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EVALUATION OF POTENTIAL TRANSLOAD FACILITY LOCATIONS IN THE UPPER PENINSULA (UP) OF MICHIGAN

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EVALUATION OF POTENTIAL TRANSLOAD FACILITY LOCATIONS IN THE UPPER PENINSULA (UP) OF MICHIGAN

By

Irfan Rasul

A REPORT

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Abstract

Shippers want to improve their transportation efficiency and rail transportation has the potential to provide an economical alternative to trucking, but it also has potential drawbacks. The pressure to optimize transportation supply chain logistics has resulted in growing interest in multimodal alternatives, such as a combination of truck and rail transportation, but the comparison of multimodal and modal alternatives can be complicated. .

Shippers in Michigan’s Upper Peninsula (UP) face similar challenges. Adding to the challenge is the distance from major markets and the absence of available facilities for transloading activities. This study reviewed three potential locations for a transload facility (Nestoria, Ishpeming, and Amasa) where truck shipments could be transferred to rail and vice versa. These locations were evaluated on the basis of transportation costs for shippers when compared to the use of single mode transportation by truck to Wisconsin, Chicago, Minneapolis, and Sault Ste. Marie. In addition to shipping costs, the study also evaluated the potential impact of future carbon emission penalties on the shipping cost and the effects of changing fuel prices on shipping cost.

The study used data obtained from TRANSEARCH database (2009) and found that although there were slight differences between percent savings for the three locations, any of the them could provide potential benefits for movements to Chicago and Minneapolis, as long as final destination could be accessed by rail for delivery. Short haul movements of less than 200 miles (Wisconsin and Sault Ste. Marie) were not cost effective for multimodal transport. The study also found that for every dollar increase in fuel price, cost savings from multimodal option increased by three to five percent, but the inclusion of emission costs would only add one to two percent additional savings.

Under a specific case study that addressed shipments by Northern Hardwoods, the most distant locations in Wisconsin would also provide cost savings, partially due to the possibility of using Michigan trucks with higher carrying capacity for the initial movement from the facility to transload location. In addition, Minneapolis movements were found to provide savings for Northern Hardwoods, even without final rail access.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Research

Transportation has been identified as the “critical link” in successful supply chains of the 21st century [1] and as part of the effort to reduce the cost of individual supply chain components, increasing transportation costs have become a growing concern for both shippers and transport service providers. There are various reasons for the increase, but one of the leading causes has been the cost of crude oil which has increased from $26 per barrel in 2002 to $104 (approx.) in 2014 (Energy Information Administration [2].

Today, trucks move around 60 percent of intercity freight tonnage and even higher percentage of the freight value, but trucks are also facing growing challenges [3]. While road/highway networks provide unparalleled access to shippers, movements by motor carriers tend to be more expensive per unit and are believed to cause higher carbon emissions and safety risks. In addition, congestion, stricter engine requirements, and high driver turnover are causing significant concerns for trucking, especially for long interstate movements.

These increasing costs have forced logistics managers and transportation planners to look into more affordable, but still reliable modes of transportation. Especially rural area businesses are in challenging environment, as they are often far from key markets and their modal options and related infrastructure access are even more limited. While rail transportation offers an alternative for these regions, it has its own challenges. Rail cannot reach all parts of a country due to rail network limitations and railroad companies are reluctant to invest in rural areas, unless there are major shippers with significant volumes. In addition, many of the rural light-density lines have been abandoned as non-profitable, further eroding the opportunities.

One of the potential solutions is using a combination of two or more modes of transportation, also known as intermodal or multimodal transport. Intermodal and multimodal transport have increased over the past several decades mainly due to growth of global trade and need for more robust transportation alternatives that combine efficiency with speed. More recently, the attention has shifted toward improvements for domestic transportation. This report discusses investigates whether multimodal transportation can provide benefits to the shippers in the Upper Peninsula of Michigan.

1.2. Statement of the Problem

The Upper Peninsula (UP) of Michigan is located in the northern part of Michigan and can be considered a rural region. The only land border with the 48 states is with Wisconsin in the southwestern portion of the Western Upper Peninsula. Additional land connections to the peninsula are to Ontario, Canada through Sault Ste. Marie and to Lower Peninsula of Michigan through Mackinac Bridge. The remainder of the region is surrounded by the Great Lakes, Lake Superior in the north, Lake Michigan in the southeast and Lake Huron in the East. The location of the UP is shown in Figure 1.

Figure 1: Location of the Upper Peninsula (UP) of Michigan

There are 15 counties in the UP. The peninsula covers 16,452 square miles (17 percent of Michigan total), but only three percent of its population (approximately 308,000). Some of the larger cities include Marquette and Escanaba. Main commodities include minerals (copper and iron), lumber and pulp products, clay, cement and stone products. These commodities account for a great majority of the total interstate movements.

Despite its remote location and high proportion of low value and long distance shipments, the majority of the UP freight tonnage moves by trucks. While rail alternatives exist, their use is limited mainly by the service levels and accessibility. There are no current alternatives for intermodal transfers and even transload options are limited. There is a growing interest to such alternatives, but it hasn’t been evaluated whether sufficient volumes exist to make them sustainable. This study, together with the Michigan Department of Transportation (MDOT) and National University Rail Center (NURail) funded project “Rural Freight Rail and Multimodal Transportation Improvements” are first steps toward such evaluations.

1.3. Objectives of the Study

This objective of the study was to investigate the potential to establish a transload facility in the UP. More specifically, the study

- Compared three locations in the UP for a potential facility: Nestoria, Ishpeming and Amasa.
- Used freight movement data and case studies to quantify potential cost savings from multimodal transportation options.
- Investigated the effect of fuel prices on percent cost savings.
- Calculated the effect of emission costs to savings.

CHAPTER TWO: LITERATURE REVIEW

2.1 Transportation Logistics in the Supply Chain

Transportation is one of the key components of efficient supply chains and efficiency must be achieved through proper management of the supply chain. Mentzer et al. (2001) defined supply chain as “a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer”. [4] Supply chain management, on the other hand, is defined by Christopher (2012) as “the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole”. [5]

Logistics is defined by Council of Logistics Management as “a part of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers’ requirements”. [6] Tilanus defined Logistics as “the process of anticipating customer needs and wants; acquiring the capital, materials, people, technologies, and information necessary to meet those needs and wants; optimizing the goods- or service-producing network to fulfill customer requests; and utilizing the network to fulfill customer requests in a timely way”. [7] The main components of logistics are “logistics services, information systems and infrastructure / resources” [8] According to Tseng et al., the importance of logistics is increasing due to the interplay of transportation systems and logistics management. Since transportation costs account for a significant portion of the overall logistics cost, it is essential to improve transportation efficiency.

Transportation can be conducted by a single mode or by a combination of multiple modal alternatives. The five main types of freight transportation modes include truck, rail, marine, air, and pipeline. Although the decision between the most suitable modes are highly dependent of the environment, each mode tends to serve a certain spectrum of the freight transportation needs, as described in the Figure 2, developed by Cambridge Systematics. [9]

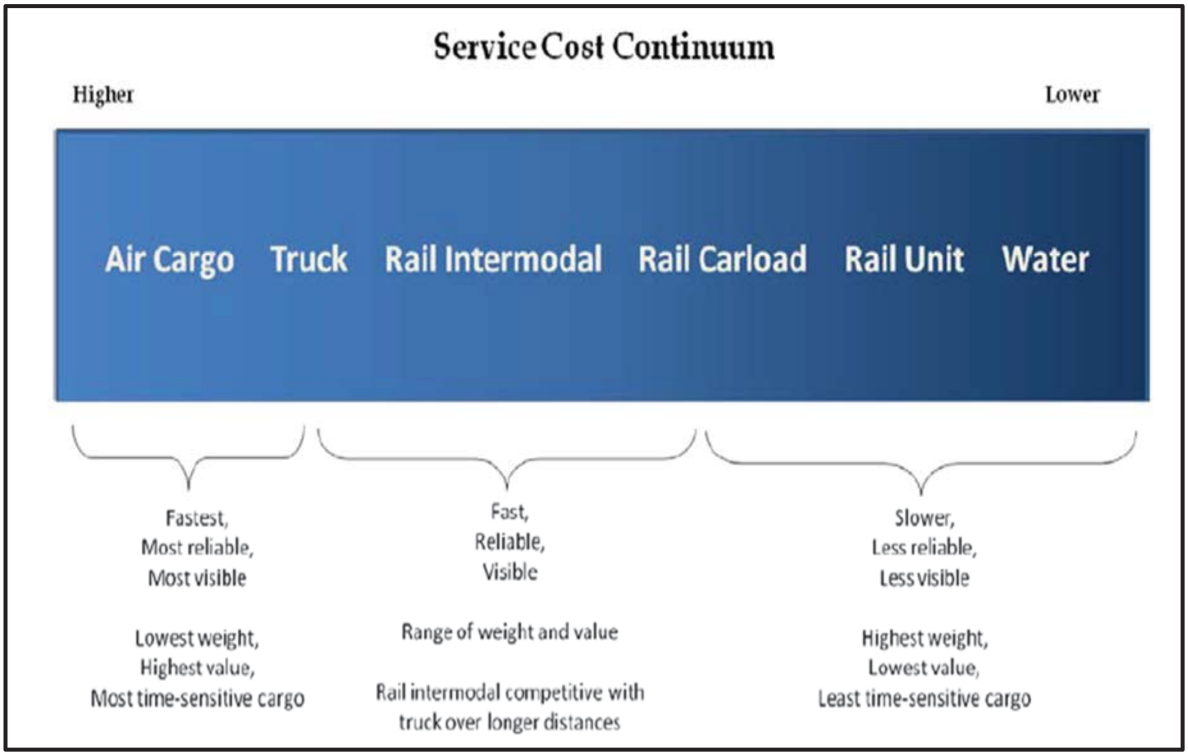

Figure 2: Freight transportation service spectrum

For surface transportation, the main modal alternatives are truck and rail, and potential combination of the two. For the past several decades, trucks have greatly dominated the overall freight transportation market in the U.S. According to the Federal Highway Administration (FHWA) Freight Analysis Framework, trucks transported approximately 72% of all freight tonnage and over 70% of freight commodity value. While trucks are dominant, they are also facing challenges. One of the greatest challenges for trucks is their limited capacity to carry weight. Most interstate highways currently allow 80,000 pounds total truck weight. [10] To accommodate more freight on the road, policy makers are considering increase in the truck weight limits to 90,000 to 97,000 pounds, [11, 12] Another challenge is hours of service. According to Federal Motor Carrier Safety

Administration’s (FMCSA) rule of “hours of driving”, truck drivers cannot drive for more than 11 hours at a time. [13] Rail transportation can provide a cost-efficient alternative to trucking, but accessibility, shipment time, and service quality all limit its use for a great portion of surface freight.

2.2 Principles of Intermodal / Multimodal Transportation

In the early 1950s, most of the commodities were being transported in ships as “break-bulk” either with or without being packaged in small boxes that are smaller than today’s containers. The term “break-bulk” means that the commodities might be in bulk (mainly dry ones) or packaged in a box. [14] A large space in the ship was required to accommodate both bulk and packaged commodities. Moreover, this increased the time and port handling cost for large volumes of bulk commodities. As described by Levinson, the port side handling could reach 60 to 75 percent of the total transportation cost. [15] Malcom McLean, of the commercial truck industry, introduced the concept of containerization in 1960s. The method was similar to the box concept used by the military, but in larger sizes, which could be transported by all of the three modes: truck, rail, and marine. [16]

The impact of containerization was seen in the drastic reduction of port side cost and since then intermodal transport has become popular. The main difference between intermodal and traditional multimodal shipments is that in intermodal transportation the commodities are not taken out or handled while transferring the container from one mode to another. [17] One common definition of intermodal is “… the movement of goods in one and the same loading unit or vehicle that successively uses two or more modes of transport without handling the goods themselves in changing modes”. [18]

Over the past two decades there has been a significant increase in intermodal shipments and at the end of the 20th century, more than 90 percent of intermodal transport was containerized international movements. [15]. Figure 3 presents the growth of intermodal transport in the U.S. from 1990 to 2012. [19]

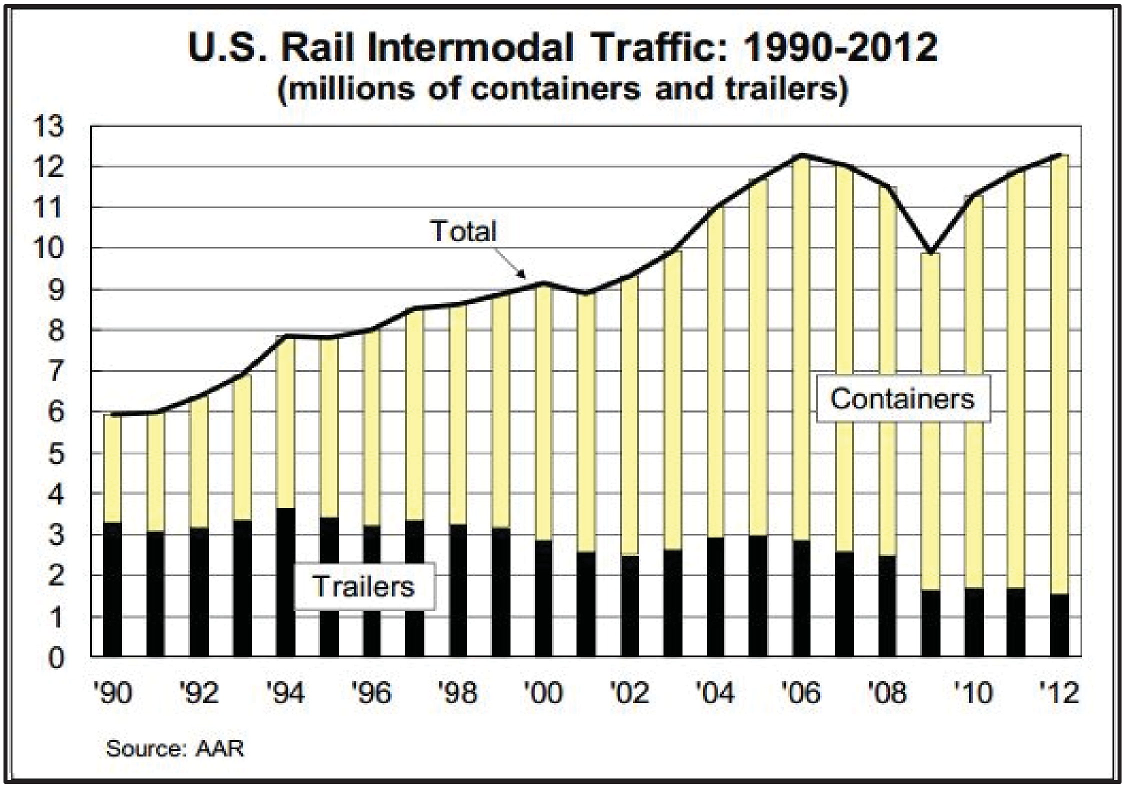

Figure 3: Growth of intermodal transport in the U.S. from 1990 to 2012 (American Association of Railroads)

Truck or rail is commonly used to transport commodities from shippers to the intermodal port terminals where the commodities are loaded on ship (usually by gantry cranes). The ship carries the long haul movement to another port where containers are unloaded and moved by rail to intermodal terminal for final delivery by trucks (called drayage). Alternatively, trucks may deliver the goods directly from the ports. A diagram showing a typical international intermodal transportation chain is illustrated in Figure 4. [20]

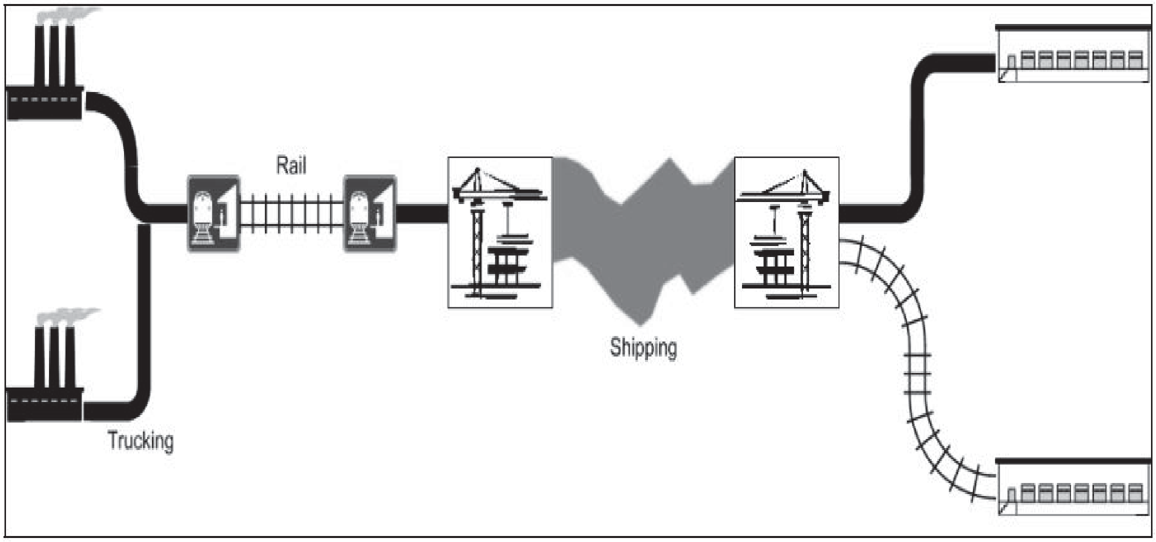

Figure 4: Intermodal transport chain

Intermodal transportation can use both containers and trailers, but only containers can be used for maritime movements and for double stack railcars which efficiently handle two containers resulting in doubled capacity of freight on a single railcar with a minimal increase in shipping cost. [1, 21] As shown in Figure 4, this had led to the increase in the use of containers, while the use of trailers has decreased. Today, trailers are mainly used for domestic freight.

While the intermodal transportation has found greatest success in international supply chains, domestic intermodal transport is also playing an important role and the number of shipments has doubled from 2004 to 2013. [22] It is also forecasted that the future growth in intermodal transportation will concentrate heavily on domestic movements.

Multimodal transportation shares many of the principles with intermodal transportation, but instead of keeping goods in a single unit (container or trailer), they move from one vessel to another at transload locations. Figure 5 presents one example of the components of the transportation chain involving a transload facility for multimodal transport. [23-25] Shippers transport their commodities as bulk or break-bulk to the transload facility where it is moved to another bulk transportation unit (such as hopper or box car). In some cases, it can be also consolidated into a container for intermodal movement. The final delivery may take place by rail, if the final destination has rail access, or the unit is taken to an intermediate transloading location where it is unloaded to a truck and transported to the final destination.

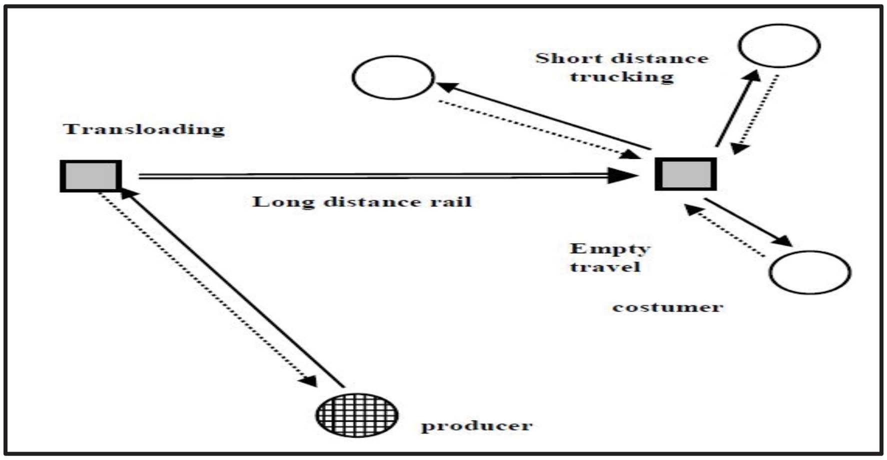

Figure 5: Rail-Truck multimodal transport using transload facility

2.3 Facilities and Equipment for Intermodal/ Multimodal Transport

If truck is used in conjunction with rail, a location known as an intermodal (container) or transload (container/ bulk) terminal is required to provide the transfer between truck and rail. Intermodal terminals are typically large facilities to accommodate full trains, repair facilities and conainer/trailer storage. A study by Steele (2010) mentioned that a feasible intermodal facility can require 100,000 carloads annually which should be travelling for 2,000 miles. [26] Another study by Middendorf (1998) investigated intermodal facilities operated by BNSF, Norfolk Southern, CSX and Union Pacific concluded that intermodal facilities should be able to handle at least 100,000 carloads annually and should have a minimum of 25 car spots.[27] Middendorf’s findings were for big metropolitan areas; Chicago; Long Beach; and Los Angeles, which handle more shippers than the rural areas.

According to Steele et al. a transload terminal can be defined as “a receiving and distributing facility for lumber, grain, concrete, petroleum, aggregates, and other such bulk products”. [26] Transload facilities usually serve bulk and break-bulk commodities and they can be of varying size, ranging from as simple as a siding track with truck access road to large facilities with warehouses and multiple tracks for different commodities. Typically, transload facilities which are able to handle both containers and bulk commodities have some common features for accommodating both truck and rail. For truck, they have amenities such as a certified weighing scale for trucks; a small office; parking lot; truck cleaning facility; driver rest area, and storage space. For rail, they have connection to the main line, storage/loading/unloading tracks, transloading equipment and so on. An example layout of a transloading facility is presented in Figure 6. [28]

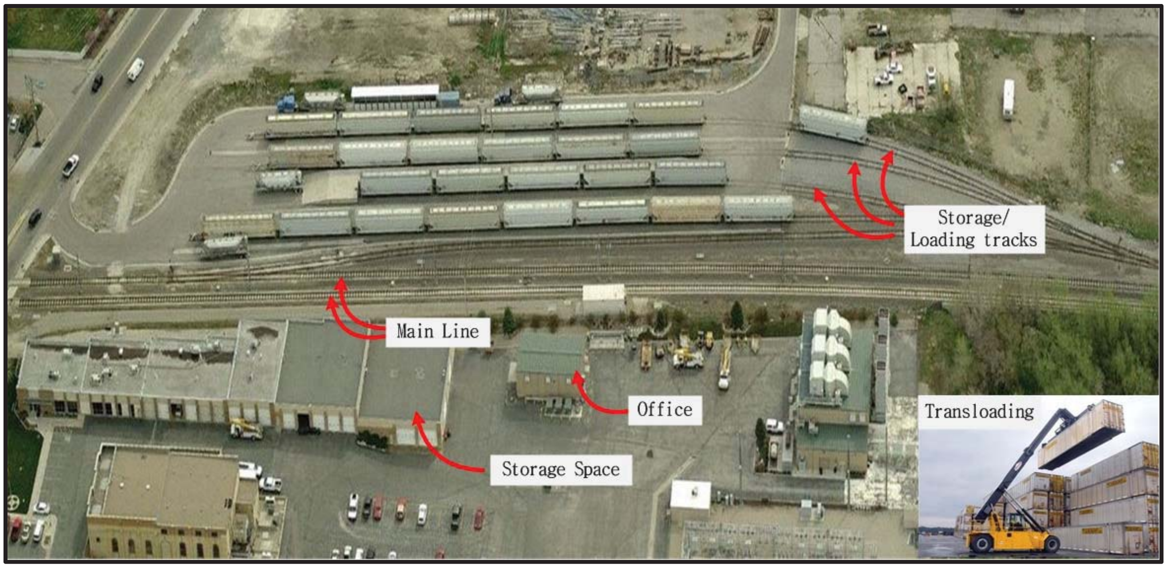

Figure 6: Typical diagram of transload facility

Thomson (2012) concluded that for bulk transload facilities, 5 to 10 acres of storage space is required and at least 1,500 carloads annually should be generated from the facility to make it feasible. [29] HDR Engineering (2007) found that a transload facility could be established for as few as 250 to 300 rail cars per year. [30]

Today, the nearest terminal for UP shippers is located 200-450 miles away (depending on origin within UP) in Chippewa Falls, serviced by CN and operated by a private contractor (Figure 44). This facility in Chippewa Falls had a projected volume of 5,000 containers per year [31] Since Chippewa Falls handles only outbound traffic for international markets, most intermodal freight to/from the UP travels first either to terminals in Chicago, or Minneapolis. The long initial/final drayage is considered a major competitive hindrance by the UP companies.

2.4 Transport Model

As the objective of the investigation was to perform comparative cost analysis, transportation modelling methods were reviewed to identify techniques and applications for the analysis. There are several alternatives for transport modelling, such as Classical Economical model; Inventory-Theoretic model; Trade-Off model; and Constrained Optimization model. [32] Of these four models, Trade-off and Constrained Optimization models have been most commonly used by the past studies related to optimizing transport mode choices and reducing transport costs.[33-38] Beside these, center of gravity; minimizing load-distance method; multi-objective optimization by linear and integer programming; and decision tree model have been used to locate optimal location of transload or intermodal facility. [39-42]

Literature review revealed a number of parameters that were incorporated in developing a transport model. Owens et al. (2013), Chen et al. (2008), Hicks (2009) and Arnold et al. (2004) developed transport models for a particular situation, rather than for a general scenario. [17, 43-45] Owens (2013) incorporated track data (distance, elevation, speed, and curvature), travel time, rail car capacity, delay, fuel cost, loading and unloading cost for containers in their model. The study by Chen et al. used number of origins, destinations and commodities, inventory, unit inventory cost and capacity to formulate their model. Hicks used origin and destination coordinates for truck trips, unit costs for rail and truck, transfer locations, and fuel surcharges. Arnold et al. (2004) included unit shipping cost, origin/destination matrix, handling cost and location of terminals.

All of the models highlighted above had an objective of optimizing cost based on the selected parameters. Owens derived total resistance for trains and sensitivity of operating cost for different fuel prices. Chen et al. found the optimized shipping and inventory cost. Hicks (2009) optimized transport routes based on cost for log movements and derived the optimal split between truck and multimodal alternatives. Arnold et al. developed five scenarios which were variations of relative cost of rail, variation of handling costs, variation of rail border effect, location of new terminals, and optimization of the existing terminals. These scenarios were compared with the existing truck movements. The Great Lakes Geographic Intermodal Freight Transport Model (GIFT) developed by Winebrake et al. (2008) optimized operating cost based on time and emissions (CO_2, NO_X, PM_{10} and SO_x) by using tradeoff concepts for the Great Lakes region. The GIFT model used the “Network Analysis” tool built in ArcGIS 9.2 by putting weights on each route and optimized the total transport route by selecting the route with the least weight value based on shipping and emission costs. Global Insight (2006) conducted studies that investigated operating cost for modes, expressed as US dollar per TEU (Twenty Foot Equivalent). The result of the model gave an optimized route for the movements from Cleveland, OH to Toronto. [46] Li et al. (2005) developed a model for transporting 12 types of coal from 29 companies in China. They used a multi-commodity logistic chain for minimum-cost optimization. The objective was to minimize the cost, optimize the capacity of the line, and not allow different types of coal to mix. The outcome of the study provided optimized route and cost savings from using such a route over the existing one. The study by Li did not include a transload facility as commodities moved on a single line by rail. [47]

2.5 Shipping Costs for Truck and Rail

The two most common rates types applied for truck shipments are “Truck Load (TL)” and “Less-than-Truck Load (LTL)”. For bulk commodities “per-mile” rate is usually charged which excludes fuel surcharges and handling cost (handling cost is assumed to be paid by the consignee). For rail, there are ty dicallyifferent rates applied for container and carload shipments. Both truck and rail may also offer contract rates which are made for individual shippers with high volumes, or for other reasons to give a preferential treatment. [1]

Literature review was conducted to identify typical shipping unit costs of surface transportation modes (rail and truck). The review revealed seven studies that identified shipping unit costs for either rail, truck, or both modes (Table 2). Typically, truck and rail transport costs were expressed as US dollars (USD) per ton-mile. [48-50] From the historical costs, it was understood that specific cost from past studies can not be used for this studies as there are lots of variation. Instead, this study used the current CN tariff rates and truck shipping cost from shipper interviews to generate the transport unit costs.

Table 1: Unit Shipping Cost from Past Studies [51-57]

Author	Study Year	Commodity	Rail				Truck		
			Type	Distance (miles)	Weight used (tons per car)	Unit cost per ton-mile (indexed to 2012)	Distance (miles)	Weight Used (tons per truck)	Unit cost per ton-mile (indexed to 2012)
Forkenbrock	1994	Bulk	Heavy unit	1000	105	0.0119 (0.02)	< 250	14.8	0.0217 (0.03)
		Bulk	Mixed freight	500	70	0.012 (0.02)	_	_	_
		Container	Intermodal	1750	28	0.0268 (0.04)	250 - 500	14.8	0.0894 (0.13)
		Container	Double-stack container	1750	56	0.0106 (0.011)	> 500	14.8	0.0769 (0.11)
Wang et al	1995	Bulk and recycled paper	_	_	60	0.12 (0.17)	_	22	0.1 (0.14)
US DOT	1995-2004	General Freight	_	_	_	0.032 (0.04)	_	_	0.1104 (0.19)
Kehoe, Owen	2001	General Freight (Forkenbrock Study)	Mixed freight	_	_	0.022 (0.03)	< 250	24	0.0217 (0.03)
		Intermodal	Intermodal	_	_	0.0268(0.04)	> 500	17.5	0.0842 (0.12)
Cambridge Systematics Inc.	2002	Bulk and Intermodal	_	_	_	0.024 (0.03)	_	_	0.08 (0.10)
Columbia River Crossing	2004	Bulk	50 tons	75	100	1.09 (1.15)	75	25	0.033(0.04)
			10,000 tons	75	100	0.0272 (0.03)	75	25	0.033(0.04)
			50 tons	2000	100	0.48 (0.52)	2000	25	0.04 (0.05)
			10,000 tons	2000	100	0.0032 (0.01)	2000	25	0.04 (0.05)
Atkinson et al	2006	Bulk	_	_	_	0.034 (0.04)	_	24	0.0842 (0.09)

An additional cost for multimodal transport is the handling cost during rail-truck (or truck-rail) interchange, also known as trans-shipment cost. Beresford (2011) and Hanssen et al. (2012) addressed the importance of the handling cost while considering multimodal transport as they can increase the multimodal transport cost to a great extent. [49, 58] According to literature, common tariff rates for loading and unloading varied from $1.5 to $6 per ton. [43, 59].

2.6 Carbon Emission Factors

Carbon emissions have been widely recognized as a challenge for the society. Transportation is responsible for 30 % of energy consumption in the U.S. and more than 70% of carbon emissions. [60, 61] Transportation has overall one of the lowest efficiencies for energy use, so any potential reductions in emissions due to modal selections play an important part of the U.S. sustainability. [62] Total carbon emissions caused by transportation can be calculated based on emission factors and fuel consumption and it is believed that multimodal transport has the potential to reduce carbon footprint due to typically lower energy consumption by rail than by trucks. [63, 64] The literature review on past studies with emission factors for rail and truck revealed six studies, summarized in Table 2.

Table 2: Unit Emission Factors from Past Studies

Author	Study Year	Chemical Constituents	Emission Factor (g/ ton-mile)		
			Rail		Truck
Forkenbrock [51]	1994	CO_2	Heavy unit train	N/A	134.4
			Mixed freight train	18.6	
			Intermodal train	17	
			Double-stack container train	15.40	
Rourke et al. [65]	2002	CO_2	General Freight	25.40	297.9
Hanaoka et al. [66]	2006 - 2009	CO_2	General Freight	41.42	172
Texas Transportation Institute [67]	2005	CO_2	General Freight	24.39	64.96
Cefic-ECTA [68]	2012	CO_2	General Freight	32	90.18
Blanco, E.E. [69]	2012	CO, CO_2	Intermodal	25.2	149.7

From Table 2 , the range of emission factors for rail range between 15.40 - 41.42 grams per ton-mile with a median value of 24.39 grams and for truck between 64.96 - 297.90 grams per ton-mile with a median value of 134.40 grams. Figure 7 shows the minimum, maximum and median values from the studies presented in .

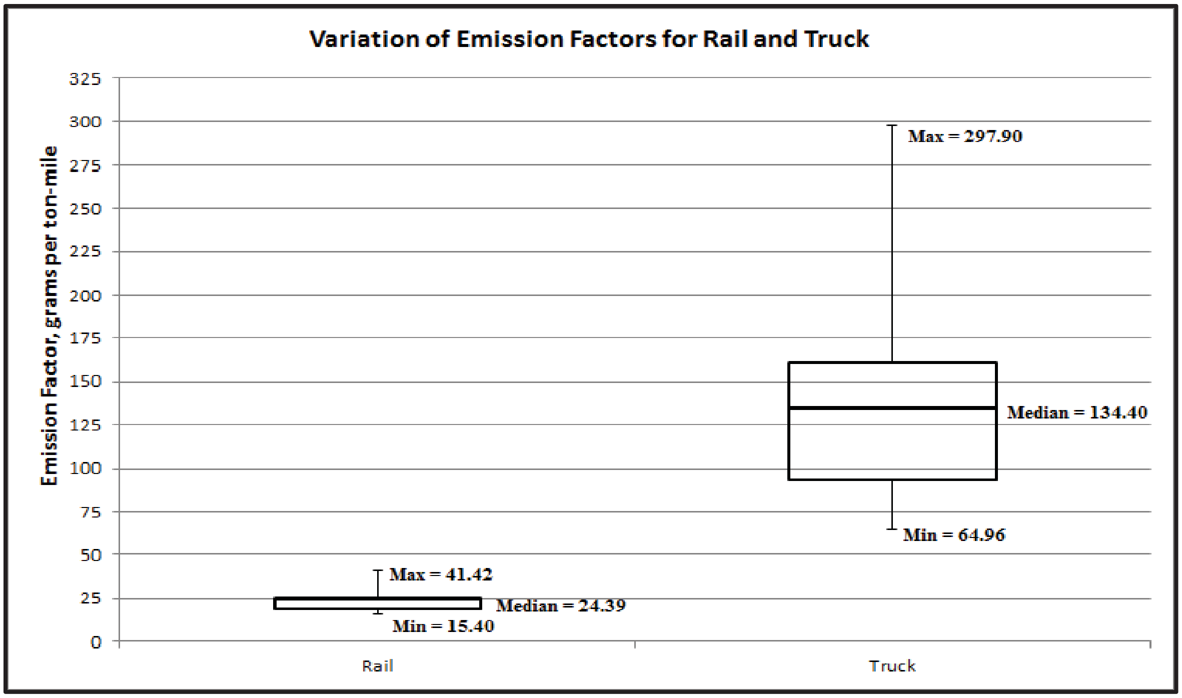

Figure 7: Variations of Emission Factors for Rail and Truck from Past Studies

One of the key factors explaining to wide range of emission values was study location. Data suggests that emission values are generally considered higher in metropolitan areas than the rural areas. Studies by Rourke et al, Texas Transportation Institute and Cefic-ECTA evaluated 15 to 25 metropolitan areas and resulted in higher rail emission factors, ranging between 24.39 to 41.42 grams per ton-mile.[65-68] The studies conducted on more than 2,000 rural counties used lower range between 15.4 to 22.3 grams per ton-mile.

Forkenbrock concluded that truck payload and speed are also relevant in calculation of emission factors. Cefic-ECTA study considered empty backhaul while calculating the emission factors. Other factors included in the studies were percent of pay load used, and amount of backhaul (Cefic-ECTA). Texas Transportation Institute and Transportation Research Board concluded that improved fuel efficiency, higher payload, and technology in today’s trucks are allowing lower emissions. On the other hand, rail tends to have lower fuel consumption and thus results in less emission. Overall, every study had different approach to address their emission factors, making it difficult to calculate general values. As an example of a practical application, Class I railroad CN uses 28.73 grams per ton-mile as emission factor for rail and 183.54 grams per ton-mile for trucks in their carbon calculator. [70] For rail it is close to the median of past studies but for truck it falls in the lower range.

This study used the average of the median of emission factors from past studies and CN emission factors for both truck and rail. CN operates in the UP and thus make it more suitable to take it into account along with the past studies.

2.7 Carbon Emission Cost

Currently, there is no monetary penalty imposed for carbon emissions, but several studies have addressed the cost of carbon. The studies provided the monetary values as US dollars (USD) per ton of CO_2 emission and the values varied widely between \$2.27 and \$36. Chernick and Caverhill provided a range of \$2.27 to \$24.95 per ton of CO_2 emission, based on relative physical and chemical toxicity, public concern, direct estimation of the effects, and societal value from the maximum cost derived from the effects. [71]. National Economic Research Associates suggested emission cost of \$3.56 per ton of CO_2 emission.[55] National Research Council provided a range of \$10 to \$20 per ton of CO_2 emission, but did not include their basis for the monetary value. [72] Forkenbrock reviewed the three earlier studies and found the lowest value (\$10) of the study by National Research Council per ton of CO_2 (\$15.25 when indexed to 2012) the most appropriate value for emission cost. [51] Finally, a recent CBC News article presented the definition of emission cost as “an estimate of the monetized damages such as property damage or changes to agricultural productivity and human health associated with increased carbon emissions”. [73] The article provided the estimation as \$22 to \$36 per ton of CO_2.

CHAPTER THREE: METHODOLOGY

3.1. Single mode and multimodal transportation chains

There are two common combinations of multimodal truck/rail transportation that provide alternatives to single mode “truck only” alternative; “truck- rail” and “truck- rail-truck”. “rail-truck” might also be option, but it occurs more rarely. Figure 6 presents a schematic of the most common alternatives. O and F represent origin and final destination, respectively, and points 1, 2, 3 and 4 are interchange points between truck and rail. For truck only transportation, the whole trip takes place in one movement, without intermediate stops or transloads. When rail has access to final destination there, freight is moved from truck to rail at transload facility (point 1), but there is no need to move shipment back to trucks for final delivery. For truck-rail-truck options, freight is transloaded to rail at point 1 and back to truck at point 2,3, or 4.The difference between the latter three options is the length of rail haulage and final truck drayage from intermediate transload facility to final destination.

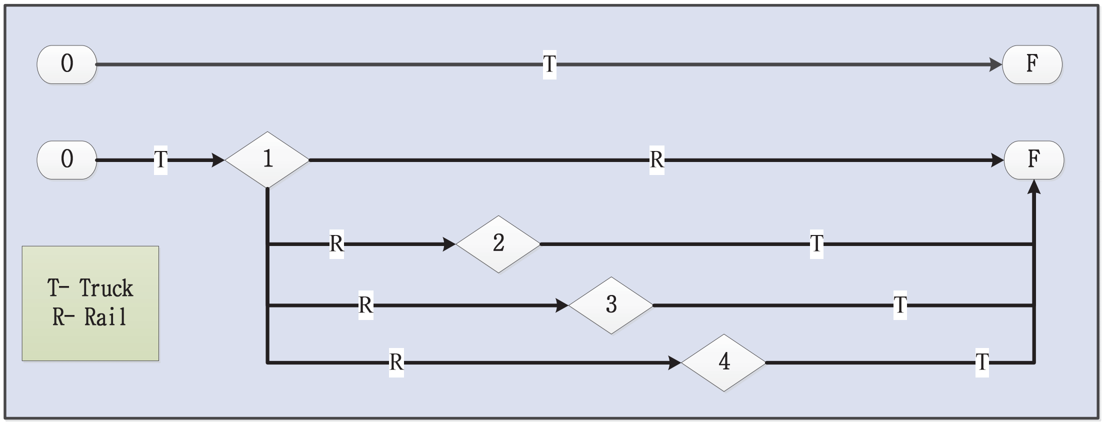

Figure 8: Truck only and multimodal alternatives

In Figure 9, the comparison between “truck only” and “truck –rail” scenarios is illustrated from purely cost perspective (no serv. Rail tends to offer lower cost per unit of shipment, explaining the shallower angle in cost graph. If rail is used to transport commodities to the final destination from a transload facility, the transport cost can be less than the truck only transport if the distance is long enough to cover the transloading cost at the transload facility.

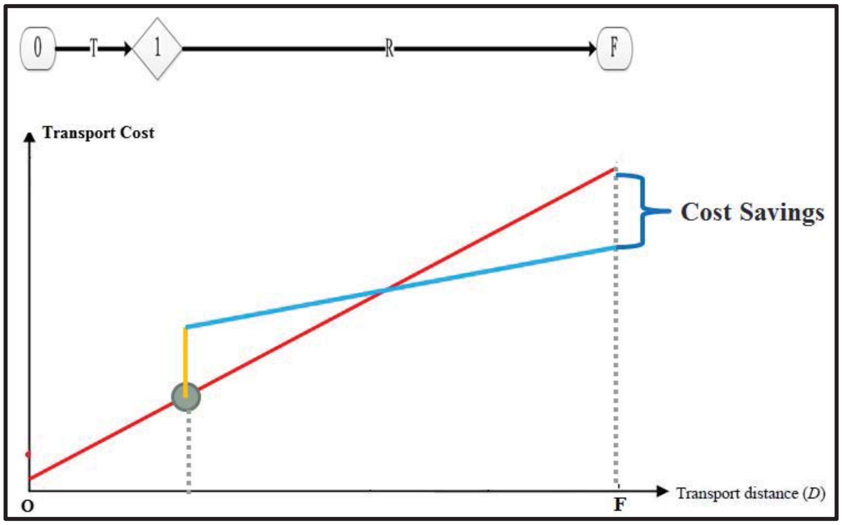

Figure 9: Comparison between "truck only" and truck-rail" transport

Figure 10 illustrates comparison between “truck only” and “truck-rail-truck” transport. As seen in Figure 10, the two main determinants of total shipment cost are - distance traveled by rail and handling cost. If shipment is shifted to final truck drayage at point 2, multimodal cost is higher than truck transport. At point 3, multimodal cost is equal to the truck transport, known as break-even distance and at point 4, it is lower than truck alternative. As the rail distance increases and drayage decreases, the balance shifts toward multimodal transportation.

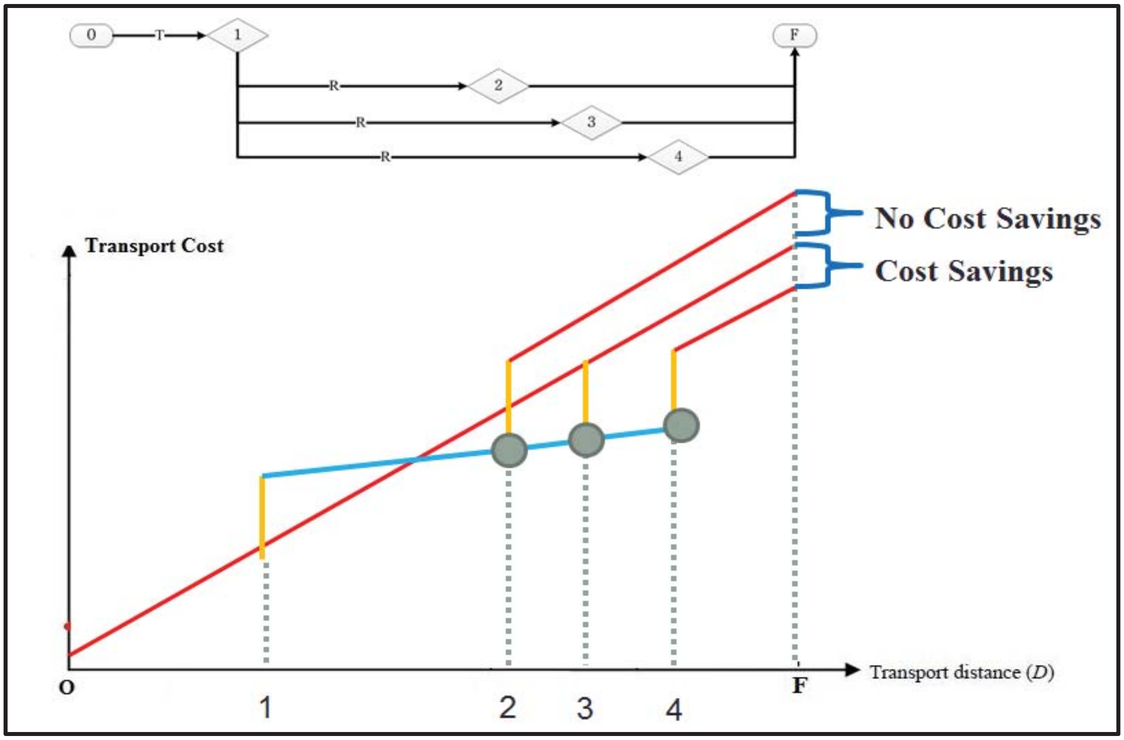

Figure 10: Comparison between "truck only" and "truck-rail-truck" transport

3.2. Transport Model for the Study

A spreadsheet calculation model was developed to compare the costs of truck only and multimodal option. The objective was to calculate shipping and emission costs for truck and multimodal (using transload) alternatives. Figure 11 illustrates the concept diagram for calculations. The input parameters are the movements, infrastructure and unit costs. From movements and infrastructure parameters shipments and possible routes were generated for truck and multimodal option using transload facility. Unit costs parameters were used to formulate cost equations and to calculate transport and emission costs for both truck and multimodal alternatives, the outputs of the model.

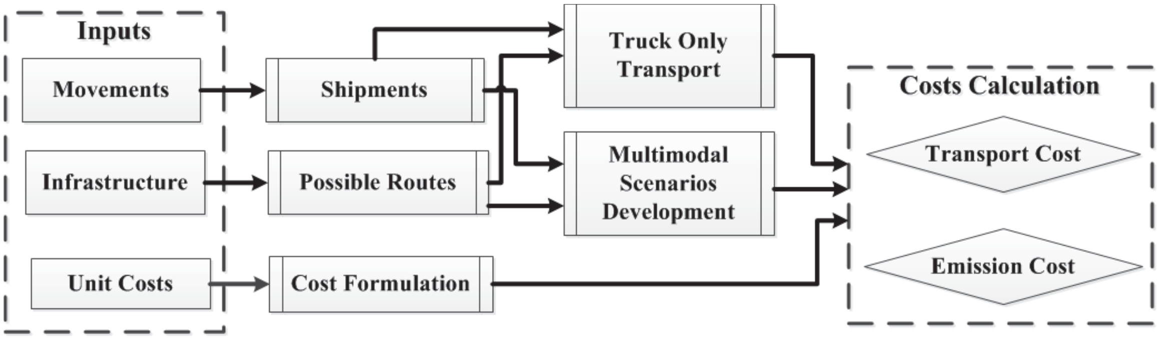

Figure 11: Conceptual spreadsheet transport model diagram

The input parameters for the spreadsheet are illustrated in Table 3 and the outputs in Table 4.

Table 3: Input parameters for developing conceptual spreadsheet transport model

Input Category	Movements	Infrastructure	Unit Costs
Input Parameters	Origin and Destination	Road network	Shipping costs
	Volume of Commodities	Rail network	Emission costs
		Potential transload locations	Fuel Surcharges
			Transloading costs

Table 4: Outputs from the conceptual spreadsheet transport model

Outputs for	Truck only transport	Multimodal transport
Outputs	Shipping cost to final destination	Shipping cost for truck drayage to transload facility
		Shipping cost for rail to intermediate/final destination
		Shipping cost for truck drayage to final destination (if final destination does not have rail access)
	Emission cost to final destination	Emission cost for truck drayage to transload facility
		Emission cost for rail to intermediate/final destination
		Emission cost for truck drayage to final destination (if final destination does not have rail access)

Examples of shipping and emission cost calculations that were later used to analyze the percent cost savings from multimodal transport from the three potential transload facility locations are provided in Appendix A-E. Examples of calculations of actual savings are shown in Appendix F and Appendix G.

3.3. Notation of Parameters for Equation Formulation

The following sections describe the notations and the equations used in the calculations. The same parameters were used for both inbound and outbound freight, as they were assumed to take the same routes.

General terms used in Notations

$\mathrm{O} =$ origin, $\mathrm{D} =$ destination

$\mathrm{T} =$ transload facility

$\mathrm{I} =$ intermediate destination out of state for rail

$\mathrm{t} =$ truck, $\mathrm{r} =$ rail

m = multimodal (truck-rail or truck-rail-truck)

$ = US dollars

Volume of Commodities:

$\mathrm{V} =$ volume of commodities (in tons) to be transported

Origin and Destination

$i =$ origin county in the UP ($\mathrm{i} = 1, 2, 3, \ldots., 15$)

$l =$ final destination outside the UP (Wisconsin, Chicago, Minneapolis, Sault Ste. Marie)$[l = 1, 2, 3, 4]$

Distances from Road and Rail Network

$D^{t}_{i,l}$ = truck distance (miles) from origin i to destination l when only truck is used

$D^{t}_{i,j}$ = truck drayage (miles) from origin i to transload j (multimodal only)

$D^{r}_{j,k}$ or $D^{r}_{j,l}$ = rail haul (miles) from transload j to intermediate k or final destination l (multimodal only)

$D^{t}_{k,l}$ = truck drayage (miles) from intermediate k to final destination l (multimodal only) [if final destination has rail access, $D^{t}_{l,j} = 0$]

Potential Transload Location

j = transload facility location in the UP [$j = 1, 2, 3$](Nestoria, Ishpeming and Amasa)

Shipping Costs

u_t = unit shipping cost for truck (\$ per ton − mile)

u_r = unit shipping cost for rail (\$ per ton − mile)

Emission Costs

C_{eft} = emission factor (grams per ton − mile) for truck

C_{efr} = emission factor (grams per ton − mile) for rail

u_e = unit cost of emission per ton of CO_2 (\$ per ton of CO_2)

Fuel Surcharges

BF_t = base fuel surcharge for truck (\$ per ton − mile)

x = increase in fuel price (\$) for truck

a = increase in fuel surcharge (\$) for truck for every dollar increase in fuel price

BF_r = base fuel surcharge for rail (\$ per ton − mile)

y = increase in fuel price (\$) for rail

b = increase in fuel surcharge (\$) for rail for every dollar increase in fuel price

Transloading Cost

h_t = transloading cost per ton (\$)

c = number of transloadings in multimodal option (for final destination with rail access c = 1, otherwise c = 2)

Total Costs

TC^t = total transport cost for truck only mode from origin i to destination l (\$)

TC^m = total transport cost for multimodal mode from origin i to destination l (\$)

$C_{i,l}^t$ = truck shipping cost from origin i to destination l (\$)

$EC_{i,l}^t$ = emission cost for truck from origin i to destination l (\$)

$EC_{j,k}^r$, $EC_{j,l}^r$ = emission cost for rail from transload j to intermediate k or final destination l (\$)

$EC_{i,l}^{m}$ = total emission cost for multimodal from origin i to destination l ($)

$DC_{i,j}^{t}$ = truck drayage cost from origin i to transload j ($)

$RC_{j,k}^{r}$, $RC_{j,l}^{r}$ = rail haul cost from transload j to intermediate k or final destination l ($)

$DC_{k,l}^{t}$ = truck drayage cost from intermediate destination k to final destination l (if direct rail access at final destination= 0) ($)

$TC_{j,k}^{m}$, $TC_{k,l}^{m}$ = transload cost for multimodal [if final destination has rail access, $TC_{k,l}^{m} = 0$]

$FC_{j,k}^{r}$ = fuel surcharge for rail ($)

$FC_{i,l}^{t}$ = fuel surcharge for truck only ($)

$FC_{i,l}^{m}$ = fuel surcharge for multimodal from origin i to destination l ($)

$FC_{i,j}^{t}$, $FC_{k,l}^{t}$ = fuel surcharge for final truck drayage

[if final destination has rail access, $FC_{k,l}^{t} = 0$] ($)

3.4. Equation Formulation

Equations were formulated using the parameters in Section 3.2. Truck and multimodal transport cost formulation is as follows:

Shipping Costs

For truck only mode, shipping cost from origin to final destination will be calculated using Equation 1.

$$C_{i,l}^{t} = \mathrm{V} \times D_{i,l}^{t} \times u_t \tag{1}$$

For multimodal option, truck drayage is required from origin to transload facility. Truck drayage from origin i to transload facility j will be calculated using Equation 2.

$$DC_{i,j}^{t} = \mathrm{V} \times D_{i,j}^{t} \times u_t \tag{2}$$

Rail transport from transload j to intermediate k (without rail access) or final destination l (if rail access is available) will be calculated using Equation 3.

$$RC_{j,k}^{r}\ ,RC_{j,l}^{r} = \mathrm{V}\ \times (D_{j,k}^{r}\ \text{ or }\ D_{j,l}^{r})\ \times\ u_t \qquad (3)$$

For final drayage in multimodal option (if needed), the cost of drayage will be calculated using Equation 4.

$$DC_{k,l}^{t} = \mathrm{V}\ \times D_{k,l}^{t}\ \times\ u_t \qquad (4)$$

Fuel Surcharges

Fuel surcharge for truck only option will be calculated using Equation 5.

$$FC_{i,l}^{t} =\ V\ \times D_{i,l}^{t}\ \times (BF_t + \mathrm{x}\ \times \mathrm{a}) \qquad (5)$$

Fuel surcharge for multimodal option will be calculated using Equation 6.

$$FC_{i,l}^{m} =\ FC_{i,j}^{t}\ +\ (FC_{j,k}^{r}\ \text{ or } FC_{j,l}^{r}) +\ FC_{k,l}^{t} \qquad (6)$$

Where,

$$FC_{i,j}^{t}\ \ or\ FC_{k,l}^{t} =\ \ V\ \times (D_{i,j}^{t}\text{ or } D_{k,l}^{t})\ \times (BF_t + \mathrm{x}\ \times \mathrm{a})$$

$$FC_{j,k}^{r}\ \text{ or } FC_{j,l}^{r} =\ V\ \times (D_{j,k}^{r}\ \text{ or }\ D_{j,l}^{r}) \times (BF_r + \mathrm{y}\ \times \mathrm{b})$$

Transloading Cost

Transloading cost for multimodal option will be calculated using Equation 7.

$$TC_{j,k}^{m}\ \text{ or } TC_{k,l}^{m}\ = c\ x\ V\ x\ \ h_t \qquad (7)$$

Emission Costs

For truck only option, Truck emission cost from origin to final destination will be calculated using Equation 8. A factor 10^{-6} is multiplied to convert grams to tons.

$$EC_{i,l}^{t} = \mathrm{V}\ \times D_{i,l}^{t}\ \times\ \mathrm{C_{eft}} \times\ u_e \times 10^{-6} \qquad (8)$$

Multimodal emission cost from origin to final destination will be calculated using Equation 9.

$$EC_{i,l}^{m} = EC_{i,j}^{t} + \left(EC_{j,k}^{r} \text{ or } EC_{j,l}^{r}\right) + EC_{k,l}^{t} \tag{9}$$

where,

$EC_{i,j}^{t} = V\ x\ D_{i,j}^{t}\ x\ \mathrm{C_{eft}}\ x\ u_e\ x\ 10^{-6}$

$EC_{k,l}^{t} = \mathrm{V} \times D_{k,l}^{t} \times \mathrm{C_{eft}} \times u_e \times 10^{-6}$ (if final destination has rail access= 0)

$EC_{j,k}^{r}, EC_{j,l}^{r} = \mathrm{V} \times (D_{j,k}^{r} \text{ or } D_{j,l}^{r}) \times \mathrm{C_{efr}} \times u_e \times 10^{-6}$

Total Costs Equations

Total transport cost for truck only option will be determined using Equation 10.

$$\mathrm{TC}^{t} = C_{i,l}^{t} + FC_{i,l}^{t} + EC_{i,l}^{t} \tag{10}$$

Total transport cost for multimodal option will be calculated using Equation 11.

$$\mathrm{TC}^{m} = DC_{i,j}^{t} + \left(RC_{j,k}^{r} \text{ or } RC_{j,l}^{r}\right) + DC_{k,l}^{t} + FC_{i,l}^{m} + EC_{i,l}^{m} + TC_{j,k}^{m} + TC_{k,l}^{m} \tag{11}$$

CHAPTER FOUR: TRANSLOAD FACILITY ANALYSIS FOR MICHIGAN’S UPPER PENINSULA

4.1. Introduction

There are currently four railroads serving the Upper Peninsula of Michigan; one Class I railroad (CN) and three short line railroads – Escanaba & Lake Superior (E&LS), Lake Superior & Ishpeming (LS&I) and Mineral Range Railroad (MNRR). CN has the largest network (511 miles) within the UP and it controls all rail connections with the neighboring states and Canada. There is no direct rail connection between Upper and Lower Peninsula and the only direct road connection is the Mackinac Bridge which allows maximum truck weight of 72 tons (144,000 lbs). [74, 75] The rail network in the UP is illustrated in Figure 12.

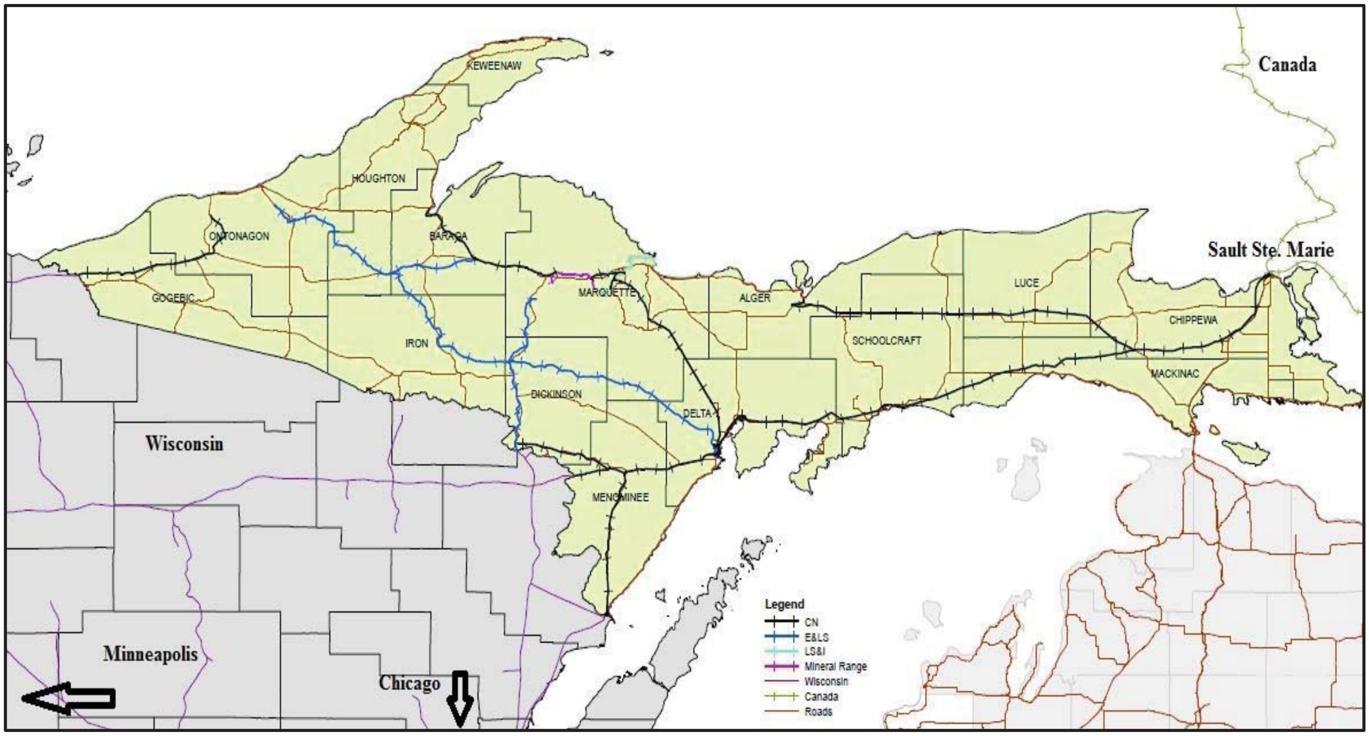

Figure 12: Upper Peninsula rail and road network

Recently, several industry stakeholders and economic development agencies have expressed desire toward establishment of an intermodal/transload facility in the UP. Currently there is no intermodal facility in the UP. The nearest one is located in Chippewa Falls, Wisconsin and owned by CN. There is one private transload facility at Menominee (southern part of UP), owned and operated by KK Integrated Logistics, Inc. and served by both CN and E&LS Railroad. KK Integrated Logistics provides comprehensive logistics service, but have had challenges to make industries aware of their services. Escanaba and Lake Superior Railroad (E&LS) also has past experience in transloading. In the late 1980's, E&LS purchased a 13,500 sq. ft. former lumber distribution center and warehouse in Kingsford, MI, and renovated it to serve as strategic truck/rail transload center for industry in the central UP.

The research concentrated on evaluating the potential to establish a transload location at one of the three locations identified by stakeholders during shipper and railroad interviews (MDOT project) (Figure 13). The selection of these locations for analysis did not follow any analytical evaluation, but was solely based on input from shipping community and railroads. The following section provides a brief introduction of each location and the primary reasons behind the selection for analysis. It should be noted again that this research concentrated purely on evaluating the potential cost benefits for shipments and excluded any evaluations of capital, acquisition, utility, and other relevant costs for a transload facility development.

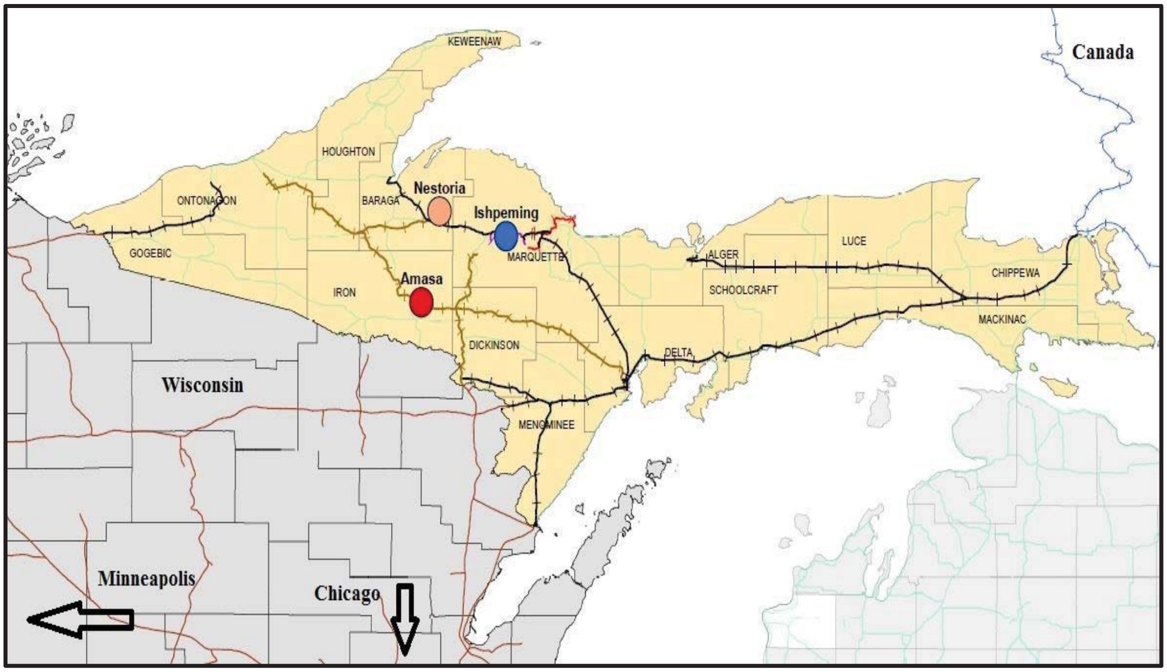

Figure 13: Potential transload facility locations

Nestoria

Nestoria is located along the Ishpeming –L'Anse rail line owned and operated by CN Railroad. The longitude and latitude of the location are 46.57^0 and -88.26^0 respectively. There is a lot of interest toward establishing a transload location in the vicinity of the industrial park in L'Anse/Baraga area, but rail service to L'Anse is extremely challenging due to extensive grades. Nestoria is a potential "compromise" location. It is past the high grades from L'Anse and the extensive swamps that surround tracks closer to L'Anse. In addition, it already hosts the Peshekee Yard by J.M Longyear and has a good road access from US-41.

Ishpeming

Ishpeming has an existing yard, owned and operated by CN Railroad (Figure 5). The longitude and latitude of the location are 46.50^0 and -87.69^0. The yard that has ample capacity, making it a prime location for establishing a transload facility. The yard is also an existing interchange point between railroads and Ishpeming / Marquette area is one of the densest locations for economic activity in the UP, offering opportunities for concentrated shipments.

Figure 14: Ishpeming rail yard owned by CN Railroad

Amasa

Amasa siding, known as Park Siding, is owned and operated by E&LS shortline Railroad. The longitude and latitude of the location are 46.39^0 and -88.53^0 respectively (Figure 6). Amasa is located further south than the other two locations, providing closer vicinity to industries in Iron county. Although there is currently no rail siding or yard available, a proper site with sufficient utilities and access has been identified and E&LS has a nearby yard in Channing with ample available capacity.

Figure 15: Amasa railsiding owned by E&LS Railroad

4.2. Modelling Scenarios

The modeling effort concentrated on three objectives:

- Calculation of shipping and emission costs for both truck and multimodal options for all three potential transload locations. (using spreadsheet method described in Chapter 3)
- Comparison of percent cost savings of each alternative transload facility.
- Identification of the impact of fuel price on the modal division (sensitivity analysis)
- Comparison of carbon emission cost for the three potential transload locations

Several scenarios were considered in calculations:

- One with direct rail access to final destination and another with a 25 miles truck drayage to the final destination.
- With and without considerations to emission costs.
- Three different On-Highway Diesel Fuel (HDF) prices ($3, $5, and $6 per gallon) to observe the effect of fuel price on total transport cost.

4.3. Input Data Sources and Preparation

Infrastructure, volume and cost data had to be developed for the analysis. The following sections explain the development and sources for key input parameters.

4.3.1. Infrastructure

Infrastructure data were collected from the following sources

- County shapefile for identifying county centroids was downloaded from Michigan Geographic Data Library. [76]
- Road and rail networks were downloaded from Michigan Geographic Data Library. Rail network was also verified with railroad companies.

4.3.2. Shipments

After it became evident that sufficient volume of freight data could not be collected for comprehensive analysis in the UP, a more limited approach, using TRANSEACH data was selected. TRANSEARCH is a unique planning tool that helps strategic transportation planners, transportation providers, and government agencies to analyze current and future freight flows by origin, destination, commodity, and transport mode. It is based on more than 100 sources including waybills, the Commodity Flow Survey, etc. The commodities are classified by “4-digit Standard Transportation Commodity Code” (STCC4) and origins and destinations are classified with Commodity Analysis Zone (CAZ). Commodity movements are measured in tons.

The TRANSEARCH database had some inconsistencies with distances and those were removed from calculation. After removing the inconsistencies for distances, the freight volumes for origination and terminating interstate freight traffic were developed for the fifteen UP counties. All UP counties were selected for the analysis, although the counties nearest to proposed facilities were expected to see the greatest benefits.

For this study interstate movement between the UP and other three out of state locations (Wisconsin, Chicago and Sault Ste. Marie) were analyzed. Shipments beyond these locations were excluded, as they required an interchange between Class 1 railroads and it was not feasible to obtain proper shipping rates from public sources.

All commodities included in the TRANSEARCH database, except secondary movements were in the analysis. Secondary traffic which includes movements between distribution stores was excluded from the research as they require door to door service were not considered as realistic candidates for multimodal movements. Table 5 summarizes the inbound and outbound interstate commodity flow by truck and rail in the UP. Commodities are categorized using “Standard Transport Commodity Code” (STCC).

Table 5: Interstate movement by truck and rail in the UP, 2009

Commodities	STCC	Tons (2009)			
		Truck Inbound	Rail Inbound	Truck Outbound	Rail Outbound
Agriculture	1	268,608	-	38,218	-
Iron Ores	10	264,050	-	0	1,460,308
Nonmetallic Ores and Minerals	14	418,265	-	64,296	-
Food Products	20	338,867	-	75,056	-
Lumber and Wood Products	24	149,875	193,920	1,713,462	576,560
Pulp and Paper Mill Products	26	138,128	105,480	299,795	908,160
Chemical Products	28	242,987	-	194,486	-
Petroleum or Coal Products	29	219,072	-	216,511	-
Rubber and Plastics	30	31,286	-	16,965	-
Clay, Cement, Glass, Stone Products	32	153,794	499,680	137,063	68,600
Primary Metal Products	33	105,414	67,920	54,732	38,080
Fabricated Metals	34	55,229	-	55,111	-
Machines	35	31,294	-	34,814	-
Waste or Scrap Material	40	-	2,800		49,200
Secondary Traffic	50	550,150	-	81,441	-
Other		222,241	306,928	364,271	4,080
Total		**3,189,260**	**1,176,728**	**3,346,220**	**3,104,988**

From Table 5, it is noted that the lumber and wood products; pulp and paper mill products; clay, cement, glass, stone products; and primary metal products; fabricated metals; and machines, are currently being hauled by both truck and rail. The selected commodities can be either handled as bulk or in containers. In this research, it was assumed that all movements from the transload facility would move in carloads, as development of a container facility would present a much more challenging scenario than that of a transload facility. The volumes were divided based on their origin/destination county for analysis, as presented in Table 6 and they accounted for almost 50 percent of total interstate movements to/from UP.

Table 6: TRANSEARCH volume for the UP counties for selected interstate movements

Counties	Wisconsin		Chicago		Minneapolis		Sault Ste. Marie	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Alger	27,409	161,951	2,910	16,132	2,406	1,487	3,017	109
Baraga	44,265	153,469	7,644	2,692	6,070	18,416	21,917	434
Houghton	76,541	94,186	9,319	3,011	18,260	22,162	14,018	735
Ontonagon	35,509	95,120	1,962	441	6,178	90,076	0	0
Keewenaw	3,078	44,534	253	0	492	1,187	0	0
Marquette	204,236	132,100	28,897	1,911	301,137	15,223	0	1,069
Gogebic	133,634	231,132	7,073	3,088	28,248	39,095	0	3,027
Dickinson	471,955	388,618	24,353	26,131	18,988	31,775	9,361	9,033
Iron	81,034	300,645	4,493	3,141	4,729	20,778	25,966	233
Delta	234,997	196,213	27,034	18,446	20,552	6,908		8,000
Menominee	177,038	403,572	22,272	17,820	13,973	25,411	412	309
Luce	6,831	10,345	732	3,331	1,492	88	15,000	200
Chippewa	40,690	15,162	6,826	20,094	3,786	1,272	1,500	550
Schoolcraft	15,309	24,354	1,334	231	983	163	2,100	321
Mackinac	17,332	51,426	1,563	44,921	1,082	129		1,221
Total	**1,569,858**	**2,302,827**	**146,665**	**161,390**	**428,376**	**274,170**	**93,291**	**25,241**

One of the greatest limitations to the analysis was the determination of shipping distances. TRANSEARCH 2009 database offers origin/destinations at county level within the UP and state level outside the State of Michigan. Centroids of counties (and states) were used as the origin/destination data. It is recognized that this assumption significantly hinders the accuracy of analysis, but researchers could not identify other alternatives. Out of state origins and destinations are illustrated in (Figure 16). The distance calculations included the following:

- Distance from centroid of counties to transload facility
- Distance from transload facility to final destinations
    - Wisconsin - Bradley
    - Chicago – Kirk yard
    - Minneapolis - Withrow
    - Sault Ste. Marie in Canada – Soo yard

Distance from transload transload facility to final destination (Bradley, Kirk Yard, Withrow) are selected relative to the centroid of the respective states.

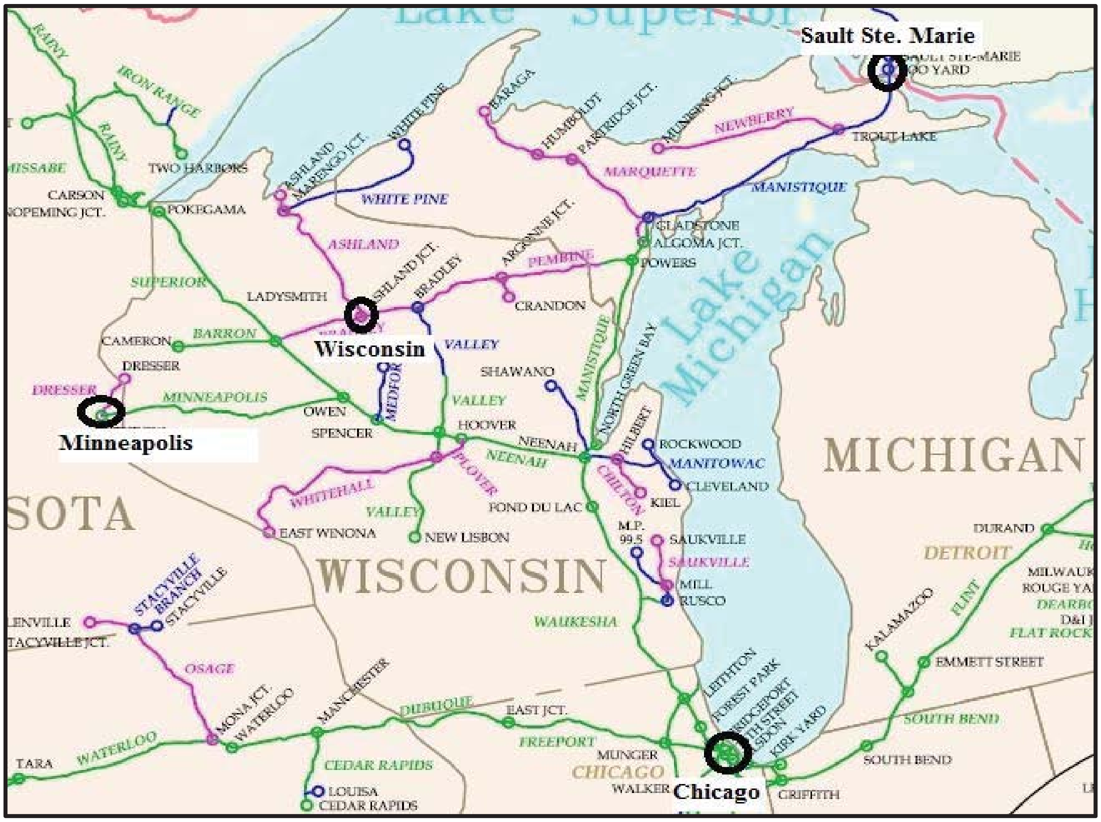

Figure 16: Out of state origins and destinations (CN Website)

County shapefile was imported into ArcGIS to locate centroids of the counties. The longitudes / latitudes of the centroids were determined using the “Polygon to Points” feature built in ArcGIS 10.1 version and further used to calculate the shortest road distance from centroids to transload locations and to county centroids of the selected destinations (Wisconsin, Chicago, Minneapolis and Sault Ste. Marie). For determining the rail distances, the research used the Mineral Occurrence Estimation and Visualization (MOREV) tool, based on ArcGIS and developed by Michigan Tech Research Institute (MTRI).

4.3.3. Costs Parameters

Truck Rates

Based on literature review on trucking rates, they vary greatly between $0.03 and $0.19 per ton-mile with a median of $0.1 and the average payload used for trucks is between 14 to 25 tons. Total weight of a Wisconsin/ Minnesota trucks are 40 tons (80,000 lbs), whereas Michigan trucks are 82 tons (164,000 lbs).[10, 43] Therefore, the payload for Wisconsin/ Minnesota truck is 25 tons, whereas for Michigan it is 50 tons. As Wisconsin/ Minnesota trucks have less carrying capacity, their rates per ton tend to be higher than Michigan trucks to overcome the operating cost. The truck rates for the UP case study used Wisconsin and Minnesota truck rates, as all movements originate or terminate beyond the state of Michigan. Hicks study (2009) conducted on WI/MN log trucks, found the rate to be $0.20 (converted to 2012 index) per ton-mile excluding the fuel surcharge. For the UP case study, three shippers and two truck companies in Michigan were contacted for the rate and they informed the truck unit shipping cost is in between “$2.50 to $3.50 per mile”. The rate was converted per ton mile for 25 ton payload truck, resulting in an average value $0.15 per ton-mile.

Rail rates

Based on the literature review on rail rates, they vary greatly between $0.01 and $0.04 per ton-mile. Instead of using historic rates, the study looked into the operating Class I CN Railroad’s tariff rates in the study area which are publicly available. Any potential discounts to shippers by CN were ignored in the research. Rail rates for this study are comprised of CN tariff rate and CN 7403 rule (mileage based) for fuel surcharge.[77, 78] These two values were combined to estimate the rail shipping cost for the research and CN tariff rates for fifty random origins and destinations were chosen to generate an equation for rail rates.[79] Each origin and destination was used to generate price for two different types of carloads (100 and 70 tons capacity) that are standard sizes for CN. [77] The distance between each origin and destination was found using MOREV tool. The carload price was converted to US dollar per ton-mile by dividing the price with volume (100 and 70 tons) and distance (MOREV). Initially, the cost per ton-mile was calculated separately for different commodities, until it was recognized that the unit cost was the same across commodity types. After calculating cost per ton-mile for each origin and destination pair, the values were plotted on a graph to match them with an equation that resembles the rates ($y = 2.5492x^{-0.584}$). (Figure 17).The R-squared value was found as 0.9572 which exhibits a good correlation between the cost per ton-mile and distances.

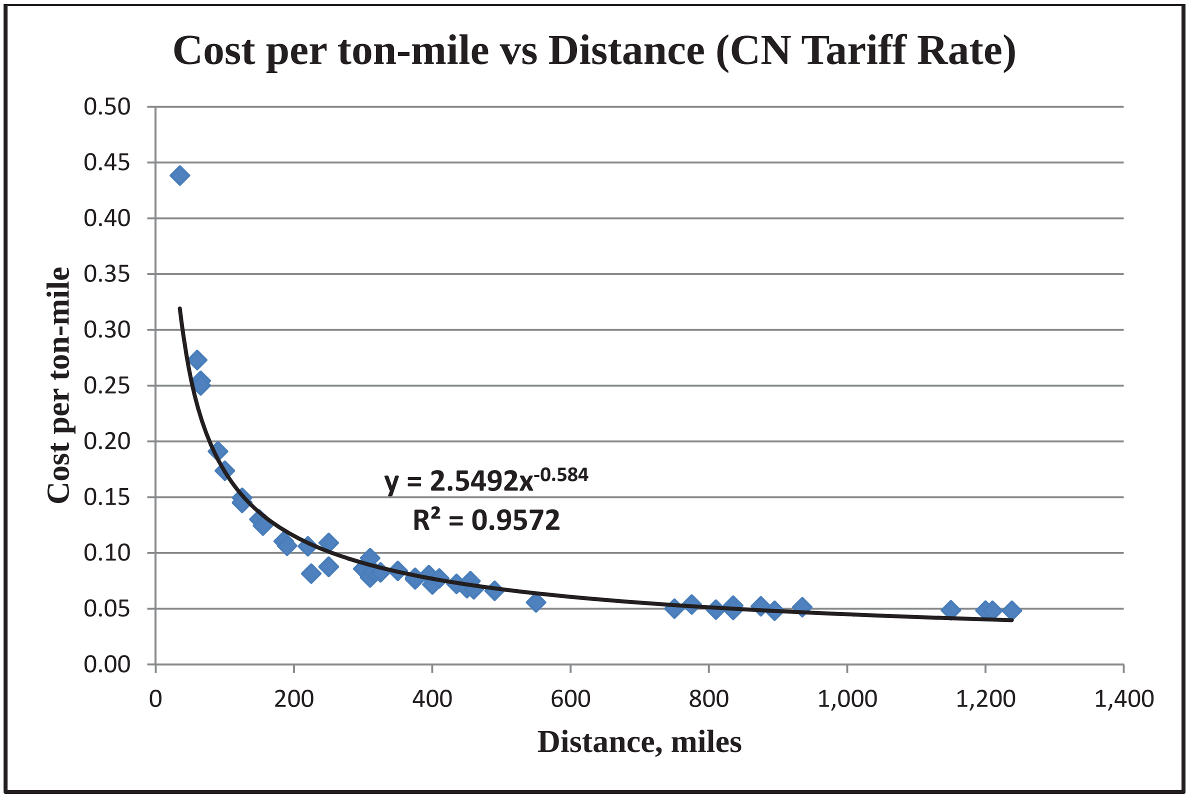

Figure 17: Cost per ton-mile vs distances from CN Tariff rate

When shipment requires an interchange between two railroads such as CN with E&LS or vice versa, there is an additional shipping cost known as interchange fee. The interchange cost varies for different railroads and is not publicly available. The study contacted E&LS railroad to get some values for interchange, but due to confidentiality they could not be provided. Hence, the study assumed the CN tariff rates for calculating rail shipping cost on E&LS lines without including interchange cost.

Transloading Cost

For single mode movements, it is assumed that shipper and receiver are responsible for loading/unloading activities and no separate charge is applied. In multimodal transportation, transloading adds one or two loading/unloading cycles, depending on whether truck drayage is required in one or both ends. Based on expert interviews and past literature, $6 per ton was applied as additional loading/ unloading cost for each transload between truck/rail.

Fuel Surcharges for rail and truck

Fuel surcharges are imposed on rail and truck as per mile basis in addition to fuel price. For trucks, current available online tariff rates were used to determine the base fuel surcharge and findings by Hicks was used to determine the increase in fuel surcharge for every dollar increase in fuel price. CN tariff rates (Rule 7403, mileage based fuel surcharge) were used for calculating fuel surcharges rail along with the increase in fuel surcharge for every dollar increase in fuel price.[43, 78]

The base price for On-Highway Diesel Fuel (HDF) was assumed different for truck (2014) and rail (2008). The base price is provided by Energy Information Administration and it was $3.989 per gallon in February 2014 for On-Highway Diesel Fuel (HDF). From the current tariff rates available online, the base fuel surcharge for truck is approx. $0.65 per mile [80, 81] and assuming payload for truck as 25 tons, the base fuel surcharge converted to $0.0256 per ton-mile. From Hicks’ study, fuel surcharge for truck increases $0.014 per ton-mile for every $1 increase in HDF price. Equation presented in Chapter 3 was used to calculate truck fuel surcharges.

For rail, the base rate of HDF was given as $2.30 in CN tariff rate and fuel surcharges in February 2014 was $0.003180 per ton-mile. Fuel surcharge for rail increases $0.002 per ton-mile for every $1 increase in HDF price (provided in CN tariff rate).

Emissions factors and costs

From past studies the range of emission factors for rail was found to be 15.40 to 41.42 grams per ton-mile with a median of 24.39. CN uses 28.73 grams per ton-mile as emission factor for rail and 183.54 grams per ton-mile for trucks in their carbon calculator. [70] CN also generated truck emission factor from the federal regulations limits which are applicable for both U.S. and Canadian trucks. It was decided that the average between the median value of past studies and CN values should be used for generating emission factors for rail and truck for the UP case study; 26.50 and 160 grams per ton-mile, respectively.

The monetary value of emissions from past studies was found in between \$2.27 to \$36 per ton of CO_2 emission. \$2.27 was considered as an outlier and an average of the remaining range; \$30.5 was selected for the case study. Forkenbrock used his cost values for rural areas in 1994. However, the recent studies in 2012 presented the values which would be applicable for both rural and urban areas.

4.4. UP Case Study results

The following sections describe the outcomes of the calculations and complimentary analysis. The various costs obtained from the calculations spreadsheet were used to further evaluate percent cost savings from multimodal options with various fuel prices, excluding and including emission costs.

4.4.1. Modeling Outcomes for County Based Analysis

For movements from various counties, it was recognized that only Minneapolis and Chicago movements could obtain cost savings from multimodal transportation. The counties surrounding the transload facilities could achieve 2 to 25 percent benefits for Chicago movements with direct rail access at final destination. (Figure 18) In the figure, negative benefits indicate an increase in transport cost with multimodal transport option and positive benefits indicated a decrease in transport cost. For Chicago movements (Figure 19), seven counties would obtain benefits for a transload facility in Amasa, whereas six counties would gain benefits for Nestoria and Ishpeming. (Figure 20).

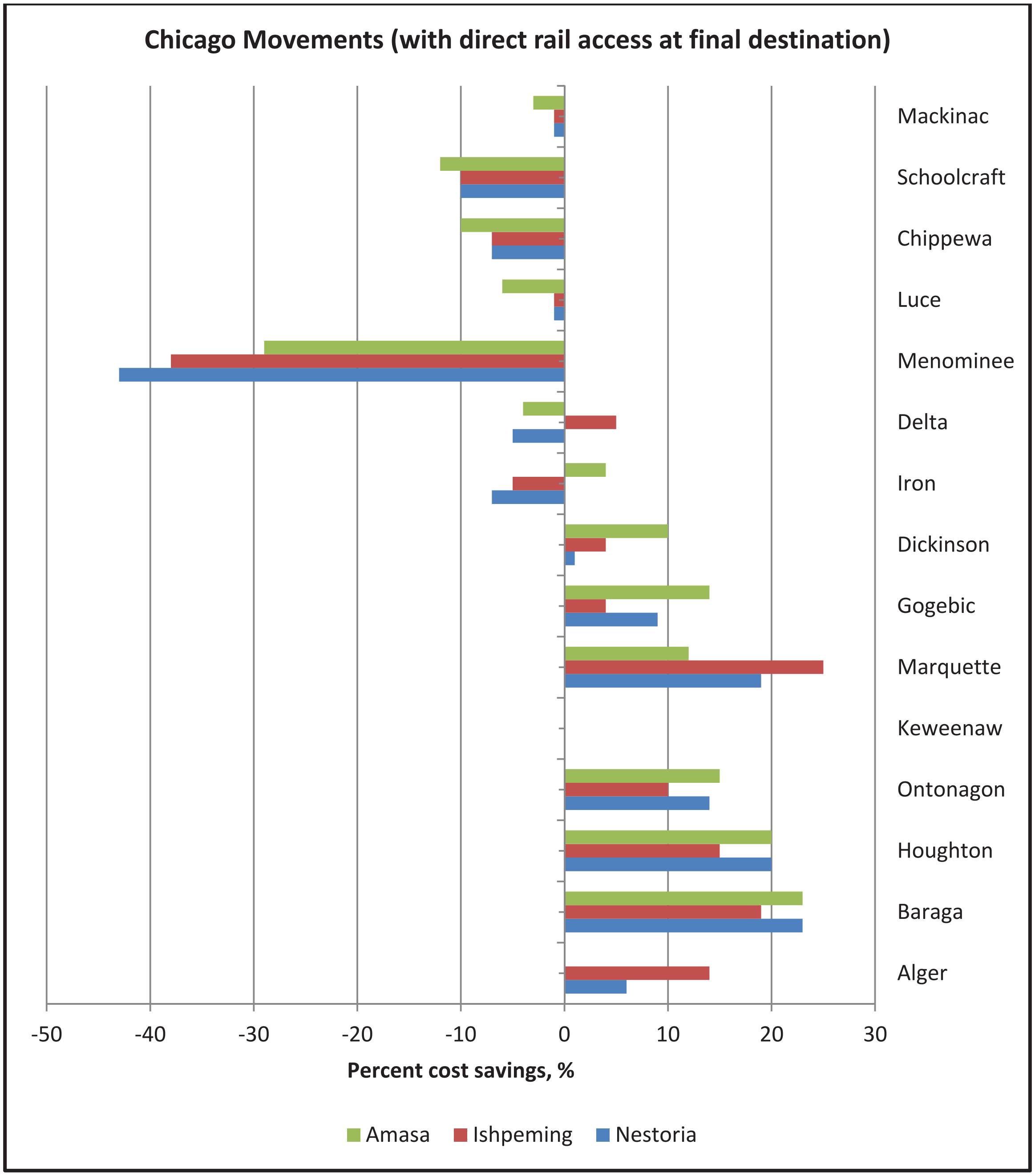

Figure 18: Percent cost savings for Chicago movements (with direct rail access at final destinations)

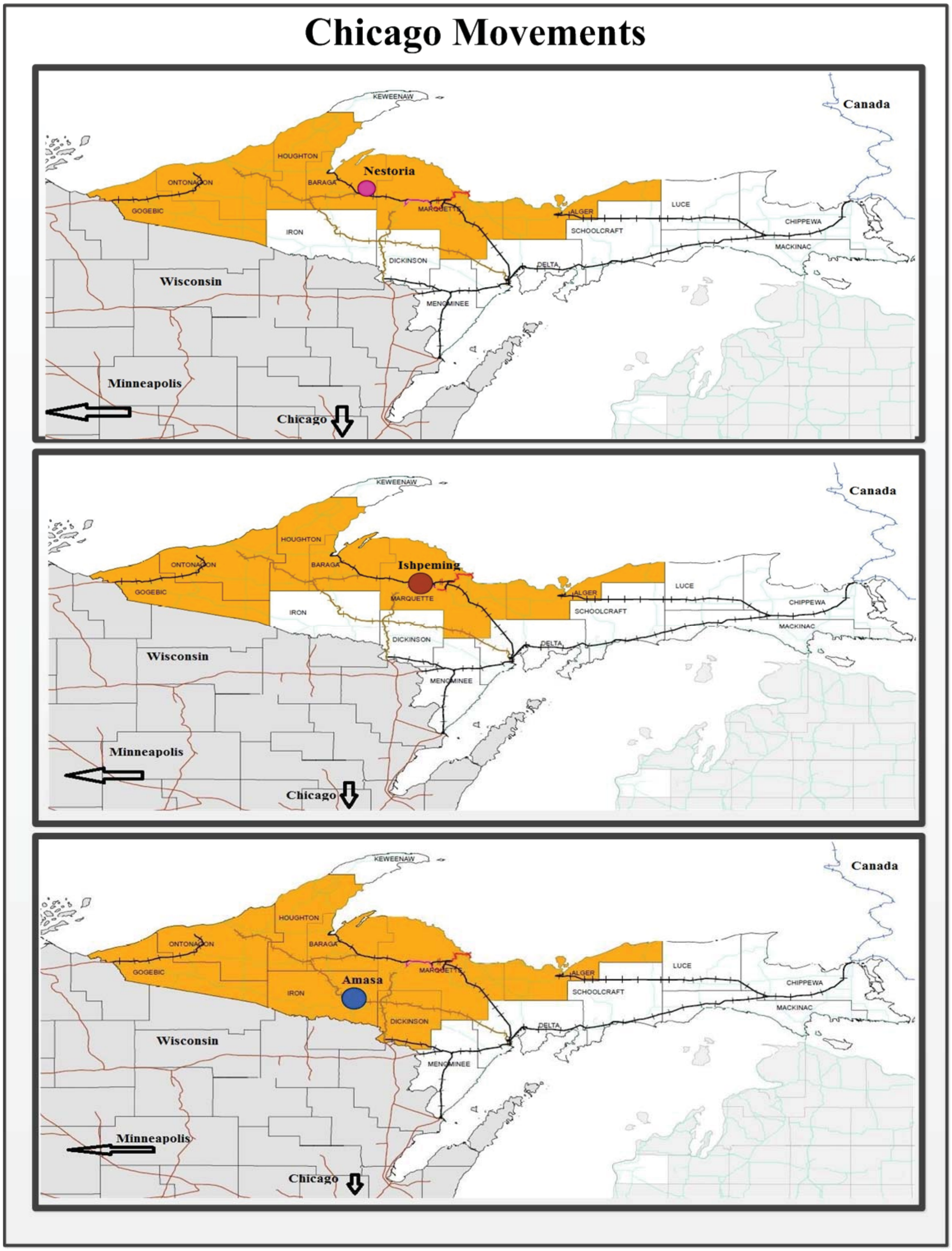

Figure 19: Benefitted counties for Chicago movements

Minneapolis movements were also analyzed for the percent cost savings. With direct rail access, Amasa would provide benefit 2 to 25 percent benefits for twelve counties, whereas Nestoria and Ishpeming would provide benefits for ten counties each.

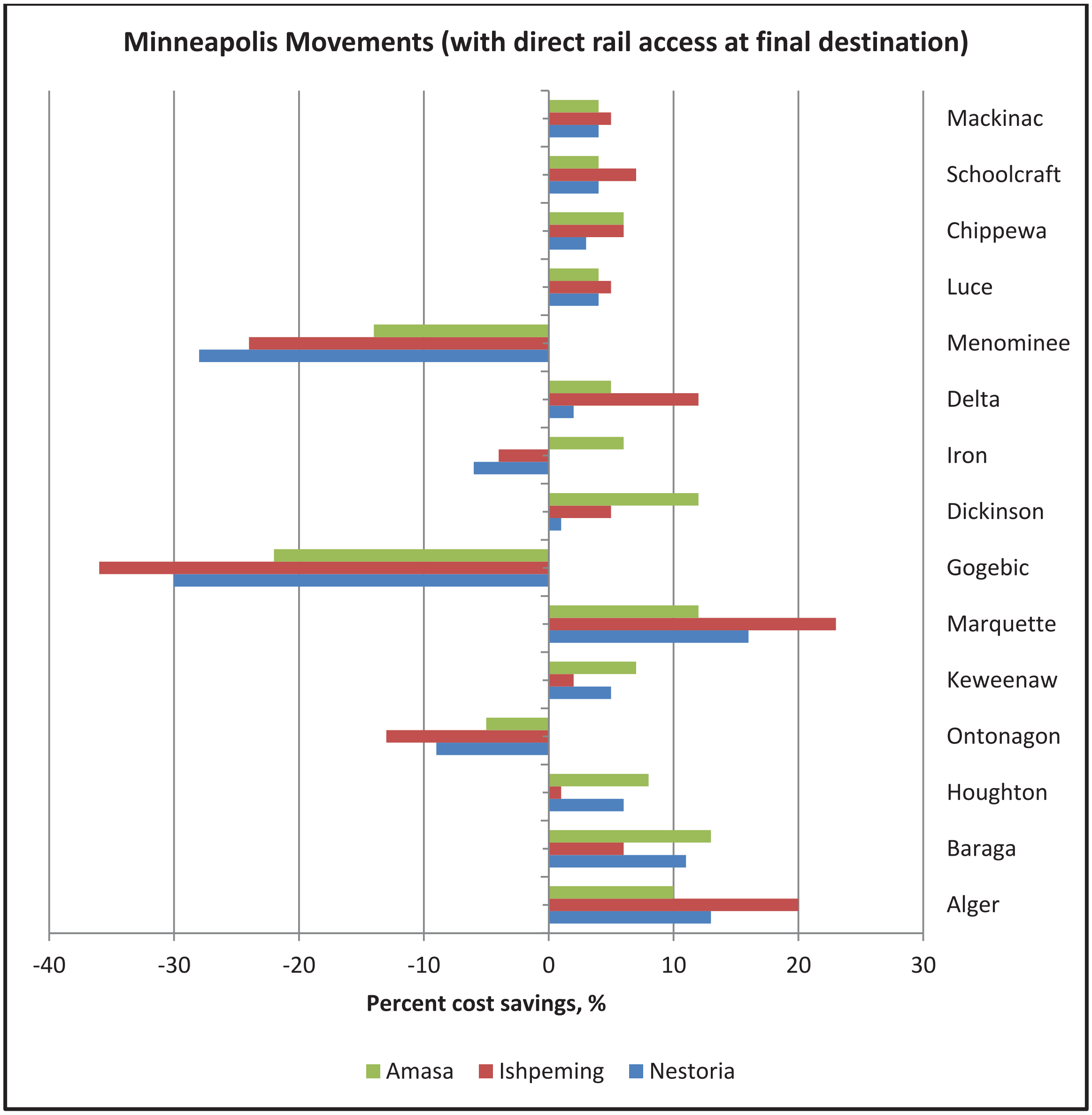

Figure 20: Percent cost savings for Minneapolis movements (with direct rail access at final destinations)

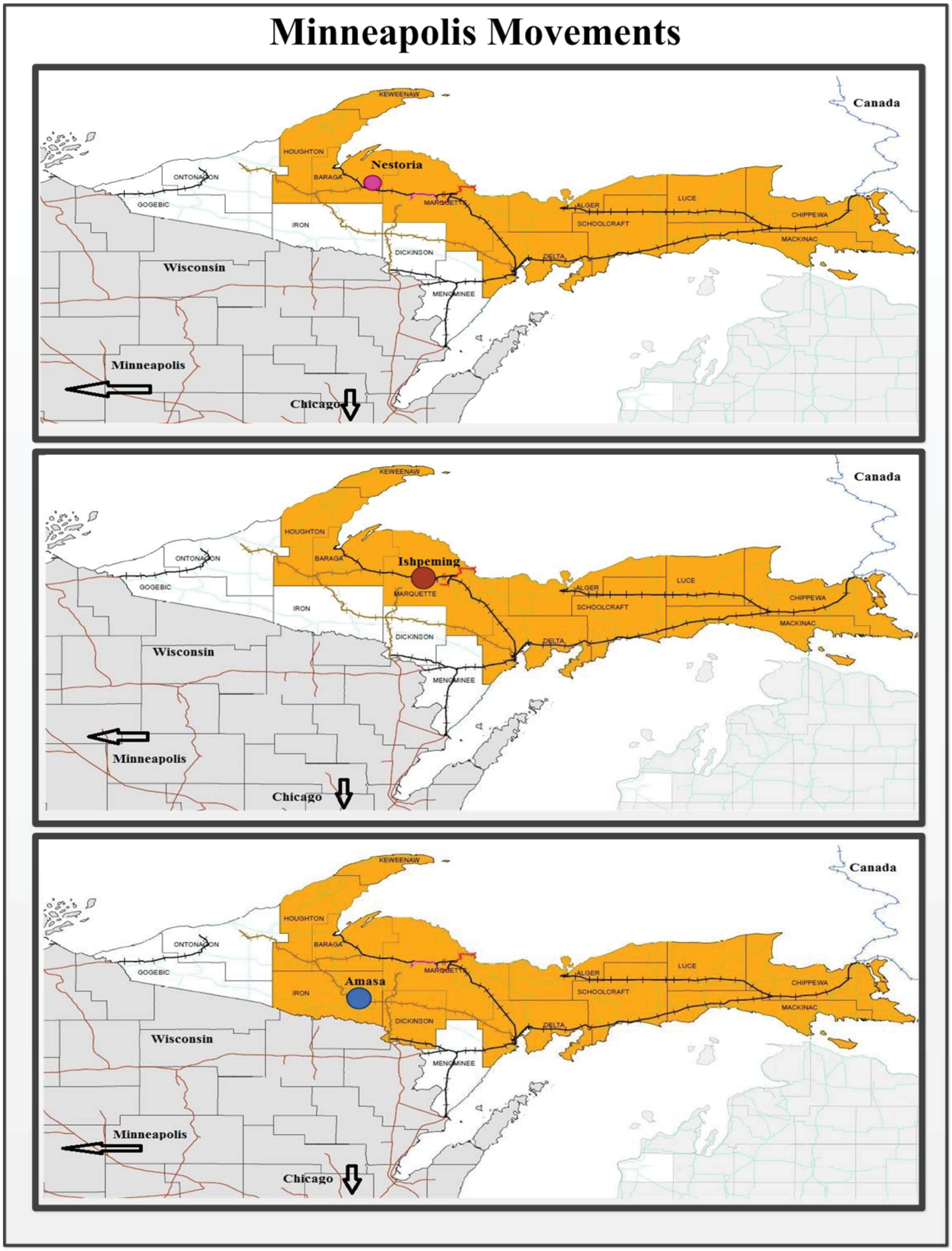

Figure 21: Benefitted counties for Minneapolis movements

If 25 mile truck drayage was added to reach the final destination, no benefit could be obtained for Chicago and Minneapolis movements. (Appendix J and Appendix K)

4.4.2. Effect of Emission Costs

When emission costs were considered, the potential benefits would increase by 1 to 2 percent (Appendix L and Appendix M) The emission cost was found as low because the emission cost calculated based on per ton of CO_2 emission. When the amount of CO_2 were calculated it was found significantly low when converted to ton of CO_2.

4.4.3. Transload facility location comparison

The analysis revealed that Amasa would had the highest potential volume for multimodal alternative. In Figure 22, percent cost savings for individual interstate movements are presented (excluding and including emission), using HDF price $3.898 per gallon (February 2014). For Chicago movements, Nestoria would offer the greatest savings with 22 and 24 percent (with and without emission costs). For Minneapolis movements, Ishpeming would be preferred, providing 20 and 22 percent savings.

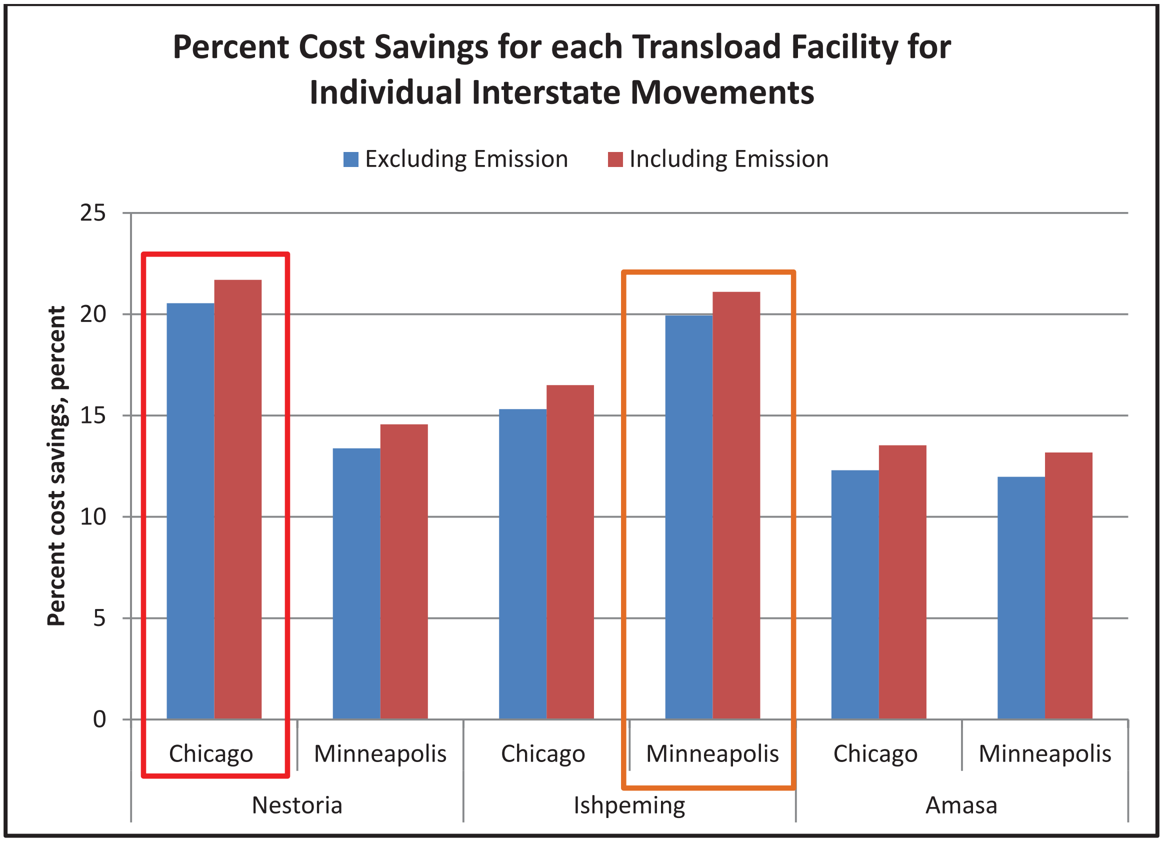

Figure 22: Percent cost savings from each transload facility for Chicago and Minneapolis movements (excluding and including emission)

The total percent cost savings (weighted average) for Chicago and Minneapolis movements (excluding and including emission) are summarized in Figure 23. Ishpeming had the greatest overall potential for savings.

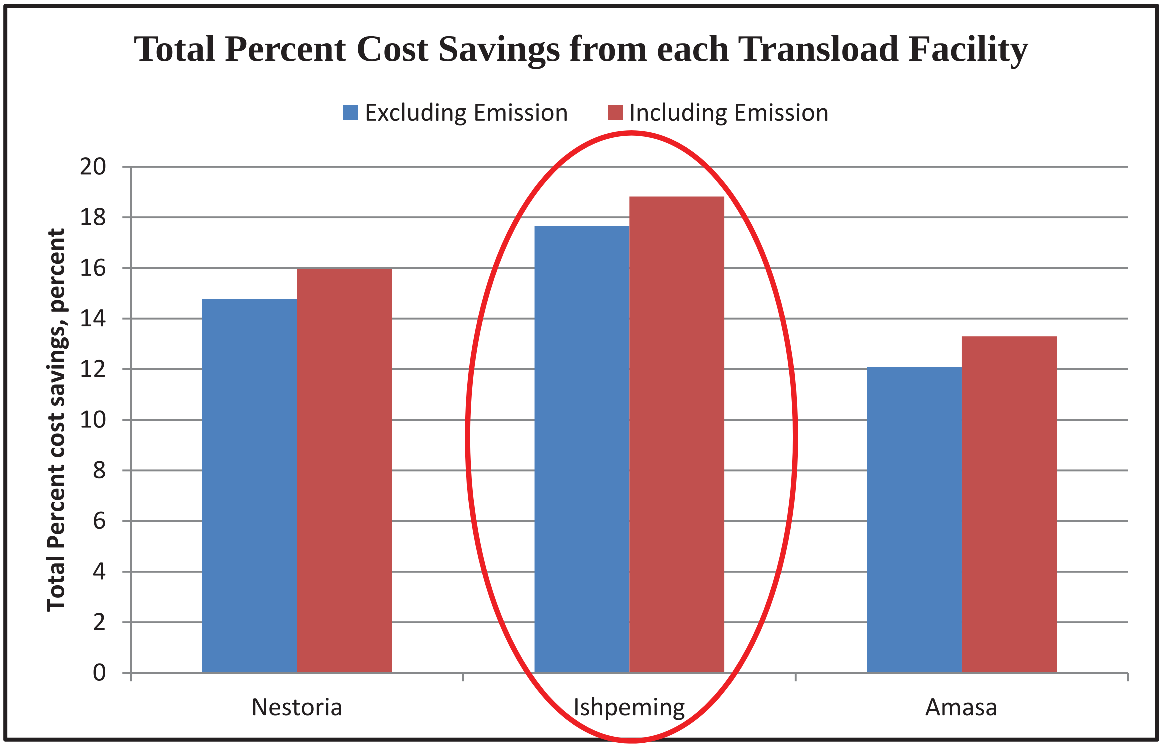

Figure 23: Total percent cost savings from each transload facility for interstate movements (Chicago and Minneapolis)

4.4.3.1. Sensitivity Analysis of Transload Facilities for Different HDF Prices

Three scenarios were created to analyze the variation of percent cost savings with different fuel prices for both truck and multimodal transport options. The sensitivity analysis was conducted for HDF price $3, $5 and $6 per gallon.

Figure 24 presents sensitivity analysis for Chicago movements with direct rail access at final destinations and Figure 26 for Minneapolis. Nestoria shows dominance over other two facilities for Chicago movements and Ishpeming for Minneapolis movements, in terms of percent cost savings. For every $1 increase in fuel prices, percent cost savings from multimodal option for such movements increased by approx. 3.5 to 4.5 percent.

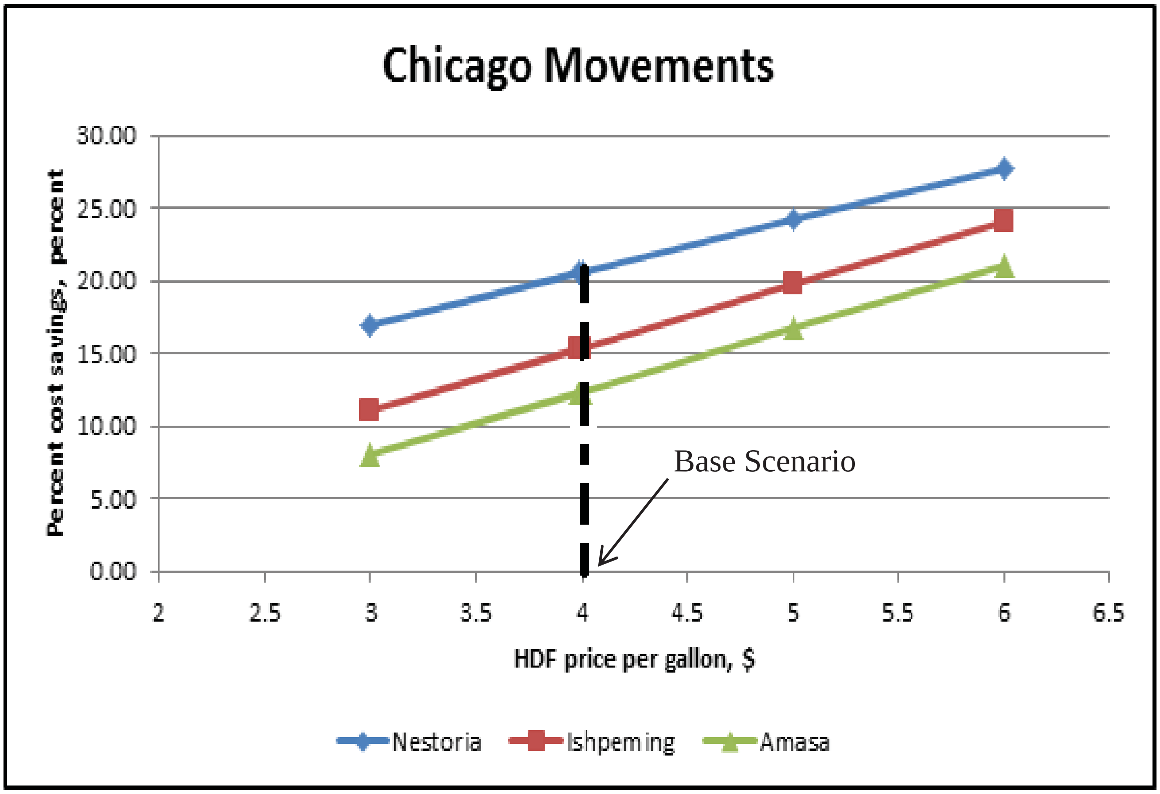

Figure 24: Sensitivity analysis of percent cost savings from each transload facility for different HDF prices for Chicago movements

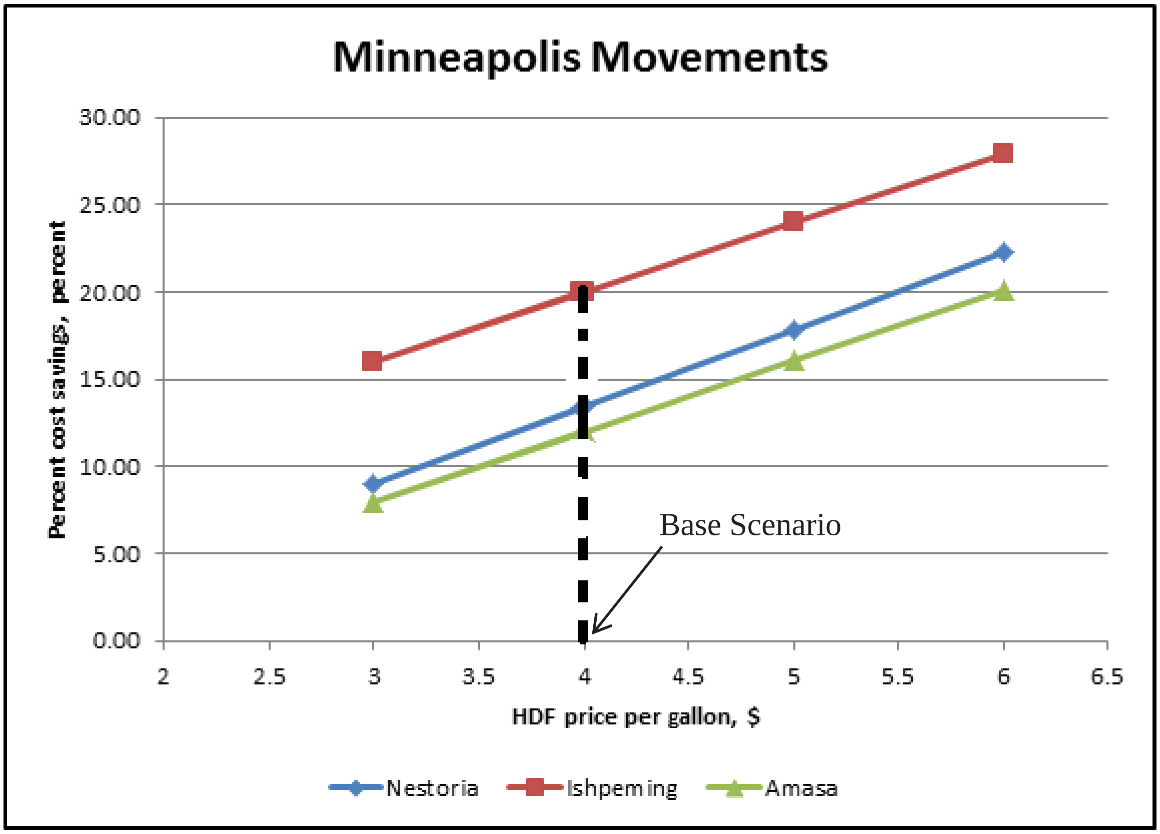

Figure 25: Sensitivity analysis of percent cost savings from each transload facility for different HDF prices for Minneapolis movements

4.5. Findings from the UP Case Study

- Based on the cost parameters used for shipping, emission, handling and fuel surcharge costs for truck and rail, only Chicago and Minneapolis movements with direct rail access would gain benefits from transload facilities.
- Ishpeming would be preferred for Minneapolis movements. On the other hand, Nestoria would be preferred for Chicago movements. (Figure 22)
- Ishpeming was found better for maximum overall percent cost savings because of its lowest distance from the benefitted counties.
- From volume perspective Amasa would be better and from cost savings perspective Ishpeming would be better.

- If emission cost is included, an additional 1 to 2 percent can be saved for using transload facility. (Appendix L and Appendix M)
- For $1 increase in HDF prices, percent cost savings would increase 3 to 5 percent for using multimodal option. (Figure 24 and Figure 25)
- Amasa would provide potential benefits to maximum number of counties for both Chicago and Minneapolis movements. (Figure 19 and Figure 21)

CHAPTER FIVE: CASE STUDIES FOR TWO MICHIGAN UP COMPANIES

5.1. Introduction

Due to lack of accuracy on TRANSEARCH data, the analysis was expanded into two specific case studies, DA Glass America and Northern Hardwoods, who were able to provice more specific data parameters. Even with case studies, the research did not look into the movements beyond Chicago and Minneapolis due to lack of information on rail shipping and interchange cost. Figure 26 illustrates the location of two companies, as it related to the three potential transload locations in the UP.

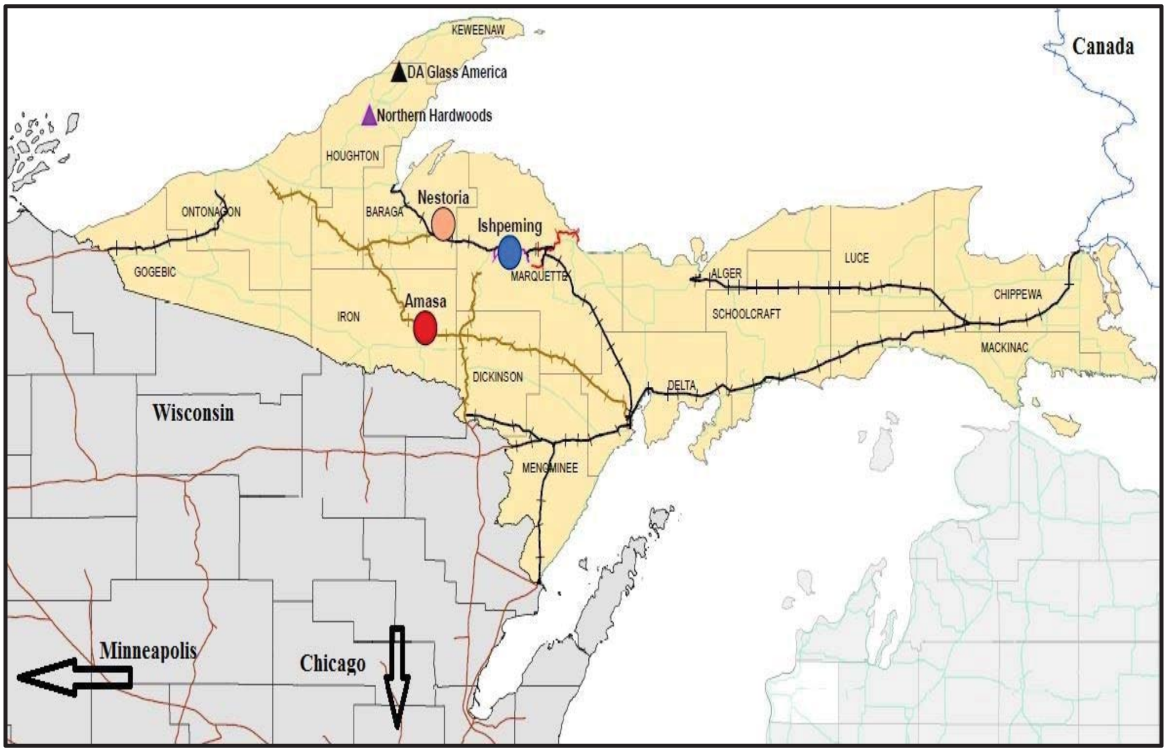

Figure 26: Case study companies' locations

5.2. DA Glass America

DA Glass America is located Near the Houghton County Memorial Airport, between Hancock and Calumet, Michigan. The company is planning to start operations in early 2014. The company will employ 30 employees to produce anti-reflective glass and process sheet glass for Greenhouses. Their main shipping destinations include Wisconsin; southwestern USA; and California and they are very interested in multimodal opportunities. Shipments would use containers filled by their glass products (24 tons each). They expect approximately 1,200 outbound and inbound container movements to Carlton, Wisconsin. The study was going to compare truck option with multimodal alternative for their container shipments to Wisconsin, but it was found that the short distance and volume would make it extremely unlikely scenario for intermodal movements, even if an intermodal facility was already existing. For this reason, the analysis was abandoned.

5.3. Northern Hardwoods

Northern Hardwoods is located in South Range, MI. They manufacture lumber products and are currently shipping around 70 percent of their volume to Wisconsin (New London, De Pere, Theresa and Mercer) and the rest to Minneapolis (St. Cloud and Maple Grove) using flatbed cars (used for lumber transport). Some of the Minneapolis movements are further transloaded to trains for more distant destinations. Northern Hardwoods is also interested in export opportunities to Asia, but lack of multimodal opportunities is impeding the development of global business. This study compared their truck option with multimodal for their shipments to Minneapolis and locations in Wisconsin.

5.3.1. Development of Parameters for Northern Hardwoods

Rail Rates

Northern hardwoods would use centerbeam cars for their rail shipments, so their rail rates used the ones based on CN tariff rates, as presented in Chapter 4: Input Data Sources and Preparation.

Truck Rates

In the UP case study, the unit cost for interstate truck movements was $0.15 per ton-mile. For these movements, the study used the flat rate of $0.15 per ton-mile. If the company shipped their products to a transload facility in the UP, they would be using Michigan trucks with higher carrying capacity. Using Michigan trucks would give them the opportunity to lower their operating cost per ton-mile by 50%, leading into $0.075 per ton-mile as the rate for the drayage to the potential transload location.

Fuel Surcharges / Transloading / Emission Costs

Values for fuel surcharges, transloading and emission costs used value and formulas presented in Chapter 4 : Costs Parameters.

5.3.2. Study results for Northern Hardwoods

For Northern Hardwoods, the distances for truck and multimodal for Wisconsin movements are presented in Figure 27. For Wisconsin, there are 4 destinations. The distances for the destinations were taken as weighted average.

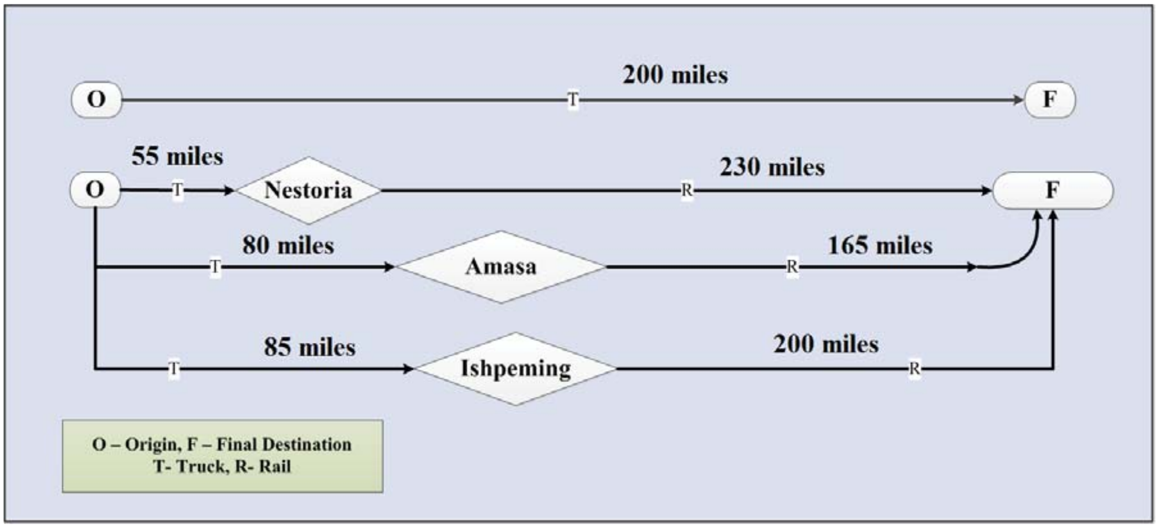

Figure 27: Distances for Northern Hardwoods for truck only and multimodal option with rail access in final destination (Wisconsin movements)

Figure 28 summarizes multimodal cost savings over truck option for Wisconsin movements, with and without emission costs. The analyses were done with and without direct rail access (25 miles) in the final destination. This also included sensitivity analysis for different HDF prices. The analysis found that without direct access by rail at final destination, no benefits could be gained for Wisconsin movements, mainly due to short overall distances. All the locations provided potential benefits, but Amasa would be the preferred location (approx. 8 to 20 percent) for current and higher fuel prices.

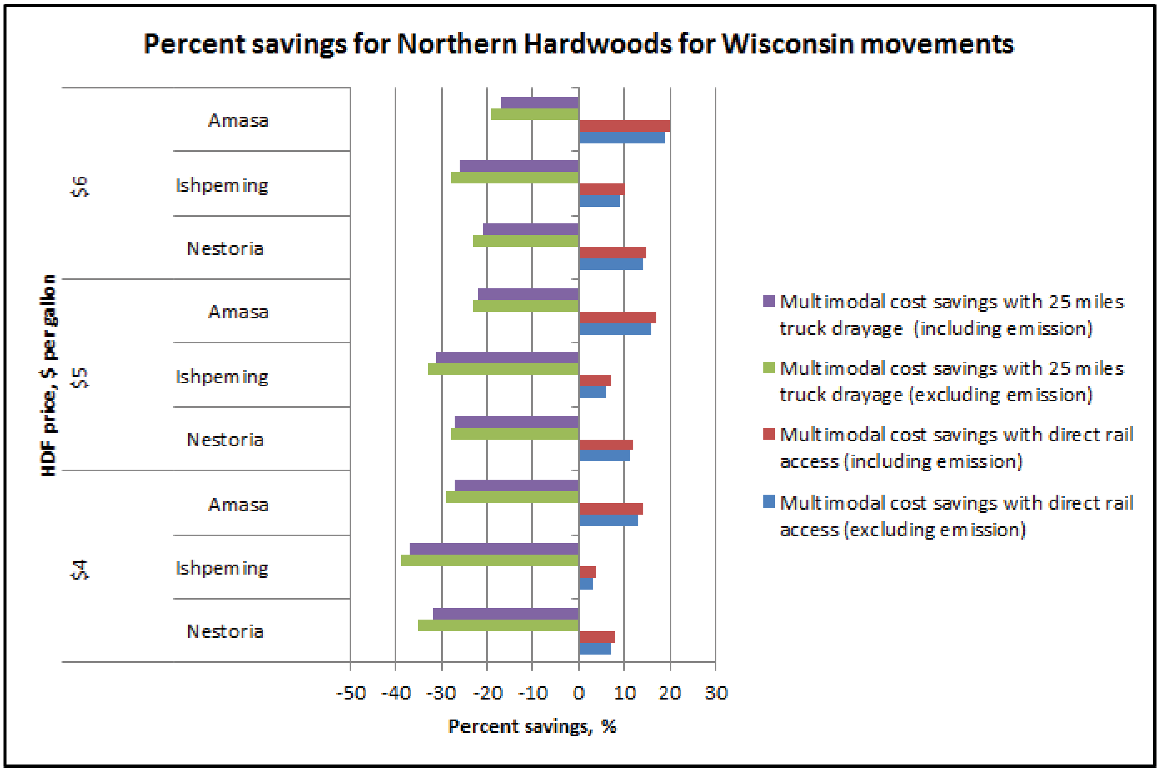

Figure 28: Multimodal cost savings for Northern Hardwoods (Wisconsin movements) using transload facility

For Northern Hardwoods, the distances for truck and multimodal for Minneapolis movements (weighted average distance for St. Cloud and Maple Grove) are presented in Figure 29. For truck only option, the distance was 360 miles. Amasa transload facility offered the shortest total multimodal distance (350 miles).

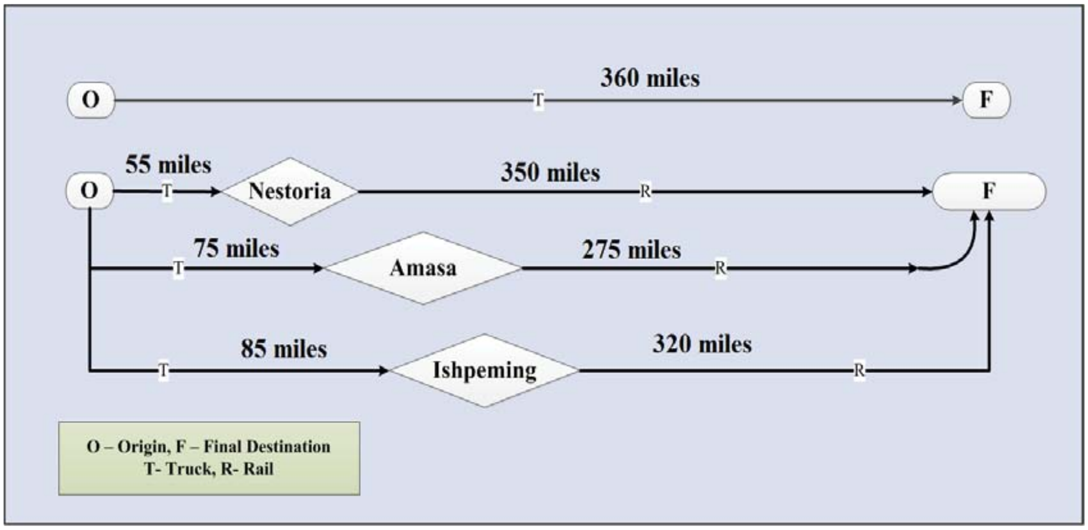

Figure 29: Distances for Northern Hardwoods for truck only and multimodal option (Minneapolis movements)

Figure 30 summarizes multimodal cost savings over the truck option for Minneapolis movements for Northern Hardwoods. The analyses were done with and without direct rail access (25 and 50 miles final truck drayage) in the final destination. This also included sensitivity analysis for different HDF prices. All transload locations would provide benefits for current and higher HDF prices, but Amasa would be the preferred location. Movements to Minneapolis have potential to gain benefits, even if 25 or 50 miles drayage were required to reach the final destination.

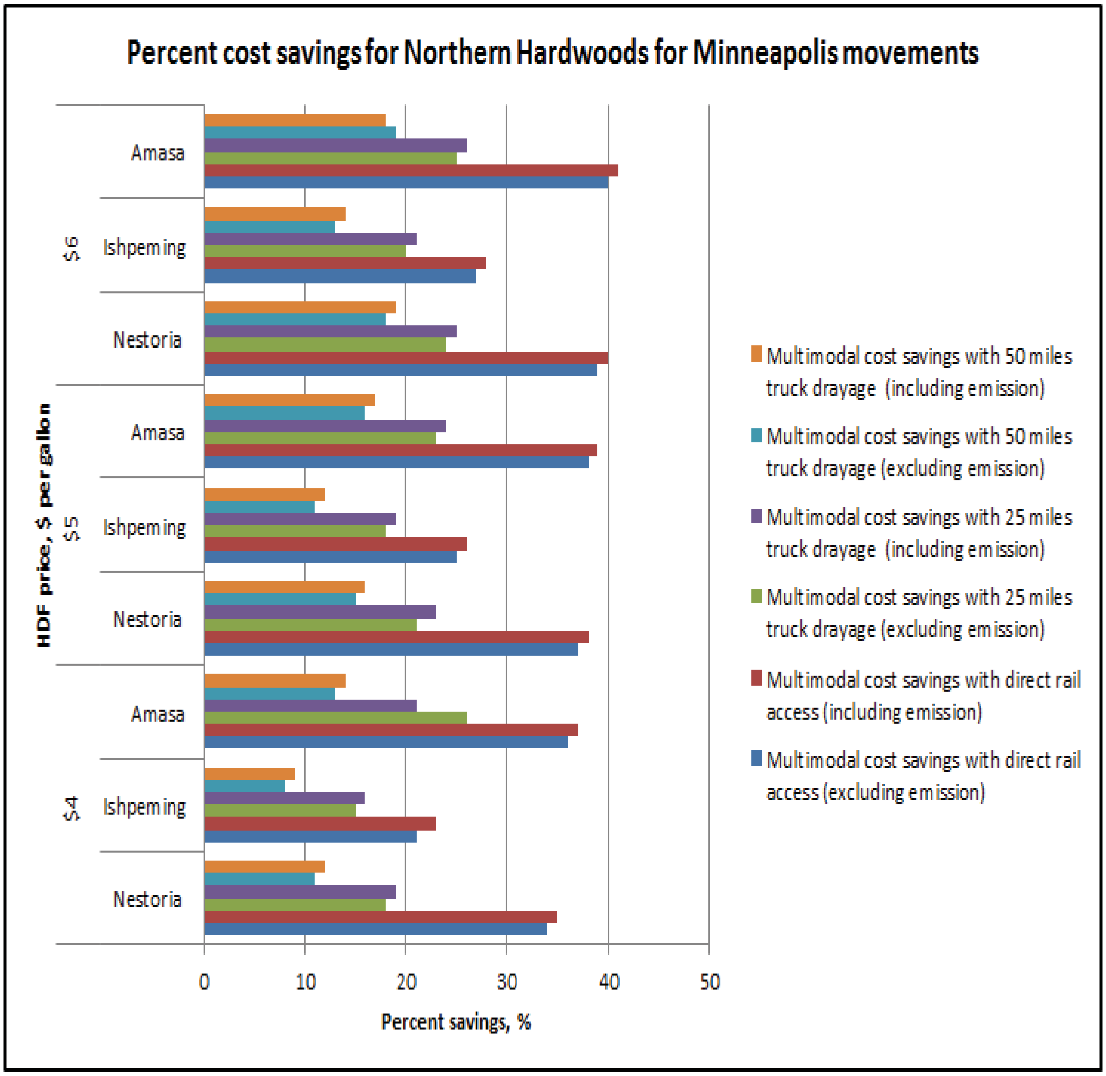

Figure 30: Multimodal cost savings for Northern Hardwoods (Minneapolis movements) using transload facility

CHAPTER SIX: CONCLUSIONS AND FUTURE RESEARCH

6.1. Conclusions

The objective of this research was to investigate whether a combination of two or more modes of transportation, also known as intermodal or multimodal transport, would provide any potential cost savings to the shippers in the Upper Peninsula of Michigan. The research developed a calculation methodology to evaluate the potential savings with and without consideration for emission costs. The analysis included sensitivity analysis of such savings to changing in fuel prices.

The research used three potential locations, Nestoria, Amasa and Ishpeming for transload facilities. The selection of locations was based purely on shipper and railroad input. TRANSEARCH 2009 database was used to evaluate the savings potential at the county level and a specific case study of Northern Hardwoods to do the same at the company level. Unfortunately, the analysis was limited to movements to/from Wisconsin, Chicago and Minneapolis, as rail rate information shipment beyond these locations could not be secured.

The calculation results showed potential cost benefits from multimodal alternatives for the counties that surrounded the potential transload facilities. The savings were present from all three potential transload locations, but could only be realized for Chicago and Minneapolis movements and only, if there was rail access to final destination, eliminating the need for final truck drayage. For Northern Hardwoods, movements to most distant locations in Wisconsin would also provide cost savings, partially due to the possibility of using Michigan trucks with higher carrying capacity for the initial movement from the facility to transload location. In addition, Minneapolis movements were found to provide savings even without final rail access. Sensitivity analysis was conducted for different On-Highway Diesel Fuel (HDF) prices and for every dollar increase in HDF price it was found that percent cost savings for multimodal option increased by 3 to 5 percent.

Emission costs, on the other hand, were quite insignificant adding only 0.5 to 2 percent in cost savings.

While the study showed some potential for savings from multimodal freight options, it is recognized that the effort was greatly hampered by insufficient data. Especially the limitation of origin/destination data accuracy made analysis results questionable and the omission of trips that go beyond Chicago and Minneapolis removed the trips with greatest potential for multimodal options from the research pool.

6.2. Future Research

For future work the following points should be considered

- There is a need for a better understanding of freight movements in the UP.
- If detailed freight shipment data could be secured, a study could be conducted to identify the optimal location for a transload facility, including the potential volumes.
- Rail interchange cost should be understood to allow the inclusion of the most potential trips for multimodal alternative.
- This analysis concentrated purely on shipping costs. For a more comprehensive analysis of potential transload facility establishment, capital and maintenance costs and long term cost-benefit analysis, should be included to understand the sustainability of such development.

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Appendix A: Example of calculating transport cost for truck drayage to transload facility (multimodal)

County/ Township of origin	Outbound for	Volume	Distance to transload facility	Unit Shipping Cost	Shipping Cost	Emission (ton of CO2)	Emission Cost	Weighted Distance	Fuel Surcharge
Alger	Wisconsin	161,951	85	0.15	2064875.25	2202.5336	67177.2748	83.91194573	4729228.928
Baraga	Wisconsin	153,469	30	0.15	690610.5	736.6512	22467.8616		
Houghton	Wisconsin	94,186	60	0.15	847674	904.1856	27577.6608		
Ontonagon	Wisconsin	95,120	75	0.15	1070100	1141.44	34813.92		
Keweenaw	Wisconsin	44,534	100	0.15	668010	712.544	21732.592		
Marquette	Wisconsin	132,100	40	0.15	792600	845.44	25785.92		
Gogebic	Wisconsin	231,132	95	0.15	3293631	3513.2064	107152.7952		
Dickinson	Wisconsin	388,618	70	0.15	4080489	4352.5216	132751.9088		
Iron	Wisconsin	300,645	65	0.15	2931288.75	3126.708	95364.594		
Delta	Wisconsin	196,213	95	0.15	2796035.25	2982.4376	90964.3468		
Menominee	Wisconsin	403,572	140	0.15	8475012	9040.0128	275720.3904		
					27710325.75	29557.6808	901509.2644		

Appendix B: Example of calculating rail transport cost for transporting out of state (multimodal)

Transload Facility	Outbound for	Volume	Distance from transload facility to out of state	Unit Shipping Cost	Shipping Cost	Emission (tons of Co2)	Emission Cost	Fuel Surcharge
Nestoria	Wisconsin	2,201,540	220	0.1093	52914942.15	12834.9782	391466.8351	1540197.384

Appendix C: Example of calculating final truck drayage cost (multimodal)

Volume	Distance to Final destination	Unit Shipping Cost	Shipping Cost	Emission (ton of CO2)	Emission Cost	Loading/ Unloading Cost	Fuel Surcharge
2,201,540	25	0.15	8255775	8806.16	268587.88	13209240	1408985.6

Appendix D: Example of calculating transport cost for "truck only" transport

County/ Township of origin	Outbound for	Volume	Distance of transport	Unit Shipping Cost	Shipping Cost	Emission (ton of CO2)	Emission Cost	Weighted Distance	Fuel Surcharge
Alger	Wisconsin	161,951	230	0.15	5587309.5	5959.7968	181773.8024	145.7806263	8216112.128
Baraga	Wisconsin	153,469	150	0.15	3453052.5	3683.256	112339.308		
Houghton	Wisconsin	94,186	170	0.15	2401743	2561.8592	78136.7056		
Ontonagon	Wisconsin	95,120	130	0.15	1854840	1978.496	60344.128		
Keweenaw	Wisconsin	44,534	210	0.15	1402821	1496.3424	45638.4432		
Marquette	Wisconsin	132,100	180	0.15	3566700	3804.48	116036.64		
Gogebic	Wisconsin	231,132	125	0.15	4333725	4622.64	140990.52		
Dickinson	Wisconsin	388,618	130	0.15	7578051	8083.2544	246539.2592		
Iron	Wisconsin	300,645	100	0.15	4509675	4810.32	146714.76		
Delta	Wisconsin	196,213	200	0.15	5886390	6278.816	191503.888		
Menominee	Wisconsin	403,572	125	0.15	7566975	8071.44	246178.92		
					48141282	51350.7008	1566196.374		

Appendix E: Example of summary of "truck only" and multimodal transport cost

Scenarios		Loading truck	Drayage to transload		Unloading truck	loading rail	rail haul		unloading rail	drayage to final destination				Fuel Surcharge	Total Rail Cost			
			Shipping cost	Emission cost			Shipping cost	Emission cost		Loading	Shipping cost	Emission cost	Unloading		Excluding emission and excluding drayage at the end	Excluding emission and including drayage at the end	Including emission and excluding drayage at the end	Including emission and including drayage at the end
Truck only Transport	Loading	0																
	Shipping	48,141,282																
	Emission	1,566,196																
	Unloading	0																
	Fuel Surcharge	8,216,112																
Total truck cost excluding emission		56,357,394																
Total truck cost including emission		57,923,591																
Multimodal transport	if rail has direct acces to final destination	0	27,710,326	901,509	0	13,209,240	52,914,942	391,467	13,209,240					6,269,426	113,313,174		114,606,150	
	if rail doesn't have direct access and a drayage 25 miles	0	27,710,326	901,509	0	13,209,240	52,914,942	391,467	13,209,240	13,209,240	8,255,775	268,588	13,209,240	7,678,412		149,396,415		150,957,979

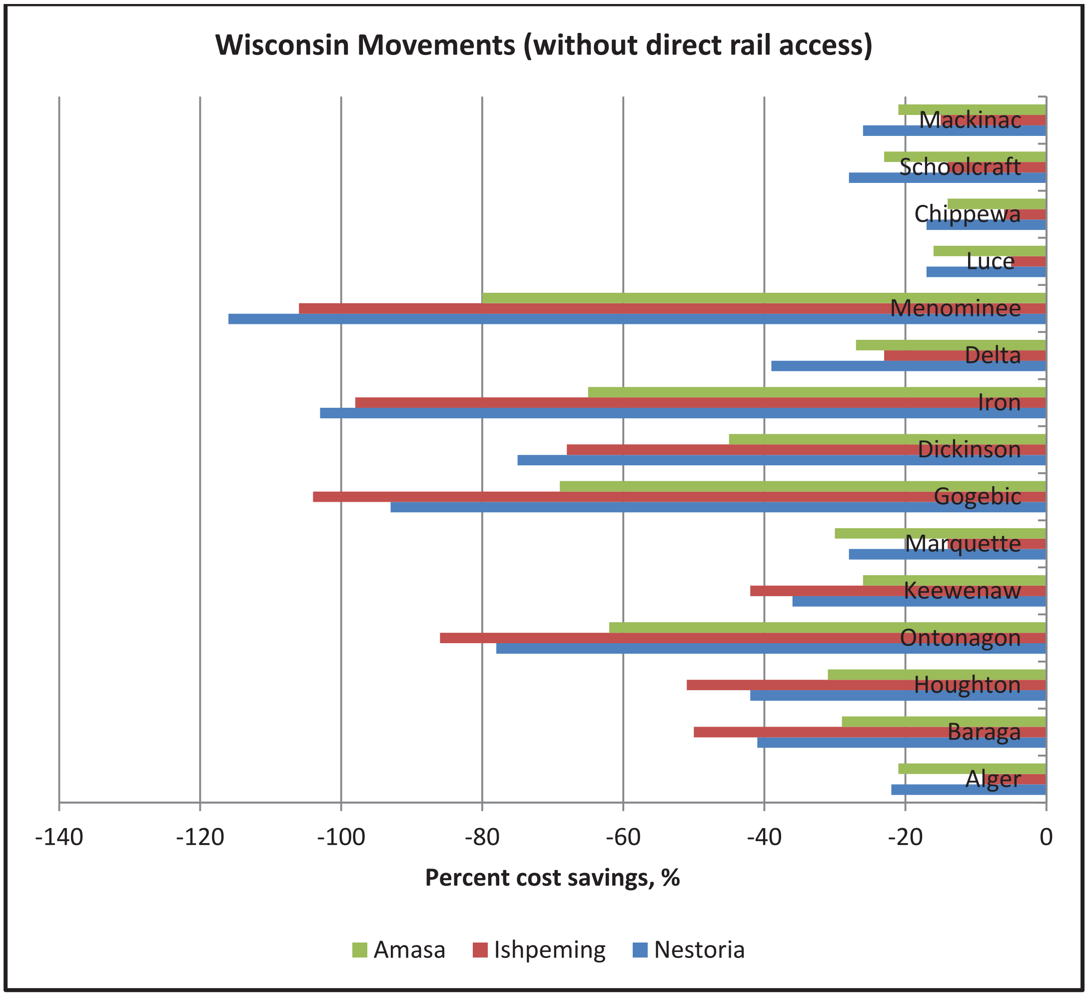
Appendix F: Example of calculating percent change of cost for using multimodal (excluding emission)

	Excluding Emission		Excluding Emission	
	Using Transload facility (Without direct access to rail)	Truck Only	Using Transload facility (With direct access to rail)	Truck Only
Cost per ton (USD)	67.86	25.60	51.47	25.60
Increase in cost per ton percent if emission is excluded	-165		-101	

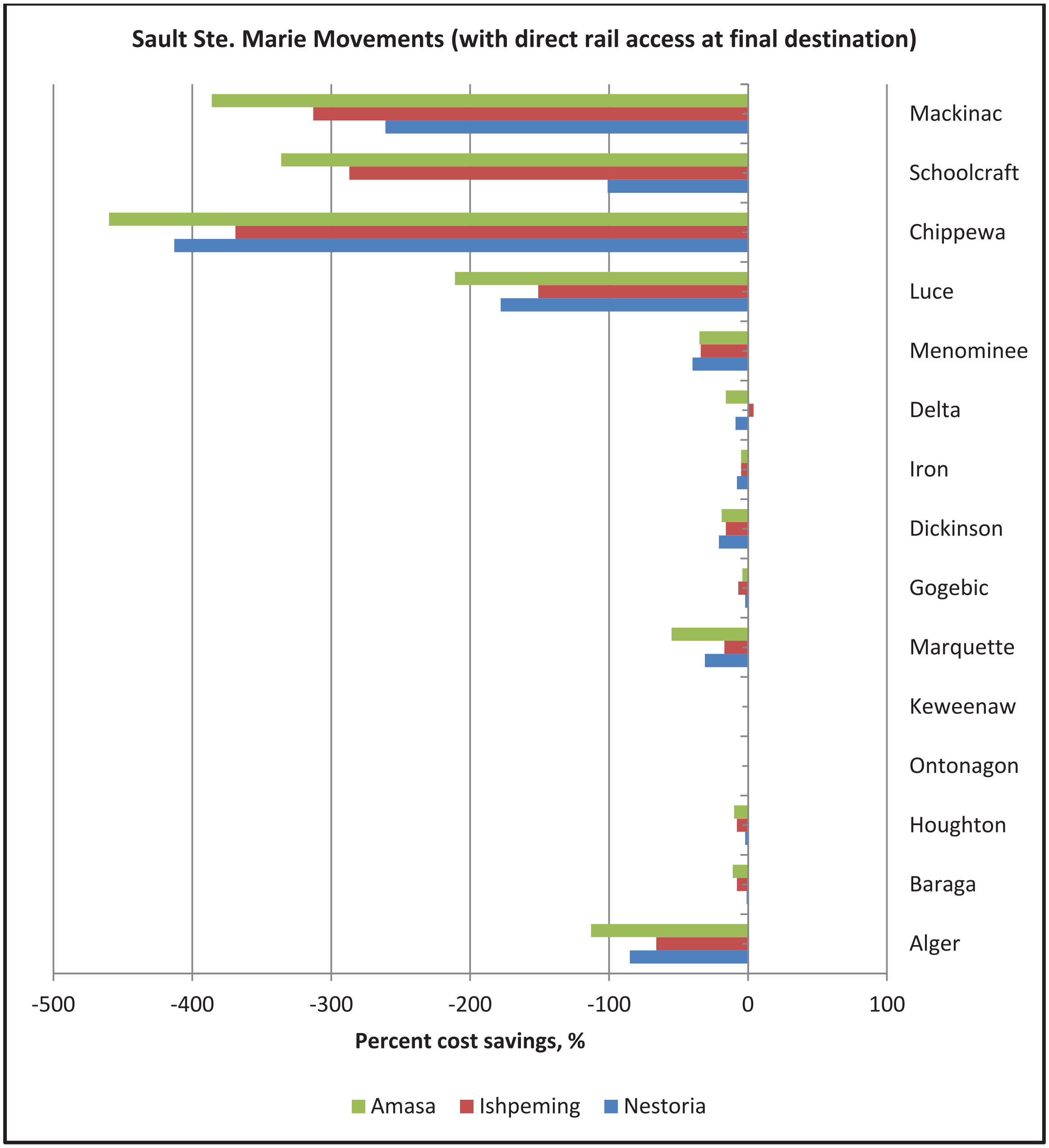
Appendix G: Example of calculating percent change of cost for multimodal (including emission)

	Including Emission		Including Emission	
	Using Transload facility (Without direct access to rail)	Truck Only	Using Transload facility (With direct access to rail)	Truck Only
Cost per ton (USD)	68.57	26.31	52.06	26.31
Increase in cost per ton percent if emission is included	-161		-98	

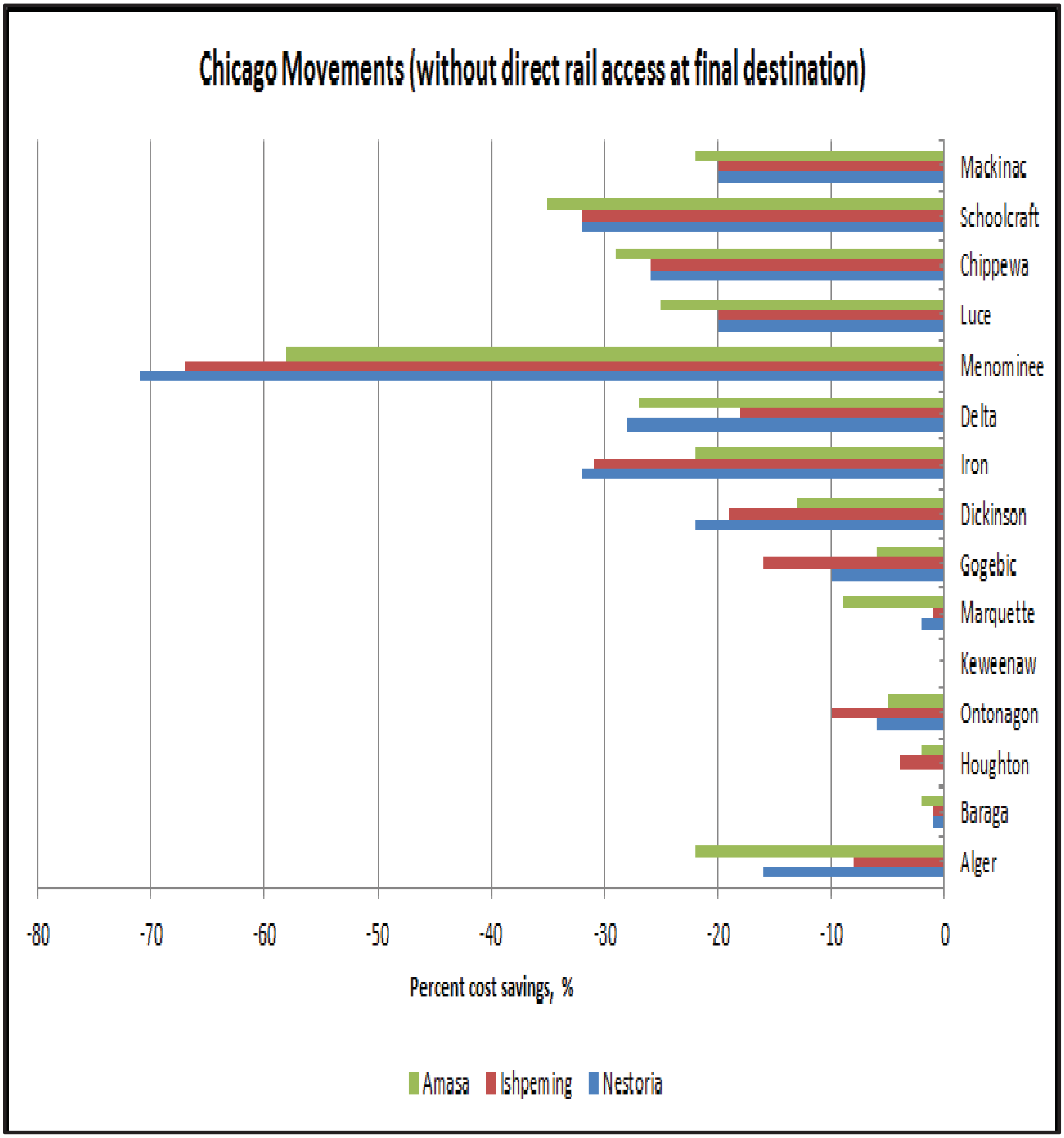
Appendix H: Exhibit of percent cost savings for Wisconsin movements (negative value means increase in cost savings for multimodal)



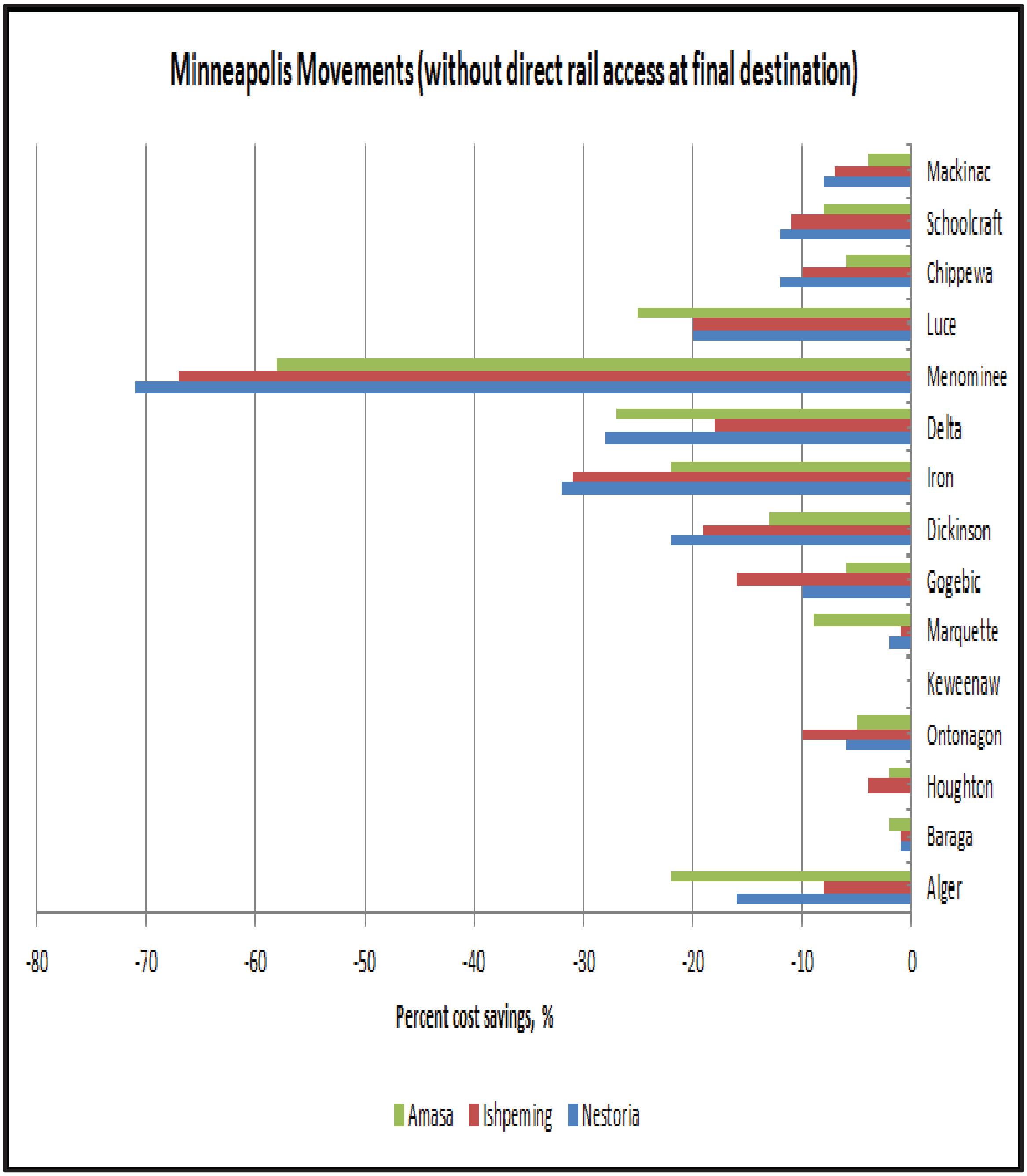
Appendix I: Exhibit of percent cost savings for Sault Ste. Marie movements (with direct rail access at final destinations) (negative value means increase in cost savings for multimodal)



Appendix J: Exhibit of percent cost savings for Chicago movements (with 25 mile truck drayage at final destinations) (negative value means increase in cost savings for multimodal)



Appendix K: Exhibit of percent cost savings for Minneapolis movements (without direct rail access at final destinations) (negative value means increase in cost savings for multimodal)



Appendix L: Summary table of percent cost savings from each transload location (direct rail access at final destinations), if emission cost is excluded

Counties	Wisconsin			Chicago			Minneapolis			Sault Ste. Marie		
	Nestoria	Ishpeming	Amasa	Nestoria	Ishpeming	Amasa	Nestoria	Ishpeming	Amasa	Nestoria	Ishpeming	Amasa
Alger	-20	-7	-20	7	15	1	14	22	11	-84	-64	-112
Baraga	-39	-48	-28	24	20	24	12	7	14	0	-6	-9
Houghton	-40	-49	-29	21	16	21	7	2	9	0	-7	-9
Ontonagon	-76	-84	-6	15	11	16	-7	-12	-4			
Keewenaw	-34	-41	-25				7	3	8			
Marquette	-26	-13	-28	20	27	13	17	25	13	-29	-16	-54
Gogebic	-91	-102	-68	11	5	15	-29	-35	-20	0	-6	-3
Dickinson	-74	-67	-43	2	5	11	3	6	13	-20	-15	-17
Iron	-157	-97	-63	-6	-4	5	-5	-3	8	-7	-4	-3
Delta	-37	-21	-26	-4	6	-3	4	13	7	-8	5	-15
Menominee	-115	-105	-78	-42	-37	-28	-27	-22	-13	-39	-33	-34
Luce	-15	-4	-15	0	0	-5	5	6	5	-177	-150	-210
Chippewa	-16	-5	-13	-6	-6	-9	4	7	7	-412	-367	-459
Schoolcraft	-26	-13	-22	-9	-9	-11	5	8	5	-100	-286	-335
Mackinac	-24	-14	-20	0	0	-2	5	6	5	-260	-312	-385

Appendix M: Summary table of percent cost savings from each transload location (25 miles truck drayage at final destinations), if emission cost is included

Counties	Wisconsin			Chicago			Minneapolis			Sault Ste. Marie		
	Nestoria	Ishpeming	Amasa	Nestoria	Ishpeming	Amasa	Nestoria	Ishpeming	Amasa	Nestoria	Ishpeming	Amasa
Alger	-51	-38	-51	-14	-6	-20	-4	3	-8	-131	-111	-159
Baraga	-81	-90	-70	5	0	5	-9	-14	-7	-30	-36	-39
Houghton	-79	-88	-68	3	2	3	-14	-19	-12	-28	-34	-37
Ontonagon	-123	-131	-107	-5	-9	-4	-31	-35	-27			
Keewenaw	-67	-74	-58				-13	-17	-11			
Marquette	-63	-50	-65	-1	7	-7	-2	5	-7	-67	-53	-92
Gogebic	-139	-150	-115	-9	-15	-5	-56	-62	-47	-25	-31	-28
Dickinson	-120	-113	-90	-20	-20	-12	-19	-15	-9	-51	-47	-49
Iron	-102	-152	-118	-31	-29	-20	-28	-26	-16	-35	-33	-32
Delta	-72	-55	-60	-27	-17	-26	-16	-7	-13	-34	-22	-41
Menominee	-162	-153	-126	-70	-65	-56	-51	-46	-37	-70	-64	-65
Luce	-39	-28	-39	-19	-19	-24	-8	-15	-11	-234	-207	-267
Chippewa	-38	-28	-36	-25	-25	-28	-9	-9	-8	-571	-467	-558
Schoolcraft	-56	-42	-51	-31	-31	-33	-13	-9	-13	-145	-349	-424
Mackinac	-49	-39	-45	-19	-9	-20	-12	-7	-12	-332	-412	-487