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U30: Evaluation of Freight Vehicles in Short-Haul Intermodal Lanes

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16. Abstract

Intermodal rail-truck transportation is often cited as a potential remedy to a number of congestion-related issues. However, intermodal's effectiveness in this role is dependent on the ability to use this freight alternative in relatively "short-haul" situations. The current analysis reviews the history of intermodal transport, current intermodal operations, and available suites of intermodal equipment in order to evaluate the potential for increased short-haul intermodal applications. The analysis includes simulations of shipper alternative choices developed through use of the Federal Railroad Administrations Intermodal Transportation and Inventory Cost (ITIC) modeling platform. These simulations consider both endogenous and exogenous changes in intermodal service costs.

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List of Abbreviations and Acronyms

Abbreviation or Acronym	Definition
AASHTO	American Association of State and Highway Transportation Officials
ARC	Appalachian Regional Commission
ATC	Average Total Cost
ATRI	American Transportation Research Institute
C&O	Chesapeake & Ohio
COFC	Container on Flatcar
CPR	Canadian Pacific Railway
DOE	US Department of Energy
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
GPS	Global Positioning System
ICG	Illinois-Central-Gulf
ISO	International Organization for Standards
ITIC	Intermodal Transportation and Inventory Cost
NTRCI	National Transportation Research Center, Inc.
TOFC	Trailer on Flatcar
TRB	Transportation Research Board
USDOT	US Department of Transportation

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Executive Summary

Intermodal rail-truck transportation is routinely noted as a possible means of mitigating roadway congestion, air quality degradation, and other negative outcomes associated with the wide use of trucks in the movement of freight. The realization of this potential remedy has, however, been hampered by the absolute dominance of motor carriage for short-haul freight movement (500 miles or less). Efforts to extend intermodal's penetration into short-haul transport markets have typically focused on achieving service improvements that more closely replicate the service characteristics of truck transport and / or further reduce the cost advantage that is often enjoyed by intermodal alternatives. Further, both strategies have routinely used alternative equipment fleets (vehicles). The current analysis summarizes these experiences, then introduces economic simulations as a means of evaluating the transportation impacts that might be expected from additional intermodal strategies or exogenously imposed economic change.

Background

Roadway congestion and its attendant costs is a growing problem across the United States and commercial vehicle use measurably contributes to this challenge. Accordingly, both policy-makers and industry researchers are exploring a variety of strategies for mitigating the negative impacts associated with roadway truck use. One popular potential strategy combines the increased substitution of rail carriage for the longer-distance segments of freight movement with truck service for local freight pickup and delivery – a hybrid service that is most commonly referred to as "intermodal" transport.

There are a number of difficulties in pursuing the "intermodal" strategy. Large among these, is intermodal's lack of economic performance in "short-haul" intermodal settings. Shorter total trip distances reduce the economic gains attributable to line-haul rail service, but leave intermodal's higher terminal and transfer costs relatively unchanged. Thus, intermodal cannot typically compete with an all-truck routing for shipments with a total distance of less than 500 – 750 miles. Given that the vast majority of commercial truck movements are over a distance of less than 500 miles, the current effectiveness of intermodal as a mitigation strategy is limited.

In practice, there are a number of distinct supply-chain activities that impose costs on intermodal shipments that are not incurred by all-truck alternatives. Over intermodal's relatively short history, transportation practitioners have tried to reduce these costs in order to simultaneously reduce the trip distances over which intermodal is competitive. Some such efforts have been, at least, temporarily successful, many others have not. But nearly every attempt contributes to our understanding of the transportation equipment, operations, and inventory management processes that define economic feasibility for domestic freight movements.

Brief Overview

The current study seeks to extend this understanding through two tasks. First, intermodal's history and conduct are carefully dissected. This includes a careful treatment of the various supply-chain activities that are necessarily a part of intermodal freight transport, including discussions of alternative equipment suites available for intermodal use.

These discussions are followed by the development of a simulation framework that allows cost parameters and shipment characteristics to be varied in order to examine how the distance threshold at which intermodal becomes competitive varies in response to changed economic conditions. Importantly, the economic changes that drive the simulation can represent either exogenous changes in the broader economy or specific efficiency gains achieved by the transportation sector. Finally, this framework is applied to consider two possible scenarios – (1) exogenously imposed increase in transportation fuel costs and (2) efficiency gains in drayage or terminal activities.

Research Process and Findings

The examination of intermodal's history, current intermodal operations, available equipment, and the role rail-truck combinations can play in short-haul markets revealed a great deal. First, and perhaps most importantly, the evolution of intermodal has been driven by customer needs. The emergence of containers and double-stack container carriage, industry forays into "no-lift" equipment use, tradeoffs favoring time-of-day service over service frequency – all these outcomes reflect shipper preferences as expressed by what they are willing to buy. What carriers want matters far less than customer preferences. Historically, short-haul intermodal has not been a dominant shipper need. Motor carrier service levels, service availability, and trucking costs have favored all-truck movements in shorter distance markets. The means for short-haul is (and has been) available in a variety of forms. There simply has been very little demand.

With these things said, the tipping point favoring a more extensive use of intermodal in shorter traffic lanes is not at all distant. Unlike many past efforts, the current analysis accounts for a set of supply-chain costs that extends beyond simple transportation expenditures. Even with a variety of inventory holding costs and reliability parameters included in the simulations, it is clear that short-haul intermodal sits on the verge of capturing increasing market share. Table E-1 summarizes the estimated distance thresholds that separate all-truck from Trailer on Flatcar (TOFC) and double-stack container intermodal. These thresholds reflect baseline (current) conditions and two scenarios – on depicting the effects of higher diesel fuel prices and the second that illustrates the impact of non-line-haul intermodal productivity improvements. The scenario results suggest that readily foreseeable economic change could drive the effective threshold between all-truck and intermodal to 350 miles or less in most cases.[1]

[1] Given the values in this table, readers may be left to wonder why more all-truck movements do not divert to double-stack intermodal service. The first answer is that double-stack (or intermodal of any kind) is not available in

Table E-1. Summary of Distance Thresholds (Miles) v. All-Truck Alternative.

	Baseline		Fuel Scenario	Productivity
Commodity	Single-Stack / TOFC	Double-Stack	Double-Stack	Double-Stack
Food & Kindred Prod.	1650	425	<350	375
Chemical Products	800	<350	<350	<350
Metal & Metal Products	1500	<350	<350	<350
Transportation Equipment	1800	475	<350	400
Freight Forwarder Traffic	1350	400	<350	<350

Conclusions

The model parameters and shipment characteristics used in the Section 5 simulations are benchmark values generally derived from commodity or regional aggregations. What is or is not feasible in specific freight markets can vary greatly, based on specific market characteristics. Still, as noted above, the simulations paint a clear picture in which all-truck and rail-truck intermodal alternatives compete effectively for traffic on either side of the distance threshold that separates their relative efficiencies. The result is a constant movement of that threshold – movement that, in turn, reflects changes in underlying demand and cost characteristics. In the early 2000s, when downstream demands were strong, rail capacity was tight, and motor carrier costs were still low, the distance at which intermodal was an effective alternative moved outward. In recent years, as rail capacity has grown, market conditions have eased, and motor carrier availability has tightened, the same threshold has receded to a more traditional level.

In terms of short-haul intermodal, we've yet to witness economic circumstances that can push the all-truck v. intermodal distance threshold to a level sufficiently low for intermodal to attract a truly large number of current truck users. However, the simulations suggest that sort of movement is certainly possible – maybe even likely if current trends continue, unabated. If a broader shift to short-haul does occur, it will likely come through the more frequent use of double-stack and container combinations rather than through the use of alternative no-lift equipment. At least for now, shippers seem to have already made that determination.

Finally, the potential congestion and environmental implications of a wider shift toward short-haul intermodal freight has motivated some policy-makers to advocate a public course that would hasten that shift. The current findings do not support the need for such policies. To the contrary, the freight markets where traffic diversions from all-truck to intermodal are likely seem remarkably responsive to the influence of pricing signals. In short, if fuel costs and roadway

many important traffic lanes. Second, even though the fixed costs of switching between all-truck and intermodal are relatively low, they are not nonexistent. Therefore, transportation price differentials must appear to be permanent (or at least long-lived) to induce mode shifts. Finally, while the simulation model attempts to capture most non-transportation supply chain costs, it does not reflect all such costs.

congestion warrant the increased use of intermodal, it is likely that the relevant freight markets will accomplish this diversion much more quickly and effectively than any policy instrument. Individual communities or even regions may choose to bolster their competitive position by improving intermodal access, but broader federal policies aimed at encouraging intermodal seem unnecessary.

Future Program Efforts

The economic treatment of intermodal's evolution reveals important lessons and the development of a simulation tool that incorporate broader supply-chain considerations into shipper decision-making is an important next step in modeling short-haul intermodal's future. However, far from being definitive, the current research merely demonstrates an available course for bringing additional information to discussions of freight transportation policy, practices, and outcomes. The work presented here is neither complete nor particularly robust, but it does help point a way forward.

One of the most encouraging outcomes is the performance of the Intermodal Transportation and Inventory Cost (ITIC) modeling platform made available through the Federal Railroad Administration (FRA). The ITIC has been available, in various iterations, for two decades and has undergone countless formal and informal revisions. The basic framework it embodies is remarkably solid. The ITIC is, however, in need of additional structure improvements, computational streamlining, and parameter updates. To the extent that model modifications were essential to the current work, these were made in advance of the simulations. This was not, however, a substitute for a well-organized and thorough model update. Not only would a revised ITIC platform provide more precise and more reliable results, it would also allow the development of a much broader set of simulation scenarios.

The current work also points to the potential value of improved intermodal traffic management. Nearly every Class I railroad and the vendors that supply them are actively engaged in the further development of Advanced Traffic Management Systems (ATMS) as a means of improving the competitiveness and profitability of intermodal freight transport. The current study cannot offer insight that will benefit this work, but the research described here does clearly illustrate the value that ATMS can play in increasing intermodal's penetration into short-haul markets.

Finally, while the current study addresses potential changes in the distance threshold that separates intermodal from all-truck alternatives, it does not extend this result to estimate the total volume of freight traffic that might be affected by changes to this threshold. Information on this total traffic volume, particularly to the extent that it can be disaggregated into specific traffic lanes, may do a great deal to answer questions regarding the value of short-haul intermodal to broader policy goals. However, developing this information will require access to wide-reaching and reliable data on current motor carrier flows – data that was not available to the current study team.

Chapter 1 – Introduction and Background

1.1 Background

Many voices in many quarters support the role that intermodal freight transportation can play as a means of improving US freight mobility and segregating freight transportation from other daily activities. To most, intermodal is defined as the combination of truck and rail in the movement of freight and the hoped-for segregation typically means a reduction in the presence of truck traffic on Interstate (or other) highway segments commonly used by local motorists and / or the mitigation of localized environmental problems.

Over the past two decades, the promise of intermodal transportation as a valuable tool for lessening roadway congestion, improving mobility, and improving environmental outcomes has also earned it a prominent place in public policy. Beginning in 1991 with the Intermodal Surface Transportation Efficiency Act (ISTEA), nearly every federal policy dealing with transportation (both statutory and executive) has embraced the concept of intermodal transport and many of these policies have committed federal resources to promote its further development.

Taking their cue from federal leadership, most state DOTs have also developed expertise devoted to issues of intermodal transport and intermodal has been treated extensively by national and state-level organizations that routinely proffer guidance to policy-makers. Indeed, both the National Academy's Transportation Research Board (TRB) and American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Intermodal have funded dozens of studies that explore nearly every aspect of intermodal freight transportation and intermodal freight is a prominent component in the policies highlighted by both organizations.[2]

As is commonly the case, a closer examination of intermodal freight transportation has revealed that, along with great promise, intermodal involves many complexities and conundrums – not the least of which is the relationship between intermodal truck-rail movements, shipment distances, and highway traffic mitigation. USDOT data suggest that less than half of the total truck miles logged annually in the US involve trips of more than 100 miles and that truck trips of 500 miles or more account for only about 22 percent of truck mile totals. Thus, it is fair to conclude that most commercial truck trips are relatively low-distance in nature. At the same time, most intermodal truck-rail shipments move a distance well in excess of 1,000 miles (Federal Highway Administration [FHWA], 2010; Zhang & Wu, n.d.). The implication is that intermodal truck-rail transport may currently be only a modest force in reducing the local truck traffic that jurisdictions wish to avoid.

For intermodal rail-truck freight transport to achieve its potential value in the US, substantially larger numbers of relatively short-haul freight movements must be diverted from all-truck

[2] Both AASHTO and TRB have worked to broaden their definitions of intermodal transportation to include other freight modes in addition to truck and rail.

routings to routings that substitute railroad carriage for most of the shipment distance. This change in shipping practice will only be motivated by changes in the underlying economic factors that drive shipper supply-chain decisions. Thus, it is essential that policy-makers gain a better understanding of these economic factors, particularly as they are related to shipment distances. Furthering this understanding is the primary motivation for the work reported here.

1.2 Project Team

The current project represents a collaborative effort between the project sponsors (NTRCI and ARC), the CTR research team from the University of Tennessee, and a group of outside advisors that includes truck and railroad freight carriers, shippers, and public sector experts.

1.2.1 Project Sponsors

The principle organizer and sponsor of the current study is NTRCI. NTRCI personnel also provided a great deal of leadership in the project's conduct. Guidance included innumerable suggestions regarding the fundamental research goals as expressed in both the study proposal and this document, tireless efforts in the identification and contact with outside expertise, and valuable help in a variety of administrative processes.

The study was co-sponsored by the Appalachian Regional Commission which, in addition to its financial support, helped to secure many of the site visits included as a part of this work. Finally, ARC personnel also provided considerable insights into the importance of intermodal access to emerging rural freight markets.

1.2.2 University of Tennessee

The University of Tennessee's Center for Transportation Research provided the principle study team for the current work. This team was headed by Dr. Mark Burton, CTR's Director of Transportation Economics who worked closely with CTR's Director, Dr. David Clarke. Other team members included graduate student assistants from UT's Department of Industrial Engineering and undergraduate student assistants from the Department of Economics. CTR's administrative staff also made important contributions to the effectiveness of the overall study effort.

1.2.3 Outside Advisors

As noted, this study effort has received significant support and guidance from a variety of additional individuals and organizations. Randy Resor (USDOT) generously shared decades of experience in intermodal research. Scott Lindsey (Kimberly-Clark) helped the study effort build and retain an understanding of shipper perspectives, and Lee Cochran (Norfolk Southern) was an endless source of help. Additionally, the study team is tremendously appreciative of the hospitality and access afforded by the operating personnel at Norfolk Southern's intermodal facilities near Austell and Atlanta, Georgia and CSX personnel at that carrier's new intermodal facility near North Baltimore, Ohio. Finally, Jim Wrinn and the staff at *TRAINS* Magazine were a continual source of help.

While these individuals and organizations were indispensible in guiding and informing the study process, any factual errors, omissions, or other deficiencies in the final study products is strictly the responsibility of the University of Tennessee and the Center for Transportation Research.

1.3 Study Organization, Conduct, and Schedule

The current research effort began through a project solicitation sponsored in the summer of 2010 by the National Transportation Research Center, Inc. The University of Tennessee's Center for Transportation Research (CTR) submitted a proposal in response to that solicitation which focused on three primary goals. These included **(1)** an evaluation of the infrastructure, operating methods and equipment suites currently used to provide rail-truck freight service in the United States, **(2)** an evaluation of foreseeable trends in these same areas, and **(3)** the development of a simulation structure suitable for testing hypotheses regarding economic changes that might lead to the increased use of intermodal transport in a "short-haul" environment. While it was not required to do so, the CTR also secured a matching fund agreement from the Appalachian Regional Commission (ARC) in conjunction with ARC's *Network Appalachia* initiative. This proposal was accepted in the fall of that year.

Actual study activities began in January of 2011 with the organization of an informal steering committee which included members from the shipping community, national motor carriers, both CSX and Norfolk Southern, and representation from USDOT. Information gathering and intermodal facility studies were undertaken in the spring and summer months, and the analytical process was completed in late fall.

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Chapter 2 – Intermodal History and Trends

2.1 The Origins and Evolution of Rail-Truck Intermodal in the US

While examples of coupling railroad service with other modes of transport date to the Nineteenth Century, the current practice of combining railroad line-haul movements with truck trailer or container carriage largely emerged in the US in the years following World War II. By the early 1960s, nearly every Class I rail carrier offered some form of “piggyback” service where truck trailers were loaded onto flatcars for movement and, for some railroads, this form of “intermodal” transport became a very visible symbol of progress.[3]

Though there were exceptions, early intermodal movements typically involved driving truck trailers “circus style” onto and off of conventional railroad flatcars . During the 1960s and 70s, this practice was gradually replaced by lift operations that used gantry (overhead and typically mobile) cranes. The design and use of cranes was soon to become an important element in next generation of rail-truck intermodal transport.

In the late 1970s western railroads began to work with steamship lines toward the more efficient haulage of international shipping containers. This included the development and testing of rail equipment where containers were, for the first time stacked two high. The Southern Pacific is credited with operating the first regularly scheduled double-stack train in 1981. Early in the double-stack era, the industry settled on articulated equipment that combines three or more low-level platforms (wells) in an articulated design that reduces equipment weight, improves ride quality, and enhances aerodynamic train performance. All early well-car equipment was designed to accommodate 40’ containers – the standard for international shipping. However, as domestic use of containerized shipping has grown, so has the presence of a segregated equipment fleet designed to accommodate 53’ domestic containers.

2.2 International Trade and the Growth of Intermodal Traffic

Figure 2.1 depicts railroad intermodal traffic from 1989 through 2000, the period of most pronounced intermodal growth in the US. During, the same period the proportion of international trade as a percentage of annual US Gross Domestic Product (GDP) grew from roughly 10 percent to more than 25 percent. Rapid increases in transportation efficiency are credited with the emergence of global trade. It is equally clear, however, that growing trade was the primary source of intermodal rail-truck traffic growth in the US.

[3] The November 2011 issue of *TRAINS Magazine* contains a number of articles describing both the evolution and current state of rail-truck intermodal transport. Much of the material presented here is directly or indirectly attributable to this publication.

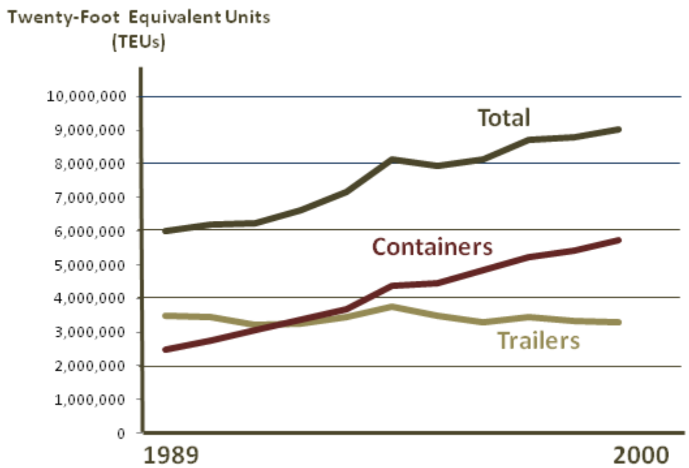

Figure 2-1. Graph. Intermodal Traffic in the US.

Growth in the importance of international commerce as a source of freight traffic has had other equally observable impacts on domestic freight flows. International trade concentrates freight traffic to and from a relatively small number of coastal deep-draft ports, whereas purely domestic production and consumption is typically more geographically diffused. The result is the concentration of freight traffic into much more easily discernable transportation corridors and a general increase in the distances over which freight is moved. Both outcomes are important to the current analysis.

Not all impacts of trade growth on intermodal traffic have been welcome. First, as noted, this growth has concentrated large volumes of new freight traffic in and around US ports. This, in turn, has lead to largely unanticipated increases in localized traffic congestion and environmental degradation. Also, initially, the rapid growth in inbound container traffic generated troublesome traffic imbalances that often left large numbers of empty containers stranded inland. However, this latter problem has dissipated through the increased use of containers for the export of often lower-valued US outputs.[4]

[4] An examination of container traffic over US ports typically reveals inbound containers loaded with consumer goods and outbound containers loaded with products like scrap, wood, pulp or other lower rated commodities that once moved in break-bulk service.

2.3 Current Intermodal Rail-Truck Transport in the US

Because of the perceived promise of intermodal as a remedy to various freight-related transportation challenges, it is important to understand what and where intermodal is and how it functions in the broader freight environment. For convenience, this discussion is broken into three distinct areas – service networks, terminals and equipment, and intermodal traffic. However, this segregation is largely artificial; each of these areas routinely overlaps the others.

2.3.1 Service Networks

Figures 2.2 – 2.5 depict the intermodal networks, including traffic volumes for the nation's largest four intermodal carriers – BNSF, CSX, Norfolk Southern, and Union Pacific. Other Class I railroads, as well as regional carriers and short-lines, also play an important role within the nation's intermodal environment, but the four carriers depicted here, together provide this system's backbone.[5]

These schematics emphasize a number of realities which are not particularly surprising. Los Angeles area ports are the dominant source of traditional land-bridge international traffic – the traffic that is most closely associated with intermodal's early growth. Both western carriers have a strong presence in serving these southern California markets. UP's principal route, via El Paso, provides strong connections to a variety of Texas markets and its connections to KCS in Dallas and Norfolk Southern in Shreveport provide a direct linkage between the Southeast and Southwest. UP also plays an important role in connecting both central California and the Pacific Northwest to the nation's midsection via various connections with its Central Corridor which leads from Denver eastward.

BNSF has the strongest concentration of intermodal traffic of any Class I anywhere along the Santa Fe's traditional "Transcon" route between Southern California and Chicago. It also provides strong services between the Pacific Northwest and upper Midwest via former Great Northern trackage across the northern tier. Finally, BNSF offers a marginally more circuitous route between the Southeast and Southwest through its connection to the former Frisco at Avard, Oklahoma.

In the eastern US, both CSX and Norfolk Southern are heavily invested in providing intermodal service between a variety of locations in the Northeast and the Greater Chicago area over what is mostly former Conrail trackage. Beyond this, both intermodal networks are somewhat more disjointed in their intermodal operations. This is largely the result of the larger number of more highly populated markets located in various regions east of the Mississippi River, as well as the evolutionary course of the two dominant eastern carriers.

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[5] While these figures are not direct reproductions, they are markedly similar to illustrations used in the aforementioned *TRAINS Magazine* issue. Specifically, see Frailey (2011).

Also, within the context of the two eastern carriers, it should be noted that both Norfolk Southern and CSX have embarked in aggressive initiatives designed to add capacity and improve competitiveness in additional eastern corridors. In the case of NS, this work is in the form of the *Crescent Corridor* initiative which, when completed, is intended to provide truck-competitive transit times for intermodal shipments between Harrisburg, Pennsylvania and a number of southeastern cities such as Memphis, Birmingham, Atlanta, and Charlotte.

In an effort of similar magnitude, but with a largely different geographic orientation, CSX has embarked on its *National Gateway* initiative which includes projects intended to improve the capacity and competitiveness of its routes within the Upper Midwest and between the Upper Midwest and a variety of East Cost Destinations. Among a wide set of projects, *National Gateway* includes the development of the now-opened traffic management facility in North Baltimore, Ohio. This facility and the management techniques it embodies are more fully described at other points within the current study.

Within the various intermodal networks supported by the Class I carriers, there are roughly 100 terminal locations that support several thousand distinct origin destination pairs. Many of these involve city pairs that fall within the range of what is commonly thought of as "short-haul" in nature. In some cases, there is no marketed rail intermodal service between the short-haul city pairs. In other cases the short-haul service is marketed, but it is simply not used. Finally, as is described in Section 3.3, there is a small set of short-haul intermodal city pairs that are supported by the existing rail network and marketed by the carriers that successfully provide a measurable volume of freight service.

2.3.2 Terminals and Equipment – The Terminals

As noted, the earliest rail-truck intermodal service typically consisted of circus loaded truck trailers moved aboard conventional 89' railroad flatcars. In that era, railroads operated more than 400 intermodal terminals with locations that roughly corresponded to railroad network Division point.

As early service practices gave way to increasingly mechanized (and capital-intensive) loading and unloading processes and as the rapid growth in international traffic focused more and more intermodal freight into a somewhat smaller number of traffic lanes, the relatively large number of early intermodal terminals collapsed into a smaller number of higher capacity network locations. Today, Class I railroads operate fewer than 100 intermodal facilities that serve approximately 75 metropolitan areas.

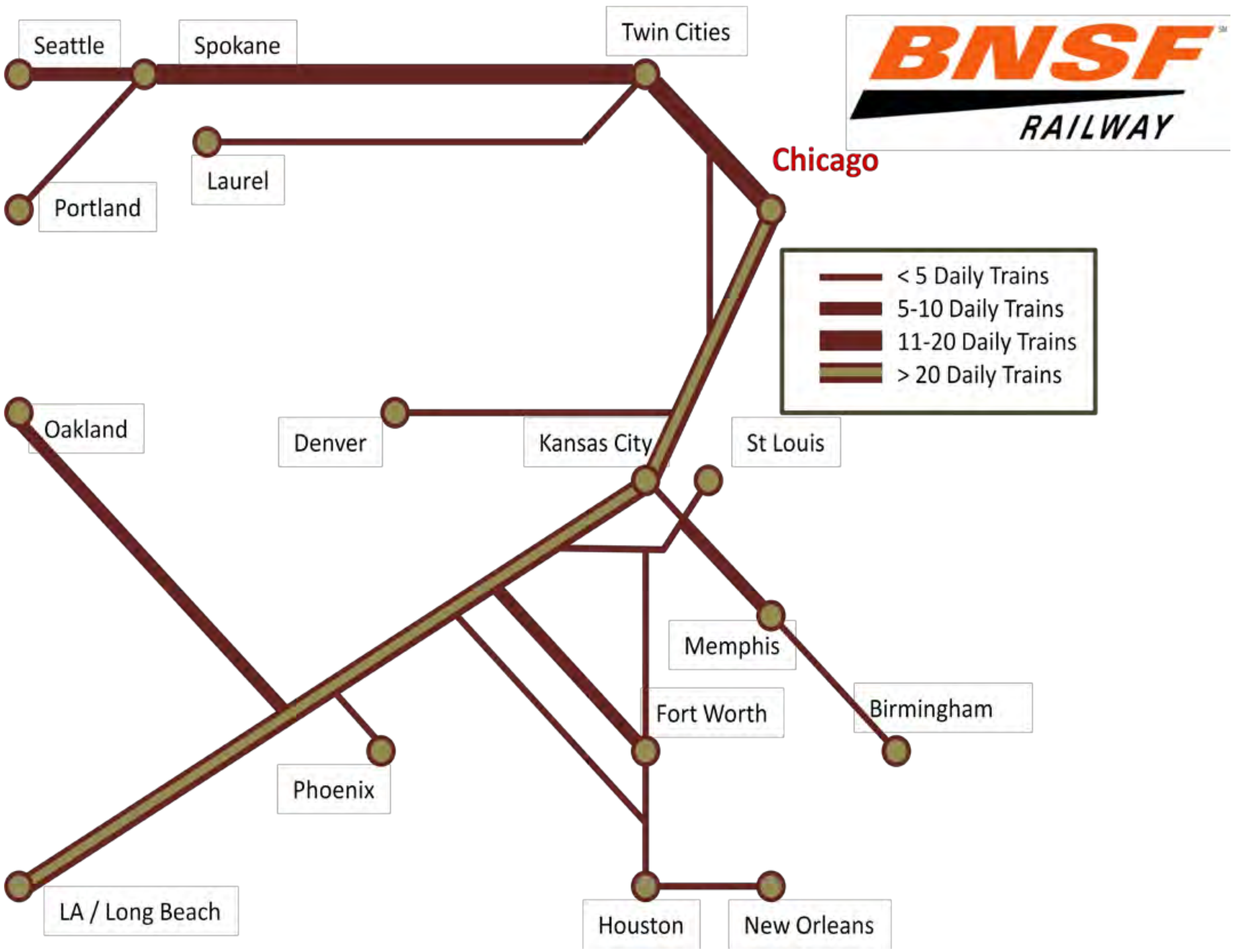

Figure 2-2. Diagram. BNSF Intermodal Network.

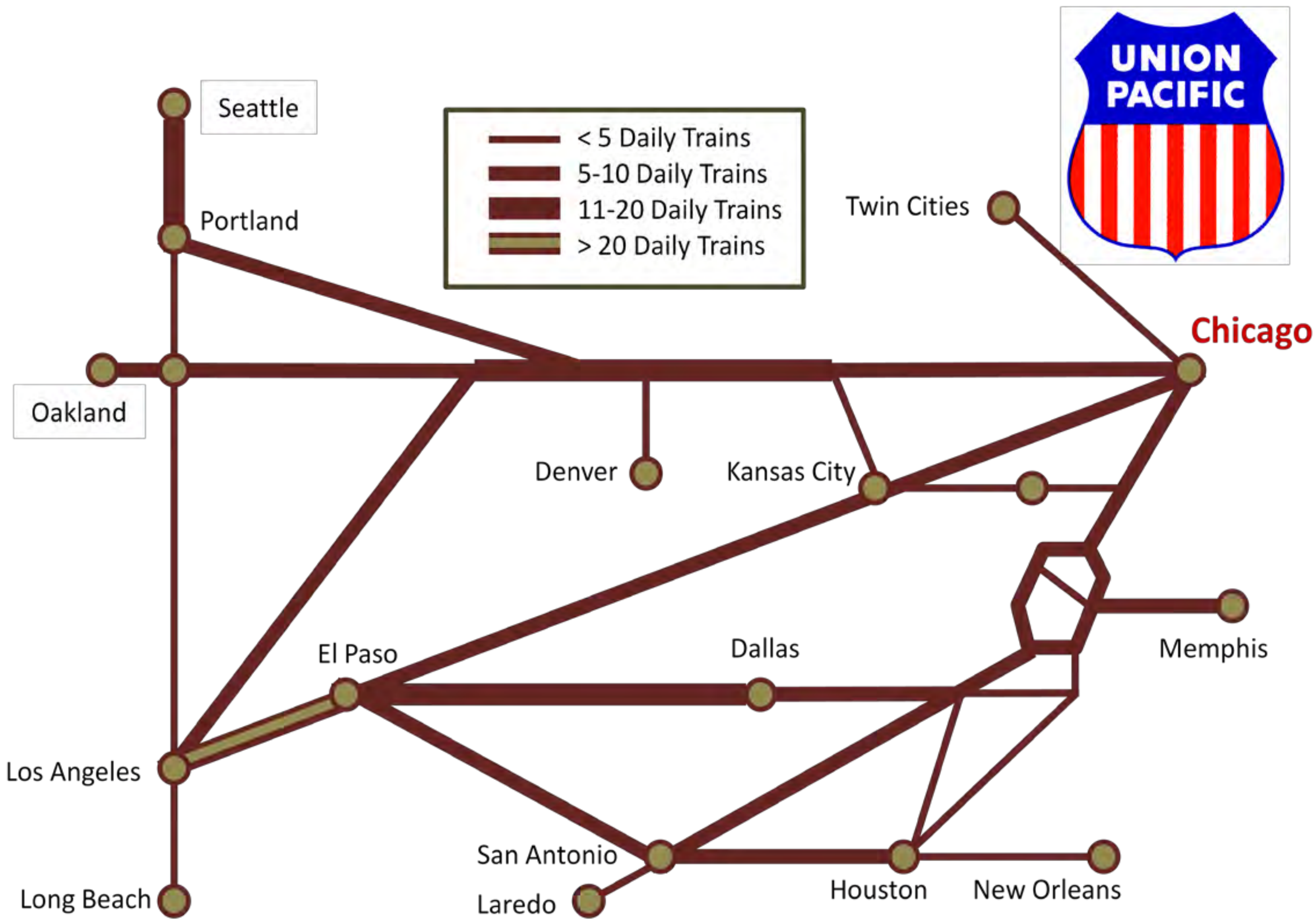

Figure 2-3. Diagram. Union Pacific Intermodal Network.

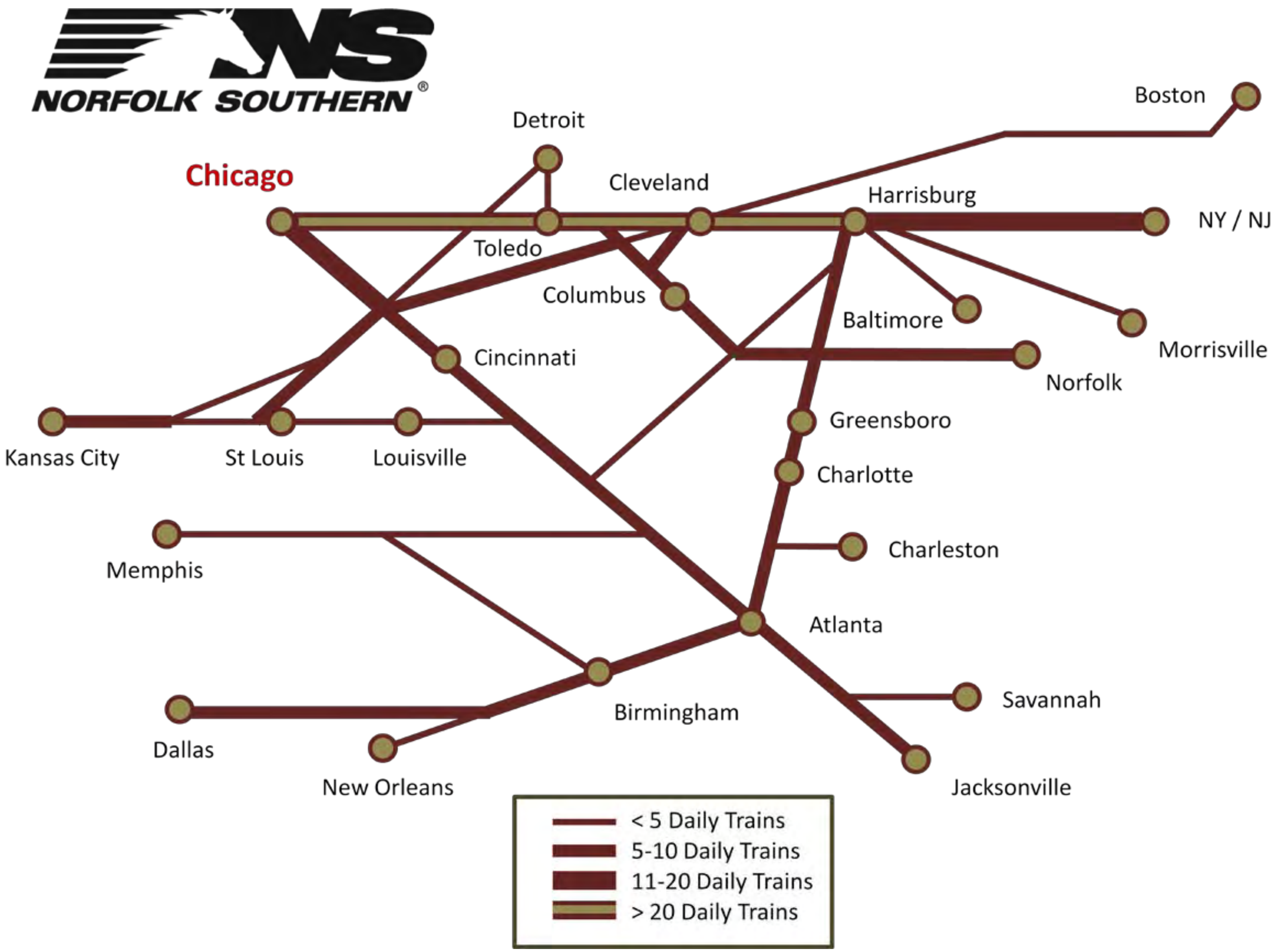

Figure 2-4. Diagram. Norfolk Southern Intermodal Network.

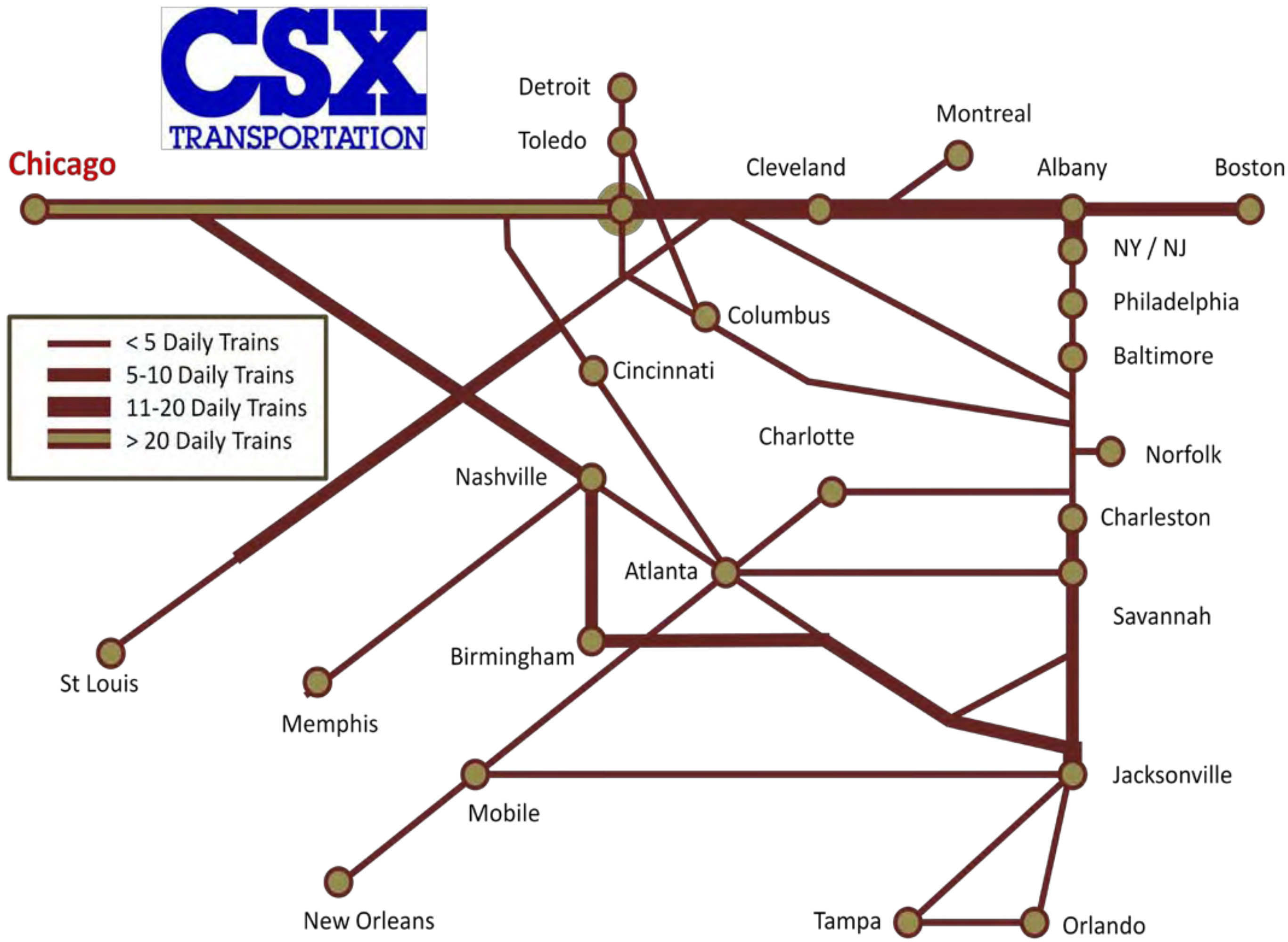

Figure 2-5. Diagram. CSXT Intermodal Network.

First generation intermodal terminals were almost always built at or near existing railroad terminals and were, therefore, often located well within the bounds of the metro areas they served. This practice imposed a number of disadvantages. First, as Zumerchik, Rodrigue & Lanagan (2009), point out, intermodal terminals require a land-use footprint that is decidedly different than the footprint needed for traditional classification facilities. Also, the urban locations often suffer from awkward and/or constrained highway access. Finally, most of the urban locations that hosted emerging intermodal facilities did not offer adjoining or nearby properties that could readily accommodate the new generation of intermodal users.

Over the past two decades, early terminals have been replaced or, at least, supplemented with a second generation of intermodal facilities that are designed to remedy many of the disadvantages inherent at smaller, highly urban locations. Examples include BNSF facilities at Alliance (Fort Worth), Texas, Joliet (Chicago) Illinois, and Germantown (Memphis), Tennessee; UP facilities at Mariana (Memphis), Arkansas, Joliet (Chicago), Illinois, Rochelle (Chicago), Illinois, and Dallas, Texas; Norfolk Southern terminals at Austell (Atlanta), Georgia, Columbus, Ohio, and Rossville (Memphis), Tennessee; and the new CSX location at North Baltimore, Ohio.

The relatively recent additions to the available set of intermodal terminals have contributed to overall network efficiency and to intermodal-related economic development opportunities within the host regions. However, their development has suffered from two notable constraints. First, these facilities are extremely costly. The estimated cost of the CSX facility at North Baltimore is $185 million and this cost is, by no means exceptional. Accordingly, new terminal development cannot occur at a pace that would allow the immediate realization of all resulting network efficiencies.

Second, the historical development of railroad line-haul networks often complicates the location of new facilities or diminishes their ability to contribute to improved network freight flows. Large tracts of network-served properties with good highway access are generally available within the reach of greater metropolitan areas, but as often as not, these available properties do not coincide with the location of railroad line-haul junctions. Thus, the locations of new intermodal terminals very often represent a compromise between line-haul network access and other desirable property attributes. Depending on the leanings of this compromise, the result can often be operationally awkward, time consuming, and undesirably expensive train movements to and from the new terminals.

In the early years of intermodal, the more numerous and (thereby) more closely spaced locations of lower capacity intermodal terminals provided more plentiful opportunities for short-haul intermodal service offerings. However, with some exception this traffic did not emerge. At the same time, the capital requirements associated with more mechanized facilities, combined with the long-haul nature of new, readily available intermodal opportunities, favored the development of the smaller number of more widely spaced terminals evident today. This evolution in terminal location and design is widely cited as a leading inhibiter in the development of additional short-haul intermodal lanes.

2.3.3 Terminals and Equipment – The Equipment

The growth in US intermodal traffic is directly tied to the growth in international trade. Therefore, it is not surprising, that the use of containers in the movement of intermodal freight has soared. Containerization provides clear advantages – Containers **(1)** are consistent with international maritime movements, **(2)** can be stacked to save space at port and other terminal locations, **(3)** can be moved by rail in a double-stack configuration with attendant economies, and **(4)** are largely substitutable for truck trailers at domestic origins and destinations.

At the same time, container shipping is not the optimal equipment choice in every setting. Thus, traditional truck trailers have not been entirely abandoned in intermodal service. Trailers still can offer marginal loading advantages based on the combined tare weight of containers and chassis. Container movements do require the use of chassis which can be difficult to secure in some settings or for which maintenance is more suspect. Finally, railroad clearances continue to allow the intermodal movement of trailers to and from some locations where double-stack container service is not possible.

For reasons already noted, most on-rail intermodal equipment is articulated (multiple platforms are permanently connected by couplings (articulators) that ride on the wheel truck). Well cars are specifically designed to accommodate double- stacked containers, while "spine cars" couple platforms that are used for both intermodal trailers and single-stacked containers. However, there are countless variants of these two primary car types.[6] The Class I rail carriers own most on-rail intermodal equipment either directly or through their ownership in TTX, a rail equipment provider owned in total by a combination of North American railroads. However, other on-rail equipment is provided by shippers or by third party vendors such as GATX.[7]

2.3.4 Intermodal Traffic

Intermodal traffic for 2010 totaled 13.4 million units, a nearly 15 percent increase over 2009, but still well below the pre-recession peak of nearly 14.2 million in 2006. This total is decomposed in Table 2.1 (Intermodal Association of North America [IANA], 2010).[8] Interestingly, it has

[6] The most common well cars are 5-unit, 40-ft articulated cars (265-ft in total length per car) for carrying 20-ft, 40-ft, and 45-ft international containers, and 3-unit, 53-ft articulated cars (203-ft in length) for transporting 53-ft containers.

[7] GATX, one of the nation's largest independent suppliers of railroad tank cars, also leases well cars and spine cars for intermodal service.

[8] With the exception of the no-lift trailer volumes, figures reported here and in Table 2.1 reflect data published by the Intermodal Association of North America (IANA). The no-lift trailer volume is based on Norfolk Sothern promotional materials.

been the post-recession recovery of domestic rather than international container traffic that has helped to restore intermodal volumes.

For a brief period in 2007, intermodal traffic replaced coal as the number one freight revenue source. While, the recession that followed diminished rail traffic across all commodity groups, it cut into intermodal traffic the most harshly. Moreover, after a brief period of intransigence, the railroads also responded to slackened demand by lowering intermodal rates. Even though intermodal traffic volumes continue to recover, the prices charged for these services remain somewhat soft. In 2010 intermodal revenues represented slightly more than 22 percent of railroad industry revenues.

Table 2-1. 2010 Intermodal Traffic Volumes.

	Revenue Loads	Percent
Total Traffic	13,390,104	100.0%
Total Container Traffic	11,726,040	87.6%
International Containers	7,237,729	54.1%
Domestic Containers	4,488,311	33.5%
Total Trailer Traffic	1,664,064	12.4%
No-Lift Trailers	300,000	2.2%

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Chapter 3 – Exploring the Components of Short-Haul Intermodal

From a theoretical standpoint, the issue of short-haul intermodal is not particularly distinct from intermodal services that are transacted over longer distances. The short-haul intermodal movements are comprised of the same elements as are long-haul movements and the competition that intermodal faces is, in most ways, identical. However, while the relevant functional relationships don't change with a change in shipment distance, the applicable parameters and their interactions do. Still, an effective treatment of the short-haul issue does not require new thinking. Instead, it calls for a careful and measured application of what has already been learned. This realization is underscored by the sidebar quote taken from a rail industry blog on the topic.

The balance of the current section pursues this thinking by summarizing the mechanics of truck-rail intermodal transport through an examination of its component parts. In Section 3.1, these parts are carefully separated and treated individually before being aggregated to reconstitute the overall shipment. Section 3.2 will consider the conventional wisdom on short-haul in light of the preceding dissection. This section also attends to past attempts (both successful and otherwise) to establish truck-rail service in relatively short traffic lanes. Finally, Section 3.3 will summarize any implications for the modeling work that is described in Sections 4 and 5 of this report.

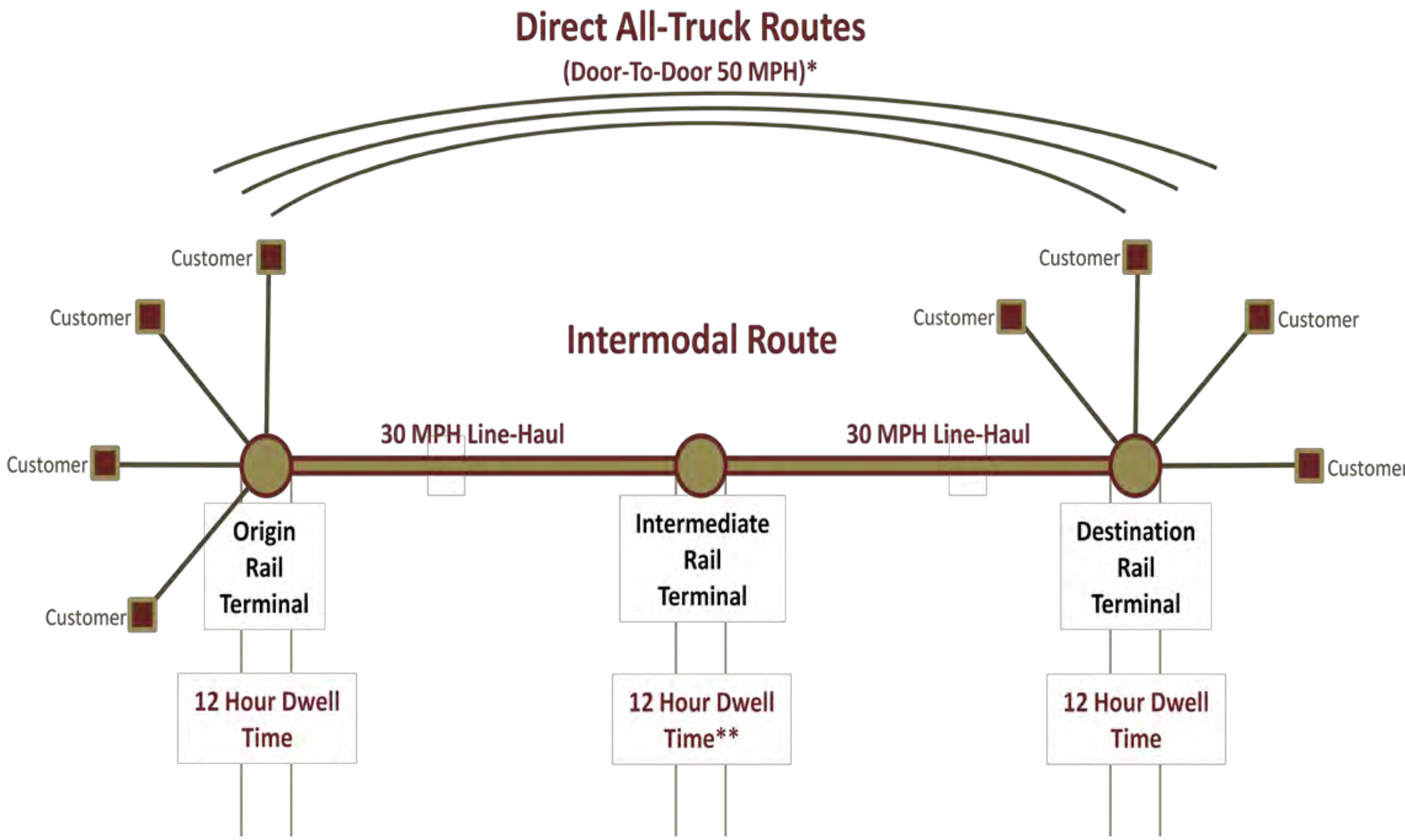
3.1 Decomposing Rail-Truck Intermodal Operations

Figure 3.1 depicts a typical setting in which rail-truck intermodal has an opportunity to compete with an all-truck routing for intercity freight traffic. Its apparent simplicity belies a number of enigmas. Even so, it is clear from the start, that the intermodal alternative has many more components than an all-truck routing.

3.1.1 The Customers

At the very beginning and end of the transportation process are the freight customers who, in one fashion or another, ultimately choose between competing transportation alternatives. In most cases, they have little interest in the mechanics of freight transportation. Their interest is that, within certain tolerances, shipped commodities arrive on time and undamaged where they are needed and that these transactions are accomplished at the lowest overall supply-chain costs.

Much about the individual customers – their time horizon, past experiences, internal supply-chain strategies, etc. – is not immediately obvious to transportation carriers who must either invest in acquiring this information or simply set prices based on what they *can* observe – commodities and their characteristics (weight, size, fragility, value, etc.), the characteristics of the customer's shipments (shipment size, frequency, (perhaps) differences in loading/unloading



*For shipments of more than 500 miles, maintaining this speed may require team drivers.

**The dwell time does not reflect railroad interchange, particularly as it is currently executed at major mid-continent gateways like Chicago or Memphis.

Figure 3-1. Diagram. The Intermodal Shipment Process.

costs, and on-site vehicle storage capacity), and the nature of the available competition.[9] If the shipper (or, in many cases, its agent) chooses an all-truck routing, the remainder of the story is relatively simple. However, if the intermodal alternative is selected, this choice begins a more extensive sequence of activities.

3.1.2 Drayage

In an intermodal setting, shipments are typically picked up and delivered by drayage firms. This is an incredibly important part of the overall intermodal sequence that contributes significantly to total movement costs. It is also an area that has been carefully researched in advance of the current analysis. In their 2004 work, Resor, Blaze, & Morlok conclude that reduced drayage costs can, in fact, contribute to the reduction of the shipment distances needed to achieve viable short-haul service. At the same time other researchers (for example, Karen Smilowitz) have been engaged in operations researched aimed at identifying cost-reducing drayage practices.[10]

3.1.3 Intermodal Ramp Activities

In most cases, the first and last rail carrier involvements in an intermodal shipment occur at the origin and destination gates to the intermodal terminals (ramps) where shipments are moved to and from trains. The activities that occur on these ramps vary widely depending on the type of intermodal equipment used, the generation and scale of the facility and the operating practices of the rail carrier(s) providing the line-haul transportation.[11]

Operations at intermodal facilities are generally structured around "cutoff" times for outbound traffic, and "available" times for inbound freight. Shipments arriving too much in advance of their assigned cutoff time (or at times when the ramp is closed) are sometimes held in secure off-ramp storage facilities. Otherwise, inbound drayage drivers are directed to either an on-ramp parking location or to a train-side location for direct loading. If shipments are held for loading, additional drayage movements by on-site employees (and/or lifts in the case of containers) are generally necessary. In any case, the delivering drayage driver is freed to conduct additional work (pickups) on the ramp or exit the facility.

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[9] Two points are worth noting. First, information about the customers or the nature of competitive alternatives is only valuable when the carrier in question has some degree of pricing power. If the competitive landscape is sufficiently severe, so that prices are driven to long-run incremental costs (LRIC), then expending resources to learn about customer preferences is of little value. Second, while the current marketing and sales strategies of rail carriers may substantially reduce transactions costs, it also makes it more difficult for these carriers to acquire customer-specific information.

[10] Randy Resor is a member of the current study's Steering Committee. See, Resor, Blaze & Morlok (2004) Also see, Smilowitz (2007).

[11] In the decade since the 9/11 attacks, a great deal about actual gate operations has changed. Increased security standards now require a much more thorough inspection of traffic and driver credentials. This has been achieved without corresponding additions to gate processing times by the development of increasingly more efficient inspection equipment and processes.

In the case of "no-lift" equipment, trailers are loaded into trains through their placement over tracks that are imbedded within the pavement. At that point, the intermodal equipment is modified for rail movement, placed on necessary bogies (railroad wheel trucks), and coupled with similar units to form the consist of an outbound train.

For conventional intermodal trailers and containers, the loading process varies greatly depending on the physical characteristics and management of the specific intermodal terminal. An examination of current intermodal schedules, including cutoff and availability times and estimated en-route terminal and line-haul transport times suggests that most shipments are on the ramp for between two and 15 hours after their cutoff time and before their actual departure.[12]

In the case of most shipments, the ramp process at the destination is exactly analogous to the origination process except that it is reversed. In the case of no-lift trailers, the equipment is reconfigured for roadway operations, bogies are removed, and the trailers are drayed to a pickup location where they are available for outbound drayage. Conventional intermodal trailers and containers are "picked" from the inbound train and are either made available for train-side pickup or stored for retrieval later. In the case of trailers that are not immediately headed for the gate, later pickups require additional on-ramp drayage. For containers that are grounded upon arrival, additional lifts are necessary.

3.1.4 Port Terminals

The ramp-to-ramp scenarios outlined above are typical of nearly all domestic intermodal movements and of most international container movements also. Even when rail facilities are located on port property, inbound and outbound container movements are typically moved between vessel and railroad terminal via rubber-tire transfers. This requires several additional lifts that can be avoided if containers can be moved directly between trains and vessels through on-dock railroad access.

The efficiencies inherent in on-dock rail access have lead to its inclusion in a number of newly constructed or renovated marine facilities. However, on-dock container processing generates a new and often vexing set of logistics challenges. Neither trains nor vessels are typically loaded in ways that facilitate on-dock transfer. Inbound vessels are usually loaded to maintain vessel balance and without regard to the positions containers will occupy on outbound trains. Similarly, inbound trains are generally blocked in a way that expedites the train's movement to the dock, without any regard for the necessary vessel loading sequence. Until these challenges are remedied, the full potential of on-dock container transfer cannot be realized.

[12] These estimates are based on an econometric treatment of publicly published Norfolk Southern intermodal schedules (including specific en-route trains) in effect during the fall of 2011. This analysis is not included within the current study document, but is available upon request from the study's author.

3.1.5 Railroad Line-Haul

As a rule, all intermodal traffic is given preference over mixed freight or unit trains containing bulk commodities, but all intermodal movements are not treated equally. Instead, there is a hierarchy that reflects the differential rates paid by shippers. Unit trains containing UPS trailers and the trailers of large truckload motor carriers typically generate the greatest level of revenue and are, therefore, afforded the highest priority in dispatching.[13]

The premium trailer movements are followed closely in importance by trains carrying domestic containers. The fact that many such shipments move in a double-stack configuration reduces their movement cost, but much of this saving is conveyed to shippers in the form of lowered rates. Still, these are shipments that typically occupy a large portion of total supply-chain activity so that both transit times and the reliability of these times is important.

International containers sit at the end of the intermodal queue. By definition, these shipments are containers, typically moving in lanes where double-stack is routine. Moreover, the goods within the container are often in transit for many weeks so that modestly slower railroad transit times are of less consequence. Again, however, even the most thinly rated intermodal traffic is usually given dispatching preference over other rail freight movements.

In the early years, all-intermodal consists were often shorter than the consists of other trains, frequently extending to no more than 5,000 feet in length. The relatively short train lengths combined with higher than average horsepower-to-tonnage ratings allowed these trains to be expedited even when passing sidings were short. However, the growth in intermodal traffic, combined with carrier investments in infrastructure, has lead to a steady increase in intermodal train length. Today's intermodal trains frequently range between 8,000 and 10,000 feet, providing slots for 200 or more containers. At the same time, investment in more efficient locomotives and the use of distributed power has allowed the rail carriers to maintain higher horsepower-to-tonnage ratings and relatively fast train speeds.

Even so, line-haul train speeds do not currently compete with average over-the-road truck speeds. Truck speeds are safely estimated at an average of 50 m.p.h. Line-haul intermodal train speed generally average between 22 and 30 m.p.h., depending on the train's consist and specific operating conditions.

3.1.6 Intermediate Terminal Activities

Many intermodal rail shipments will travel from origin terminal to destination aboard a single train; many other shipments will not. On average 2.2 trains are involved in each line-haul movement and three or more trains are common for shipments that move over less heavily trafficked routes or which are interchanged between railroads. The number and nature of terminal stops is a critical determinant of both the transportation costs incurred by the railroad

[13] These shipments also often include harsh performance penalties as an incentive for on-time delivery.

and the total supply-chain costs incurred by shippers. Intermediate terminal activity increases carrier costs, transit times, and decreases the reliability of scheduled freight arrivals. At the same time, the need to sort, consolidate, and, redistribute traffic makes these activities unavoidable.

Terminal activity for through intermodal traffic typically takes one of two forms. If the volume of inbound traffic bound for a particular destination is sufficient, the traffic will be grouped together in a “block” at the origin. In such cases, the arriving train can set out these organized blocks where they can be combined with similar blocks bound for the same destination and, thereby, expedited. This form of traffic management is aptly referred to as a “block swap.” Interestingly, the locations of intermediate terminals where block swaps are most feasible are determined largely by the carrier’s system network and are not influenced by the volume of local traffic. Thus, many such terminals are remotely located.[14]

When traffic densities between specific origins and destinations are light, shipments can suffer two affronts at intermediate locations. Even if such shipments are blocked into the intermediate terminal, they will still require individual attention (multiple lifts and possible grounding) to assure their availability for their connecting train. Worse, if the arriving train or requisite handling is delayed, the shipment may be unavailable for its planned connection. Missed connections of this sort can result in shipment final delivery delays that are measured in days, not hours.

Short-haul movements are often dispatched as a block within a long-haul train. Because the longer hauls typically involve greater traffic volumes and greater carrier revenues, it is their scheduling needs that dictate the train’s overall schedule. In some cases, the resulting timing coincides with the needs of the short-haul shippers; in other cases it does not. This schedule compatibility (or lack thereof) can greatly affect the viability of short-haul service. This phenomenon is partially responsible for Norfolk Southern’s successful service between Savannah and Atlanta.

3.1.7 Operations Summary

The discussion of intermodal operations provided here underscores the relative complexity inherent in intermodal transport when it is compared to an all-truck route alternative. Intermodal simply includes many more elements that must be carefully coordinated to ensure a smooth flow of network traffic and the timely transit of individual shipments. All the while, these tasks must be accomplished without causing too much insult to the lower unit costs that allow intermodal to compete in markets where its levels of service will never exceed those of trucks.

[14] This outcome is analogous to the swap of trailers between LTL drivers that routinely occur at remote locations.

3.2 Short-Haul Intermodal Strategies

The majority of truck movements are completed over distances of less than the 500 – 700 mile threshold at which intermodal is currently judged to be competitive.[15] Thus, there is (and has been) a general consensus that "shorter" haul intermodal traffic represents a vast, untapped source of potential railroad commerce. Discussions of the topic are not new. They have, however, been given a broader audience by the perceived role that short-haul intermodal might play in mitigating further increases to roadway congestion. Invariably, these discussions include available strategies to increase rail-truck intermodal penetration into the short-haul arena.

The chief advantage of intermodal transportation is its lower unit cost. Its primary deficit is its inability to match the service performance of all-truck routings. The various strategies aimed at increasing short-haul intermodal traffic have tended to focus on either **(a)** amplifying the advantage by further reducing short-haul intermodal costs or **(b)** mitigating the disadvantage by improving service characteristics so that they compare more favorably with motor carriage without imposing costs that are too high.

3.2.1 Shorter, Faster, More Frequent Trains

Trucks' service advantage rests in shippers' abilities to dispatch fast and reliable freight movements at any time and with very little advance notice. This ability substantially reduces the risks associated with planning and executing other supply-chain activities. Many short-haul strategies have attempted to replicate these service attributes by providing faster, more frequent services that do not depend on large train volumes (long trains) to maintain intermodal's economic advantage.

One of the earliest and most referenced attempts to replicate truck performance was the Chesapeake & Ohio's (C&O) introduction of Rail Van service in the 1950s. The C&O equipment, in many ways, resembled first-generation RoadRailer trailers, where a single set of retractable rail wheels facilitated on-rail movements. The C&O originally designed this equipment to operate in freight train service, but regulatory intransigence confined the trailers' use to mail carriage provided in conjunction with passenger train operations. At roughly the same time, the New York Central began to experiment with its Flexi-Van service which relied on largely conventional truck trailers and an innovative rail car design that allowed a no-lift alternative to conventional circus loading and unloading. Flexi-Vans were operated through most of the 1960s, but their use – did not survive the NYC-Pennsylvania railroad merger and subsequent Penn Central bankruptcy.

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[15] As the quote at the beginning of this section suggests, the working definition of short-haul seems to be shipments that are too short to currently benefit from intermodal competition. During the 1980s, 1990s, and the earliest years of the current decade, that threshold distance increased from 500 to 700, and eventually, to nearly 1,000 miles. In recent years, however the relevant threshold has receded, so that truck movements in the 500 – 700 mile range are again sometimes subject to intermodal diversion.

Alternative, no-lift, road-to-rail technologies have remained a strong focus among those who seek to mesh truck-like service characteristics with railroad intermodal efficiency. Less than a decade after the Rail Van and Flexi-Van experiences, the railroad industry looked to embrace the first generation, Mark IV, RoadRailer equipment manufactured, at the time by Bi-Modal. Featuring a design much like the Rail Van, the original RoadRailers were placed in service by the Burlington Northern between Chicago and the Twin Cities and by Conrail between New York and Buffalo. Even though neither attempt was a commercial success, the experience induced Norfolk Southern to purchase the surplus RoadRailer equipment and develop what is now its "Triple-Crown" Roadrailer network.[16]

Subsequent design improvements in the Mark V RoadRailer eliminated much of the weight penalty attributable to the stow-away railroad wheels by replacing these wheels with independent bogies that fully support the RoadRailer trailers while in train service. For a brief period during the 1990s, RoadRailers gained popularity among nearly every Class I carrier in the US. However, one-by-one experimental service lanes were eliminated so that, by 2004, Norfolk Southern was, again, the only freight carrier with RoadRailers in service. NS also ultimately purchased the RoadRailer fleet developed by Amtrak when the latter's entry into railroad express service ended in 2004.

In addition to the development and use of alternative equipment suites, railroads have also attempted to develop truck-competitive intermodal services through the use of traditional equipment placed in specialized service. However, like the equipment-based initiatives, these attempts have met with only limited success.

One attempt at service innovation occurred in the early 1980s when the Illinois Central Gulf (ICG) initiated and operated its "Slingshot" service between St Louis and Chicago. Aimed at service frequency and speed, the ICG ran three Slingshots each day in both directions. Initially, these were scheduled at eight hour intervals. The ICG was able to negotiate a labor agreement that allowed the trains to be operated with two-person crews, but that agreement also restricted train length to 15 cars. Early experience showed that the trains scheduled for overnight service and early morning availability were to be oversubscribed while the other two trains in each direction were underused. The ICG attempted to remedy this problem through schedule adjustments, but in doing so, encountered crew rest issues and other labor problems, so that the entire service scheme was abandoned in 1984.[17]

In the middle 1990s, the Canadian Pacific Railway (CPR) also began a foray into more frequent, less traditional intermodal service. Originally operated between Montreal, Toronto, and Detroit,

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[16] At least in the case of the BN, the failure of the RoadRailer implementation is more easily traced to associated labor issues than to the economic performance of the equipment.

[17] Information describing the ICG's development and use of its Slingshot service was developed through anecdotal sources with reliability that cannot be immediately verified.

the service referred to as *Iron Highway* offered two trains each day in each direction. The service as designed, was to use an alternative equipment suite bearing the same name. However, operational issues lead to the substitution of traditional intermodal cars that are circus loaded. This latter attribute allows customers to engage the intermodal service (on a reservation basis), with standard highway trailers. In 1999 the service was renamed *Expressway* and plans were announced to expand its routing to include Chicago. However, Chicago was never actually included in train operation and Detroit was ultimately dropped, so that the surviving service currently operates between Montreal and Toronto only.

3.2.2 Short-Haul Gains Through Broad-Based Cost Reductions

Figure 3.2 provides a simple, but often used depiction of railroad and motor carrier average total transportation costs (ATC) as a function of shipment distance. These costs, labeled ATC_T and ATC_R reflect the high fixed terminal costs associated with railroad operation and the relatively low terminal costs associated with trucking. The distance at which these cost curves intersect represents the distance beyond which the lower marginal cost of railroad operations dominates motor carrier costs. If one assumes that the additional unit supply-chain costs associated with intermodal service are invariant to distance (a tolerable assumption), then the curve labeled ATC_{R+SC} provides a reasonable representation of the true unit cost of intermodal service. The fact that ATC_{R+SC} intersects ATC_T to the right of its intersection with ATC_R simply suggests that longer shipment distances are required to offset the undesirable impact of the additional supply burdens associated with intermodal shipping.

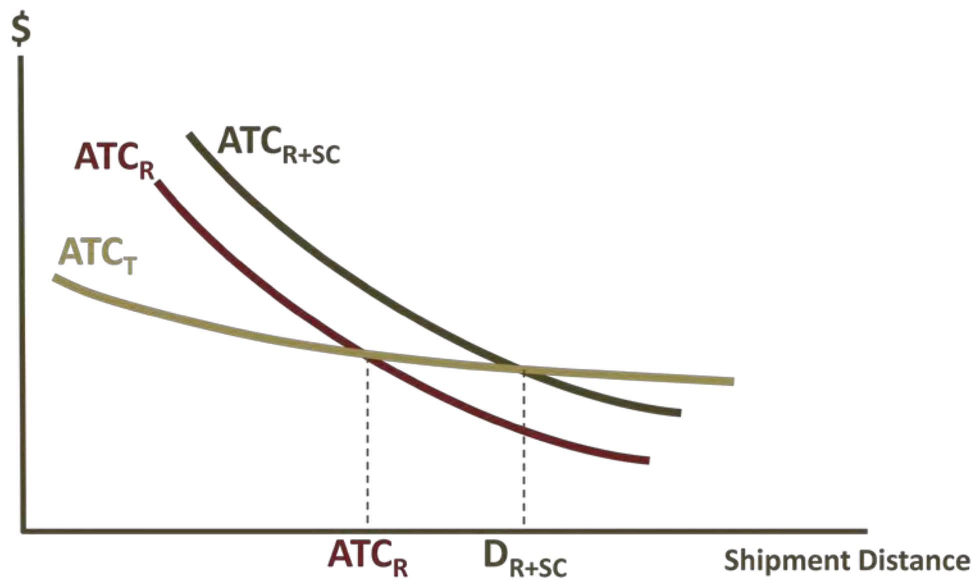

Figure 3-2. Graph. Simplified Comparative Modal Costs.

The main point of this simple diagram is to illustrate that anything that reduces supply-chain costs or railroad line-haul costs or anything that increases motor carrier costs works to reduce the shipment distance at which intermodal becomes economically viable. Thus the fact that these distances have been non-stationary over time simply reflects the temporal movement of relative truck and rail costs.

From an analytical standpoint, this realization begs two questions. First, are there currently trends that are likely to lead to further foreseeable changes in relative costs? Second, and more importantly within a strategy discussion, are there deliberate private sector actions that can lower the cost for all intermodal traffic that will simultaneously reduce the distance at which intermodal rail-truck transport becomes an economically viable substitute for all-truck transport?

With regard to the first of these two questions, predictions suggest that carbon-based fuels will remain the dominant source of transportation energy and that the cost of these fuels will steadily increase. Support for this hypothesis is further discussed in Section 3.4. If this outcome is, in fact, realized it will naturally increase the advantage of intermodal transportation and reduce the distance at which such transport is feasible. The same *may* be true of regulations that further restrict the mobile source emission of air pollutants. The second of the two questions posed above has many complex answers that demand careful thought. These are enumerated and given further attention in the text that follows.

3.3 Considering Short-Haul Intermodal and Modeling Inputs

Table 3.1 summarizes, many of the technological and infrastructure changes that may affect the provision of the intermodal elements discussed thus far. These potential advances are treated more fully in the text that follows. There are two aims here. First, we wish to stimulate further the discussions that can render this list more comprehensive. Second, we hope to establish the motivation for the economic simulations performed in connection with this research.

3.3.1 Shipper Supply-Chain Activities

Firm-level supply-chain managers are responsible for myriad decisions affecting a wide range of production and inventory management outcomes – decisions that include supplier and vendor selections and the form and content of resulting relationships. Invariably these decisions are reflected in firm decisions regarding the purchase of freight transportation services. In the case of very large freight customers, carriers may work to understand as much of the firm's supply-chain practices as possible, but this is generally the exception not the rule.

Supply-chain management is a field in which there is constant progress, but it is outside the realm of the current analysis. Consequently, no effort was made to incorporate anything more than the outcomes that are immediately observable by transportation providers – primarily, the characteristics of the shipped commodities, shipment characteristics, and what little carriers can gleam about customers' freight transportation alternatives.

Table 3-1. Summary of Productivity Possibilities.

Intermodal Element		Infrastructure, Equipment, or Technological Advance	Inhibiting Factor(s)
Shipper Supply-Chain	1	Not Considered within the Current Analysis	None
Intermodal Equipment	2	Additional No-Lift Alternatives	Economics
Local Drayage	3	Improved Drayage Management	None
Intermodal Terminals	4	Additional Terminal Construction / Relocation	Cost, Environmental
	5	Additional Automated Traffic Management Systems	Cost, Technological
Railroad Line-Haul Ops.	6	Additional Clearance Gauge Improvements	Cost, Environmental
	7	Track Capacity Improvements	Cost, Environmental
	8	Positive Train Control (PTC)	Cost, Technological
Rail Network Management	9	Additional Automated Traffic Management Systems	Cost, Technological

3.3.2 Intermodal Equipment

As described above, intermodal transport is largely a function of moving international ISO and domestic freight containers. The share of intermodal trailer traffic continues to diminish measurably each year and as trailer traffic declines, so does the number of terminals that will handle this form of shipment. Still, so long as major customers continue to demand TOFC services, it is unlikely to disappear entirely.

The real question from a forward-looking perspective is whether or not no-lift intermodal equipment can and will make an appreciable contribution to future efficiency gains. Currently RoadRailer manufactures the only no-lift equipment used to any extent in the United States and RoadRailers are strictly a no-lift alternative to conventional TOFC shipment. Moreover, while it was originally envisioned as a valuable tool in low-volume, short-haul, clearance-constrained markets, its current use by Norfolk Southern is primarily over conventional terminals in markets that would seem capable of supporting alternative intermodal services. To that extent it is something of an enigma.

A second, similar technology has been advanced by RailRunner a northeastern manufacturer of railroad equipment. Like RoadRailer, RailRunner depends on bogies to provide on-rail mobility. However, rather than a conventional dry van, RoadRailers are essentially an intermodal chassis. Thus, containers can be moved seamlessly in land-side service without the need for additional lifts and without regard to the local availability of chassis at intermodal terminals. RailRunner has been marketed heavily in the US, but is not currently in service here. It has, however, found favor in emerging equipment markets in both Europe and Asia.[18]

Both RoadRailer and RailRunner have been viewed as a possible avenues for escaping the daunting capital investments necessary to new-generation, lift-oriented intermodal terminals. In both cases, all that is *required* is a relatively small pad with embedded rail tracks and a surrounding area sufficient to accommodate related drayage. The modest investment also means that users are not locked into a specific form of transport or transport technology by the need to recover long-run capital costs.

There are a great many parameters necessary to the calculation of per-movement capital costs for lifts – the number of lifts per movement, the capacity and cost of the lift equipment, the time horizon over which capital costs are amortized, and the necessary rate of return on investments. Table 3.2 summarizes just a few such parameter values and the resulting capital cost calculations. If, as it appears, the use of no-lift equipment avoids these costs on a per-movement basis, then these are the costs that must be weighed against the increased operating costs of using no-lift trailers and foregoing the line-haul economies of double-stack. Both the need for, and the results of, this comparison bring up a number of important economic questions that are further treated in Section 5.5.

Table 3-2. Representative Terminal Capital Costs per Movement at Mechanized Facilities.

	3% Real Return	6% Real Return	12% Real Return
Total Terminal Cost	$150,000	$150,000	$150,000
Real Annual Rate of Return[19]	3.0%	6.0%	12.0%
Required Annual Return	7,588,872	10,791,900	18,515,016
Number of Annual Lifts	750,000	750,000	750,000
Capital Cost per Lift	$10	$14	$25
Number of Lifts per Movement	4	4	4
Terminal Capital Costs per Movement	$40	$58	$99

[18] The current study also investigated a third no-lift alternative equipment suite broadly known as "swap bodies." Swap body equipment is similar to ISO container equipment in that it typically involves a container and a chassis for highway movements. However, swap body designs do not typically meet ISO criteria and are instead are more lightly structured, so that lifts must be made from the bottom of the container and stacking, either for storage or transit, is not possible. Even with these restrictions, swap body equipment has found favor in a variety of European corridors, where it is evidenced in both large numbers and great variety.

[19] Determination of an appropriate real rate of return on capital is a thorny question that typically involves whether or not the capital is funded through private or public sector investment.

3.3.3 Local Drayage

Like most transportation movements, local drayage revenues must account for fixed costs (dispatching, billing, etc.) and variable costs that increase with the length of the dray and the time consumed in its execution. Drayage services are, however, typically set at fixed levels according to zones defined by varying distances from some point. In addition to the actual movement of the trailer or container, the terms of these fixed agreements also usually specify an allowed number of hours for loading or unloading. Drays that extend beyond the local areas where zone prices are in force are typically priced on a dollar per mile basis. In some cases, drayage drivers (and their tractors) will stay with the trailers or containers during the loading and unloading process; other times, they will leave and return. The decision between these two courses is based on the remoteness of the facilities, the volume of other traffic to be drayed, and the availability of other drayage units.

Using very average values for total shipment cost and drayage charges, drayage costs can constitute between 20 and 40 percent of shipment totals and, thereby, can sometimes eclipse the actual line-haul cost of moving a particular intermodal shipment. Clearly, actions that can reduce drayage costs can substantially reduce overall trip costs and / or the length of time needed for the haul. Hence, more effective drayage management may be a powerful tool in promoting short-haul intermodal transport.

Currently, most drays take place in relatively congested urban areas where per-mile transit times are higher and where volatile traffic patterns can complicate scheduling and routing. There are, however, two ongoing courses, that can mitigate these problems and improve drayage productivity. First, the combination of real-time traffic data, GPS, and automated scheduling algorithms that constantly adapt to changing conditions have been demonstrated to measurably improve the efficiency of drayage activities in urban settings. The widespread deployment of these techniques is very promising.

Second, many of the new-generation intermodal terminals and their customers are purposely located apart from localized metro traffic in areas where drayage distances are reduced and / or where the variability of transit times is minimal. In combination, the advances in drayage management and the relocation to less congested areas, hold the promise to reduce drayage costs measurably.

3.3.4 Intermodal Terminals

Within the course of the current work, study team members visited a number of intermodal facilities – some of the first generation variety, some newer terminals developed over the past decade, and one of the very newest terminals – the CSX terminal at North Baltimore, Ohio. These visits, yielded quantitative measures of terminal efficiency under differing operating scenarios, but more importantly, they provided a qualitative glimpse at intermodal traffic management trends.

Operations at legacy terminals are not altogether different now than they were two decades ago except for greater traffic volumes. Traffic management outcomes must be affected over terminal facilities that are often cramped and ill-suited to accommodate flows. To be sure, decades of managerial learning and incremental facility improvements have lead to improved efficiencies, but there are finite limits to potential accomplishments at such facilities. On-ramp drayage movements are frequent and this frequency combined with space constraints often leads to congestion. This is compounded, in part, by equipment storage and staging areas that are often fragmented, remote, and ill-organized. Moreover, the same problems also typically plague rail operations at these facilities. Storage and sorting tracks are too few and too short, train disposition areas are too small and require switch moves that are awkward. Finally, like the ramps themselves, the areas outside the terminals are often a problem. They commonly provide inferior highway access and are surrounded by commercial and / or residential activities that are not conducive to intermodal freight in its current form much less service expansions.

In an attempt to either replace or supplement legacy terminals, the railroad industry has steadily added to the list of new-generation intermodal facilities. A few of these are enumerated in Section 2.3, others were accidentally omitted from the discussion, and still others are only in various stages of development. In the last decade alone, total industry investment in new intermodal terminals has reached well into the billions of dollars.

The new-generation terminals remedy many of the deficits evident in their predecessors. By comparison, they are typically spacious and well organized, so that ramp traffic (both truck and rail) flows far more efficiently. Outside the ramp, these facilities generally offer vastly improved highway access and very often are situated near easily developable property that can be used for third-party supply-chain developments. While these newer facilities provide badly needed intermodal capacity, they also can reduce supply-chain, drayage, and railroad operating costs. These reduced costs have already impacted the competitiveness of intermodal transport as it compares to all-truck routing alternatives.

3.3.5 Automated Traffic Management Systems

Historically, intermodal terminals operated in isolation, with daily operations based on the experience of management personnel and very modest information about actual inbound (either gate or rail) traffic flows. This pattern is quickly giving way to the sharing of system-level data among terminals – even terminals on other railroads – and the processing of this data via automated traffic management systems (ATMS). These systems blend historical data on traffic flows with observed activity to form and constantly update terminal operating plans. While these systems are monitored by experienced managers, a fully implemented ATMS typically generates the work orders that direct ramp equipment and personnel. The use of ATMS can measurably reduce the number of necessary drays, lifts, and train movements, thereby reducing both dwell times and terminal costs.

The management system in place at the CSX North Baltimore facility includes a highly refined ATMS, but this facility hints at a still greater potential. Data from other CSX terminals describing the origins, destinations, and quantities of the traffic bound for North Baltimore is already integrated into the Ohio facility's ATMS. In a few cases this data is inputted manually, but in most cases it is automatically fed to the North Baltimore system. Ultimately, however, it will be possible for the ATMS to operate system-wide so that work orders at all facilities can be coordinated to optimized *overall* system flows. Thus, the handling of each container will represent a fully coordinated movement from gate to gate. Internal CSX planners have estimated the savings related to the implementation of a system-wide ATMS. However, these estimates are not shared publicly.

3.3.6 Line-Haul Rail Carriage

Most of the time and expense associated with rail-truck intermodal routings are attributable to terminal activities or moving shipments by road to and from origin and destination terminals. Most of the shipment distance is comprised of line-haul rail carriage. It is the savings generated through the efficiency of line-haul rail moves that makes intermodal competitive.

Intermodal assets are developed, acquired, and used to provide intermodal freight transportation. However, line-haul rail trackage is designed, built and managed to accommodate a variety of railroad traffic that, in addition to intermodal, rail routes must handle bulk commodity unit train movements, the movement of mixed trains with highly varied consists, and in some cases, passenger trains. Therefore, the physical characteristics and operation of individual railroad network links are varied depending on traffic mix. Very few of these segments exist or are operated purely to support intermodal.

On the one hand, the multi-product nature of rail network service means that most traffic sources will benefit from line-haul improvements designed to accommodate any single traffic source. Alternatively, this multi-product setting also means that no individual traffic source is likely to find network facilities that precisely meet its needs. Instead, the characteristics of most railroad network infrastructures represent something of a profit-maximizing compromise.

In terms of intermodal traffic, the most important network characteristic is the available clearance gauge – and specifically whether or not this gauge will accommodate the use of double-stacks. Beginning in the 1980s with Conrail, nearly every Class I has invested tens of millions of dollars to extend double-stack clearances where feasible. In most cases, this has meant modifying or removing isolated obstructions. In some cases, however, remediation programs involve large expenditures to establish the desired clearance gauge over a particular route.

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Chapter 4 – The Simulation Modeling Framework

Very often, deterministic transportation models are used to decide between specific alternatives. These models are almost always, by necessity, disaggregated in nature and precise in their outputs. Other times, stochastic econometric models are developed in order to unravel and, to some extent, quantify, causal relationships. However, the current setting requires neither the exactness necessary to business decision models, nor the latitude afforded by data-driven econometric models.

Here, the goal is to use representations of well understood transportation and supply-chain relationships to approximate the current threshold that typically separates a preference for all-truck routings from a willingness to use an intermodal rail-truck alternative and to vary parameter values to see how these thresholds may change.

4.1 Model Selection and Development

From a theoretical perspective, the desired framework is not particularly demanding. However, in application, we required two uncompromised attributes. First, the model's representation of the specific supply-chain and transportation relationships had to be sufficiently flexible to allow variations in relevant parameters like fuel costs or new-found drayage efficiencies. Second, and as importantly, the model structure had to include a reasonable representation that loosely approximates the supply-chain management process engaged in by shippers, so that the resulting threshold values represent more than a simple comparison of transportation costs.

The initial intent was to develop this modeling framework independently. However, a review of the existing literature revealed the availability of a publicly accessible, well-tested, but somewhat obscure deterministic intermodal model currently under the control of the Federal Railroad Administration. This model is generally referenced as the Intermodal Transportation and Inventory Cost (ITIC) model and the specific version selected here is a rail-truck adaptation known as the Intermodal Transportation and Inventory Cost – Intermodal Model or ITIC-IM. A careful inspection of the ITIC-IM's workings suggested that it generally contains the modeling attributes necessary to the current analysis and where it did not, desired attributes could easily be achieved through pre and post processing. Moreover, through repeated application, the ITIC-IM has undergone vetting and refinement that would have not been possible for any substitute developed by the current study team.

4.2 The ITIC-IM – History, Structure, and Attributes

A thorough history of the ITIC-IM is provided in documentation available from the Federal Railroad Administration (FRA) (2005). To summarize, the model is a deterministic model based on the costs incurred by transportation users and carriers. As the name implies, the model's structure is based on the supply-chain perspectives of transportation customers. Accordingly, it includes structural elements that capture order frequency, ordering costs, various inventory holding costs, reliability cost factors, and shipper estimates of transport alternative reliability.

In terms of intermodal transportation, the model accommodates varying assumptions regarding both the structure and magnitude of drayage costs, ramp costs, intermodal line-haul costs, and intermediate terminal and / or interchange costs. A model schematic is provided in Figure 4.1.

The ITIC-IM has its roots as a 1980s product of the Association of American Railroads, USDOT, and a research team at MIT headed by Paul Roberts (1981). The original model was ultimately modified at the direction of the Federal Highway Administration (FHWA) and the FRA for use in the federal government's truck size and weight analyses aimed at estimating the volume of truck-to-rail diversions that might be expected under various policy scenarios. Later, the model was refined for use in state and multi-state jurisdictions (Roberts, 1997).

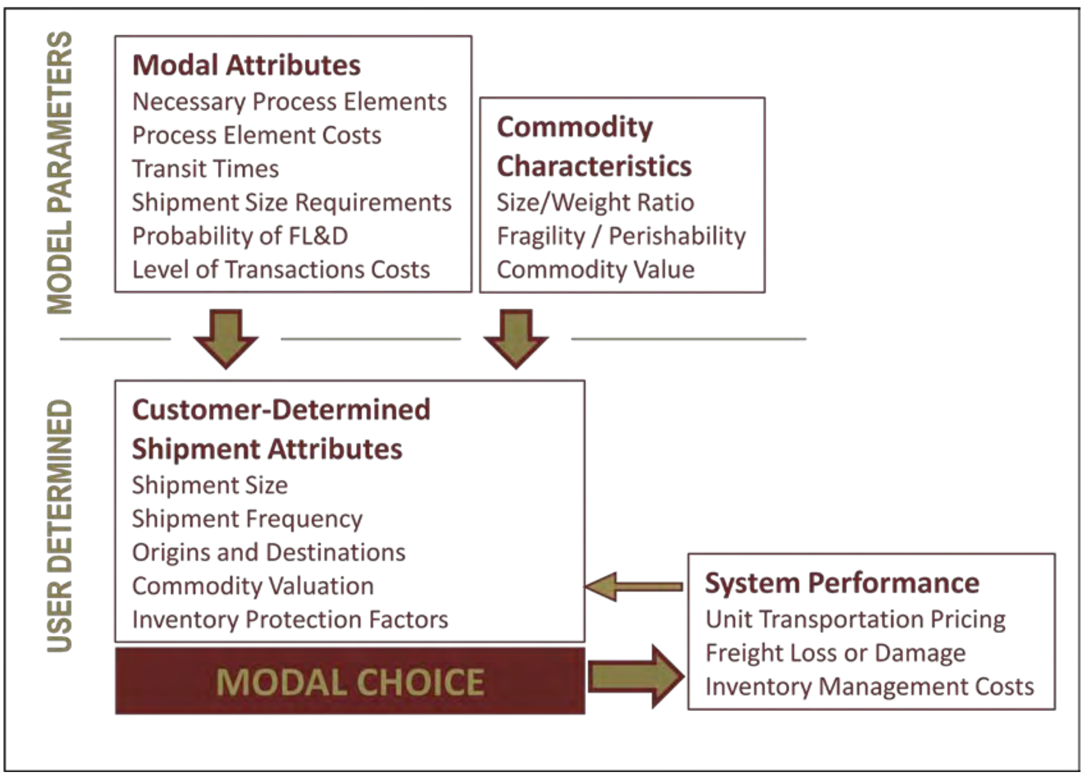

Figure 4-1. Diagram. ITIC-IM Simplified Model Structure.

4.3 Model Parameterization and Extensions

The ITIC-IM, as currently provided by the FRA, is parameterized based on a generic application. It is also supplied with supplemental data that allow users to vary these parameter based on the FRA's collection of historic information. Finally, users can easily adjust model parameters to reflect specific supply-chain, shipment, or carrier data where this data is available. Table 4.1

provides brief descriptions of the parameter values used within the current analysis and is followed by an enumerated discussion.

Table 4-1. ITIC-IM Parameters and Parameter Values.

		Intermodal	Truck Only
	SHIPMENT INPUTS AND PARAMETERS		
1	Commodity (2-Digit STCC)		
2	Commodity Value (per Pound)		
3	Annual Tonnage (Pounds)	4,500,000	4,500,000
4	Individual Shipment Size (Pounds)	30,000	30,000
5	Number of Annual Shipments	150	150
6	Days Between Orders	2.4	2.4
7	Origin State (2-Digit FIPS)		
8	Destination State (2-Digit FIPS)		
9	Shipment Distance		
10	Origin Drayage Distance	10	----
11	Destination Drayage Distance	10	----
12	Equipment Length (Feet)	53	53
	MODAL PARAMETERS		
13	Line-Haul Speed (M.P.H.)	30	50
14	Reliability Factor	45	40
15	FL&D as Fraction of Freight Revenue	0.002	0.0007
16	Claim Payment Days	90	60
17	Terminal Processing Time (Hours)	12	----
	TRANSPORT COST PARAMETERS		
18	Line-Haul Cost (per Mile)		
19	Drayage Cost (per Mile)	$1.38	----
20	Lift Cost (Fixed)	$125.00	----
	LOGISTICS PARAMETERS		
21	Required Service Protection Level (Pct)		
22	Inventory Cost Carrying Factor		

1. Five commodity groups were chosen for the simulations. These include (20) Food and Kindred Products, (28) Chemical Products, (34) Fabricated Metal Products, (37) Transportation Equipment, and (44) Freight Forwarder Traffic. Commodity selection determines a number of logistics parameters.

2. Commodity values per pound were determined through an application of the 2007 Commodity Flow Survey (Bureau of Transportation Statistics, 2009).

3. The annual number of pounds shipped was assumed to be 4,500,000 for all movements.

4. Individual shipment size was set at a threshold well below legal maximums.

5. The number of annual shipments is a direct function of shipment size and annual volume.

6. The number of between orders is a direct function of shipment size and annual volume.

7. Representative origin states were selected based on shipment distance.[20]

8. Representative destination states were selected based on shipment distance.

9. Baseline and simulation values were calculated for five shipment distances – 350, 500, 750, 1,000, and 2,000 miles. These distances were chosen to bracket the threshold distance over which rail-truck intermodal is currently economically viable. For purposes of the current analysis, line-haul rail and highway distances are assumed to be equal.

10. Origin drayage distance was simply assumed for the purpose of the current demonstration.

11. Destination drayage distance was simply assumed for the purpose of the current demonstration.

12. All movements were assumed to be domestic in nature, so that domestic equipment sizes were applied. This assumption probably results in a very modest overstatement of intermodal's efficiency.

13. Line-haul transit speeds are the same as those used in earlier applications of the ITIC-IM. However, their reasonableness was confirmed through other sources.

14. Entries represent the coefficients of variations of transit times applied as parameters within a gamma distribution. This form allows for both symmetrical and asymmetrical distribution of transit times around the mean value depending on the selected parameter value.[21]

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[20] Earlier versions of the ITIC-IM include parameter values that were determined based on geography.

[21] See the referenced documentation of the ITIC-IM for further discussion.

15. Probabilities for freight loss and damage were assumed based on past applications of the ITIC-IM.

16. Claim payment days were based on previous application of the ITIC-IM and confirmed through independent sources.

17. Terminal processing times were determined based on an econometric evaluation of currently scheduled cutoff and availability times, shipment distance and the number of trains involved in each movement. For purposes of the current analysis end-point and intermediate terminal times are treated as equal.

18. Fully capitalized motor carrier costs were determined based on data provided through American Transportation Research Institute (ATRI). These data were supplemented with information provided through a Minnesota motor carrier survey (ATRI, 2008). Motor carrier mileage rates were assumed to be invariant to shipment distance, but differed based on the use of single drivers for all shipments and the use of team drivers for shipments of 750 miles or more. Rail costs are calculated separately for double-stack container movements and for the movement of single stack or TOFC shipments. For the purpose of the current analysis, rates are assumed to equal fully capitalized incremental costs and are allowed to vary based on shipment distance.

19. Per-mile drayage costs are based on past applications of the ITIC-IM. However, these rates were reconciled with the ATRI rates to ensure that they reflect appropriate differences in horsepower per ton, maintenance, fuel efficiency, etc.

20. Lift costs are drawn directly from past applications of the ITIC-IM, but were confirmed as consistent with other ongoing modeling work.

21. Required service protection factors are commodity specific and are based on past applications of the ITIC-IM.

22. Inventory carrying factors are commodity specific and are based on past applications of the ITIC-IM.

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Chapter 5 – Simulation Designs and Outputs

Unlike simulations designed to evaluate the impacts of a specific project or policy change, the current work is aimed at providing general information describing the potential effects of non-specific changes in underlying transportation costs. Thus, the simulations and their results should be viewed as “hypotheticals”. They certainly cannot be applied to predict the outcomes of individual real-world actions. They do, however, yield a sense of potential forward-looking outcomes and quantify these to within an order of magnitude of what may be achievable in the future. The simulations are based on the parameters and input values described in Section 4. Accordingly, they also give readers the opportunity to consider further simulations that further modify the ITIC-IM framework in order to evaluate additional scenarios.

The balance of the current section contains descriptions of three separate simulations. The first of these is designed to establish a reasonable set of baseline values associated with all-truck and rail-truck intermodal freight routings. The baseline estimates are followed by two hypotheticals. The first of these recalculates user costs under a sustained and significant increase in petroleum costs. The second simulation scenario provides an estimate of transportation and supply-chain costs in the wake of improvements that reduce both the temporal and financial costs attributable to intermodal. In all three cases, the simulation outputs are presented in a way that allows specific conclusions regarding the distance threshold at which intermodal rail-truck transport provides overall supply-chain outcomes that are truck competitive.

The ITIC-IM platform cannot simulate the potential contribution of non-traditional, no-lift intermodal equipment and how the wide-spread application of this equipment might affect capital costs and / or intermodal’s further penetration into short-haul freight markets. Available data do not support the modifications and parameterization of the model needed to produce this sort of simulation. Consequently, the equipment issue is addressed through a discussion in Section 5’s final subsection.

5.1 Baseline Simulations and Results

The purpose of the baseline simulations is two-fold. First, because they are based on parameter values and other model inputs that are intended to reflect current transportation and supply-chain conditions, they should yield results that, at least loosely, mirror the outcomes we currently observe. To the extent that this is the case, it validates both the functional structure of the model and its parameterization. The second role of the baseline simulations is to provide the benchmark values against which later simulation results are compared.

Table 5.1 reports three sets of baseline values based on the parameters described in Section 4. The first of these are all-truck, door-to-door routings. The second set of values corresponds to a double-stacked container intermodal routing, and the third set of reported values reflects the estimated user cost of either single-stack container or TOFC movements.[22]

Table 5-1. Baseline Total User Supply-Chain Costs.

Commodity	Origin State	Destination State	Shipment Distance	All-Truck Routing	Double-Stack Intermodal Routing	Single-Stack / TOFC Intermodal Routing
Food & Kindred Products	GA	GA	350	101,139	105,616	131,635
	NC	TN	500	140,261	133,605	170,178
	NC	TN	750	205,464	175,308	228,380
	MO	NJ	1,000	270,667	213,734	280,206
	CA	IL	2,000	531,479	393,140	526,961
Chemical Products	NJ	PA	350	100,613	94,463	121,937
	IL	MO	500	140,698	121,913	160,012
	VA	AL	750	207,507	162,848	217,545
	VA	MS	1,000	274,316	200,247	268,478
	WA	IL	2,000	541,552	376,407	512,410
Fabricated Metal Products	TN	MO	350	98,592	97,258	124,367
	TN	MO	500	137,473	124,834	162,552
	NJ	SC	750	202,274	165,720	220,042
	NJ	TN	1,000	267,076	203,587	271,383
	CA	AL	2,000	526,281	380,586	516,045
Transportation Equipment	SC	GA	350	106,291	117,335	141,825
	PA	IL	500	146,290	138,982	174,854
	MO	NY	750	212,954	188,644	239,975
	MO	NY	1,000	279,619	227,869	292,497
	CO	FL	2,000	546,277	411,337	542,785
Forwarder Traffic	PA	KY	350	99,861	100,484	127,173
	MD	OH	500	138,916	121,313	159,490
	OH	GA	750	204,008	169,612	223,426
	IL	FL	1,000	269,100	207,474	274,762
	NJ	TX	2,000	529,467	385,489	520,308

These results are, for the most part, consistent with expectations. At the shortest shipment distance, 350 miles, the all-truck routing generally generates total supply-chain costs that are equal to or less than the costs associated with a double-stack intermodal routing. In most cases the crossover threshold is in the area of 500-750 miles. The single-stack or TOFC intermodal alternative generally does not generate competitive supply-chain costs until the shipment distance is at least 1,000 miles. Moreover, the variations in costs across commodities are consistent with differences in commodity values and handling costs. The results even show the

[22] In all cases, truck movements are assumed to occur with a single driver, so that truck transit times reflect the application of Hours of Service regulations at varying distances that depend on the assumed vehicle speed. An attempt was made to modify the ITIC-IM structure so that it can also estimate user costs under a team-driver scenario. However, the results of these attempts could not be validated, so that the results are not reported here. Also, for modeling purposes, the costs associated with single-stack container movements and TOFC movements were assumed to be sufficiently similar to allow their grouping within the simulation process.

impact of the hours of service regulations on single-driver tuck movements, with distance-cost differences somewhat greater as the 500 mile threshold is crossed.

The baseline simulation results bring an essential point closer to the analytical surface. There is a general sense among transportation economists that shippers should be largely indifferent between all-truck service and intermodal when the full supply-chain costs of these alternatives are roughly equal. It follows, then, that shippers should be willing to divert traffic to intermodal when intermodal rates fall below truck rates for any significant period of time. Evidence from the recent recession, however, suggests that this is not the case.

The question of why shippers are intransigent was taken up in a study summarized in a 2009 *Progressive Railroading* article. The original work, performed by Northbridge, Inc., was based on extensive surveys of both existing and potential intermodal shippers that sought to determine the extent to which these shippers had (or had not) responded to relative declines in intermodal rates and to uncover the reasons behind the shipper response (Blair & Fox, 2009).

There were several shipper answers that are worth understanding. First, even though the packing and loading practices available for 53’ domestic containers largely mirror the alternative available to shippers who typically use truck trailers of the same length, 53’ container availability was not always certain. Second, the shipping schedules of the available intermodal service did not always coincide with shipping practices currently used by potential customers or their ability to store equipment on-site.[23] Third, completely apart from reliability issues, intermodal shipping does not readily allow shipments to be rerouted in transit and is, otherwise, less flexible. Finally, there was a general sense that doing business with rail carriers or others who might market intermodal services is simply not as easy as dealing with all-motor carrier transportation vendors.

5.2 Fuel Cost Simulations and Results

Fuel costs are a significant component of overall trucking and railroad intermodal operating costs. In the case of trucking, the ATRI estimates, used here to develop motor carrier costs, suggest that fuel represents roughly one-third of total per-mile truck costs. For railroad intermodal movements the corresponding value is roughly 35 percent for double-stack movements and 50 percent for TOFC traffic. For the drayage movements associated with rail-truck intermodal, fuel costs also represent more than 50 percent of total costs.

While fuel costs represent a large fraction of total costs for these surface freight alternatives, the relative fuel efficiency of each option is very different. Long-haul motor carriage typically can achieve 125 ton-miles of transportation per gallon. For TOFC movements, the corresponding value is roughly double at 235 ton-miles per gallon. Double-stack movements are the most fuel

[23] This issue was also mentioned by study steering committee members.

efficient with an average ton-mile per gallon rate of nearly 400.[24] Thus, the relative competitiveness of these alternatives, particularly over shorter distances, is affected by fuel costs.

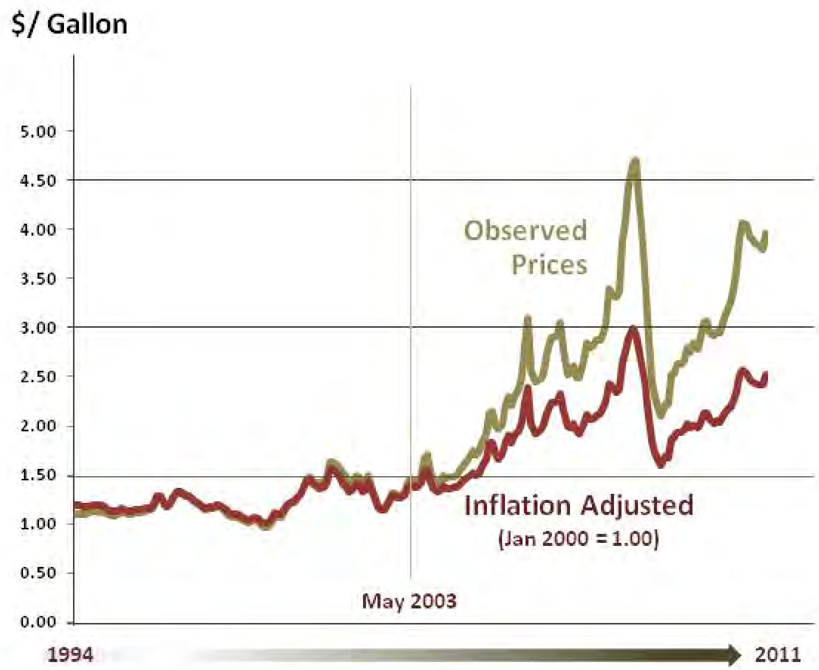

Figure 5-1. Graph. Nominal and Inflation-Adjusted Retail Diesel Prices in the US.

Figure 5.1 depicts both nominal and inflation-adjusted diesel fuel prices over the past three decades. This figure supports two conclusions – real fuel prices have risen modestly over this period, but without question, these prices have become more volatile. This latter pattern makes predicting future fuel prices particularly difficult. The US Department of Energy's Energy Information Administration predicts that international crude oil prices will increase by as much as 50 percent over the coming three decades. However, Global Insight, a leading international producer of commodity price forecasts, predicts a somewhat slower rise in these prices of roughly 1.5 percent per year over inflation. This translates to an aggregate real price increase of roughly 30 percent over the same period.[25] Thus, it is reasonable to hypothesize that real fuel prices will increase between 25 and 50 percent over the next three decades.

[24] The motor carrier ton-mile rates were calculated based on the ATRI cost figures and an average loading of 20 tons per shipment. The railroad values are based on relatively recent study sponsored by the Federal Railroad Administration. See Federal Railroad Administration (2009).

[25] See, Global Insight (2010). The Global Insight data were provided for use in the study by the University of Tennessee's Center for Business and Economic Research.

To simulate the change in supply-chain costs that might be attributable to a sustained increase in fuel prices, the fuel cost components within the line-haul per-mile cost estimates for both rail and truck were increased by 50 percent. The same increase was also imposed on the fuel cost portion of estimated drayage costs.[26] The results of these estimations are reported in Table 5.2.[27]

Table 5-2. Simulated Supply-Chain Costs with Increased Fuel Costs.

Commodity	Origin State	Destination State	Shipment Distance	All-Truck Routing	Double-Stack Intermodal Routing	Single-Stack / TOFC Intermodal Routing
Food & Kindred Products	GA	GA	350	117,939	109,565	133,903
	NC	TN	500	164,261	138,770	173,211
	NC	TN	750	241,464	182,500	232,688
	MO	NJ	1,000	318,667	222,953	285,789
	CA	IL	2,000	627,479	410,466	537,644
Chemical Products	NJ	PA	350	117,413	98,412	124,205
	IL	MO	500	164,698	127,078	163,045
	VA	AL	750	243,507	170,040	221,853
	VA	MS	1,000	322,316	209,465	274,061
	WA	IL	2,000	637,552	393,733	523,093
Fabricated Metal Products	TN	MO	350	115,392	101,207	126,635
	TN	MO	500	161,473	129,999	165,585
	NJ	SC	750	238,274	172,912	224,350
	NJ	TN	1,000	315,076	212,806	276,966
	CA	AL	2,000	622,281	397,912	526,728
Transportation Equipment	SC	GA	350	123,091	121,284	144,093
	PA	IL	500	170,290	144,146	177,887
	MO	NY	750	248,954	195,835	244,283
	MO	NY	1,000	327,619	237,088	298,080
	CO	FL	2,000	642,277	428,663	553,468
Forwarder Traffic	PA	KY	350	116,661	104,433	129,441
	MD	OH	500	162,916	126,478	162,523
	OH	GA	750	240,008	176,803	227,734
	IL	FL	1,000	317,100	216,693	280,345
	NJ	TX	2,000	625,467	402,815	530,991

[26] Based on the inflation-adjusted data depicted in Table 5.1, today's inflation adjusted price of diesel fuel is $2.52 per gallon. A 50 percent increase would result in a real price of $3.78, a value only 26 percent greater than the real price of $2.99 per gallon observed in June of 2008. While a price change of this magnitude may seem probable to some and unlikely to others, it is certainly not beyond the realm of possibility.

[27] This scenario does not assume compliance with either motor carrier or railroad locomotive fuel efficiency standards beyond what has already take place, nor does it account for any potential adjustment in carrier behaviors that might mitigate the impact of a sustained fuel price increase.

The result of the simulation exercise is a set of modal supply-chain costs that is dominated by the double-stack intermodal alternative. In every case, the double-stack total supply-chain cost is between 7.4 percent and 47.3 percent lower than the competing all-truck supply-chain costs, depending on commodity and shipment distance. The simulations also point to relative gains for single-stack container and TOFC shipping. For all five commodity groups, the single-stack/TOFC supply- chain costs were lower than the corresponding all-truck costs beyond a distance of 750 mile and in one case (chemicals), the threshold falls to below 500 miles.

5.3 Reductions in Non-Line-Haul Intermodal Costs

Section 3.4 describes a variety of ongoing activities that each hold the potential to reduce the line-haul and non-line-haul total supply-chain costs associated with intermodal transportation. Some of these improvements will come to a productive end, while it is likely that some will not. Some productivity gains will be realized within a relatively short timeframe; others may take decades to mature. Ideally, the current analysis would be able to pinpoint which foreseeable improvements will succeed, when these will be realized, and the precise extent to which they will improve intermodal productivity. Sadly, this is not possible. As a rather feeble substitute, the current work will simply assume a cumulative impact without regard to its precise source(s). This cumulative effect will then be simulated in order to anticipate implications on the economic viability of short-haul intermodal transport. Table 5.3 summarizes a number of characteristics and outcomes associated with the baseline estimate of total supply-chain costs for double-stack container movements.

For the purposes of the described simulations, the study team assumed a combination of improvements that would result in (1) a total reduction in transport supply-chain costs of 25 percent ($292) and (2) a total transit time reduction (with unspecified reductions in inventory costs) of 25 percent (23 Hours). To be sure, these are aggressive reductions in both cost and time. Again, however, we would maintain that these simulated increases in productivity are not beyond the realm of reason. As a matter of comparison Norfolk Southern's announced goal for its *Crescent Corridor* initiative is to match the single drive truck transit time. Based on the numbers developed above, this would require a more than 50 percent reduction in total transit times. Also, CSX can already claim a one-day reduction in the transit times of its Chicago traffic that is now processed at the *National Gateway's* North Baltimore hub.

Table 5.4 provides the simulation results that come from the assumed increases in intermodal productivity discussed above. While not quite as dramatic as the simulation results describing the impact of fuel price increases, the results portrayed in this table suggest that the assumed efficiency gains would effectively lower the threshold that separates intermodal from all-truck routings, so that intermodal would be economically viable in what is now considered by many to be an effective floor on even the most ambitious to extend intermodal services into shorter traffic lanes.

Table 5-3. Simulation Averages, Double-Stack Intermodal.

	Average per Shipment
Distance	920
Total Supply-Chain Cost	$1,338
Non-Transport Supply-Chain Cost	$171
Transport Supply-Chain Cost	$1,167
Drayage Cost	$250
Railroad Revenue	$917
Total Transit Time	91.2
Total Pickup and Delivery (Hours)	24.0
Total Ramp Dwell Time (Hours)	35.4
Total Line-Haul Time (Hours)	31.8
Line-Haul Miles per Hour	28.9

Table 5-4. Simulation Results, Productivity Improvements.

Commodity	Origin State	Destination State	Shipment Distance	All-Truck Routing	Double-Stack Intermodal Routing
Food & Kindred Products	GA	GA	350	101,665	102,047
	NC	TN	500	141,012	130,036
	NC	TN	750	206,590	171,870
	MO	NJ	1,000	272,168	210,167
	CA	IL	2,000	534,481	389,921
Chemical Products	NJ	PA	350	100,606	93,480
	IL	MO	500	140,690	120,929
	VA	AL	750	207,497	161,863
	VA	MS	1,000	274,305	199,260
	WA	IL	2,000	541,534	375,414
Fabricated Metal Products	TN	MO	350	98,601	95,688
	TN	MO	500	137,483	123,265
	NJ	SC	750	202,286	164,412
	NJ	TN	1,000	267,089	202,022
	CA	AL	2,000	526,302	385,583
Transportation Equipment	SC	GA	350	106,328	111,163
	PA	IL	500	146,332	139,714
	MO	NY	750	213,005	182,484
	MO	NY	1,000	279,678	221,717
	CO	FL	2,000	546,372	405,216
Forwarder Traffic	PA	KY	350	99,550	97,555
	MD	OH	500	138,562	125,246
	OH	GA	750	204,055	167,372
	IL	FL	1,000	269,155	205,242
	NJ	TX	2,000	529,554	383,284

5.4 Revisiting the Potential of No-Lift Intermodal Equipment

If one were to envision a strategy for introducing short-haul intermodal transportation into an environment where no intermodal transportation exists in any form, it is hard to imagine a better suited technology than the suites of no-lift equipment that are currently available (either the Mark V RoadRailer or RailRunner equipment).

The equipment and the cost of the locomotives that move it represent nearly the whole of the required capital investment. Moreover, the notable lack of fixed (and largely sunk) costs typically associated with highly capitalized intermodal terminals means that no-lift equipment operates at no particular disadvantage in short distance traffic lanes. From a performance standpoint, RoadRailer equipment is routinely operated by Norfolk Sothern in 8,000 foot trains and Amtrak has operated this equipment in passenger consists at velocities that easily surpass typical freight train speeds. If there is any disadvantage whatsoever to the no-lift equipment, it is from a lack of flexibility inherent in the use of bogies over a limited service network. This disadvantage would quickly diminish in importance if no-lift equipment was more widely used in greater volumes.

The economic characteristics of no-lift intermodal equipment are a complete contrast with the attributes of twenty-first century container carriage. Containers are least expensive to move when they are double-stacked to take the greatest possible advantage of available clearances. Double-stack traffic is most efficiently handled via highly mechanized, high-volume terminals and the efficiencies are increasingly pronounced when they are averaged over longer and longer shipment distances.

Historically, what might have been an interesting co-emergence of two very different intermodal technologies was not so. While the meager capital requirements of no-lift equipment was (and is) attractive to the railroad industry, it could not ignore the ready-made demand for container movements that came from the steamship lines. This large source of long-distance traffic very quickly grew even larger during the 1990s as international trade volumes exploded.

At the same time, on the highway side of the no-lift equation, deregulated truckers, burning still-affordable fuel and operating over relatively uncongested roadways, dampened any real demand-side zeal for short-haul intermodal in the lower density markets no-lift equipment can make affordable. The eventual development of domestic containers with true trailer-like dimensions and the adoption of that technology by large truckload motor carriers seems to have closed the door on any further market-driven growth in the use of no-lift intermodal equipment. Yet, it is a topic that does not disappear.

The reasons for this survival are understandable. First, the lack of capital intensity and proven technology designs of no-lift equipment make them “evergreen” in terms of availability. Any emergent demand for this equipment could be almost instantly satisfied. Second, many of the conditions (cheap fuel, uncongested roadways, etc.) that made most truck-served markets invulnerable to non-roadway competition in earlier decades are eroding and may not be restored.

Next, purely market-derived equilibria in transportation settings are no longer always the rule. Various levels of public-sector jurisdictions in many parts of the US are actively seeking to influence freight practices in order to promote other public sector goals (land-use, environmental outcomes, etc.). Freely operating markets may have, for the time being, rejected no-lift intermodal equipment, but as freight system demands are integrated into the broader tableau of public endeavor, no-lift alternatives may find new advocates who are ready to support intermodal service in a form in which it would not otherwise exist.

Finally, there is nothing inherently damning in the coexistence of lift-oriented container service and services based on no-lift trailer equipment. Much as the railroads first feared that intermodal would "cannibalize" boxcar traffic, some argue that no-lift equipment will siphon away container traffic and dilute cost reducing traffic densities. This seems unlikely. The two technologies compete for only a shred of common traffic. Otherwise, each is suited to its own purpose. Norfolk Southern's experience with its Triple Crown Service readily demonstrates this. The NS success also suggests that there is no inherent operating conflict between RoadRailers and lift-oriented intermodal services.

As noted above, the ITIC-IM used to conduct the simulations presented in this section is not immediately suited to the execution of simulations that include no-lift intermodal equipment. This does not, however, imply that these simulations are not worth performing. To the contrary, this outcome simply points to the desirability of additional work.

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Chapter 6 – Concluding Thoughts

Probably the most meaningful result of the current analysis has been a renewed appreciation of the profound role that freight shippers play in shaping the availability of current and future freight transportation alternatives. This is very clearly the case regarding intermodal transportation in general and perhaps, even more true for short-haul intermodal. Shippers decide what they will and will not purchase and in doing so spur breathtaking growth for one freight activity just as they confer complete commercial irrelevance to others.

Large international shippers, with steamship lines as their agents, wanted the ability to move containers inexpensively and they achieved that goal. When domestic motor carriers exhibited an interest in no-lift intermodal equipment in the early 1990s, nearly every Class I railroad began to offer these services. But when motor carrier demands for a no-lift alternative evaporated in favor of domestic containers, most no-lift services quickly disappeared. Freight carriers, from any mode, who fail to carefully regard the preferences of shippers, operate at great peril.

The current analysis also makes it clear that freight markets and their outcomes are dynamic. During the early years of the last decade, when shipper demands were strong, motor carrier capacity was plentiful, and railroad capacity was tight, the distance threshold that defined the viability of rail-truck intermodal was pushed outward to nearly 1,000 miles. Today, with aggregate demand still slack, inventory requirements less severe, and fewer dollars available to buy freight, this intermodal demand threshold has regressed to roughly 750 miles. And if we are to believe the results of the current analysis, that distance could be cut in half as a result of fuel price increases that are quite easily imagined.

Some policy-makers wish to promote short-haul intermodal as a remedy for increasing highway congestion. However, if increasing congestion measurably elevates motor carrier costs through increased delays and reduced reliability and if short-haul intermodal is the best available solution, freight markets will reach for this cure long before the identification or implementation of any public policy. The same conclusion is largely true regarding the future role of no-lift intermodal equipment. Freight users know it is available, are aware of its characteristics and currently choose not to use it to any great degree. This is a decision that can be reversed at almost any time with very little forethought and very little risk. There is no need to promote, support, or in any way subsidize this equipment's use.

None of this is to suggest that public policy cannot be relevant to short-haul intermodal transport. First, policies that assure the vitality of competitive processes within the freight market place and reward successful private sector investment will, in doing so, produce the best possible mix of intermodal alternatives. It is also quite appropriate for individual jurisdictions to support short-haul intermodal as an economic development tool or a means of addressing specific public concerns that extend beyond the normal bounds of transportation transactions. However, with these latter actions come two important cautions. First, if individual jurisdictions choose to manipulate transportation market outcomes through financial awards, they must be aware that the outcomes they desire may only survive as long as financial support is forthcoming. More importantly, any public intervention into intermodal freight markets must be structured in a way so that it does not distort or impede private sector investment activity.

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