DEMAND FOR INTERMODAL TRANSPORTATION IN ARKANSAS

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John Ozment

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Demand for Intermodal Transportation in Arkansas

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16. Abstract

Intermodal transportation offers many benefits to shippers and society in general, and intermodal movements have grown rapidly over the past 20 years; however, it still represents a very small portion of the total freight market. Thus, the benefits to shippers and society are not being fully realized. Many shippers who use truck transportation assume that service times of intermodal movements would prohibit their use of it, and shippers who use rail service often assume that transportation costs of intermodal would prohibit its use; however, few shippers actually base their mode selection on a total cost basis. The purpose of this study is to examine the role that intermodal transportation plays in today's logistics environment and to assess its potential for further growth and adoption by examining the potential for intermodal service based on total logistics costs. Based on data provided in the DOT's 1997 Commodity Flow Survey, a selection of products of different values were used as examples to assess the total cost of movements between hypothetical origins and destinations. The result of the total cost of these movements provide insight into the potential impact of shifting freight from truck to truck-rail intermodal.

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Demand for Intermodal Transportation in Arkansas

ABSTRACT

Intermodal transportation offers many benefits to shippers and society in general, and intermodal movements have grown rapidly over the past 20 years; however, it still represents a very small portion of the total freight market. Thus, the benefits to shippers and society are not being fully realized. Many shippers who use truck transportation assume that service times of intermodal movements would prohibit their use of it, and shippers who use rail service often assume that transportation costs of intermodal would prohibit its use; however, few shippers actually base their mode selection on a total cost basis.

The purpose of this study was to examine the role that intermodal transportation plays in today's logistics environment and to assess its potential for further growth and adoption by examining the potential for intermodal service based on total logistics costs.

Products of different values were used as examples to assess the total cost of movements between hypothetical origins and destinations. The total logistics cost of truck-rail intermodal were compared to the total cost of shipping by truck. Data provided in the DOT's 1997 Commodity Flow Survey were then examined to show the potential for other products to benefit from intermodal transportation. The results provide insight into the potential impact of shifting freight from truck to truck-rail intermodal. Additionally, the results suggest that the current demand for intermodal service is probably not sufficient to justify the development of additional intermodal facilities.

Demand for Intermodal Transportation in Arkansas

INTRODUCTION

Intermodal transportation is the combination of two or modes of transportation to move a shipment from its origin to its destination, while combining the advantages of each mode used. There are many combinations of modes available to shippers, but this study will focus primarily on the combination of truck and rail to move containers and/or trailers.

Intermodal transportation offers many benefits to shippers and society in general, and intermodal movements have grown rapidly over the past 20 years; however, it still represents a very small portion of the total freight market. Thus, the benefits to shippers and society are not being fully realized. A major question which should be asked is, "Given the potential benefits of intermodal transportation, why is it not being used more extensively? Are the benefits overstated or are there impediments to its growth and adoption? The purpose of this study is to examine the role that intermodal transportation plays in today's logistics environment and to assess its potential for further growth and adoption, especially within Arkansas.

BENEFITS OF TRUCK-RAIL INTERMODAL

Truck-rail intermodal combines the efficiency of rail transportation with the convenience and flexibility of trucks. By using rail for the long haul portion of the movement, intermodal transportation offers shippers a lower cost option compared to motor carrier movements, while the truck portion offers the flexibility of door to door service. Intermodal rates are typically 15 to 20 percent below motor carrier rates for comparable moves, but transit times may be 2 or 3 days longer and more variable, depending on the length of haul.

In addition to the benefits that shippers realize directly, intermodal transportation is beneficial to society as a whole. These benefits include increased energy efficiency, improved air quality, reduced highway congestion, and fewer accidents, all of which arise as a result of fewer trucks on the highways. A single intermodal train can take as many as 280 trucks off of the highways. This shifts the focus from long haul, cross-country movements to short haul trips to and from customers and intermodal ramps. Rail intermodal service on average uses less than half as much fuel as highway transport to move the same shipment the same distance, and moving a ton of freight by rail instead of truck results in less than one-third the emissions into the air. Driver fatigue is often cited as one of the primary reasons for large truck accidents, and by using rail for the long haul portion of a shipment, truck drivers are used for shorter, regional moves which reduces the probability of an accident.

THE GROWTH OF TRUCK-RAIL INTERMODAL

The concept of intermodal transportation has been around since the 1840s when wagonloads of goods were loaded directly on to rail cars for shipment to market. However, it really never caught on until the mid-1950s when Malcolm McLean developed the concept of using trucks to move freight by both highway and water carriers. McLean's venture developed into Sea-Land Services, one to the nation's largest water carriers (Coyle, Bardi, and Novack, p. 212). Critical to the railroad industry's involvement was the New Haven Railroad Case in which the Interstate Commerce Commission ruled that railroads could handle trailers and containers on flat cars which were usually handled by motor carriers. This led to railroads offering domestic "piggy-back service" known as either Trailer on Flatcar (TOFC) or Container on Flatcar (COFC).

For many years, the growth of intermodal transportation was inhibited by government and labor groups concerned about the loss of jobs. Railroad executives at that time viewed intermodalism more as a threat to their business than as a potential source of new revenues, and railroads lacked the proper equipment for efficient loading and unloading of trailers and containers. However, intermodalism continued to grow in spite of these restrictions. Today it is often considered to be the fastest growing segment of transportation, and it is clearly the fastest growing segment of the U.S. freight railroad industry.

Table 1 shows the growth in intermodal traffic from 1961 through 1999. The first year in which trailers and containers were reported separately was 1988. Figure 1 shows graphically the growth of total intermodal movements by rail. Figure 2 shows the growth of containers relative to trailers. As can be seen, the movement of trailers intermodally has declined slightly while the number of container shipments has grown steadily, and in 1992, the number of containers surpassed the number of trailers shipped intermodally. This growth, especially in container shipments, can be attributed to many factors, including the introduction of innovative technology and operations (such as double stacking containers), the growth of international trade, and the deregulation of both railroads and motor carriers in 1980. Motor carriers are also responsible for much of this growth. As the driver shortage has taken its toll on the truckload sector, many carriers like JB Hunt and Schneider National have entering agreements with railroads to move their trailers. Furthermore, many LTL trailers are shipped intermodally; UPS is widely recognized as the largest user of intermodal service. However, in spite of this growth, truck-rail intermodal movements account for a very small part of the freight transportation market.

Table 1
Growth in Intermodal Traffic: 1961-1999

Year	Total	(A) Trailers	(B) Containers	Difference (A-B)	Percentage Growth Total	Percentage Growth Trailers	Percentage Growth Containers
1961	902,260	na	na	na	na	na	na
1965	1,664,929	na	na	na	21.13	na	na
1970	2,363,200	na	na	na	8.39	na	na
1975	2,238,117	na	na	na	-1.06	na	na
1980	3,059,402	na	na	na	7.34	na	na
1981	3,150,522	na	na	na	2.98	na	na
1982	3,396,973	na	na	na	7.82	na	na
1983	4,090,078	na	na	na	20.40	na	na
1984	4,565,743	na	na	na	11.63	na	na
1985	4,590,952	na	na	na	0.55	na	na
1986	4,997,229	na	na	na	8.85	na	na
1987	5,503,819	na	na	na	10.14	na	na
1988	5,579,547	3,481,020	2,298,527	1,182,493	1.38	na	na
1989	5,987,355	3,496,262	2,491,093	1,005,169	7.31	0.44	8.38
1990	6,206,782	3,451,953	2,754,829	697,124	3.66	-1.27	10.59
1991	6,246,134	3,201,560	3,044,574	156,986	0.63	-7.25	10.52
1992	6,627,841	3,264,597	3,363,244	-98,647	6.11	1.97	10.47
1993	7,150,457	3,458,406	3,692,051	-233,645	7.89	5.94	9.78
1994	8,128,228	3,752,502	4,375,726	-516,790	12.50	8.83	15.94
1995	7,936,172	3,492,463	4,443,709	-951,246	10.89	0.82	20.34
1996	8,143,258	3,302,128	4,841,130	-1,539,002	2.61	-5.45	8.94
1997	8,695,860	3,453,081	5,242,779	-1,789,698	6.79	4.57	8.30
1998	8,772,663	3,353,032	5,419,631	-2,066,599	0.88	-2.90	3.37
1999	9,041,771	3,298,024	5,743,747	-2,445,723	3.07	-1.64	5.98

Source: Association of American Railroads, Railroad Facts: 2000 Edition, (Washington, DC: Policy and Economics Department, October, 2000) p. 26.

Figure 1
Intermodal Traffic Growth: 1961-1999

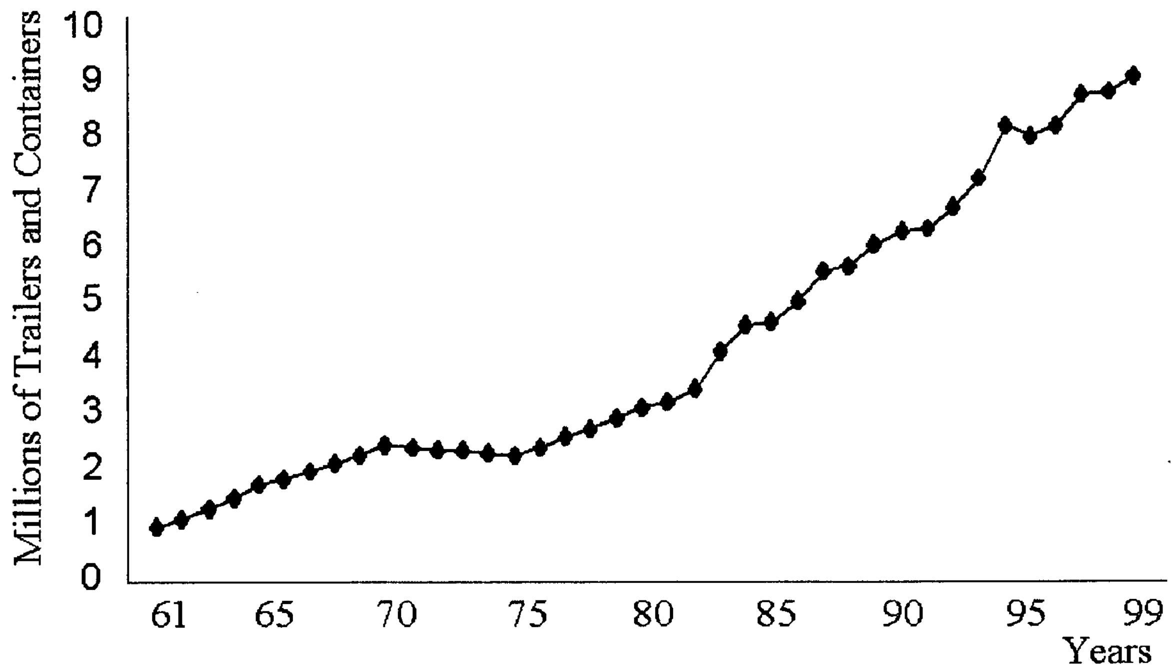


Figure 2
Intermodal Traffic Growth: 1988-1999

Tables 2a and 2b show the market shares nationally and for Arkansas of the various modes by value of product hauled, tons shipped, and total ton-miles for 1993 and 1997 (BTS, 1999a, Table 1c, p. 10). As can be seen in Table 2a, truck-rail intermodal accounted for only 2.1 percent of all freight ton-miles nationally. While this is up from 1.6 percent in 1993, it is still a very small part of the overall freight market. Moreover, the actual tons moved is up only by 1 tenth of one percent, and the percentage of goods shipped by value is actually down. During that same period, individual truck shipments increased from 35.9 percent of the total ton-miles to 38.5 percent. Although the market share based on value declined somewhat, the actual number of tons hauled was up from 65.9 percent to 69.4. Given the potential benefits that truck-rail intermodal transportation offer, the level of usage is no where near where it ought to be, and the growth rates are relatively small given the overall market for transportation services. This implies that there are still restrictive problems associated with its adoption and growth.

Table 2b shows the market shares in Arkansas of the various modes by value of product hauled, tons shipped, and total ton-miles for 1993 and 1997 (BTS, 1999b, Table 1c, p. 10). As can be seen, truck-rail intermodal accounted for less than 1 percent of Arkansas ton-miles. Moreover, this is down considerably from 1993 when the intermodal market share was 2.0 percent. Thus, in Arkansas as with the nation as a whole, there is very limited use of intermodal transportation, suggesting serious problems limiting its adoption and growth.

Table 2a
National Mode Shares by Value, Tons, and Ton-Miles: 1993, 1997

Mode	Percent of Value		Percent of tons		Percent of ton-miles	
	1997	1993	1997	1993	1997	1993
All modes	100.0	100.0	100.0	100.0	100.0	100.0
Single modes	82.4	84.5	94.1	92.1	89.6	88.3
Truck	71.7	75.3	69.4	65.9	38.5	35.9
For ~ hire truck	41.8	44.9	30.7	29.0	27.8	26.0
Private truck	29.3	30.0	37.3	36.6	10.1	9.7
Rail	4.6	4.2	14.0	15.9	38.4	38.9
Water	1.1	1.1	5.1	5.2	9.8	11.2
Shallow draft	0.8	0.7	3.7	3.7	7.1	6.8
Great Lakes	---	---	0.3	0.3	0.5	0.5
Deep draft	0.3	0.3	1.0	1.1	2.2	3.9
Air (includes truck and air)	3.3	2.4	---	---	0.2	0.2
Pipeline	1.6	1.5	5.6	5.0	---	---
Multiple modes	13.6	11.3	2.0	2.3	7.7	7.9
Parcel, USPS or courier	12.3	9.6	0.2	0.2	0.7	0.5
Truck and rail	**1.1**	**1.4**	**0.5**	**0.4**	**2.1**	**1.6**
Truck and water	0.1	0.2	0.3	0.7	1.3	1.7
Rail and water	---	---	0.7	0.8	2.9	2.9
Other multiple modes	---	---	0.2	0.2	0.7	---
Other and unknown modes	**4.0**	**4.1**	**3.9**	**5.6**	**2.8**	**3.8**

Source: Bureau of Transportation Statistics (1999a), 1997 Commodity Flow Survey, (Washington, DC: US Department of Transportation and US Department of Commerce,Table 1c, p. 10.

Table 2b
Arkansas Mode Shares by Value, Tons, and Ton-Miles: 1993, 1997

Mode	Percent of Value		Percent of tons		Percent of ton-miles	
	1997	1993	1997	1993	1997	1993
All modes	100.0	100.0	100.0	100.0	100.0	100.0
Single modes	92.2	93.9	96.6	97.5	95.8	94.0
Truck	82.4	87.6	80.6	85.1	61.2	61.5
For ~ hire truck	45.3	44.8	36.4	33.7	43.1	42.7
Private truck	36.6	42.6	42.0	51.2	17.0	18.7
Rail	7.5	5.2	11.2	11.2	26.1	30.4
Water	1.2	---	---	---	8.5	---
Shallow draft	1.2	---	---	---	8.5	---
Great Lakes	---	---	---	---	---	---
Deep draft	---	---	---	---	---	---
Air (includes truck and air)	1.1	0.6	---	---	0.2	0.2
Pipeline	---	---	---	---	---	---
Multiple modes	4.8	4.2	---	0.7	2.8	3.7
Parcel, USPS or courier	4.1	3.4	---	0.1	0.3	0.3
Truck and rail	**0.6**	**0.8**	**0.1**	**0.3**	**0.9**	**2.0**
Truck and water	---	---	---	---	---	---
Rail and water	---	---	---	---	---	---
Other multiple modes	---	---	---	---	---	---
Other and unknown modes	**3.0**	**1.9**	**2.0**	**1.9**	**1.4**	**2.3**

Source: Bureau of Transportation Statistics (1999b), 1997 Commodity Flow Survey - Arkansas, (Washington, DC: US Department of Transportation and US Department of Commerce,Table 1c, p. 10.

IMPEDIMENTS TO THE GROWTH OF TRUCK-RAIL INTERMODAL

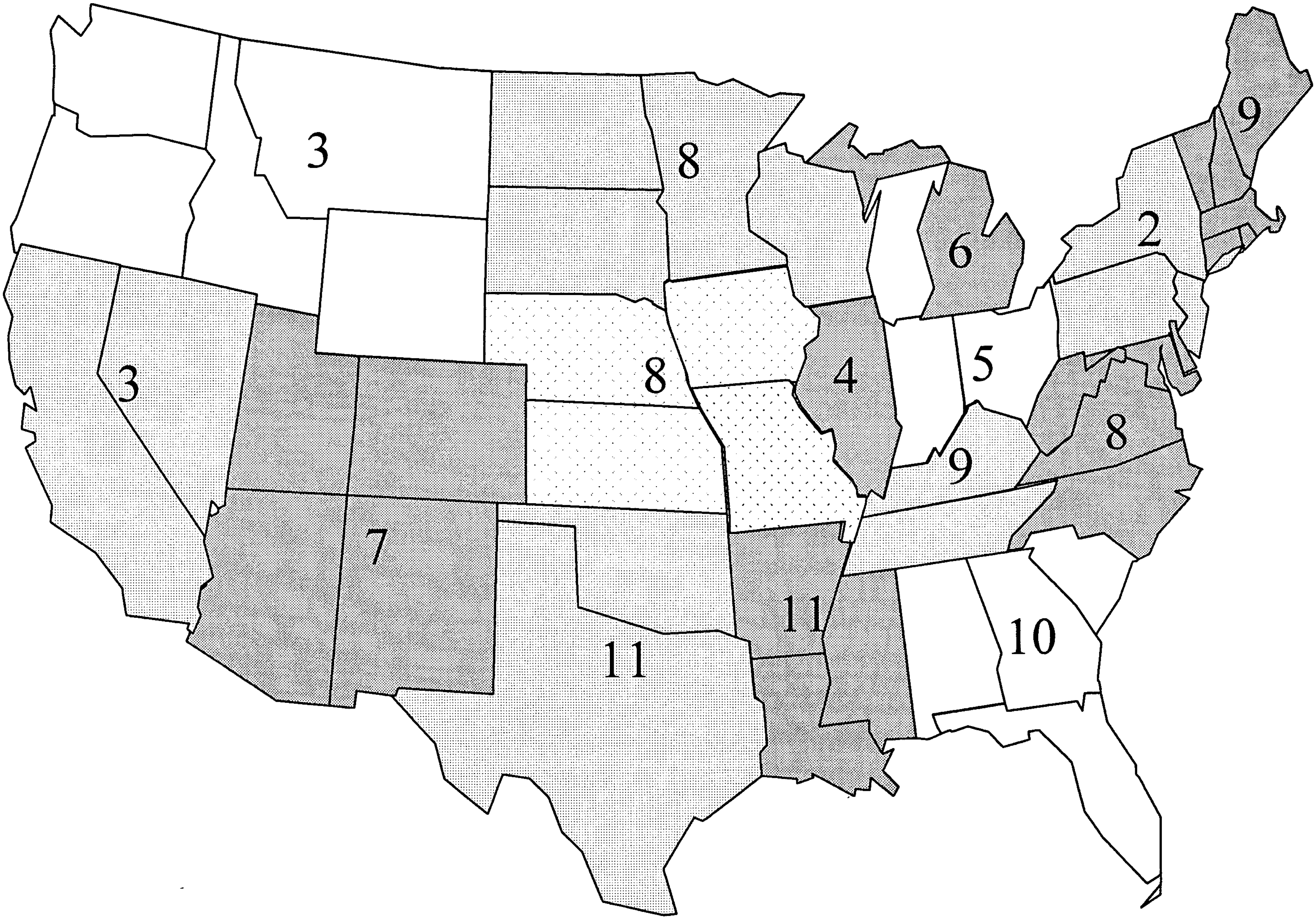
Although truck-rail intermodal shipments are increasing, there is still an enormous untapped potential from which benefits can be realized. In spite of recent growth rates, there are still obstacles restricting its growth. These obstacles fall into at least three categories: railroad policy, government policy, and shipper perceptions. Each of these areas will be discussed briefly.

Railroad Policy

Much of the growth in intermodal traffic can be attributed to railroad innovations such as the introduction of double stacking, dedicated trains, and separation of intermodal from other traffic. In fact, intermodal traffic is extremely important to the railroad industry. Intermodal traffic represents more than 17 percent of all railroad revenue, second only to coal (Association of American Railroads, 2000). However, in recent years railroad operating policies have restricted additional growth to only the largest shippers. This has been done through their consolidation of intermodal terminals and increased use of dedicated trains. These policies reduce the railroad operating costs because of the economies of scale and efficiencies associated with larger intermodal yards and fewer train stops (Evers, 1994). Naturally, this permits competition with long haul trucking, but it has reduced the opportunity for many shippers to utilize intermodal services so that now intermodal use is dominated by the largest shippers (Harper and Evers, 1993).

The number of intermodal terminals was estimated to be 760 in 1981 and 244 in 1990, a decline of almost 68 percent. Despite the passage of ISTEA, the declining trend has accelerated during the 1990s as Class I railroads continue to close many of the smaller satellite intermodal

Figure 3
Intermodal Ramp Closings by Region: 1990-1997



terminals and channel intermodal freight through fewer, larger "hub" terminals. Figure 3 shows the number of intermodal ramp closings from 1990 through 1997. During that time, 104 ramps were closed.

Reducing the number of intermodal terminals increases the lengths of haul for both the dray portion and the total distance of intermodal shipments. Naturally, this increasing length of haul adds to the cost of shipments, adversely impacting shippers of intermodal freight unless extremely large numbers of trailers/containers are shipped. It also adds to the number of highway miles generated by large commercial vehicles that haul containers, and this compounds energy use, pollution, and public safety issues. Additionally, as the cost of using intermodal service increases, the choice of shipping totally by truck becomes favorable to more and more shippers, especially the smaller ones. Thus, the volume of traffic on the nation's highways could potentially increase even more, adding further to congestion and safety issues. Obviously, these consequences are counter to the intent of ISTEA, yet this phenomenon is occurring all over the U.S. as the Class I railroads continue their consolidation of intermodal facilities.

These changes have affected Arkansas too. Ramp closings in Little Rock and Pine Bluff in Arkansas and in Tulsa and Sallisaw in Oklahoma have left Arkansas shippers with longer drays and more expensive intermodal service. Intermodal shipments to and from the west coast are typically drayed to Fort Worth, Kansas City, and in some instances Memphis. Shipments to and from the east coast are typically drayed to St. Louis or Memphis. For shippers in Arkansas, the added cost to dray a container to or from a major hub has been estimated to be approximately $300.

After the Union Pacific Railroad closed the intermodal ramp in Little Rock, the company opened a major intermodal hub in Marion Arkansas (near Memphis) and a “paper ramp” in Fort

Smith, Arkansas. Paper ramps are part of the UP railroad's Intermodal Outreach Program and are a collecting place for local shippers to drop or pickup their trailers and/or containers. In the case of Fort Smith, trailers are then drayed to or from Kansas City by UP railroad contractors for the rail portion of the shipments. Additionally, the Georgia Pacific Corporation opened an intermodal ramp on the Arkansas, Louisiana, and Mississippi Railroad in Crossett, Arkansas to meet its needs and has made it available to the public. However, only about 10 trailers per day are handled at the facility while the capacity is well in excess of that volume.

Government Policy

While government policy is frequently cited as a reason for much of the recent development of intermodal transportation, those policies were in the form of deregulation of railroads and motor carriers, or the removal of restrictions to its growth. Government has done very little to promote intermodal transportation. There would be many who would argue that such a statement is not true given government's attention to intermodal transportation in the two most recent federal highway spending bills: the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act of the 21st Century (TEA-21).

The federal government recognized the importance of intermodal transportation and attempted to promote its development through provisions of ISTEA. The broad objectives of ISTEA were to "develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner." However, implementation of this policy has not been very effective. Within ISTEA, there were 51 pre-approved intermodal projects with more than 400 million dollars in funding authorized. A summary of these projects is shown in Table 3. The purpose of the section was to provide for the construction of innovative intermodal projects, but most of the projects provided access to airports and/or freeways and were intermodal only in the broadest sense of the term. They were designed to give users of one mode access to another, not to permit two or modes to work together to provide customers with complete origin to destination service. Approximately 60 percent of the projects and funding were earmarked for these types of projects. Only 5 of the projects (fewer than 10 percent) were actually related to intermodal freight movement and involved only 39 million dollars, less than ten percent of the pre-approved funding.

Table 3
Priority Intermodal Projects In ISTEA

Type	Number	Percent	Amount	Percent
Airport related	14	27.45	134.0	30.67
Freeway related	18	35.29	124.0	28.38
Highway access to transit	4	7.84	37.9	8.67
Grade separation	8	15.69	86.1	19.71
Intermodal freight related	5	9.80	39.0	8.93
Needs/corridor studies	2	3.92	15.9	3.64
Total	**51**	**100.00**	**436.9**	**100.00**

Source: Intermodal Surface Transportation Efficiency Act of 1991.

ISTEA authorized additional funding for intermodal projects beyond those pre-approved projects; however, according to the General Accounting Office, as of September 30, 1995, ten states had obligated only about 36 million dollars for 23 freight-related intermodal projects (General Accounting Office, 1996). This represents less than one-half of one percent of ISTEA's 155 billion dollar authorization.

The Arkansas Highway and Transportation Department has been active in attempting to provide intermodal opportunities to shippers through out the state by approving intermodal projects and applying for ISTEA funding, as have transportation agencies in other states. Arkansas' Regional Intermodal Facilities Act of 1997 authorized the creation of Regional Authorities, "for the purpose of acquiring, equipping, constructing, maintaining, and operating regional intermodal facilities (Arcode 14-143-103)." Authorities are authorized to issue revenue bonds for use "either alone or together with other available funds and revenues (Arcode 14-143-110)."

The Southeast Arkansas Regional Intermodal Facility Authority in Warren was the first in the state to be established under the provisions of the Act. The Arkansas State Highway and Transportation Department conducted a pilot study and found potential transportation benefits and positive economic impacts of a regional intermodal facility in Southeast Arkansas (AHTD 1998).

In addition to the facility in Warren, the Arkansas Highway and Transportation Department and/or regional organizations have sponsored or conducted studies of other intermodal projects throughout the state, including Little Rock (TAMS, Inc., 1995), Northwest Arkansas (McAllister, et al., 2000), Russellville (Planning and Research Division, 1998), and Van Buren. With the exception of the Northwest Arkansas study, these studies have led to further development of intermodal transportation facilities within the state. The Northwest Arkansas study found that there was not sufficient potential to justify an intermodal, especially given the approval of the facility in Van Buren just 50 miles away (McAllister, et al., 2000).

Unfortunately, it is not clear that the facilities will result in a significant increase in the use of intermodal services. First, the major railroads have made it clear that they do not want a feeder system to provide intermodal traffic. Thus, intermodal shipments that are loaded on to rail cars at places other than major intermodal hubs will not receive premium service. That is, they will not be included in dedicated trains that will improve transit times and service reliability. Secondly, shippers may not use publicly provided intermodal facilities because of their perceptions of intermodal service. This problem is discussed in the next section.

Shipper Perceptions

Perhaps the most serious problem which continues to restrict the adoption and use of intermodal services stems from shippers' perceptions of intermodal service, and the impact that these perceptions have on carrier and mode selection. Harper and Evers (1993) surveyed shippers in Minnesota and found that truck-rail intermodal service was used almost exclusively by large shippers and certainly was not used as extensively as it could be.

Part of the problem has been the lack of availability of intermodal service. This problem has only intensified in recent years as the railroads have closed down many of their smaller satellite intermodal ramps. The main attraction of intermodal service has been its low cost, not the service, and many shippers want improved service. However, Harper and Evers (1993) also found that there is a serious lack of knowledge about intermodal service by potential users, and shippers have poor perceptions of intermodal service levels. Since intermodal service is more complex and requires much more coordination than simpler truckload movements, there is a transit-time and dependability disadvantage associated with intermodal service. However, those disadvantages may not be as serious as some believe, but as long as shippers perceive that there is a service disadvantage, it is not likely that they will adopt the use of intermodal services on a large scale.

Many shippers who use truck transportation assume that service times of intermodal movements would prohibit their use of it, and shippers who use rail service often assume that transportation costs of intermodal would prohibit its use; however, few shippers actually base their mode selection on a total cost basis. In a survey of shippers in Arkansas, Missouri, and Oklahoma, respondents were asked about the importance of transit time reliability and how it was used (Ozment, 2001). On a scale of 1 to 5, with 5 being the most important, respondents were asked how important transit time reliability was to their firm. The mean response was 4.3. When asked if they measured transit time reliability, 57.3 percent indicated that they did. However, only 13.1 percent indicated that they actually used that information in selecting carriers, and none of the respondents indicated that they used it in evaluating inventory decisions.

The time-honored method of dealing with undependable carrier service has been to hold additional inventory as safety stock to protect against stockouts in the event of service failures on the part of the carrier (Coyle, Bardi, and Novack, 1996; Ballou, 1999). While goals of reducing inventory levels are widespread, managers should be concerned with the total logistics costs rather than just minimizing costs associated with inventory. If the savings in transportation from using intermodal service are enough, they may more than offset the additional costs associated with larger inventories. The literature in the area of mode/carrier selection has reported for many years that shippers are very concerned with transit time and, especially, transit time reliability. In most cases, these criteria are considered more important that rates, per se. This was true before deregulation and remains true today (McGinnis, 1990, Murphy, et al., 1995). Clearly, shippers believe these criteria are important, but since few shippers actually measure carrier service levels or use them in a meaningful way in mode/carrier selection decisions, and rely instead on preconceived perceptions, there is enormous potential for misrouted freight.

The next section provides a brief review of the relevant logistics costs which should be considered when selecting the mode of transportation or specific carriers where service times, dependability and costs vary among the alternatives.

METHODOLOGY

Few shippers actually measure carrier service levels or use them in a meaningful way in mode/carrier selection decisions. They rely instead on preconceived perceptions of the impact of those service levels. Shippers who avoid the use of intermodal transportation because of perceived poor service may actually be incurring higher costs than anticipated if the savings in transportation costs are sufficient to off-set the higher costs associated with longer and less dependable transit times.

To assess the potential for truck-rail intermodal transportation, a selection of products of different values were subjected to a total cost analysis under certain assumptions. The results of those cost analyses were then used as a basis for examining data from the 1997 Commodity Flow Survey (BTS, 1999a) to illustrate the potential for increasing intermodal shipments.

This section provides an overview of the total cost concept which should be used when evaluating logistics services that affect the levels of inventory in the system. The description of the method provided is quite limited. Readers who are unfamiliar with the concept should consult a logistics textbook such as Coyle, Bardi, and Novack (1996), Lambert and Stock (1996), or Ballou (1999).

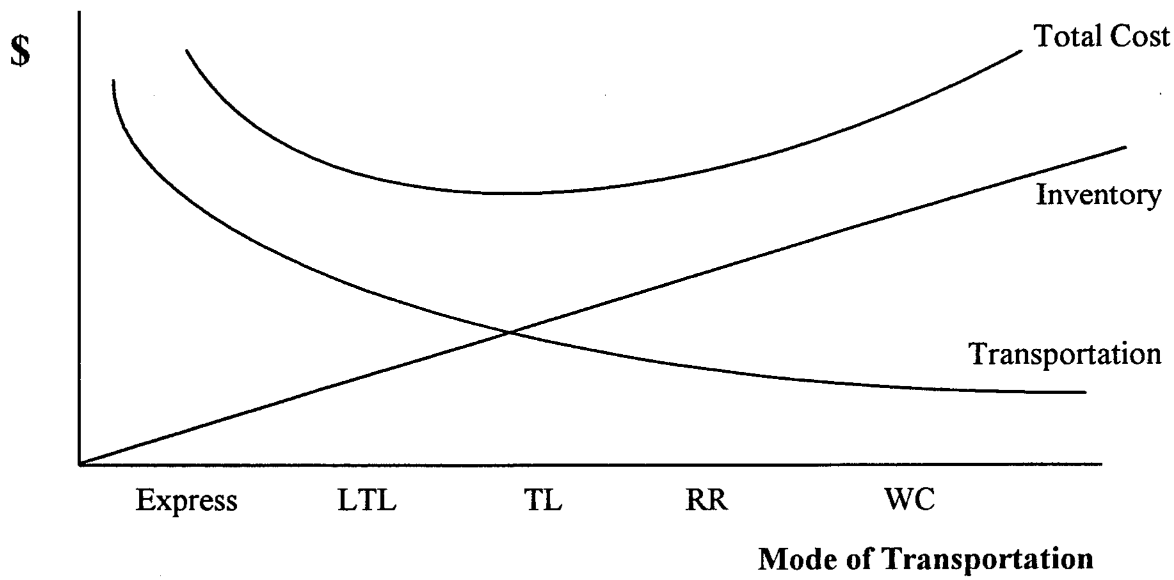
Also discussed in this section are the basic assumptions which serve as input to the total cost analysis. These assumptions include the cost to place orders, an inventory carrying cost factor, the annual volume of use or sales, average distance, service times, and transportation rates. Next, an overview of the products used in the analysis is presented. Finally, a discussion is provided relative to the data taken from the 1997 Commodity Flow Survey to which the sample products are compared to illustrate the potential for increasing intermodal shipments.

Total Cost Analysis

Decisions regarding logistics services should be made on a total relevant cost basis, not based just on the cost of one specific area such as transportation. For example, if a traffic manager is given responsibility for minimizing transportation costs, the effect may be that slower modes of transportation are used which means larger shipment sizes and subsequent increases in inventory levels. Thus, the cost associated with holding inventory in the system increases. This is due to more inventory on hand during the order cycle and more inventory costs while goods are in transit. It may also mean more inventory held as safety stock to prevent stockouts if specific delivery dates are unknown and variable. Thus, minimizing transportation costs may lead to significantly higher inventory carrying costs which may more than offset the savings associated with using a cheaper mode of transportation.

On the other hand, logistics managers who are responsible for inventory carrying costs and/or customer service levels may have policies which force traffic managers to incur higher costs that arise from smaller shipment sizes and/or the use of premium forms of transportation. Figure 4 shows the trade-offs between inventory and transportation in a generic sense. The general relationship is one of increasing inventory costs as volume capabilities increase. Generally, railroads (RR) move smaller shipment sizes that water carriers (WC), truckload (TL) motor carriers move smaller volumes than rail, and less-than-truckload (LTL) motor carriers move smaller volumes than truckload carriers. However, since it is generally true that modes with larger volume capabilities have slower and less dependable delivery times, all three types of inventory (cycle stock, inventory in transit, and safety stock) also tend to increase. Naturally, there are exceptions. Some people may argue that TL shipments are sometimes faster that less-than-truckload (LTL) shipments, but for the purposes here the general relationships can be assumed. This simple points to the need to accurately determine the cost and service levels of carriers before making selection decisions.

Figure 4
Logistical Trade-offs: Transportation vs Inventory



Total cost analysis should begin with a determination of the economic order quantity (EOQ). The EOQ is based on the total annual cost of ordering and carrying inventory. EOQ is based on several assumptions which are often considered unrealistic, but it offers an excellent starting place to test whether lower transportation costs associated with larger shipments are enough to off-set the higher costs of carrying additional inventory in the system (Coyle, Bardi, and Novack, 1996). Once the EOQ is determined, the total relevant costs of each alternative form of transportation can be compared.

Economic Order Quantity

Figure 5 shows the basic components of the EOQ and how they are calculated. The total relevant costs are assumed to be the cost of placing orders and the cost of carrying inventory. The cost of transportation and costs associated with inventory in transit and/or safety stock are not relevant this point. By adding the two costs together, taking the first derivative, and setting it equal to zero, we can derive the formula for the EOQ. This then becomes the default order quantity and, consequently, the default shipment size.

With no other information, this would be the quantity of product that a logistics manager would order, and it would likely be shipped by the mode which most closely conforms to the volume shipped. That is, if the EOQ is small, say less than 100 pounds, it would probably be moved by an express package carrier such as UPS, or one of FedEx's ground services. If the EOQ was slightly larger, say 2 or 3 thousand pounds, it would probably be moved by an LTL carrier such as ABF Freight System, American Freightways, Yellow Freight, etc. If the EOQ were larger still, say 30 or 40 thousand pounds, it would probably be moved via a TL carrier such as JB Hunt, PAM Transport, Schneider National, USA Truck, etc. If the size were larger still, say 100 or 200 thousand pounds, it might be shipped by rail, or larger volumes might go by barge, if the service were available.

Figure 5
Determining the Economic Order Quantity

OC = Order Placement Cost = A(R/Q)
CC = Inventory Carrying Cost = 1/2(QVW)
Where:

- Q = Optimal Order Quantity (EOQ)
- A = Cost of placing an order
- R = Annual Rate of use
- V = Value per unit
- W = Carrying cost as a percentage of average value of inventory

By adding OC + CC, taking the first derivative, and solving for Q, we get:

$$EOQ = \sqrt{2AR / VW}$$

Source: Coyle John J., Edward J. Bardi, and C. John Langley, Jr., The Management of Business Logistics, 6th edition (St. Paul MN: West Publishing 1996).

By simply shipping the EOQ with the mode that the volume best corresponds with can lead to lost opportunities to ship in larger volumes and save transportation costs that could more than off-set increased inventory carrying costs. Thus, logistics managers should look at the total cost associated with all relevant options, not just ship the EOQ.

Total Costs

Figure 6 shows the additional costs associated with logistics when adjusting the EOQ for transportation costs, when volumes vary, and when delivery times and transit times vary by mode. Product cost (PC) is included here to accommodate product discounts from vendors; however, this will not be considered in the analysis presented here. Transportation costs (Tr) is stated here as a rate per 100 pounds (cwt) multiplied times the number of 100 pound units shipped annually (not just for a single shipment).

Figure 6
Adjusting EOQ Based on Total Logistics Costs

Total Cost = OC + CC + Tr + PC + It + SS + Other
Where:

OC = Order Placement Cost
CC = Inventory Carrying Cost
Tr = Transportation Cost
PC = Product Cost
It = Inventory in Transit Cost
SS = Safety Stock Cost

And Where:

OC = A(R/Q)
CC = 1/2(QVW)
Tr = rRwt/100
PC = VR
It = iVRt/365
SS = BVW
Where:

Q R A V W = As previously defined
r = Transportation rate per 100 pounds (CWT)
wt = Weight per unit
i = Interest rate or cost of capital
t = Lead time in days
B = Buffer of inventory to prevent stockouts

TC = A(R/Q) + 1/2(QVW) + rRwt/100 + VR + iVRt/365 + BVW eq. (1)

Source: Coyle John J., Edward J. Bardi, and C. John Langley, Jr., The Management of Business Logistics, 6th edition (St. Paul MN: West Publishing 1996) and Ronald H. Ballou, Business Logistics Management, 4th edition (Upper Sadler River, NJ: Prentice-Hall).

Inventory in transit (It) is simply the daily finance charges on goods purchased annually times the number of days the goods are tied up in transit. At some time during the year, all goods will be in transit and subject to these charges.

The cost of holding safety stock is based on the buffer stock (B) used to protect against stockouts. The dollar value of buffer stock is simply that buffer times value per unit, and the cost of holding safety stock (SS) is the money tied up in buffer stock times the carrying cost rate (W), or SS = BVW. However, determining the buffer stock requires some explanation.

Determining Buffer Stock

Buffer stock is traditionally determined based on the probability of a stockout occurring. To guard against stockout, logistics managers place orders sooner than they would if they knew exactly when the last unit available was to be sold. Since sales during lead time vary, the standard deviation of lead time demand is typically used for this purpose. One standard deviation of demand added to the mean sales during lead time yields an 84 percent fill-rate. Adding two standard deviations yields roughly a 97.5 percent fill-rate (Coyle, Bardi, and Novack, 1996). When transit times vary as well as demand, the probability of a stockout is increased since more problems can occur. To account for both sources of variation, it is recommended that the units of buffer stock be based not on the standard deviation of demand alone, but rather on the standard deviation of demand over time. This is shown in Figure 7.

Figure 7
Determining Buffer Stock

The Buffer Stock used to protect against stockouts when both demand and transit times vary is given by:

$$\sigma_{Dt} = \sqrt{(t)(S_D)^2 + (D)^2\,(S_t)^2} \qquad \text{eq. (2)}$$

Where:

σ_{Dt} = The number of units added to the order point (mean sales)
t = average transit time
S_t = Standard deviation of transit time
D = Average demand during lead time
D_t = Average demand during lead time

Source: Lambert Douglas M. and James R. Stock, Strategic Logistics Management, 3rd ed, Homewood, IL, Irwin, Inc., 1994; and Ballou, 1999.

Basic Assumptions

To compare truckload service with truck-rail intermodal, several products are evaluated; however, for the purposes of this particular analysis, only one basic comparison is provided. Figure 8 shows the basic assumptions used in the analysis. The annual sales are assumed to be 100, 000 units, the cost to place orders is $30.00, the inventory carrying cost as a percentage of the average value of goods on hand is 20%, and the interest rate is 10%. It is further assumed that average sales are based on a 365 day year and that they vary plus or minus 10 percent on a daily basis. This is assumed to be representative of the standard deviation of sales and is used in the calculation of buffer stock. To determine safety stock, it assumed that the fill rate must be 97.5% (holding 2 standard deviations of buffer stock).

Figure 8
Impact of Transit Time and Transit Time Variability on Intermodal Shippers: Basic Assumptions

Basic Assumptions:		
Annual Sales/Use	=	100,000 units
Cost to place orders	=	$30.00
Carrying cost	=	20 %
Interest expense	=	10 %
Average Daily Sales	=	based on 365 days
Variation in Daily Sales	=	+/- 10 %
Service Level (fill-rate)	=	97.5 %

Transportation Assumptions:

	Motor Carrier	**Intermodal**
Distance	1, 000 miles	1000 miles
Volume	40,000 lbs	40,000 lbs
Rates	$1.20/mile	1.00/mile
Transit time	3 days	5 days
Transit time variation	+/- 1 day	+/- 2 days

The average distance per shipment is assumed to be 1,000 miles, and the full truckload or container volume is 40,000 pounds. The truckload rate for the 1,000 mile shipment is $1.20 per mile, and the intermodal rate is 20 percent less than the truckload rate. Since transportation costs is a rate per 100 pounds (cwt) multiplied times the number of 100 pound units shipped annually, an equivalent rate/cwt would be $3.00 (i.e., (1,000 x 1.20) / 400cwt). The equivalent intermodal rate then is $2.50/cwt. Transit time by truck is 3 days, +/- 1 day, and by intermodal it is 5 days, +/- 2 days. These assumptions are based on input from several traffic managers, some of whom use intermodal and some who use TL.

Sample Products

Table 4 provides an overview of the product characteristics used in the analysis. Computers were selected to represent extremely high value products, and televisions were selected to represent high value products. Medium value products were represented by mattresses and box springs, lamps, kitchen appliances, and insect spray. Xerox paper and glass containers were representative of low value products. Product values ranged from $1,500 to $5.00 per unit, and weights per unit ranged from 250 lbs to 10 lbs. The values per pound ranged from $30.00 to $0.50. Also shown are the SCTG codes (Standard Classification of Transported Goods) which can be used to show the extent to which these sample products move intermodally.

Table 4
Characteristics of Sample Products

Value	Description	SCTG	Weight/unit	Value/unit	Value/lb
Extreme Value	Computers	35	50 lbs	$1,500.00	$30.00
High Value	Televisions	35	50 lbs	$350.00	$7.00
Medium Value	Mattress/Box Springs	39	100 lbs	$250.00	$2.50
Medium Value	Lamps	39	10 lbs	$20.00	$2.00
Medium Value	Kitchen Appliances	35	250 lbs	$500.00	$2.00
Medium Value	Insect Spray	23	25 lbs	$40.00	$1.60
Low Value	Xerox Paper	28	50 lbs	$25.00	$0.50
Low Value	Glass Containers	31	10 lbs	$5.00	$0.50

Commodity Flow Survey Data

To assess the potential for shipping various products intermodally, data from the DOT's 1997 Commodity Flow Survey were examined with respect to the results of the total cost analysis of the sample products. The Commodity Flow Survey was undertaken jointly between the Bureau of the Census, U.S. Department of Commerce, and the Bureau of Transportation Statistics, U.S. Department of Transportation. The study produced data on the movement of goods in the United States and provided information on commodities shipped, including value, weight, and mode of transportation. It also provided information as to the origin and destination of shipments of manufacturing, mining, wholesale, and selected retail establishments (BTS, 1999a, p. 3).

RESULTS

Equations (1) and (2) were entered into an Excel@ spreadsheet together with data from the assumptions shown in Figure 8 and the characteristics of the specific products shown in Table 4. The results of the analysis is shown in Table 5. The lowest total cost alternative (truck vs intermodal) is noted in bold face type. As can be seen, as the value per pound drops, intermodal transportation becomes more and more favorable. For higher value goods, the savings in transportation costs provided by the intermodal service is eroded away by the added cost of inventory in transit and the higher costs associated with safety stock. However, as the value per unit drops, the savings from intermodal compensates for the increases in these other costs. At some value between $5.00 and $7.00 per pound, intermodal be comes more economical in spite of its service disadvantages. The slower transit time is not a problem as long as shippers plan for it in advance. The added cost of holding inventory in transit is covered by the lower cost of transportation. The fact that shippers are concerned with undependable delivery times is also not a problem if they are willing to hold the additional safety stock to prevent stockouts. Again, with the lower value products, the cost of the extra safety stock is more than compensated for by the lower transportation costs.

Since the order quantities (shipments sizes) are the same for truck vs intermodal, the basic inventory carrying cost (or cost of holding cycle stock) is the same for each alterative. In some instances, the order quantity is quite small (a single trailer/container load). For example, for heavy items like appliances, a single trailer load is a very small quantity and would require the shipper to place over or 600 orders per year. Naturally, that is unrealistic. Similarly, shippers of mattresses and box springs would need to place almost an order per day. To bring the analysis more into line with realistic ordering policies and inventory turnover rates, order quantities were increased to as much as 20 trailers per order. The increased order size has no meaningful effect on the mode selection. This is because the inventory in transit and safety stock

Table 5
Total Logistics Costs of Sample Product Movements: Truck vs Intermodal

Product	Value per Pound	Mode	Order Quantity	Ordering Cost	Carrying Cost	Transport Cost	Inventory in Transit	Safety Stock	Total Cost
Computers	$30.00	Truck	800	3750	120000	150000	123288	166848	**560135**
		Intermodal	800	3750	120000	125000	205479	330849	781328
Televisions	7.00	Truck	800	3750	28000	150000	28767	38931	**245698**
		Intermodal	800	3750	28000	125000	47945	77198	278143
Mattress/Box Springs	2.50	Truck	400	7500	10000	300000	20548	27808	358356
		Intermodal	400	7500	10000	250000	34247	55141	**349388**
Lamps	2.00	Truck	4000	750	8000	30000	1644	2225	41868
		Intermodal	4000	750	8000	25000	2740	4411	**40151**
Kitchen Appliances	2.00	Truck	160	18750	8000	750000	41096	55616	854712
		Intermodal	160	18750	8000	625000	68493	110283	**811776**
Insect Spray	1.60	Truck	1600	1875	6400	75000	3288	4449	89137
		Intermodal	1600	1875	6400	62500	5479	8823	**83202**
Xerox paper	.50	Truck	800	3750	2000	150000	2055	2781	156836
		Intermodal	800	3750	2000	125000	3425	5514	**135939**
Glass Containers	.50	Truck	4000	750	2000	30000	411	556	32967
		Intermodal	4000	750	2000	25000	685	1103	**28788**

levels are independent of the order quantity. The main effect of increasing the order quantity is to increase cycle stock, and since this remains the same for each alternative, the proportional change between transportation costs and the other elements of inventory remains the same. If we were to compute safety stock as dependent upon the order quantity (which can be done), the effect would favor the intermodal option since it is treated as the less dependable mode. If we tie safety stock to the order quantity, it means that as the order quantity increases, there are fewer opportunities to stock out, and, therefore, less need for safety stock, and this would mean that the cost of safety stock would be less and it would take less savings in transportation to cover that portion of the total logistics costs.

POTENTIAL FOR INTERMODAL GROWTH

While there are many assumptions included in this analysis, it seems clear that lower value products (those whose value is around or below $5.00 per pound) can be shipped economically by truck-rail intermodal alternatives. To assess the potential for such movements, data from the 1997 Commodity Flow Survey was used. Table 6 shows the ton-mile market shares of each mode for two-digit SCTGs (Standard Classification of Transported Goods). The categories are sorted by value per pound which was determined by dividing the total value of goods in each SCTG category by the total tons shipped (BTS, 1999a, Table 5a, p. 170; mode shares are from Table 7 of the Commodity Flow Survey, pp. 23-37).

An examination of the intermodal market shares from Table 6 suggests that shippers have significant opportunities to reduce their total logistics costs by considering intermodal service.

Table 6
Ton-Mile Market Shares by SCTG and Value

SCTG	Description	Value *	% RR	% MC	% IM	% Other
0	**All commodities**	**0.31**	**38.4**	**38.5**	**2.1**	**21.0**
38	Precision instruments	26.87	0.0	60.2	0.0	39.8
37	Transportation equipment	11.79	31.1	52.5	2.0	14.4
21	Pharmaceutical products	11.34	0.0	76.7	0.4	22.9
35	Electronic and electrical equip	10.98	2.2	80.2	2.7	14.9
9	Tobacco products	6.83	0.0	92.1	0.0	7.9
34	Machinery	4.18	3.9	80.5	5.9	9.7
30	Textiles, leather, and articles	4.13	2.2	83.1	0.0	14.7
36	Motorized vehicles (incl. parts)	2.91	25.3	55.5	10.0	9.2
39	Furniture, mattresses, lighting	2.44	1.8	88.4	2.7	7.1
40	Misc. manufactured products	1.87	4.4	75.3	1.4	18.9
29	Printed products	1.67	0.7	76.3	1.6	21.4
5	Meat, fish, seafood, preparations	1.16	2.8	92.3	0.3	4.6
23	Chemical products etc.	1.14	15.3	72.4	7.6	4.7
24	Plastics and rubber	1.07	32.0	59.6	4.2	4.2
33	Articles of base metal	1.07	11.6	72.7	0.9	14.8
43	Mixed freight	1.04	0.0	92.6	1.5	5.9
28	Paper or paperboard articles	0.67	5.8	84.3	2.8	7.1
8	Alcoholic beverages	0.54	39.6	49.6	8.2	2.6
6	Milled grain and bakery products	0.53	33.5	59.6	3.0	3.9
1	Live animals and live fish	0.52	0.0	94.6	0.0	5.4
7	Prepared foodstuffs, fats and oils	0.44	27.0	63.5	3.9	5.6
32	Base metal, primary/semi-finished	0.43	30.9	57.5	1.2	10.4
27	Pulp, newsprint, paper, etc.	0.35	42.3	52.3	3.0	2.4
20	Basic chemicals	0.27	50.8	24.7	1.3	23.2
3	Other agricultural products	0.25	18.7	41.0	1.8	38.5
26	Wood products	0.19	36.7	53.9	3.3	6.1
4	Animal feed and animal products	0.15	28.9	57.1	4.2	9.8
18	Fuel oils	0.10	9.1	25.8	0.0	65.1
41	Waste and scrap	0.09	32.5	49.1	2.1	16.3
10	Monumental or building stone	0.09	4.4	87.1	0.0	8.5
19	Coal and petroleum products	0.08	35.6	28.5	0.0	35.9
22	Fertilizers	0.08	55.4	23.4	0.0	21.2
14	Metallic ores and concentrates	0.07	33.6	4.6	0.4	61.4
2	Cereal grains	0.06	58.0	9.1	0.4	32.5
31	Nonmetallic mineral products	0.06	15.4	69.7	1.8	13.1
13	Nonmetallic minerals	0.02	39.3	31.2	0.0	29.5
25	Logs and other wood in the rough	0.02	0.0	75.3	1.9	22.8
15	Coal	0.01	81.0	1.7	0.0	17.3
17	Gasoline and aviation turbine fuel	0.01	2.1	21.5	0.0	76.4
11	Natural sands	0.00	18.9	67.2	0.0	13.9
12	Gravel and crushed stone	0.00	11.8	62.8	0.8	24.6

* Value show is value per pound. This was computed from information in Table 5a of the 1997 Commodity Flow Survey.

As can be seen, the vast majority of SCTG categories have products with an average value below $5.00 per pound. These represent opportunities for cost reductions and increased competitive advantage.

Clearly, there are many different values of products within each STCG category, and some may not be economically moved by intermodal options. Furthermore, the length of haul is obviously not the same for all products, and those with a shorter average length of haul may not be good candidates for intermodal services. On the other hand, however, there are undoubtedly many products for which intermodal transportation could reduce total logistics costs.

Unfortunately, these products are probably not moving intermodally due to traffic managers selecting carriers and modes of transportation on the basis of transportation costs and their perceptions of how service levels will affect other areas such as inventory rather than to considering the actual total costs of logistics.

CONCLUSIONS

Truck-rail intermodal service has been growing at a relatively fast rate, but it still represents barely 2 percent of the total freight ton-mile market, even less in Arkansas. Moreover, the intermodal share of the total freight market in Arkansas declined from 2.0 percent in 1993 to 0.9 percent in 1997. Intermodal services offer many benefits to shippers and society in general, but these benefits are not being realized. In spite of its consistent growth, there are still many impediments to truck-rail intermodal service. These can be attributed to rail policy, government policy, and shipper practices with respect to selecting modes and carriers.

Rail policy is biased toward only the largest shippers, and government policy at the federal level has not been fully committed to promoting intermodal transportation. However, the most serious problem would appear to be the failure of shippers to base the selection of modes and carriers on a solid economic basis involving a total logistics cost approach. Shippers depend on perceptions of carrier services and their impact to guide their decisions rather than basing them on a total cost analysis. The fact that few shippers actually measure carrier service levels is serious in itself, but when virtually none of them use the data to assess the impact of carrier services on their firm's inventory levels and cost suggest that freight is being routed in inefficient ways. Most shippers recognize that there are trade-offs between transportation costs and inventory costs, but few actually quantify those trade-offs to see if transportation costs savings can off-set higher costs of inventory. By basing their decisions on preconceived perceptions of service, many are overlooking significant opportunities for cost reduction and increased competitive advantage.

In Arkansas, the state's attempt to provide intermodal facilities may be of little use if shippers do not perceive advantages to the use of intermodal services. Attempts to take advantage of federal funding together with other sources to develop intermodal facilities have not been part of a coordinated approach. Funding and development of intermodal facilities seems to be driven more by the efforts of local governments and special interest groups to create growth and employment opportunities than from demand for new facilities by shippers who actually perceive opportunities to develop a competitive advantage by reducing their overall operating expenses.

At this point, state transportation planners must evaluate proposals individually, based on potential volumes which could move intermodally, and the potential savings associated with those movements make it easy to conclude that an intermodal facility is justified. However, it will be a serious waste of scarce resources if facilities are developed and not used, and this could very likely be what happens if shippers do not perceive the services to be adequate to meet their needs.

Major railroads are reluctant to accept intermodal shipments other than those delivered to their major hubs. Thus, intermodal shipments originating from other sources will continue to be handled as general freight that moves through the regular system of freight classification yards, and service levels are not likely to be perceived as adequate for shippers using this type of service. However, the premium intermodal service levels created by dedicated intermodal trains and major intermodal hubs are not necessary to create total cost savings for all shippers. There are many shippers of many products that can take advantage of slower less dependable service levels if rates are sufficient to offset that added costs of inventory. Until shippers realize this and begin to make their mode/carrier choices on the basis of total costs, the development of intermodal facilities may be a waste of scarce resources.

At this point, it seems that demand for intermodal services is not sufficient to justify the addition of capacity in the form of intermodal terminals. If it were, it is most likely that the profit-oriented railroads would not have closed down their satellite terminals. If shippers are able to understand the value provided by intermodal transportation, the demand will follow. At that point, investment in intermodal facilities will probably be met by the railroad industry. Naturally, there may be opportunities for state governments such as that of Arkansas to assist in the development of those facilities, but at this point, focusing on generating demand seems more appropriate than creating supply.

In order to promote the development of intermodal transportation, government sponsored programs to provide education to shippers may be of more value than the creation of facilities that shippers are not likely to use. Once shippers understand the real value of intermodal transportation and are able to determine the best way to route their freight based on a total logistics cost approach, our economy will begin to realize many benefits associated with more efficient acquisition of raw materials and distribution of finished goods, not just those benefits associated with the use of intermodal transportation.

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