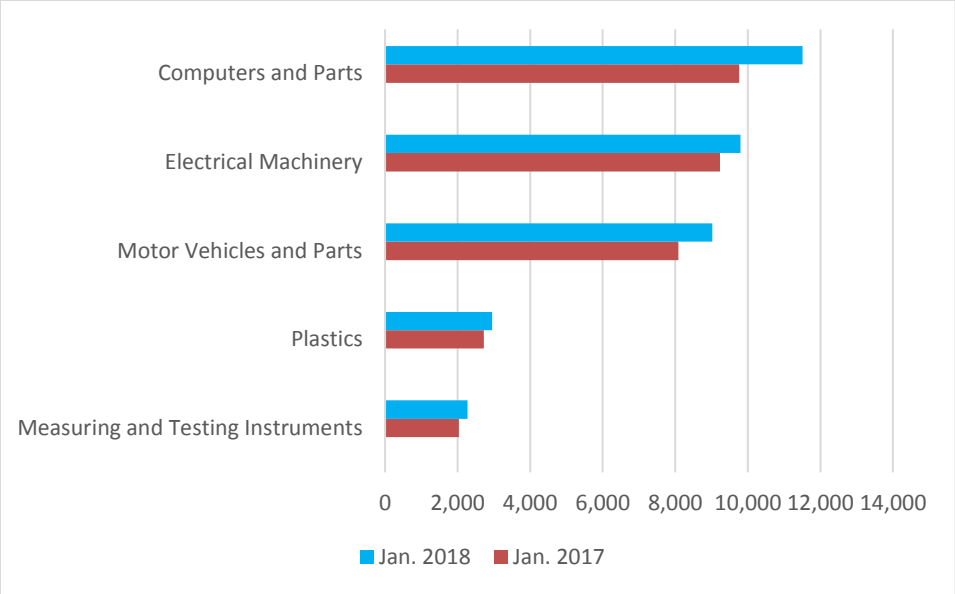
Currently, the size of the U.S. chassis fleet is not adequate for resilience in the case of natural disasters or other severe events. During the winter of 2017-2018, the major freight transportation hubs of Chicago and Memphis were hit by chassis shortages at intermodal rail terminals. The shortages required IEP's to scramble to shift chassis from other locations to meet the need (Ashe 2018d, 2018c, 2018a). One of the major IEPs, TRAC Intermodal, was even forced by this chassis shortage to begin temporary negotiations with the ocean carriers and shipping customers for truckers to use the same chassis on multiple trips, instead of following the legacy contract practice of swapping out a chassis on each trip leg (Stich, et. al. 2019; Ashe 2018b).

Hurricane Irma was also a significant dislocator of chassis: "Tracey Burbank, global supply chain manager for BASF, expressed concern about chassis shortages after Hurricane Irma last September, which crippled its export business even beyond the holiday season. He told the FMC that the company had to idle production at one location and the decision cost more than $2 million … 'It is important that the number of chassis available keep track with the growth of export volumes. It is also important that the region have access to extra chassis from another region during localized disruptions'" (Ashe 2018g).

Time and Money

The shift in ownership of international chassis from ocean carriers to leasing companies occurred quite rapidly, and "…many acquisitions of the assets by the leasing companies had ancillary conditions negotiated by the ocean carriers linked to continued chassis usage" (Federal Maritime Commission Bureau of Trade Analysis 2015:32, 33). In many cases, the original contracts between ocean carriers and leasing companies dating from when the carriers divested themselves of international chassis have ongoing legacy effects on leasing options for shippers, even though the carriers no longer own the chassis. In some chassis pools, this can limit leasing options for international chassis users.

Although ultimately the customer pays the entire cost, that customer does not see all the component parts or the tradeoffs between them, particularly the costs associated with transport. Just the top five commodities moved by trucks accounted for $35.5 billion in 2018 alone. See figure 1.



Commodities	Jan. 2017	Jan. 2018
Measuring and Testing Instruments	2,031	2,271
Plastics	2,724	2,950
Motor Vehicles and Parts	8,089	9,024
Electrical Machinery	9,236	9,795
Computers and Parts	9,760	11,514
Total	**31,840**	**35,554**

FIGURE 1. TOP 5 COMMODITIES BY TRUCK (DOLLARS IN MILLIONS).

SOURCE: BUREAU OF TRANSPORTATION STATISTICS, TRANSBORDER FREIGHT DATA, HTTPS://WWW.BTS.GOV/TRANSBORDER

Figure 2 illustrates the complexities in chassis supply created by the abovementioned dynamic:

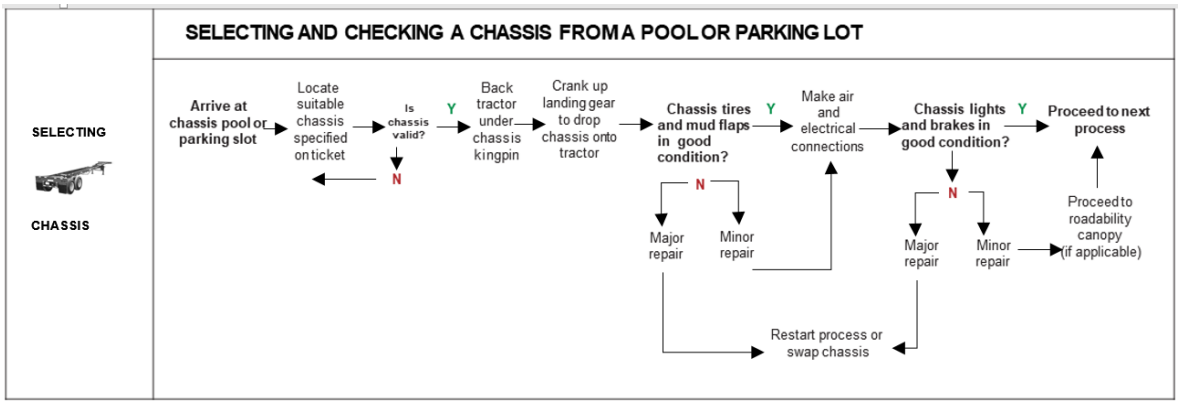


FIGURE 2. CHASSIS SELECTION DYNAMICS.

SOURCE: (TIOGA GROUP, INCORPORATED 2011:14)

Many chassis pools, such as the regional pool in use at Savannah, have greatly increased efficiency, and the practice of various pooling arrangements in general has become widespread. However, while chassis pooling is a step in the right direction, problems remain. For example,

the "pool of pools" at LA-LB still experiences delays. International chassis remain concentrated with overflows of empty containers at different terminals, leaving less chassis availability at other yards when they are in demand. This is due to an imbalance of international chassis with given demand due to fewer leasing options because of legacy links between ocean carriers and the few chassis lessors available. These linkages inhibit the motor carriers' choices of choosing a chassis leasing firm. Also, the large number of terminals linked to multiple different carriers makes the tasks of leasing, dropping off, and picking up international chassis more complicated. Other problems include different chassis load requirements at different terminals; that is, whether a truck can enter a given terminal yard with or without a chassis attached already (Mongelluzzo 2017a).

There are numerous opinions as to why chassis pooling is not more efficient. In the past, some have cited the actual number of international chassis as the root of the problem: "…the number of chassis has increased only 2.7% in the last four years, compared with an 11% rise in containers entering U.S. ports…" (Whelan 2015). Others cite labor issues, such as an insufficient supply of mechanics to maintain and repair international chassis (ibid). Negotiations with organized labor—the International Longshoremen's Association (ILA) on the east and Gulf coast; the International Longshore and Warehouse Union (ILWU) on the west coast—can be complicated when considering the necessary labor to maintain and repair an aging chassis fleet. Maintenance and repair of chassis is a factor that will become increasingly important as the chassis fleet ages (Tirschwell 2017a). And, concerns have been raised of possible overcharging on the part of chassis pools with few lessors and therefore less market competition (Morley 2015).

U.S. Chassis vs Global Chassis Systems

"Everywhere else in the world container chassis are supplied by customers, truckers, or off-terminal pools, and are brought to the marine terminal by the drayage driver. Drivers in other countries do not interchange chassis with the ocean carriers or terminal operators. Costs or delays in obtaining a chassis are therefore an internal drayage company issue in those countries, and of no concern to the marine terminals…" (Tioga Group, Incorporated 2011:64). In the U.S., however, chassis leasing companies are the predominant model.

When discussing the differences between chassis access in the U.S. and the rest of the world, it is important to understand the distinction between "carrier haulage" and "merchant haulage". Carrier haulage is when the charge made for truck transportation (drayage) including the chassis, is handled by the ocean carrier (Rodrigue and Booth 2013:2). Merchant haulage refers to instances where drayage is arranged by the BCO using their standard trucking company, in which case the trucking company is responsible for arranging the chassis (Rodrigue and Booth 2013:2).

In the U.S., larger shipping companies use carrier haulage, and do not pay separate chassis fees in most cases (Tirschwell 2017b). Small-to-medium sized shipping companies, however, rely on merchant haulage (Mediterranean Shipping Company 2018a). These smaller companies are in essence footing the chassis bill for the larger ones, and the smaller companies' rates for ocean-carrier-mandated leasing companies are rising (Tirschwell 2017b).

Merchant haulage is predominant in Europe (Rodrigue and Booth 2013:2). “China, Hong Kong, and Japan [practice carrier haulage at a rate of 70 to 75 per cent],” but in other parts of Asia merchant haulage is also more common (Rodrigue and Booth 2013:2). Regarding the specifics of chassis economics in Asia, “A possible explanatory factor behind the lower supply of chassis in Asia concerns drayage distances and the nature of economic activities. The export-oriented economic development model has favored the location of factories close to marine terminal facilities. Drayage distances are relatively short, and containers are loaded/unloaded immediately, with the tractor remaining hooked to the chassis and the driver waiting until the next move. In this context, the utilization level of chassis assets is therefore higher” (Rodrigue and Booth 2013:2).

RECOMMENDATIONS

Key Chassis Regulations

OCEMA needs to be updated so that its bylaws reflect the fact that the ocean carriers no longer own or directly lease chassis. Codify a system whereby individual ocean carriers have nothing to do with chassis provision, maintenance, and management. This should also be the case for non-vessel operating common carriers (NVOCCs; basically those freight forwarders who are classified as carriers because they hold bills of lading) as well, which are starting to establish contracts with the big three IEP's similar to ocean carrier legacy contracts (Ashe 2018e). In this new system, all responsibility for inspection and M&R would become the province of the motor carriers. Such an update will require the direct oversight and management of the FMC.
Another critical regulatory issue is chassis roadability. The average age for chassis in the U.S. is 19 years. All chassis should be state-of-the-art, a mandated nationwide modernized chassis fleet with LED lights, radial tires, and anti-lock brakes. Provision should be made for the inspection, maintenance and repair of chassis to be assigned to the respective unions as part of their contract negotiations. This can be accomplished via the use of public-private partnerships, similar to how the target dates for clean air technology implementation have been handled at ports with the clean truck program (Mongelluzzo 2017b).

Antitrust Issues

Let the FMC declare all legacy contracts related to chassis null and void and have the big three chassis lessors compete on an even playing field with all other chassis providers. The free market determines which ones of all the providers will be successful. The FMC should also bar the three shipping alliances from any involvement in chassis provision or negotiation. Since the chassis is the business of the truck, let it be the domain of the motor carriers.

Environmental Sustainability

One way to achieve this is through technology. Diesel trucks can be retrofitted with filters which reduce emissions, and Port LA-LB has made significant investment in liquefied natural gas (LNG) fueled freight trucks as part of its Clean Truck Program (John A. Volpe National Transportation Systems Center 2018:44). Legislation is another means. The Federal Congestion Mitigation and Air Quality Improvement (CMAQ) program, funded by the USDOT, has been utilized by the state of Ohio to fund the replacement of diesel trucks with LNG vehicles (John A. Volpe National Transportation Systems Center 2018:41). European experiments with subsidized electric varieties of the largest over the road freight trucking vehicles, however, have not proved to be cost effective thus far (John A. Volpe National Transportation Systems Center 2018:46). In addition to CMAQ, other federal funding sources for emission reduction technologies, focused on diesel retrofitting and the use of alternative fuels for large freight trucks, include the National Highway Freight Program (NHFP), the EPA's National Clean Diesel Campaign, and the U.S. Department of Energy's Clean Cities Program (John A. Volpe National Transportation Systems Center 2018:55–56).

Time and Money

One proposed solution is more competitive pricing among more international chassis lessors. If truckers could choose their chassis provider by cost, instead of being mandated for one associated with an ocean carrier, they would save money (Mongelluzzo 2017c). The differentiation in chassis provision models means that there is "…no consistent prevailing strategy" (Kellaway 2014:11). Co-op pools, neutral pools, third-party chassis pools (Flexi Van, TRAC, DCLI), legacy contracts, and trucker-owned chassis are all mixed together in an uncoordinated way that results in increased turn times for truckers (Kellaway 2014:11). When chassis were uniformly provided by the ocean carriers as part of the business cost, turnaround time at ports and intermodal terminals was about one hour. Under the modern chassis regime, turnaround time can be from two to six hours, and off-terminal pools can exacerbate this problem (Kellaway 2014:11, 13–14). The aging chassis fleet is increasing maintenance times for truckers, and "…chassis flips [the mounting of grounded containers on chassis] and pool transfers [are] adding additional delays" (Kellaway 2014:12). All of this means more time for trucks to drive within, and to and from, terminals, increasing emissions and last mile congestion (the buildup of freight traffic at the approach to ports and intermodal terminals). The overarching solution to the chassis problem is to make the entire chassis process uniform, with the ocean carriers, truckers, shipping companies, rail companies, ports, and terminals working together towards a common paradigm (Kellaway 2014:23). The solution should focus on neutral chassis pools, as these have been shown to generate less truck movement and emissions at the American-style stacked-chassis terminals (Tioga Group, Incorporated 2012:14). Indeed, at several large ports on both coasts, chassis leasing companies have formed pools where chassis are offered to truckers regardless of their affiliation to a shipping line. This ameliorates the problem of double truck turns. However, truckers now view "open choice" as the next logical improvement. All these arrangements increase the speed of truck turns, improving terminal efficiency. However, to address this issue throughout the U.S. port system, a national program of "open choice" should be promoted by the FMC. The FMC should also do everything it can to promote the model of owner-operator chassis. Additionally, it would be beneficial to investigate chassis utilization analytics and chassis fleet right-sizing for typical U.S. port sizes. DCLI has taken steps in this direction (DCLI 2018). Recently, investigators have attempted to predict the availability of chassis based upon the size of ships discharging cargo. To date, their efforts have been challenged by the extreme fluctuation of ship sizes at ports. Nonetheless, these investigations should be supported and expanded. They should also be paired with studies on the right-sizing of chassis fleets at pilot U.S. coastal ports, small, medium and large.

Disaster Resilience

A nationally mandated, premium chassis fleet which used the metrics of shortage from the winter of 2017-2018, and Hurricane Irma, as a baseline from which to calculate needed surpluses, could be a start in addressing the resiliency dynamics of chassis (Stich, et. al. 2019).

U.S. Chassis vs Global Chassis Systems

"Motor carriers, logistics companies…and to a lesser extent…long term [chassis] leasing companies" are the main providers of chassis in European and Asian shipping (Rodrigue and Booth 2013:2). The chassis and truck are managed as a single resource separate from the leasing

companies or ocean carriers (Rodrigue and Booth 2013:3). A similar model is being tried on the shipping market in the U.S., and has been responsible for the surge in demand for new, state-of-the-art chassis with LED lights, radial tires, and anti-lock brakes (Bonney 2017). Apart from the U.S., shipping containers are utilized at terminals via the "*grounded*" method, in which they are stacked without chassis attached. This means more space at the terminal yard. In the U.S., "wheeled" containers are those which are stored on chassis, and although this can make for easier movement of containers onto ships and rail cars, this method leads to a much higher usage of chassis, as well as requiring more chassis storage space. "Usually there is also more yard tractor time and mileage driving to and from the storage area" (Rodrigue and Booth 2013:1). This in turn generates more emissions from the trucks, negatively impacting air quality. If motor carriers could choose a lessor from among the chassis pools, based upon cost-competitiveness, rather than being mandated to one with legacy linkages to ocean carriers, the market would generate cost savings. A necessary condition to achieve this is the exit of the ocean carriers from the chassis node of the supply chain. A fuller answer is to encourage the developing practice of trucker ownership of chassis, which is the global model.

FURTHER RESEARCH

Ultimately, what is needed is a full-scale, extensive study of the chassis landscape in the U.S. The most recent such study is seven years old (Rodrigue 2012). It is unclear how many chassis exist, what condition they are in, and where there is excess capacity or capacity shortages. Determining the "right placement" of chassis is essential to avoid chokepoints, congestion and inflated lessor rates. Furthermore, the current issues faced by relevant stakeholders need to be documented as this is crucial to understanding potential solutions to the problems overviewed in this report. The last such stakeholder engagement was undertaken by the Federal Maritime Commission in 2015, and, as such, this too is outdated (Federal Maritime Commission Bureau of Trade Analysis 2015).

REFERENCES

Amdal, James. 2017. "POHA Executive Interview."

American Export Lines. 2017. "Understanding the 3 New Ocean Carrier Shipping Alliances | Learn How the New Carrier Alliances Affect Your Ocean Freight Contracts and/or Shipments." *Cargo*. Retrieved March 12, 2018 (https://www.shipit.com/archives/2017/05/08/understanding-the-3-new-ocean-carrier-shipping-alliances/).

Ashe, Ari. 2018a. "US Railroad Industry Analysis: US Truckers, Shippers Frustrated with Chassis Splits, Shortages." *Journal of Commerce*. Retrieved June 5, 2018 (https://www.joc.com/trucking-logistics/us-truckers-shippers-frustrated-chassis-splits-shortages_20180530.html).

Ashe, Ari. 2018b. "US Trade: TRAC Shifting Chassis to Chicago to Alleviate Congestion." *Journal of Commerce*. Retrieved July 19, 2018 (https://www.joc.com/rail-intermodal/intermodal-shipping/trac-shifting-chassis-chicago-alleviate-congestion_20180301.html).

Ashe, Ari. 2018c. "US Trucking: Addressing Dislocation, DCLI Shifts Chassis to Chicago." *Journal of Commerce*. Retrieved July 19, 2018 (https://www.joc.com/trucking-logistics/drayage/addressing-dislocation-dcli-shifts-chassis-chicago_20180226.html).

Ashe, Ari. 2018d. "US Trucking and Rail: Chicago Intermodal Rail Delays 'Unprecedented' since January." *Journal of Commerce*. Retrieved July 19, 2018 (https://www.joc.com/rail-intermodal/class-i-railroads/chicago-intermodal-rail-delays-unprecedented-january_20180222.html).

Ashe, Ari. 2018e. "US Trucking: Non-Vessel Operating Common Carriers (NVOCCs) Signing Contracts to Lock up Chassis Capacity." *Journal of Commerce*. Retrieved July 19, 2018 (https://www.joc.com/trucking-logistics/nvoccs-signing-contracts-lock-chassis-capacity_20180606.html).

Ashe, Ari. 2018f. "US Trucking Sector: Georgia, South Carolina Sign Interoperable Chassis Pool Deal." *Journal of Commerce*. Retrieved July 19, 2018 (https://www.joc.com/trucking-logistics/georgia-south-carolina-sign-interoperable-chassis-pool-deal_20180621.html).

Ashe, Ari. 2018g. "US Trucking: Shippers and Chassis Providers Clash over Planned Southeast Chassis Pool." *Journal of Commerce*. Retrieved July 16, 2018 (https://www.joc.com/trucking-logistics/shippers-and-chassis-providers-clash-over-planned-southeast-chassis-pool_20180713.html).

Bonney, Joseph. 2012. "'Open Pools' for Chassis." *Journal of Commerce*. Retrieved March 14, 2018 (https://www.joc.com/maritime-news/open-pools-chassis_20120116.html).

Bonney, Joseph. 2014. "DOJ Won't Challenge LA-LB 'Gray Chassis' Plan." *Journal of Commerce*. Retrieved November 21, 2017 (https://www.joc.com/port-news/us-ports/port-

los-angeles/doj-won%E2%80%99t-challenge-la-lb-%E2%80%98gray-chassis%E2%80%99-plan_20140923.html).

Bonney, Joseph. 2016a. "FMC's Doyle Warns of Alliance's Contracting Power." *Journal of Commerce*. Retrieved March 12, 2018 (https://www.joc.com/regulation-policy/transportation-regulations/us-transportation-regulations/fmc-doyle-warns-alliance-contracting-power_20161129.html).

Bonney, Joseph. 2016b. "Lessors: THE Alliance Members Shouldn't Jointly Buy Equipment." *Journal of Commerce*. Retrieved March 12, 2018 (https://www.joc.com/maritime-news/container-lines/alliance/lessors-alliance-members-shouldnt-jointly-buy-equipment_20161123.html).

Bonney, Joseph. 2017. "Trucker-Led Pool Adds Chassis, Plans More Expansion." *Journal of Commerce*. Retrieved March 7, 2018 (https://www.joc.com/trucking-logistics/trucking-equipment/trucker-led-pool-adds-chassis-plans-more-expansion_20171204.html).

Bureau of Transportation Statistics. 2017. "August 2017 North American Freight Numbers | Bureau of Transportation Statistics." Retrieved October 30, 2017 (https://www.bts.gov/newsroom/august-2017-north-american-freight-numbers).

Cambridge Systematics, Inc., Economic Development research Group, Inc., Halcrow, Inc., DecisionTek, LLC, and Boston Strategies International. 2011. *NCFRP REPORT 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investments*. *Research and Innovative Technology Administration*. 12. Washington, D.C.: Transportation Research Board.

Connors, Phil. 2017. "Shippers Need 'open Choice' for Chassis." *Journal of Commerce*. Retrieved March 1, 2018 (https://www.joc.com/port-news/port-equipment/evolution-chassis-business-model-must-continue_20171113.html).

DCLI. 2017. "DCLI to Purchase TRAC Intermodal's Domestic Chassis Fleet | Direct ChassisLink Inc." Retrieved April 19, 2018 (https://dcli.com/about/news/dcli-to-purchase-trac-intermodals-domestic-chassis-fleet/).

DCLI. 2018. "DCLI Invests Millions to Ensure Chassis Availability | DCLI." *DCLI*. Retrieved June 24, 2019 (https://dcli.com/about/news/dcli-invests-millions-to-ensure-chassis-availability/).

Federal Highway Administration. 2017. "FHWA Freight and Land Use Handbook: Section 3.0 - FHWA Freight Management and Operations." *Freight Management and Operations*. Retrieved September 19, 2018 (https://ops.fhwa.dot.gov/publications/fhwahop12006/sec_3.htm).

Federal Maritime Commission Bureau of Trade Analysis. 2015. *U.S. Container Port Congestion & Related International Supply Chain Issues: Causes, Consequences & Challenges*.

George, Rose. 2013. *Ninety Percent of Everything: Inside Shipping, the Invisible Industry That Puts Clothes on Your Back, Gas in Your Car, and Food on Your Plate*. New York: Metropolitan Books/ Henry Holt and Co.

Hutchins, Reynolds. 2015. "Can Miami Be a Major Gateway for Asian Imports Heading out of Florida?" *Journal of Commerce*. Retrieved October 13, 2017 (https://www.joc.com/port-news/us-ports/port-miami/can-miami-be-major-gateway-asian-imports-heading-out-florida_20151031.html).

Hutchins, Reynolds. 2017a. "Container Lines Defend against Collusion Suspicion." *Journal of Commerce*. Retrieved March 12, 2018 (https://www.joc.com/maritime-news/container-lines/container-lines-defend-against-collusion-suspicion_20170323.html).

Hutchins, Reynolds. 2017b. "Fearing Alliance Collusion, Congress Eyes US Supplier Protection." *Journal of Commerce*. Retrieved March 12, 2018 (https://www.joc.com/regulation-policy/transportation-regulations/us-transportation-regulations/fearing-alliance-collusion-us-congress-considers-oversight-expansion_20170503.html).

Hutchins, Reynolds. 2017c. "Legislation Would Give FMC More Alliance Muscle and Money." *Journal of Commerce*. Retrieved March 12, 2018 (https://www.joc.com/regulation-policy/transportation-regulations/us-transportation-regulations/legislation-would-give-fmc-more-alliance-muscle-and-money_20170609.html).

John A. Volpe National Transportation Systems Center. 2018. *Primer for Improved Urban Freight Mobility and Delivery - Operations, Logistics, and Technology Strategies*. *Performimg Organization Report*. FHWA-HOP-18-020. Cambridge, MA: Federal Highway Administration.

Johnson, Melissa P. 2014. "Secondary Data Analysis: A Method of which the Time has Come." *Qualitative and Quantitative Methods in Libraries (QQLM) 3:619-626.*

Journal of Commerce. 2016. "THE Alliance Strips Joint-Contracting Language from VSA." *Journal of Commerce*. Retrieved March 12, 2018 (https://www.joc.com/maritime-news/container-lines/alliance/alliance-strips-joint-contracting-language-vsa_20161206.html).

Journal of Commerce. 2018. "US and Global Trade: TPM 2018 Tracker - The Latest News, Insights, and Analysis from the JOC's TPM 2018 Conference in Long Beach." *Journal of Commerce*. Retrieved March 16, 2018 (https://www.joc.com/international-logistics/tpm-2018-tracker-news-insights-analysis_20180307.html).

Kellaway, Ken. 2014."State of the Union in the Drayage Industry and the Impact on Green Fleet Initiatives." Presented at the Port Stakeholders Summit, April 8, Baltimore, Md.

Lane, John C. 2015. "NY-Appellate-Division-Rules-Graves-Amendment-Extends-to-Intermodal-Chassis." *Law Offices of John C. Lane*. Retrieved October 12, 2017

(http://www.thelanelawfirm.com/ny-appellate-division-rules-graves-amendment-extends-to-intermodal-chassis.html?no_redirect=true).

Levinson, Marc. 2008. *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton, N.J.; Woodstock: Princeton University Press.

Magnier, Mark. 1988. "CONTAINER LEASING ENTERS NEW ERA." *Journal of Commerce*. Retrieved March 14, 2018 (https://www.joc.com/container-leasing-enters-new-era_19880616.html).

Mediterranean Shipping Company. 2018a. "Intermodalism | MSC." *Mediterranean Shipping Company- Intermodalism*. Retrieved March 5, 2018 (https://www.msc.com/gin/help-centre/guide-to-international-shipping/new-to-international-trade-intermodalism?lang=ru-ru).

Mediterranean Shipping Company. 2018b. "Shipping Glossary of Terms | MSC." Retrieved May 7, 2018 (https://www.msc.com/usa/help-centre/interactive-shipping-glossary).

Mongelluzo, Bill. 2018. "Los Angeles News: Long Beach Pursues Chassis Support Yard to Boost Fluidity." *Journal of Commerce*. Retrieved July 19, 2018 (https://www.joc.com/port-news/us-ports/port-long-beach/long-beach-pursues-chassis-support-yard-boost-fluidity_20180427.html).

Mongelluzzo, Bill. 2015a. "Drayage Community Praises New LA-LB Gray Chassis Pool." *Journal of Commerce*. Retrieved October 5, 2017 (https://www.joc.com/port-news/us-ports/port-los-angeles/drayage-community-praises-new-la-lb-gray-chassis-pool_20150305.html).

Mongelluzzo, Bill. 2015b. "ILWU Chassis Trouble Likely to Be Resolved in Court." *Journal of Commerce*. Retrieved October 5, 2017 (https://www.joc.com/port-news/longshoreman-labor/international-longshore-and-warehouse-union/ilwu-chassis-trouble-likely-be-resolved-court_20151021.html).

Mongelluzzo, Bill. 2017a. "LA-LB Chassis Back-up Sends Warning Signals." *Journal of Commerce*. Retrieved October 5, 2017 (https://www.joc.com/port-news/terminal-operators/la-lb-chassis-back-sends-warning-signals_20170327.html).

Mongelluzzo, Bill. 2017b. "LA-LB Clean-Air Rules Set to Become US Port Industry Norm." *Journal of Commerce*. Retrieved July 23, 2018 (https://www.joc.com/port-news/us-ports/port-long-beach/la-lb-clean-air-efforts-could-soon-be-industry-norm_20171103.html).

Mongelluzzo, Bill. 2017c. "New Chassis Business Model Would Cut Costs, Trucker Says." *Journal of Commerce*. Retrieved October 5, 2017 (https://www.joc.com/port-news/us-ports/new-chassis-business-model-would-cut-costs-trucker-says_20170609.html).

Morley, Hugh. 2015. "Long-Delayed NY-NJ Chassis Pool 'Making Progress.'" *Journal of Commerce*. Retrieved October 5, 2017 (https://www.joc.com/port-news/us-ports/port-

new-york-and-new-jersey/long-delayed-ny-nj-chassis-pool-%E2%80%98making-progress%E2%80%99_20150921.html).

Morley, Hugh. 2017a. "DCLI Snags TRAC's Domestic Chassis Fleet." *Journal of Commerce*. Retrieved November 6, 2017 (https://www.joc.com/trucking-logistics/trucking-equipment/dcli-snags-trac%E2%80%99s-domestic-chassis-fleet_20171025.html).

Morley, Hugh. 2017b. "NY-NJ Joint Chassis Pool Collapses." *Journal of Commerce*. Retrieved October 5, 2017 (https://www.joc.com/trucking-logistics/drayage/ny-nj-joint-chassis-pool-collapses_20170914.html).

North American Chassis Pool Cooperative (NACPC). 2018. "About." *NACPC*. Retrieved March 16, 2018 (http://www.nacpc.org/about/).

Ocean Carrier Equipment Management Association. 2017. "OCEAN CARRIER EQUIPMENT MANAGEMENT ASSOCIATION 4th Edition."

Port director one. 2017. "Transcript Port Director One 07/26/2017."

Rep Don Young (R) Alaska. 2005. *SAFE, ACCOUNTABLE, FLEXIBLE, EFFICIENT TRANSPORTATION EQUITY ACT: A LEGACY FOR USERS*.

Rodrigue, J. P. 2012. *Guidebook for Assessing Evolving International Container Chassis Supply Models*. Transportation Research Board.

Rodrigue, Jean-Paul and Mark Booth. 2013. "Grounded and Chassis Container Terminal Operations." *Port Technology International*. Retrieved March 7, 2018 (https://people.hofstra.edu/jean-paul_rodrigue/downloads/Booth%20&%20Rodrigue_PT57_V5.pdf).

Stich, Bethany, James Amdal And Peter Webb. 2019. "Chassis: The Unsung Linchpin in the Global Supply Chain." in *Building A Sustainable Transportation Infrastructure for Long-Term Economic Growth*, IGI Global Publishing.

The Institute of International Container Lessors. 2017. "The Institute of International Container Lessors (IICL): About the Industry - Laws, Regulations, Conventions and Standards." Retrieved November 21, 2017 (https://www.iicl.org/aboutIndustry/laws.cfm).

Tioga Group, Incorporated. 2011. *Truck Drayage Productivity Guide*. Vol. 11. Publisher: Transportation Research Board.

Tioga Group, Incorporated. 2012. *SmartWay DrayFLEET, Truck Drayage Environment and Energy Model Version 2.0 User's Guide. Final Report*. EP 11H000338. Transportation and Climate Division Office of Transportation and Air Quality U.S. Environmental Protection Agency.

Tirschwell, Peter. 2017a. “Demise of Chassis Pool an Ominous Sign for NY-NJ.” *Journal of Commerce*. Retrieved October 9, 2017 (https://www.joc.com/port-news/us-ports/demise-chassis-pool-ny-nj-has-many-shaking-heads_20171009.html).

Tirschwell, Peter. 2017b. “It Is Time to Give Shippers a Choice on Chassis.” *Journal of Commerce*. Retrieved March 1, 2018 (https://www.joc.com/maritime-news/container-lines/it%E2%80%99s-time-give-shippers-choice-chassis_20171117.html).

United States Congress. 1999. *THE SHIPPING ACT OF 1984 as Modified by The Ocean Shipping Reform Act of 1998*.

United States Congress. 2014. “U.S.C. Title 46 - SHIPPING.” Retrieved March 14, 2018 (https://www.gpo.gov/fdsys/pkg/USCODE-2014-title46/html/USCODE-2014-title46-subtitleIV-partA-chap403-sec40307.htm).

U.S. Customs and Border Protection. 2018. “CBP Trade and Travel Fiscal Year 2017 Report | U.S. Customs and Border Protection.” *U.S. Customs and Border Protection*. Retrieved June 25, 2019 (https://www.cbp.gov/document/annual-report/cbp-trade-and-travel-fiscal-year-2017-report#).

Whelan, Robbie. 2015. “Ports, Truckers Contend With Chassis Shortage.” *Wall Street Journal*, July 6.