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The primary purpose of the JTM is to publish managerial and policy articles that are relevant to academics, policymakers, and practitioners in the transportation, logistics and supply chain fields. Acceptable articles could include conceptual, theoretical, legal, case, and applied research that contributes to better understanding and management of transportation and logistics. Saying that, our policy requires that articles be of interest to both academics and practitioners, and that they specifically address the managerial or policy implications of the subject matter. Articles that are strictly theoretical in nature, with no direct application to transportation and logistics activities, or to related policy matters, would be inappropriate for the *JTM*. Articles related to any and all types of organizations, and of local to global scope, will be considered for publication.
Acceptable topics for submission include, but are not limited to, broad logistics topics, logistics and transportation related legal issues, carrier management, shipper management of transportation functions, modal and intermodal transportation, international transportation issues, transportation safety, marketing of transportation services, transportation operations, domestic and international transportation policy, transportation economics, customer service, and the changing technology of transportation. Articles from related areas, such as third party logistics, purchasing and materials management, and supply chain management, are acceptable as long as they are related to transportation and logistics activities.

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Publishing Data

Manuscripts. Submit manuscripts to the editor by email attachment at taylorjohn@wayne.edu. Manuscripts should be no longer than 30 double-spaced pages and 7000 words. Guidelines for manuscript submission and publication can be found in the back of this issue.

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From the Editor...

Welcome to the Spring/Summer, 2011 issue of the Journal of Transportation Management!

This issue of the Journal contains five articles on various aspects of carrier management, logistics, passenger rail, and traffic analysis. The first article focuses on motor carrier safety and profits, and the role that an understanding of fleet drivers plays. The second article examines how manufacturers can use a logistics service orientation to build logistics service competency. The third article reports on a data envelopment/analytic approach to selecting transshipment ports. The fourth article discusses a study of Michigan passenger rail stations and the benefits they provide to local communities. The final article reports on a method for adjusting Origin-Destination Matrixes in traffic analysis projects.

At the Journal, we are continuing to make a number of changes that will improve the visibility of JTM, and improve its position in the supply chain publishing world. These include registering and updating journal information with several publishing guides, placing the journal content with the EBSCO, Gale and JSTOR databases faculty have access to, registering the journal with Google Scholar, and placing abstracts of all past journal articles on an open area of the DNA Journal web page. We are in the process of uploading all past issues to these various sites. Full journal article PDF's continue to be available to subscribers on the web page at www.deltanualpha.org with password: dna4education.

I look forward to hearing from you our readers; with questions, comments and article submissions. The submission guidelines are included at the end of this issue's articles and I encourage both academics and practitioners to consider submitting an article to the Journal. Also included in this Issue is a subscription form and I hope you will consider subscribing personally, and/or encouraging your libraries to subscribe.

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DRIVER SAFETY AND MOTOR CARRIER PROFITABILITY: IDENTIFYING AND UNDERSTANDING DRIVERS IN THE FLEET

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ABSTRACT

The objective of the study was to quantitatively explore truck driver safety records in an effort to determine and classify various types of drivers. Six safety variables relating to the number of safety points each driver had accumulated were analyzed using a cluster analysis procedure on 368 active drivers. The results of the study identified three clusters of drivers. Over 49.3 percent of the drivers were identified in a cluster labeled as the "Best Drivers." The label "Ticket Magnets" was given to 23.6 percent of the drivers, and 27.1 percent of the sample was given the label "Accident Prone." The individual clusters were also profiled on additional variables. The study findings indicate that most drivers are very good in all aspects of driver safety. Other drivers have some deficiencies which are addressed as managerial implications in the manuscript.

INTRODUCTION

At a time when companies are looking for ways to trim costs, many are seeking to limit layoffs and to preserve talent. Most will cut employee salaries, hours, and benefits, but they are concerned about preserving talent for the eventual economic recovery (Tuna, 2009). During the same time period, motor carriers have faced record high fuel costs and litigation attorneys eagerly eyeing trucking accidents as potential billing revenues, but until recently they have also faced the rapid turnover of drivers willing to move to a new motor carrier for almost no salary increases. How does management decide which drivers should be kept at all costs and which drivers should be allowed to leave if they so desire? Even in tough economic times, motor carriers strive to remain profitable and thus sustainable. Two issues are very relevant in a motor carriers' ability to remain profitable: the costs of replacing drivers and the costs associated with the consequences of unsafe drivers.

Drivers who shift from one carrier to another create additional costs as motor carriers have to find, hire, and train new drivers to maintain their fleet. It requires additional training costs and often results in short-term service delays and other problems. These concerns all relate to lower carrier profitability. A variety of studies have been conducted to determine why drivers move from carrier to carrier, and what can be done to retain drivers. Most researchers agree that the issue is complex and critical to the long-term success of trucking firms. The next logical step for a motor carrier is to determine which drivers have more desirable characteristics than other drivers and thus should receive more incentives and attention by management to keep them in the fleet.

Another key profitability issue related to drivers is their safety record. Safe drivers are less likely to involve the motor carrier in latent cost problems including litigation. For example, safe drivers, by definition, will be involved in fewer accidents and other incidents, resulting in fewer traffic violations, and more on-time deliveries. This makes safe drivers more valuable to a motor carrier than drivers who receive more citations and are involved in more safety-related incidents. In short, safe drivers allow carriers to be more profitable and thus are more valuable to

the company. The most tangible indicator of how safe a driver is will be found in the safety record of the driver, which should be a part of a motor carrier's database.

The purpose of the present study is to determine if natural groupings or segments of drivers exist in a motor carrier's database safety records, and thus to identify the firm's best drivers. Research questions to be answered include: what safety variables are relevant in determining more desirable drivers than those less desirable drivers, and what are other related characteristics of the best drivers in the fleet. By identifying the best drivers, companies can determine which drivers to expend the most effort and resources to retain. Such an approach should be based on data normally kept by motor carriers on their drivers. The development of such a methodology can help existing carriers more fully utilize their company databases to make informed driver retention decisions. The study examines data from a Midwestern motor carrier's driver population database in an attempt to answer these relevant questions.

BACKGROUND LITERATURE

For any company to survive in the motor carrier industry the bottom line is profitability. A variety of issues relate to profitability for motor carriers, including maintaining a quality fleet of safe drivers and equipment, an organizational culture promoting high levels of safety, and being in compliance with the federal department of transportation motor carrier regulations. Therefore, this literature review will examine the issues of driver recruitment and retention, as well as driver safety. Driver safety issues as they relate to motor carrier profitability, and the use of carrier databases to classify drivers on a variety of safety issues will also be examined. Two key issues that relate to the quality and profitability of the drivers in a motor carrier's fleet are driver turnover and retention, and the drivers' past safety record.

Driver Turnover and Profitability

Since the late 1980s one key issue facing the motor carrier industry has been the shortage of qualified drivers (Lemay and Taylor, 1989). Only recently have drivers stopped jumping from one carrier to another as the economy has slowed and carriers have had less business requiring fewer drivers (Watson, 2008). While the economic situation has eased the driver turnover problem, the situation is not expected to last as it has been estimated that driver shortages will exist for the next ten years (American Trucking Association, 2005; Kilcarr, 2005; Watson, 2008). As the economic recovery begins, carriers will again need more drivers, and driver retirements and fewer new drivers entering the industry will only magnify the problem. A concern for motor carriers is that they may have an excessive turnover of "desirable" drivers (Richard, et. al., 1994).

Driver Turnover Issues

Success in the trucking industry is closely related to the critical role played by drivers (McElroy et. al., 1993). Drivers are the essence of a motor carrier, and they represent the trucking industry to the public. They constitute the largest operating cost for any carrier's operations, and as such they are the easiest way for a carrier to control costs (Stephenson and Fox, 1996). For nearly three decades there has been a shortage of drivers, which has allowed some drivers to move from one carrier to another with little concern about carriers. The term "churning" was coined by the American Trucking Association (Spillenger, 1997) to describe the phenomena. Early researchers believed drivers were leaving or moving from carrier to carrier because of low pay, being away from home for days at a time, and irregular schedules (Lemay, et. al., 1993), but later research revealed that drivers were often leaving one firm to go to another for little pay differences and similar working conditions (Richard et. al., 1995).

Researchers have approached the problem from a variety of angles including: attitude congruence between drivers and management (Adam, 1979); the use of expectations theory to see if carriers were meeting the expectations of their drivers (Richard et. al., 1994), and use of relationship theory which specifically examined the interaction of the dispatcher and his or her drivers (Keller and Ozment, 1999a; 1999b). They argued that dispatchers who communicate well with drivers and provide them with respect, essentially treating them as customers, should have lower driver turnover levels than dispatchers who do a poor job of handling their drivers. Suzuki (2007) developed a modeling decision tool to help motor carriers determine an acceptable level of truck driver turnover; essentially stating that some rate of driver turnover was inevitable for every carrier and could be determined.

Costs of Driver Turnover to Motor Carriers

Replacing existing drivers has a negative effect on carrier profitability. Min and Emam (2003) have argued that profitability in the trucking industry has clearly been undermined by the driver shortage. The costs of attracting new drivers, and providing incentives to keep existing drivers has been very high, especially given the highly competitive nature of the deregulated trucking industry and its narrow profit margins. Driver costs to carriers become extreme when the company has to replace drivers. The cost to replace a single driver has been estimated to be anywhere from $3,000 to $12,000 (Richard et. al., 1994; Stephenson and Fox, 1996; Keller and Ozment, 1999a; 1999b).

Just as service marketers discovered it was more expensive to find new customers than to retain existing customers (Zurburg, 1994), motor carriers have also recognized the high costs of replacing their current drivers who choose to leave them for another carrier (Keller and Ozment, 1999a). Therefore, it is clearly in a motor carrier's best interest to retain its best drivers. The relevant question then becomes,

how does a carrier determine which drivers are "quality" drivers before deciding how to retain them. Safe driving records are an important characteristic of a motor carrier's best drivers. As Stephenson and Fox (1996) have stated, "Companies must not tolerate unsafe driving practices by any driver, no matter how severe the driver shortage problem is." High quality, desirable drivers help motor carriers remain profitable with lower accident rates, lower associated lawsuits, and lower insurance costs (Richard, et. al.,1994). These factors are all reflected in higher levels of motor carrier profitability.

Higher driver turnover rates have been shown to be associated with higher accident rates (Corsi and Fanara, 1988). Thus, carrier safety is related to driver turnover. Accidents result in insurance claims, bad publicity, higher insurance rates, and additional costs associated with litigation and negative legal judgments. Drivers who have longer tenures with a single motor carrier are thus more likely to help their carriers be profitable (Bruning, 1989). As such their carriers should want to retain them in their fleets. Younger drivers are however needed for the future as old drivers retire or move to other carriers. The crux of the issue is that the only way young drivers can become better drivers is with good carrier training and driving experience. Thus the literature has indirectly again and again indicated that some drivers as a market have characteristics more desirable to motor carriers than do others. This would argue for the use of some type of classification approach to learn which drivers are more desirable than others, and would therefore justify higher expenditures to attract and retain them for the carrier.

Driver Safety and Motor Carrier Profitability

The importance of safety in the motor carrier industry cannot be understated. Essentially, almost every aspect of safety is related to company drivers in one form or another. Besides driving loads from one point to another,

drivers' must be sure their equipment is in good operating condition, they must drive in a responsible manner, and they must represent the carrier to its customers. Yet some drivers may be more willing than others to stretch operational rules and policies.

Driver Safety

The past few years of slow growth, which has decreased motor carrier business and temporarily reduced the driver shortage, does provide carriers with an opportunity to evaluate the current drivers in their fleet and to determine which are more valuable than others. Thus motor carriers can evaluate existing fleet drivers, and thus decide which drivers they should make a more concentrated effort to retain. While the "churning" of drivers has been a major concern to motor carriers over the past 30 years, the retention of quality or "desirable" (Richard, et. al.,1994) drivers, who have a strong emphasis on safety, is also an important aspect of driver selection and retention. Therefore it is imperative for drivers to place a high level of importance on safety, and to realize their actions as drivers represent their employers to the public. Related to this issue is a feeling that drivers must understand that when they are on the road they are responsible not only for their safety and the safety of their carrier, but also for the safety of the general public as well (Roetting et. al., 2003).

Prior research has indicated that the main causes of most commercial vehicle-related accidents are driver-related factors (Beilock, 1995; Lantz and Loftus, 2005). Equally relevant is the importance management places on safety and how drivers internalize safety (Arboleda, et. al., 2003). It is generally believed that drivers are viewed as being the motor carrier to the general public; and thus, carrier safety is synonymous with driver safety given that 95 percent of all carrier accidents are related to driver actions (Dole, 1991).

Motor carriers, therefore, have both an ethical and an economic obligation to hire and retain the safest, most qualified drivers. Mejza and his colleagues (2003) indicated that prior research efforts have pointed to driver selection as an important activity that might affect driver performance. A variety of negative outcomes for the motor carrier related to poor driver safety include: liability lawsuits related to driver accidents, higher insurance carrier premiums, more worker compensation claims for injuries by on the clock drivers, lower public image perceptions of the carrier, and lower company productivity levels. Driver safety characteristics also play an extremely important role for on time deliveries, damage losses, insurance rates, and the ultimate profitability of the company (Richard et. al., 1994). It would therefore seem logical that one of the most important issues to motor carriers is the retention of their best drivers (Keller and Ozment, 1999; Richard et. al., 1994).

A number of researchers have examined the potential effects of variables on driver safety. They include the effects of government regulations, such as hours of service, etc. (Corsi et. al., 1984; Saltzman and Belzer, 2002; Hanowski et. al., 2007; Chen, 2008); and carrier/ dispatcher scheduling practices (Beilock, 1995; Braver et. al., 1999; Lemay et. al., 1993; Morrow, 2002); but the bottom line still resides in the actual safety records of the individual drivers.

Mejza, Bernard, Corsi and Keane (2003) surveyed the safest motor carriers in the United States. They concluded that the safest motor carriers emphasized pre-service and in-service training for both drivers and owner-operators. The training covered many topics and the drivers were evaluated using a variety of methods. Finally, the safest carriers provided their safe drivers with an array of different types of rewards. In essence, drivers of the safest carriers were aware of the level of importance placed on safety by their companies. As such, motor

carriers with pre-service and in-service training for their drivers should, in theory, create the safest drivers found in their respective fleets.

More research effort should be undertaken to understand how carriers can identify their best drivers. As stated by Stephenson and Fox (1996) "Companies need to focus on retention of quality drivers as a long-range strategy to enhance corporate profitability." Lower quality drivers can lead to increased costs to firms in the form of operations difficulties, service problems for shippers, and other hidden costs due to safety issues such as down time due to accidents and higher reliability insurance rates (Richard et. al., 1994). Profitability remains a major concern to motor carriers in the highly competitive, deregulated, motor carrier industry.

Driver Safety and Profitability

Motor carrier safety is perhaps the most important consideration related to motor carrier profitability and sustainability (Corsi and Fanara, 1988). Safety as it relates to profitability is an important factor, because to some degree it is controllable, while fuel costs and other variables are generally not controllable. Driver training can help to maintain higher safety standards and lower overall operating costs. A driver's attitude toward safety is also an important consideration, but the most tangible indicator is likely to be the safety record of the driver. This should be an important part of any motor carrier's database.

It has been reported that a large proportion of motor carrier accidents are the responsibility of a small number of drivers (Murray and Whiteing, 1995). The Federal Motor Carrier Safety Administration (FMCSA, 2008) has estimated that for a motor carrier to pay for a $25,000 accident, it would be required to generate an additional $1,250,000 in revenue, assuming an average profit of only 2 percent. It has also been reported that in "2005 dollars," the average cost per truck crash from 2001 to 2003, was $91,112 (Miller et. al., 2006). Direct expenses include

actual costs to replace equipment and personnel, medical expenses, higher insurance premiums and potential litigation expenses. Indirect costs include lost clients, lost sales, poor public relations/ publicity, and increased public relations costs (FMCSA, 2008). Both direct and indirect cost situations are related to lower levels of profitability and thus are detrimental to the long-range success of the carrier. It is clearly in the best interests of a motor carrier who wants to be profitable not to retain unsafe drivers.

Richardson (1994) indicated that lower profits related to drivers are associated with operation difficulties, service problems and other hidden costs. These problems are often due to safety issues linked to down time resulting from accidents and higher liability insurance rates. Besides the direct costs related to carrier accidents, indirect costs in the form of lost clients, lost sales, and poor publicity are also serious carrier concerns (FMCSA, 2008). Other driver safety factors involve costs associated with items damaged in transit, vehicle inspection problems, moving vehicle citations, and even complaints called in by the public about a driver. All of these variables may be useful in understanding differences between the safest drivers and other less desirable drivers. As a relatively controllable dimension, safety should be an important consideration to motor carriers in the selection and retention of drivers.

Carrier safety and profitability are related constructs when emphasized by management. Previous research has examined this relationship often positing that as financial conditions decrease so does safety performance. Research conducted by Corsi, Fanara, and Roberts (1984) reported a positive relationship between accident rates and the use of owner-operators. Chow and his colleagues (1987) found that a carrier's safety performance was related to the carrier's financial condition, in that less was spent on safety and maintenance of equipment as a carrier's financial position disintegrated. These findings were supported by Bruning's (1989)

research when he reported that a carrier's accident rate was inversely related to its profitability. He also reported that a firm's accident rate was inversely related to a driver's tenure with the carrier. This is consistent with Corsi and Fanara's (1988) finding that higher driver turnover rates were associated with higher accident rates. Once again, safety is related to driver retention.

Motor Carrier Database Strategies to Improve Safety and Profitability

Database management has been touted as the next logical step in the analysis of motor carrier safety information. As such, researchers have argued that databases can be useful in managing safety. Murray and Whiteing (1995) were early proponents of employing accident databases as a way to help reduce motor carrier accidents. They argued that accident reduction strategies could operate at two levels: the national policy level and at the individual company level. Both strategies exist, as the federal government's Department of Transportation keeps data on motor carrier audits and roadside vehicle inspections including specific directives related to truck driver hours of service regulations. Safety reports also include accident reports, so carriers could use carrier databases to systematically analyze accident levels, as well as their causes and costs. It is likely that at the individual company level, the safest firms likely maintain in-depth databases containing safety and compliance data for both the firm and for the individual drivers in their fleet. Murray and Whiteing (1995) argued that by employing a systematic database strategy, motor carriers could examine both human elements and vehicle management issues to reduce commercial vehicle accidents.

Moses and Savage (1996) developed and tested a methodology for predicting the safety performance of motor carriers based upon the U.S. government's audit of carrier management safety practices and roadside safety compliance

inspections. Specific carrier characteristics were also studied. The study examined 20,000 carriers in an attempt to identify the most dangerous firms so government agencies could prioritize which companies to target for educational programs and enforcement actions. The most dangerous firms they identified were generally small, for-hire companies, which is consistent with Corsi, Fanara, and Roberts (1984) previous findings. They also concluded that those dangerous carriers who rated low on both audits and roadside inspections have significantly higher accident rates, even though they comprised only about 10 percent of the sample.

In a 2003 study, Mejza and his colleagues conducted a large survey of the safest motor carriers in the United States. The results of the study indicated that: (1) the safest firms have a standard, consistently-applied screening criteria to use in hiring drivers; (2) both company-drivers and owner-operator drivers receive important pre-service and in-service training; (3) their training programs are comprehensive and drivers are evaluated using a variety of methods; and (4) safe drivers are rewarded in a variety of ways to support their efforts. In essence, the safest motor carriers, with high compliance and safety records, have a safety strategy they constantly monitor to ensure they remain effective in implementing a culture of organizational safety. The researchers' study implied, "that driver selection could impact the carrier's driver performance if drivers with certain characteristics are not selected" (Mejza et. al. 2003). Database usage would be a logical and important management tool for individual carriers interested in retaining drivers demonstrating high levels of safety performance.

The use of data mining technology to profile truck drivers as a way to identify and develop a driver recruitment and retention strategy was proposed and demonstrated by Min and Emam (2003). They sent a mail survey to 3000 American motor carriers and received 422 valid

responses for a response rate of 14.14 percent. They applied a data mining procedure to the data set and drew four conclusions from their results. The first conclusion was that smaller firms having less than 50 drivers were better able to retain their drivers when compared to larger firms. Second, drivers who had been with a firm less than six years were more likely to leave than drivers who had been with the firm for over six years. Third, unionized or full-time drivers were less likely to leave than were non-unionized or part-time drivers. Finally, drivers with limited driving experience, less than six years, were more likely to leave than were other drivers. Likely because they have less invested in a specific carrier and the cost of switching was low.

Based upon the driver profiles they developed, they suggested that carrier firms should formulate some type of recruitment and retention strategy based upon a multitude of attributes including "a driver's demographic profile (e.g. age), longevity, prior driving experiences, union status, and the trucking firm's organizational settings." Driver safety performance variables in a carrier's database provide hard evidence of past safety records for drivers.

Lantz and Loftus (2005) argued for the importance of developing and implementing a driver safety history indicator into the federal roadside selection system to target unsafe carriers. Like previously reviewed research, this suggestion argues for improved carrier safety at the national policy level. While other studies have also employed a macro approach, examining many carriers and drivers, no published studies have examined the database of a single large motor carrier. From a managerial perspective, this micro approach would allow single motor carriers to examine the drivers in their individual firms. The present study presents such an approach.

The present study argues that the carrier can actually employ database information to better understand the driver's in the fleet. Most of the

previous studies have examined safety characteristics from a macro approach. The present study will be a micro approach using the existing database of a single motor carrier and its drivers. Most carriers will collect and retain needed information for their own needs as well as to be in compliance with government regulations. As Murray and Whiteing (1995) indicated, the use of a simple accident database to monitor and analyze the causes of carrier vehicle accidents can benefit individual companies. Accurate and complete management database information is clearly important in understanding how to reduce motor carrier accidents, as well as which drivers are higher "quality" drivers, and thus more attractive to retain should they decide to leave. This concept is consistent with Stephenson and Fox's (1996) earlier described belief that motor carriers should retain "quality" drivers tempered by the concern for safety in their statement that "Companies must not tolerate unsafe driving practices by any driver, no matter how severe the driver shortage problem is."

Market Segmentation and Database Usage

Morgan and Hunt's (1994) commitment-trust theory of relationship marketing led to a variety of marketing studies approaching employees as internal customers (Berry, 1981; George, 1990; Gronroos, 1981, 1990; Taylor and Cosenza, 1998). In a previously discussed study of ways to retain drivers, Keller and Ozment (1999a, 1999b) applied the theory to examine the relationship between dispatchers and drivers, concluding that drivers could be viewed as "internal customers who may be marketed to as firms traditionally market to customers." Their application expanded the use of the theory to motor carriers and indicated that motor carriers should consider looking at their employees as internal customers if they desire to retain them.

An important basic marketing approach associated with organizations and their markets is segmentation theory (Haire, et. al., 1995).

Segmentation theory argues that natural groupings of consumers may exist in a market or population. Each segment will have different characteristics, wants, and needs when compared to other segments. As such the firm can select those segments it wants to target for its customers, based upon a match of the company's strengths and abilities to profitably service the selected segments. Organizations often classify and segment their markets based upon characteristics that will allow them to better identify and serve subpopulations of the total market. Businesses have segmented their markets based upon a variety of variables including: demographics, psychographics, attitudes and customer-relevant benefits.

Using a similar analogy, motor carriers looking at their population of drivers as an internal market might choose to better understand driver differences through segmentation theory. By segmenting internal driver markets, carriers might better understand different natural groupings of drivers to help them decide which individuals are "quality" drivers that they would want to retain at all costs, while other driver segments might not be as important to retain due to safety considerations. A motor carrier example would be TL and LTL motor carriers, who have decided they can best serve their respective markets using different approaches. Thus a logical extension of both theories is the use of segmentation techniques to better understand and explain differences in internal motor carrier customers (i.e. drivers). The purpose of the present study is to examine the segmentation concept and how it can be applied by motor carriers in their efforts to retain their best drivers.

Motor carriers can theoretically segment their market of fleet drivers using the information they have on each driver in their databases. Especially relevant database information would be driver safety data. Segmentation techniques can thus help motor carriers decide which drivers in their fleets are helping them to meet their organizational goals of profitability and

sustainability using safety and other types of data in their databases. The present study will demonstrate a segmentation approach for a large Mid-western motor carrier to examine its fleet of drivers from a safety perspective.

METHODOLOGY

Driver data for the study were provided by a Midwest-based motor carrier that has a combination of owner-operators and company drivers. Data were provided on the Midwest trucking company's drivers. Specific data included their identification (unit) number, their addresses, age, gender, number of children, education level, marital status, race, location of residence type, division, seat classification, whether they were Hazardous Materials certified, the number of jobs they had in the last three years, whether they were graduates of the local national trucking corporation's driver school, and their longevity in months with the company. Data were also provided for each trucker's number of service failures, number of loads hauled, total revenue, and fuel mileage. Specific safety variables included accident points, cargo damage points, citation points, incident report points, inspection problem points, and motorist call-in complaint points (MOTO). These were added to provide a total safety point total. A total of 368 cases were provided for examination. A demographic profile of the truckers in the study is presented in Table 1.

The data base was dominated by male drivers, comprising over 90 percent of the sample. Nearly 73 percent of the database was Caucasian, followed by nearly 20 percent African American, over four percent Hispanic Americans, and just over three percent were classified in the "other" category. Over 41 percent of the drivers lived in urban areas, nearly 32 percent were from suburban residences, and over 26 percent lived in rural areas. The demographic findings were considered representative and acceptable for the purposes of the study.

TABLE 1
DEMOGRAPHIC PROFILE OF MOTOR CARRIER DRIVERS

	Frequencies	Percentage
1. Gender		
Male	333	90.5
Female	35	9.5
2. Race		
Caucasian	268	72.8
African American	72	19.6
Hispanic American	16	4.3
Other	12	3.3
3. Residence Location		
Urban	153	41.7
Suburban	117	31.9
Ruran	97	26.4

FINDINGS

The six safety variables relating to the number of points each driver had accumulated were initially analyzed using a cluster analysis procedure. The first variable measured the number of points accumulated by the driver due to accidents, the second variable were points acquired by the driver for items damaged in transit within the trailer, the third variable counted citation points for tickets received by the driver, and the fourth safety variable measured incident points (for example incidents occurring in the loading areas without formal reporting to law enforcement). The fifth variable was inspection points where the driver's vehicle had violations at inspection checkpoints, and the final variable was accumulated points from motorists who called the trucking company to report bad driving by the driver. The larger the number of accumulated points in each category, the more negative the driver was in that category.

Ward's clustering algorithm was employed with squared Euclidian distance measures to analyze the data. The resulting clustering criterion scores, and a visual examination of the resulting dendogram, indicated that a three-cluster solution should be selected for further testing and analysis. Discriminant analysis was next performed to determine how well the three clusters discriminated between the six original safety variables and to interpret the meaning of the three groups. Tukey tests were also conducted to determine exactly which cluster members were significantly different from other cluster members on each of the six safety variables. The results of that analysis are presented in Table 2. It should be noted that no significant differences were detected for any cluster solutions for Cargo points, the second safety variable. It would appear that this variable has very little variance across the clusters of drivers. It is also a variable that the driver may have less control over, given that as

drivers they do not load the trailers, they simply move the trailers from one geographic location to another. Demographic and other variables were also examined across cluster membership to profile each cluster. The significant findings are presented in Tables 3 and 4.

Cluster 1

The first cluster was the largest group and consisted of 169 drivers. This represented 49.3 percent of the sample. Members of this cluster were given the label of "Best Drivers." These respondents had very low accident points when compared to drivers from the other two clusters. Tukey tests showed that all three groups were significantly different from each other on this variable. As previously stated, no significant differences were found between the three clusters on cargo damage points. Members of

Cluster 1 also had the a low number of citation points, which were significantly lower than those drivers in Cluster 2, but not for drivers in Cluster 3. Cluster 1 was significantly lower in incident reports when compared to the other two clusters. While drivers in Cluster 1 did not have the lowest overall inspection point means, they were significantly lower than drivers in Cluster 2, but not significantly different than drivers in Cluster 3. On the final variable of motorist's call complaints, drivers in Cluster 1 again had the lowest mean score, which was statistically lower than the scores from Clusters 2 and 3.

Cluster 2

Eighty-one drivers, 23.6 percent of the sample, were assigned to the second cluster. They were given the label of "Ticket Magnets" because of the high average numbers they received for

TABLE 2
CLUSTER INTERPRETATION OF WARD'S 3 GROUP SOLUTION
OF TRUCKER SAFETY VARIABLES

Cluster						
	1. Best Overall Drivers	2. Ticket Magnets	3. Accident Prone	Overall	F-Ratio	Sig.
1. Accident Points	1.84	6.93	18.60	7.58	235.80	.000
2. Cargo Points	.92	.99	1.02	.96	.08	.923
3. Citation Points	.75	2.1	.82	1.09	8.39	.000
4. Incident Points	.82	11.0	2.0	3.55	188.17	.000
5. Inspection Points	1.36	8.73	1.05	3.02	85.44	.000
6. MOTO	.19	.51	.37	.32	9.70	.000
	n=169	n=81	n=93	N=343		

citation, incident, inspection, and motorist complaint points. While they were slightly under the overall average for all drivers' accident points, members of this cluster had significantly more points than drivers in Cluster 1, but significantly fewer accident points than drivers in Cluster 3. Cluster 2 drivers had significantly more citation points than members of the other two clusters. They also had significantly higher means for incident points and inspection points when compared to the scores of drivers in Clusters 1 and 3. Drivers from Cluster 2 had the highest average of motorist call-in complaints, which was statistically higher than the average for Cluster 1, but not for Cluster 3.

Cluster 3

The last cluster was comprised of 93 drivers, or 27.1 percent of the sample. The label of "Accident Prone" was given to this driver segment. Drivers in this cluster were distinguishable from drivers in the other two clusters based upon their high mean score for accident points. The average score for accident points was significantly higher for this group when compared to the other two clusters. This group also had the largest mean score for cargo points, but as previously stated, it was not significantly different from drivers in the other two groups. Citation points for Cluster 3 drivers were below the average for the overall drivers' mean scores, significantly lower than Cluster 2 drivers, but not Cluster 1 drivers. The same pattern held for incident points. Drivers in Cluster 3 had the lowest mean score for inspection points, which again was significantly lower than drivers in Cluster 2 but not for drivers in Cluster 1. Finally, Cluster 3 drivers had slightly above average mean scores for motorists' complaints which were not significantly different from Cluster 2 driver's scores, but significantly higher than drivers in Cluster 1.

Profiling Other Characteristics Across the Three Driver Clusters

Table 3 provides a profile analysis of other metric demographic and service variables not originally employed to create the three driver clusters. Seven variables were analyzed in the Table. Three variables were statistically significant ($p<.05$), two variables had practical significance ($p> .05$ but $< .10$), and two other variables did not differ across the three clusters.

Measured in months, the mean longevity scores of the drivers working for the company was statistically different across the three driver segments. The drivers in Cluster 1, the "Best Drivers," had a significantly higher mean score (41.45 months) with the company when compared to the drivers in Cluster 2 (33.07 months) and drivers in Cluster 3 (32.99 months). There was no statistical difference between the means for drivers in Cluster 2 and Cluster 3 on this variable.

The second variable, the average age of drivers, was not significantly different across the three clusters. Variable 3 examined the number of jobs held by the drivers over the last three years. Mean scores on this variable were also not statistically significant across the three clusters. All drivers had held approximately three jobs in the last three years.

Variable 4, number of service failures, was not significant at the .05 level, but was close with a probability of .056. It is examined as having practical significance. Drivers in Cluster 1 had a lower mean average (1.18) of service failures when compared to drivers in Cluster 2 (1.89) and in Cluster 3 (1.78). This finding is related and similar to the average percentage of service failures across the three groups. Again, the average number of service failures was visibly lower for the best overall drivers in Cluster 1 when compared to drivers in the other two clusters. The number of loads hauled, Variable 5, provided results similar to those found for

TABLE 3
CLUSTER PROFILING OF WARD'S 3 GROUP SOLUTION
ON TRUCKER SAFETY VARIABLES

| | Cluster | | | | | |
	1. Best Overall Drivers	2. Ticket Magnets	3. Accident Prone	Overall	F-Ratio	Sig.
1. Longevity in Months	44.95	37.27	37.07	41.00	5.74	.004
2. Age	41.99	40.43	42.52	41.77	.980	.377
3. Jobs in 3 years	3.01	3.10	3.30	3.11	.783	.458
4. Service Failures	1.18	1.89	1.78	1.51	2.911	.056
5. Loads Hauled	498.1	434.95	430.90	464.77	4.386	.013
6. Total Revenue	695,302.06	586,346.18	575,534.09	636,787.44	6.317	.002
7. Percent Service Failures	.0025	.0043	.0035	.0032	2.700	.069
	n=169	n=81	n=93	N=343		

Variable 4. Drivers in Cluster 1, the best overall drivers, hauled a significantly larger average number of loads than drivers from Cluster 2 and Cluster 3. Related to this finding, drivers in Cluster 1 had significantly larger mean total revenue, Variable 6, when compared to drivers in the other two clusters. While only practically significant with a p-value of .069, the percent of service failures found in Variable 7, showed that the drivers in Cluster 1 again had the lowest percentage of service failures, followed by members of Cluster 3 and then Cluster 2.

Finally, Table 4 looks at two contingency tables across the three cluster segments. The first examined whether any differences exist across the clusters related to whether the drivers were certified to handle hazardous materials. Practical significance for the Chi Square test (p=.090) indicated that 46.7 percent of the drivers from Cluster 1 were hazmat trained,

while drivers from Cluster 2 and Cluster 3 respectively had only 38.3 percent and 33.3 percent of drivers who were hazmat trained. The second contingency table reflected whether drivers from the three groups had received their training from the local motor carrier affiliated trucking school or whether they had received their driver training from another organization. Again, the findings had only practical significance with a significance level of .081. Drivers in Cluster 1 were nearly equally divided as to where they had received their training, while drivers from Clusters 2 and 3 were more than twice as likely to have received their training from the local trucking school.

DISCUSSION

The present study has employed marketing segmentation theory associated with the belief that differences in the drivers of a motor carrier

can be identified and organized into groups by employing existing company data base information related to driver safety and other descriptive variables. Cluster analysis assumes that natural groupings of objects or individuals exist in a population. This is a logical assumption for a motor carrier's fleet of drivers, as Richard et. al. (1994) and Stephenson and Fox (1996) have indicated that some drivers are more desirable than others. If carriers treat their drivers as customers to establish better understanding and long-term relationships, they are in effect looking to meet the needs of their drivers. The application of cluster analysis to a large Midwestern motor carrier's driver safety database was successfully employed to identify the existence of three segments of drivers.

The first cluster was given the name "Best Overall Drivers". This segment represents the best quality drivers in the carrier's fleet. They are dependable, they avoid accidents, as well tickets and other citations. Even though they present no problems for their employers, they still should be offered any additional training and safety programs. These will probably be the drivers most likely to appreciate and use new safety technologies as they become available, as they have the largest number of months invested in the carrier. Related to these drivers' positive contributions to the motor carrier's profitability is the need to continually recognize drivers in this segment and to reward them. These are drivers who have generally been with their carrier for a long period of time (Bruning, 1989; Min and Emam, 2003). The drivers in this segment are the best drivers in the fleet and carrier management should consider all alternatives and incentives to keep them driving for the company.

TABLE 4
CROSS TABULATIONS OF VARIOUS DEMOGRAPHIC VARIABLES ACROSS 3 TRUCKER CLUSTERS

Cluster						
	1. Best Overall Drivers	2. Ticket Magnets	3. Accident Prone		ChiSquare	Sig.
1. HazMat Certified						
					4.81	.090
Yes	79	31	31			
No	90	50	62			
2. Truck School Graduate						
					5.023	.081
Local School	84	52	54			
Other School	85	29	39			
	n=169	n=81	n=93	N=343		

As Keller and Ozment (1999a; 1999b) and others have indicated, dispatchers and other company employees must do a good job communicating and managing the company's drivers. The relationship is symbiotic for both parties as the drivers recognize the carrier is interested in their needs, and the carrier can identify and implement strategies to retain the highest quality drivers so as to to be more profitable. Surprisingly, those drivers who were in the best driver category were the least likely to have been trained by their current employer. This may be related to the fact that drivers in the best overall driver category are older and likely had good driving experiences before they were employed by their current carrier. Another possibility may be related to specific generational differences in attitudes and learning styles. Clearly more research is needed to examine potential training differences and requirements across all driver segments.

Drivers in the second cluster, given the label of "ticket magnets," were actually slightly below the overall average for all drivers on accident points. Drivers in this cluster were most noteworthy for averaging more than twice as many citations as drivers in the other two clusters. They also had significantly higher incident points, inspection points, and complaint calls from other motorists (MOTO) when compared to drivers from any other cluster. Profiling "Ticket Magnets" on other variables indicated that drivers in this cluster had the highest average number and percentage of service failures. They also had the lowest average number of loads hauled as well as lower total revenue. These findings were significantly lower than the averages found for drivers in the first cluster. The relationship of safer drivers to profitability is evident. These drivers also need additional training to stay under the radar of police and patrolmen. By doing so, drivers in this segment can avoid putting points on their driving records, thus helping to lower insurance costs for their company. They will also be less likely to become involved in accidents. The

challenge to the carrier is to improve the drivers in this cluster before they possibly slip into the third cluster of "accident prone" drivers.

The third cluster of drivers was given the label of "accident prone". They were distinguished from drivers in the other two clusters because of their high average number of accident points. Their accident points were almost nine times greater than drivers in the "Best Overall Drivers" category, and more than twice as many as drivers in the "Ticket Magnet" cluster. Interestingly, drivers in this cluster averaged only slightly more citation points than did drivers in the "Best Overall Drivers" cluster. They also had the lowest overall average of inspection points across the three clusters. With the exception of the high average accident points, as a cluster they were close to the overall average on most of the other safety point variables. Surprisingly, members of this cluster had service failure averages, average loads hauled, and average percentages of service failures similar to those of the drivers in the second "ticket magnet" cluster. They also had the lowest average for total revenue. It is clear that these drivers provide the most risk and challenge for the motor carrier. They also present their company with the most serious concerns related to profitability.

At the very least, the motor carrier must consider providing, or insisting, that these drivers receive additional driver training to avoid future accidents. This should help drivers in this cluster to recognize that the carrier is willing to further invest time and money in them. As previously discussed, accidents severely decrease motor carrier profitability (Corsi and Fanara, 1988; Bruning, 1989; Stephenson and Fox, 1996; FMCSA, 2008). The direct and indirect costs of accidents not only relate to immediate expenses, but also to long-term concerns of lost customers and poor public image (Richardson, 1994). Drivers in this segment are the riskiest in terms of profitability, and thus could be considered by the motor carrier to be the most expendable if any drivers

in this segment should decide to move to another carrier. The motor carrier will have to evaluate the value of each driver in this segment against the potential cost of the driver being retained. How long ago was the last accident of each driver in the cluster, and does the driver seem to be improving, should be a few of the questions asked by motor carrier management. Such a decision will also have to be made in light of the prevailing economic conditions.

MANAGERIAL IMPLICATIONS

The results of this study have demonstrated the use of a micro approach for motor carriers to use with company databases to better understand the drivers in a company's fleet. Drivers that were described as the "best overall" drivers can be identified and encouraged to act as mentors to other drivers who were classified as "ticket magnets" or "accident prone." Some type of reward system should be implemented for the "solid and dependable drivers" to encourage them to be leaders in helping the other drivers to become "solid and dependable" drivers. The reward system will also encourage more risky drivers to become better drivers to receive the advantages of being in the reward system. Reward systems have been described by other researchers as being an important component of any motor carrier's safety strategy for drivers (Mejza, et. al., 2003). The goal is to establish a relationship between the carrier's best drivers to help those that could become better drivers. It has been argued that drivers often jump from carrier to carrier because they have not become invested in their current carrier (Min and Emam, 2003). Such an approach might help to get drivers socialized with the best drivers in a carrier's fleet and help younger drivers develop stronger personal relationships within the organization. The ultimate goal of such a program is to increase carrier profitability by increasing safety and reducing the number of drivers who move from carrier to carrier. Direct and indirect safety costs are ultimately reduced.

Carrier management employing a database segmentation strategy can evaluate drivers who are considering a move to another carrier before they actually move. Drivers who are considered to be in the "best overall drivers" category would likely merit additional company resources to retain them since they are the most profitable drivers in the fleet. The methodology may also allow carriers to better track drivers at risk. By understanding the safety issues they present, company safety programs may help at risk drivers to better internalize the need for safety (Arboleda et.al., 2003) thus making them safer drivers. Drivers who consider moving to another carrier but have a continuing history of moving violations and/or accidents can be evaluated by management and thus may not receive as much consideration and resources to keep them with the firm.

One limitation for this study was that it examined the driver database of a single motor carrier. Future studies should examine the driver databases of additional motor carriers. Examining other carrier databases will also address any regional differences that might exist for motor carriers based in different states and operating in different regions of the country. Future studies should also consider examining personality characteristics of drivers as they relate to drivers safety records.

If the American economy does not improve at a faster rate, motor carriers may be forced to release some drivers until the economy improves. Such a scenario makes it important for motor carriers to preserve the best driver talent in their fleets to have a quality start for the eventual economic recovery (Tuna, 2009). A recently released national survey has indicated that the economy is starting to improve and some fleets are now boosting driver's pay (Watson and Bearth, 2010). Given that some drivers can contribute more to a carrier's profitability than others, the present study has provided motor carriers with a tool based upon usable theory to identify and retain the best

drivers in their fleets. As drivers become aware of the carrier's use of a database classification system, it may help motivate them to become safer drivers and to receive more rewards, and thus make the carrier more profitable. The purpose of employing such a database system is to allow the carrier to make better decisions about its drivers, to retain the best drivers who make the carrier more profitable, and to help those drivers in the fleet who are more of a safety risk to become safer drivers. In the long run everyone wins, including the safety of the general public.

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LOGISTICS SERVICE ORIENTATION: AN INTEGRATED STRATEGY TO BUILD LOGISTICS SERVICE COMPETENCY

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ABSTRACT

While the importance of logistics service competency is widely acknowledged, more research is needed to investigate its antecedents. In this conceptual paper, we synthesize extant marketing and logistics/supply chain literature and propose a new concept – logistics service orientation, which consists of both logistics service's internal and external market orientation. It is argued that a firm's logistics service orientation has direct impacts on its logistics service performance. In addition, it is also proposed that this impact can be indirectly achieved through enhanced internal integration. This research contributes to existing knowledge by offering new insights on the development of logistics service competency.

INTRODUCTION

Building core competency in logistics services has important strategic implications for all firm executives. A firm's core competencies are its valuable resources and capabilities that are deemed to be unique, not imitable by competitors, and sustainable over time (Prahalad and Hamel, 1990). Likewise in logistics services, a core competency refers to a firm's unique and inimitable ability to provide superior customer and physical distribution services for its customers (Mentzer, Gomes, and Krapfel, 1989). When attained, logistics service competency may become one of the key drivers of customer equity. In today's dynamic marketplace, customer equity is arguably a firm's most valuable asset (Rust, Lemon, and Narayandas, 2005). In order to enhance their customer equity, firms invest enormous amounts of resources to build loyalty and to improve satisfaction among profitable customers. Logistics service competency helps this strategic

cause by providing customers with the right product, in the right quantity, at the right place, at the right time, and for the right price (Stank, Goldsby, Vickery, and Savitskie, 2003; Daugherty, Stank, and Ellinger, 1998). Customers that are continuously satisfied with supplier performance in logistics services, then, face high switching costs when they consider an alternative supplier (Burnham, Frels, and Mahajan, 2003). Continuous satisfaction and high switching costs lead to high retention rates and ultimately to improved customer equity (Rust, Lemon, and Zeithaml, 2004). Previous empirical studies have confirmed that competency in logistics services leads to such outcomes as customer satisfaction, loyalty, and repurchase intentions (Innis and La Londe, 1994; Daugherty, Stank, and Ellinger, 1998; Mentzer, Flint, and Kent, 1999; Mentzer, Flint, and Hult, 2001) and ultimately to market share and shareholder value (Stank, Goldsby, Vickery, and Savitskie, 2003; Lambert and Burduroglu, 2000). These findings validate the nature of

logistics service competency as a source of superior firm performance, i.e. competitive advantage (Hunt and Morgan, 1995). Therefore, the number of firms considering logistics service competency as a source of competitive advantage is on the rise internationally.

While logistics service competency's importance is widely acknowledged and confirmed by extant literature, it is equally critical for both logistics/supply chain researchers and managers to identify the ways in which firms can attain logistics service competency. Although Fawcett, Stanley, and Smith (1997) called for more research on antecedents of logistics competency more than ten years ago, our literature review revealed that only a few studies have attempted to explore antecedents of logistics service competency. For example, Fawcett, Stanley, and Smith (1997) proposed that information support and strategic planning facilitate the development of logistics competency. Closs, Goldsby, and Clinton (1997) found that effective use of information technology significantly impacts the development of world class logistics competency. More specifically, Closs, Swink, and Nair (2005) argued that information connectivity significantly contributes to a key logistics service competency – logistics flexibility. Richey, Daugherty, and Roath (2007) suggested that a firm's technological readiness is critical to the development of logistics service competency. While these studies provide valuable insights on logistics service competency development, more research on this topic is warranted. Therefore, the current study was undertaken to expand the current knowledge base.

In their seminal article on "Defining Supply Chain Management", Mentzer et al. (2001) emphasized the importance of supply chain orientation, which is defined as "the recognition by an organization of the systemic, strategic implications of the tactical activities involved in managing the various flows in a supply chain" (p. 11). They also argued that the systemic view

and strategic view embedded in supply chain orientation are the key antecedents of supply chain management. In line with their approach, we propose the concept of logistics service orientation, which is defined as the recognition by an organization of the systemic and strategic implications of the tactical activities involved in managing a firm's logistics services. Due to the exploratory nature of this paper, we limit the discussion to a single firm for feasibility consideration.

The rest of the paper is organized as follows. First, the concept of logistics service orientation is developed and discussed based on extensive literature view. Then, a conceptual framework is presented, along with the discussion of proposed relationships. Finally, research and practical implications are discussed.

LOGISTICS SERVICE ORIENTATION

Effective logistics management ties all logistics activities together in a system which simultaneously works to minimize total inbound and outbound costs and maintain desired customer service levels (Kenderdine and Larson, 1988). Therefore, an integrated approach is critical to logistics management (Daugherty, Ellinger, and Gustin, 1996). Strategy researchers have suggested that successful implementation of a strategy depends on the firm's adoption of an appropriate strategic orientation (Day and Wensley, 1983; Voss and Voss, 2000; Noble, Sinha, and Kumar, 2002). In line with Mentzer et al.'s (2001) argument related to supply chain orientation and supply chain management, we propose that a firm's view or perspective on its logistics services/activities is different from the actual implementation of logistics management. Thus, we introduce the new concept of logistics service orientation and explore its relationship with logistics competency development. As discussed previously, logistics service orientation views a firm's logistics management from an overall system perspective and each of the logistics activities is seen within a broader

strategic context. In other words, logistics service orientation is a management philosophy related to a firm's logistics service.

In reviewing the literature on logistics service competency, we identified two separate streams of research. The first one is the external market oriented approach, where the focus is on understanding the needs and expectations of the customers and other supply chain members so the firm can provide solutions to meet such needs and/or expectations in a more efficient and effective manner (e.g. Mentzer, Rutner, and Matsuno, 1997; Min and Mentzer, 2004; Lambert and Burduroglu, 2000; Zhao, Droge, and Stank, 2001; Richey, 2003; Panayides, 2004). The other research stream that investigates logistics service competency is the internal market oriented approach, where the focus is on satisfying employee needs and expectations since they are the ones that interact with customers during the service experience (e.g. Keller, 2002; Keller and Ozment, 1999a; Keller and Ozment, 1999b; Autry and Daugherty, 2003; Gooley, 2001; McAfee, Glassman, and Honeycutt, 2002; Gammelgaard

and Larson, 2001; Richard, LeMay, Taylor, and Turner, 1994). To this point, little research has been done to investigate the interplay between the two research streams.

In the process of conceptualizing logistics service orientation, we believe it is necessary and appropriate to develop the concept based on extant literature. Therefore, we argue that a firm's logistics service orientation has two key dimensions: logistics service' external and internal market orientation. Next, we further review and synthesize the marketing literature on market orientation and apply it to the logistics service context. Our conceptualization of logistics service orientation is presented in Figure 1.

Logistics Service's External Market Orientation

In this section, we first review the external market orientation concept and then examine the three external market orientation dimensions and how these dimensions relate to logistics service orientation. We refer to market orientation as

FIGURE 1
CONCEPTUALIZATION OF LOGISTICS SERVICE ORIENTATION
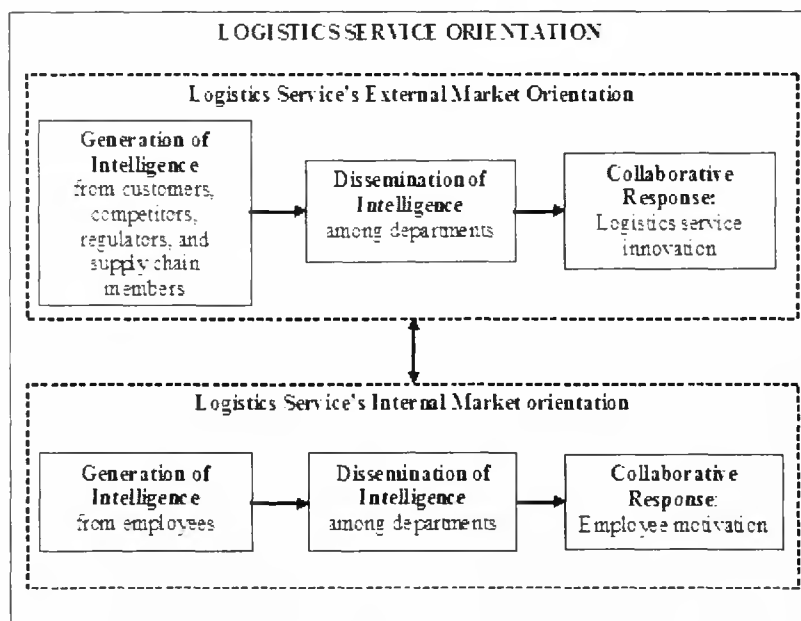
being external to differentiate it from the newly developed internal market orientation concept (Lings and Greenley, 2005). Two strongly connected studies have been the basis for a large part of the external *market orientation* research. First, Narver and Slater (1990) conceptualize *market orientation* as an organizational culture that "most effectively and efficiently creates the necessary behaviors for the creation of superior value for buyers, and thus, continuous superior performance for the business." Moreover, Narver and Slater's market orientation conceptualization involved three dimensions – namely, customer *orientation*, competitor *orientation*, and inter-functional coordination. However, several researchers oppose the idea of conceptualizing market orientation as an organizational culture (e.g. Deshpande and Farley, 1998). These opposing scholars (Deshpande and Farley, 1998, p.233) argue that market orientation is rather a set of "activities" related to continuous assessment of customer needs than a "culture". Kohli and Jaworski (1990, p.1), on the other hand, refer to market orientation as "implementation of the marketing concept" and provide a more process-driven framework that deems the dimensions of generating, disseminating, and responding to market intelligence as the core of market orientation.

These two models of market orientation share many essential notions, such as the focus on customer needs, importance of competitive intelligence, and cross-functional collaboration within the firm. Nevertheless, Matsuno, Mentzer, and Rentz (2005) developed an extended version of Kohli and Jaworski's (1990) market orientation scale and compared it to the two preceding scales of market orientation. Matsuno et al. (2005) concluded that the Kohli and Jaworski (1990) model was superior to Narver and Slater's (1990) scale in terms of theoretical consistency and scale operationalization. Moreover, Matsuno et al.'s (2005) extended market orientation scale not only provided a theoretical improvement to

Kohli and Jaworski (1990) scale, but also had "better internal consistency, unidimensionality, and fewer items than the Kohli and Jaworski scale" (p.7). In the light of these inferences, we adopted Matsuno et al.'s (2005) extended conceptualization of market orientation.

We extend the "customer" focus of the above literature to include in the concept of "market orientation" an expanded view which includes various supply chain partners in addition to customers. These partners could include components suppliers, carriers, 3PL's, and all the other relationships with suppliers that help develop a supply chain orientation that provides value to customers.

From the logistics services perspective and according to our expanded conceptualization, logistics service's external market orientation comprises three interrelated dimensions (see Figure 1). First, the generation of intelligence which may involve customer or supplier surveys, monitoring of government regulations, technology, competitive activities, and transparent communications with supply chain partners. Therefore, the scope of domains that intelligence is gathered from goes beyond customers and competitors (as suggested by Kohli and Jaworski, 1990) and includes other supply chain partners like suppliers, transportation outsourcers, 3PL firms, governmental regulators, etc. (Matsuno et al., 2005). The gathered information then helps firms anticipate such customer needs as timeliness, cost efficiency, accuracy, responsiveness and other logistics service attributes (Sterling and Lambert, 1987; Stank, Daugherty, and Ellinger, 1999). Information that is obtained could also be used to help better understand how suppliers can play a role in helping the firm to better serve customers. For instance, manufacturers should gather information on their suppliers' perceptions about the relationship with the manufacturer buyer (Zhang, Henke, and Griffith, 2009). Strong supplier relationships can help the firm innovate

in a way that will provide added value to customers

The second dimension in logistics service's external market orientation is the dissemination of the gathered intelligence across various functional areas such as logistics, purchasing, and marketing. As Kohli and Jaworski (1990, p.5) suggest "effective dissemination of market intelligence is important because it provides a shared basis for concerted action by different departments." While many firms use such tools as newsletters and formal electronic communications, truly effective information sharing occurs when different departments collaborate with each other. Due to differential job functions and expertise, different departments can all generate valuable information. For example, the logistics department generates and houses intelligence related to customers, supply chain partners, and logistical government regulations whereas marketing maintains the customer and competitor information, and purchasing maintains information on supplier desires and capabilities. Thus, intelligence sharing through cross-functional interaction is an important element of logistics service's external orientation (c.f. Kahn and Mentzer, 1996).

Through combining their informational resources, logistics, purchasing, and marketing departments can better understand the needs and expectations of their customers for which they can develop a collaborative response – the third dimension in logistics service's external market orientation. A collaborative response may take the form of a just-in-time (JIT) or a material requirement planning (MRP) system that answers such customer needs as order timeliness and accuracy (Herron, 1987) as well as an electronic data interchange (EDI) or an extranet system that satisfies information quality and convenient ordering procedure needs (Emmelhainz, 1989; Murphy, Daley, and Hall, 1998). The response is developed collaboratively among different departments based on the

information gathered from external sources like customers and/or suppliers, and it comprises an innovative solution to meet the needs of customers. Innovation is defined as the generation, acceptance, and implementation of new ideas, processes, products, or services (Hurley and Hult, 1998). Competitive pressures usually call for new ways of identifying and satisfying buyers needs (Scheuing and Johnson, 1989). In order to adopt successful new ideas or innovations, different departments should work together to create a collaborative environment that focuses on exploration of innovative scenarios, joint expeditions with leading customers and/or suppliers, and development of intellectual capital in a flatter, customer-focused, boundary-less organization (Morash and Droge, 1997; Ellinger, Daugherty, and Keller, 2000). Therefore, we propose that the third dimension of logistics service's external market orientation involves a collaborative response by different departments in the form of a service innovation.

Logistics Service's Internal Market Orientation

In this section, we first review the internal marketing concept and then the three dimensions of logistics service's internal market orientation are discussed. The term internal marketing was defined by Berry (1981) as viewing employees as internal customers, viewing jobs as internal products that satisfy the needs and wants of these internal customers while addressing the objectives of the organization. The key assumption underlying the internal marketing concept is the notion that "to have satisfied customers, the firm must also have satisfied employees" (George, 1977, p.86). Attraction, selection, retention, and motivation of high quality staff is especially critical in situations where the quality of service is the only real differentiating factor between competitors (Harvey and Richey, 2001; Richey and Bachrach, 2004). Gronroos (1981) emphasized the front line employees' interaction with customers and the importance of being

responsive to customers' needs. In this view, it is not sufficient that employees are motivated to perform better, but they must also be customer oriented. More recent studies on internal marketing suggest that the scope of internal marketing activity is much wider than motivation of employees towards customer orientation (Rafiq and Ahmed, 1993; 2000). In fact, it can also be used to motivate non-contact employees towards behaving in a manner that enhances the service for end-customers and helps an organization achieve superior customer service compared to their competitors. This is especially relevant in the supply chain world, where purchasing, production scheduling and other departments have a critical role in assuring customer satisfaction. Hence, Rafiq and Ahmed (1993) defined internal marketing as "planned effort to change and to align, motivate, and integrate employees towards the effective implementation of corporate and functional strategies."

In order to examine internal market orientation, Lings and Greenley (2005) adapted the external market orientation conceptualization. Thus, logistics service's internal market orientation is comprised of three dimensions, namely internal information generation, internal communications, and responsiveness to the internal market (Lings and Greenley, 2005) (see Figure 1). Rather than customers and competitors, the internal market consists of employees. Regarding the internal information generation dimension, two major factors are deemed to be important when gathering information from employees – namely, the type and the mode of information (Mohr and Nevin, 1990). While the type of information may include the benefits the employees seek, the sacrifices that they are willing to make, how much they value their jobs, their perceptions of job fairness and organizational justice, and the alternatives that they consider, the mode of information gathering may be formal (face-to-face or written) or informal (hallway conversations) (Lings and Greenley, 2005). The

information gathered from employees can be then utilized to make the jobs more attractive, to retain the skilled employees, and to motivate them towards the achievement of strategic goals (Wheeler, Tokman, Richey, and Sybanski 2007).

The second dimension of logistics service's internal market orientation is the internal information exchange. Internal information exchange is a key factor in aligning employees' attitudes and behaviors with the organization's strategic goals (Guest and Conway, 2002) and can be best performed – once again – when different departments collaborate. Similarly, different departments can contribute valuable information from different perspectives.

For example, human resource (HR) departments gather employee related information and logistics determines roles the employees should play in attaining strategic logistics goals. At the same time purchasing employees have vital information on suppliers and market conditions that must be shared effectively across the organization. And it is critical that logistics and purchasing employees share information and cooperate in efforts to lower costs and improve service. Examples of information that must be shared and processes that must be jointly carried out include those related to sales terms, freight payment terms, order sizes, product flow routings, etc. Yet companies oftentimes experience a great deal of difficulty in driving coordination and information sharing across departments.

As a result of merging their informational resources, departments can better understand the needs and expectations of their employees for which they can develop a collaborative response. This collaborative response is then the third dimension of logistics service's internal market orientation.

A collaborative response may take the form of rewarding, coaching, empowering, training, and/or providing a vision to skilled logistics employees so that they can be retained and motivated to perform their logistics service

duties in a satisfactory manner (Ahmed and Rafiq, 2003; Foreman and Money, 1995). In other words, firms can combine strategic HR tools (e.g. rewarding, coaching, training, etc.) with strategic logistics goals (e.g. order timeliness, accuracy, etc.) to provide their employees with clear job roles and motivation to perform. In fact, several logistics researchers have emphasized development of HR strategies to retain and motivate logistics employees (Keller, 2002; Keller and Ozment, 1999a; Keller and Ozment, 1999b; Autry and Daugherty, 2003). Therefore, we propose that the third dimension of logistics service's internal market orientation involves a collaborative response by departments in the form of employee motivation.

THE CONCEPTUAL FRAMEWORK

Having reviewed relevant literature, we now attempt to provide the conceptualization of logistics service orientation and further explore its impacts on the development of logistics service competency and how the proposed positive impacts can be achieved. We propose that logistics service orientation can improve a firm's logistics service competency both directly and through enhanced internal process integration. As discussed previously, the scope of the current study is limited to a single firm for feasibility consideration, we nonetheless suggest that internal process integration mediates the

positive relationship between logistics service orientation and logistics service competency. The proposed conceptual framework is shown in Figure 2, and proposition development will be presented next.

Relationship Between External and Internal Market Orientation

Research in services marketing suggests that the customer's service quality perceptions are largely affected by the performance of the frontline service employees (Wasmer and Brunner, 1991; Hartline and Ferrell, 1996; Bitner, 1990; Bitner, Booms, and Tetrault, 1990). In consequence, Sasser and Arbeit (1976) suggested that service employees are at the vanguard of the firm's image, and, therefore, highly skilled and well-motivated employees are, in effect, the firm's products. Moreover, Sasser and Arbeit (1976) expressed that managers should focus on satisfying and motivating their front-line personnel by regarding jobs as primary products and employees as the most valuable customer. In addition, Rosenbluth and Peters (1994) went beyond the preceding arguments and suggested that the needs of the employees should come before the needs of customers since the customers can only be satisfied if the employees are satisfied with their jobs.

FIGURE 2
AN INTEGRATED FRAMEWORK OF LOGISTICS SERVICE ORIENTATION
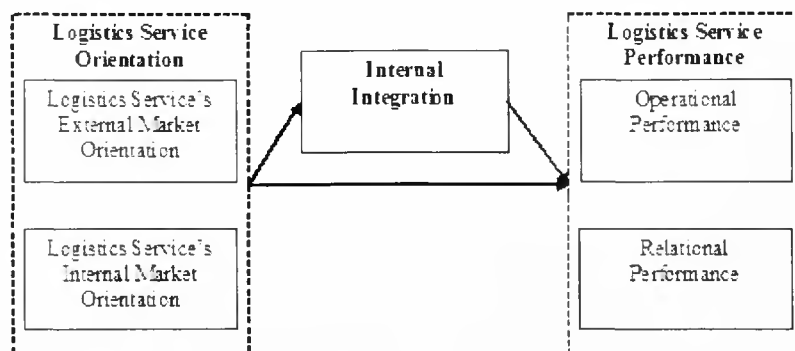
The preceding arguments imply that once the firms collect and share intelligence from external sources, they recognize that they have to cope with such customer needs as response timeliness and accuracy as well personnel honesty, knowledge ability, and promptness (Stank, Goldsby, and Vickery, 1999; Mentzer, Flint, and Kent, 1999). Much of these external customer needs can only be satisfied by well-motivated frontline service employees. The way to motivate the logistics employees, in this case, is contingent upon the logistics and other departments' mutual commitment to understand the needs of the service employees by collecting and sharing the necessary relevant information. By undertaking a collaborative approach, HR and logistics can satisfy logistics service employees and motivate them to perform better in the service encounter with the external customers, and so increase customer satisfaction (Sasser and Arbeit, 1976). In sum, firms that adopt external and internal market orientation have a better understanding of the importance of the employee's role in satisfying customers' needs, and employees within different departments are thus treated as internal customers.

Because both logistics service's external and internal market orientation emphasize inter-functional collaboration, it is appropriate to suggest that collaborative relationships among different departments within a firm contributes to the development of both orientations. Therefore, we propose that

> **P1:** Logistics service's external market orientation is positively associated with logistics service's internal market orientation.

Summarizing the above discussion, we propose that logistics service orientation is a higher-level construct, which consists of two related dimensions: logistics service's external market orientation with suppliers and customers and logistics service's internal market orientation. However, caution must be taken when managing

these two related dimensions. Although we suggest logistics service's external and internal market orientations are related to each other, this does not mean a firm will automatically achieve a high level of internal market orientation if it possesses a high level of external market orientation; or vice versa. Instead, we argue that a firm should actively manage logistics service's external and internal market orientations simultaneously with a systematic approach. More detailed discussion will be provided in the later in this section.

Logistics Service Orientation and Internal Process Integration

Because inter-functional collaboration is a key dimension of both logistics service's external and internal market orientations, it is necessary to differentiate the concepts of collaboration and integration. Collaboration refers to collaborative partners working together toward common goals to achieve mutual benefit (Mentzer et al., 2001; Stank et al., 2001). Extant literature suggests that collaboration involves information sharing, joint decision-making, joint problem-solving, joint performance measurement, and leveraging resources and skills (Min et al., 2005; Spekman et al., 1997; Stank et al., 2001). While sometimes researchers use collaboration and integration interchangeably, a more accurate definition of supply chain integration provided by Chen, Daugherty, and Roath (2009) suggests supply chain integration involves a much higher level of synergy across different supply chain entities. According to them, internal process integration refers to "the management of restructuring activities that aims at seamlessly linking relevant business processes and reducing redundant processes within a firm" (p. 67) for the purpose of building a better functioning supply chain. In other words, integration not only involves working together but also aims at developing seamless process connectivity and reducing redundancies through organizational restructuring. This is in line with Kahn and Mentzer's (1996) definition of inter-functional

integration, which indicates that integration is more than interdepartmental collaboration and is targeted at bringing departments together into a cohesive organization.

As discussed previously, logistics service orientation consists of both external and internal market orientations. Since extant literature has explicitly suggested the linkage between market orientation and integration, we argue that logistics service orientation is significantly associated with internal process integration. A firm's strategic direction or orientation develops from an awareness of opportunities and needs (Chandler, 1962). However, a firm may need to restructure operations to implement a chosen strategy or orientation. When a firm fully embraces market orientation as its strategic priority, all functional activities and organizational processes need to be focused toward anticipating and responding to changing market and customer requirements ahead of competitors. Researchers have suggested that the implementation of market orientation naturally leads to integrating all functions (Felton, 1959). To be more specific, creating value for customers involves the synergistic efforts of the entire business and not merely of a single department or function in it (Narver and Slater, 1990; Webster, 1988).

Researchers, thus, have argued that the coordinated integration of the business's resources in creating superior value for customers is tied closely to market orientation (Narver and Slater, 1990; Wind and Robertson, 1983). In reality, firms often use cross-functional teams to manage various processes in order to meet customer needs rather than managing each function independently. This parallels the underlying rationale of Bowersox, Closs, and Stank's (1999, p. 59) definition of internal integration: "the competency of linking internally performed work into a seamless process to support customer requirements." Firms with strong market orientation are likely to implement integration programs such as

Customer Relationship Management (CRM). For example, it might be necessary to redesign the personal selling process to better integrate it with other sales and support activities of the firm or redesign and align incentive structure across the firm.

In the current research context, logistics service's external market orientation includes the generation of intelligence (both from the external environment and employees), dissemination of the gathered intelligence across various functional areas, and developing a collaborative response (in the form of service innovation or employee motivation). Due to logistics activities' unique cross-functional feature, logistics service orientation is in a unique position to contribute to the integration process. Based on the above discussion, these initiatives and activities are likely to contribute to enhanced internal process integration. Thus, we propose:

> **P2:** Logistics service orientation - (a) external market orientation and (b) internal market orientation - is positively associated with internal process integration.

Internal Process Integration and Logistics Service Competency

La Londe, Cooper, and Noordewier (1988, p.5) define logistical services as "a process for providing significant value–added benefits to the supply chain in a cost effective way." Moreover when developing their logistics service quality scale, Mentzer, Flint, and Kent (1999) recognized the need to integrate marketing aspects of customer service with physical distribution and reflected this integrative view when identifying the specific value-added benefits of logistical services. Mentzer et al. (1999) found nine value-added benefits including information quality, ordering procedures, ordering release quantities,

timeliness, order accuracy, order quality, order condition, order discrepancy handling, and personnel contact quality. Many of these benefits encapsulated the 17 universal logistical capabilities identified by Michigan State University's Global Logistics Research Team (1995).

Paralleling Mentzer et al.'s (1999) research, Stank, Goldsby, and Vickery (1999) also examined the value-added service benefits using the conceptual model of service quality (SERVQUAL) developed by Parasuraman, Zeithaml, and Berry (1985; 1988). Parasuraman et al. (1985) defined SERVQUAL as the gap between customers' expectations and perceptions of service performance and identified five distinct dimensions of SERVQUAL: (1) reliability (the ability to perform the promised service dependably and accurately); (2) responsiveness (the willingness to help customers and to provide prompt service); (3) assurance (the knowledge and courtesy of employees and the ability to convey trust and confidence), (4) empathy (the provision of caring, individualized attention to customers), and (5) tangibles (the appearance of physical facilities, equipment, personnel, and communications materials). Even though the SERVQUAL model has been criticized for not being consistent across industries (Babakus and Boller, 1992; Cronin and Taylor, 1992), Stank et al. (1999) identified two major elements of value-added benefits related to logistics services: relational and operational service performance. Within Stank et al.'s (1999) framework, operational performance captured the reliability and tangible aspects of SERVQUAL, whereas relational performance encapsulated the responsiveness, assurance, and empathy dimensions. While Stank et al.'s model provides logic and practicality, the Mentzer et al. (1999) model included a larger set of variables such as information quality, order discrepancy handling, and order release quantities. Therefore, we adopted an extended version of Stank et al.'s model for the purposes of this study. Our extended version integrates Stank et al. and Mentzer et al. models and proposes logistics service competency is reflected as logistics performance which consists of the dimensions of relational and operational performance (see Table 1).

Studies have shown that integration can help firms develop logistics competency. Gustin, Stank, and Daugherty (1994) found that integrated firms are more likely to computerize their business processes, thus achieving significant tangible results including substantial inventory savings and lead time reductions. Process integration also ensures that operational interfaces within firms are synchronized to reduce duplication, redundancy, and dwell time (Rodrigues, Stank, and Lynch 2004). In order to satisfy customers in a volatile environment, an increasing number of firms consider prompt reaction to changes as a priority (Daugherty, Stank, and Rogers 1996). Internal process integration can help firms respond to changing customer demands. A firm's responsiveness to customers requires the support of integrated logistics processes (Daugherty, Sabath, and Rogers 1992), because where there is a lack of integration, sub-optimization with inevitable conflict between departments and activities tends to be the norm (Stuade, 1987).

Closs and Savitskie (2003) further found that internal logistics information technology integration can significantly improve the firm's responsiveness to key customers and delivery time flexibility. While it is obvious that extant literature support the positive link between internal process integration and the operational aspect of logistics service performance, internal process integration in fact also enhances the relational aspect of logistics service performance. When a firm is highly integrated internally, it can be expected that different functional areas will be "on the same page" when interacting with outside customers – that is the customer interfaces are standardized. Therefore, we suggest that,

TABLE 1
LOGISTICS SERVICE COMPETENCY

Operational	Relational
● Delivery timeliness	● Personnel contact quality
● Order accuracy	● Information quality
● Order condition	● Courtesy
● Order quality	● Responsiveness
● Order discrepancy handling	● Assurance
● Ordering procedures	● Individualized attention
● Price	

P3: A firm's internal process integration is positively related to (a) the operational aspect and (b) relational aspect of logistics service performance.

Logistics Service Orientation and Logistics Service Competency

Although we argue that logistics service orientation impacts logistics service competency through enhanced internal process integration, we also suggest that logistics service orientation has direct impacts on logistics service competency. A large number of previous studies found a link between external market orientation and firm performance (e.g., Narver and Slater, 1990; Jaworski and Kohli, 1993; Slater and Narver, 1994; Pelham and Wilson, 1996; Han, Kim, and Srivastava, 1998; Narver, Jacobson, and Slater, 1999; Pelham, 2000). Moreover, the positive impacts of both external market oriented strategies (Min and Mentzer, 2004) and internal market oriented strategies (Keller, 2002) on logistics service performance have been expressed in the supply chain literature. Firm executives that are committed to building logistics service competency can develop service innovations through collaborative efforts of different departments.

Often, marketing departments acquire, silo, and store information regarding specific customer needs and expectations. Purchasing departments also have valuable information on supplier capabilities and opportunities for shared innovation and collaboration that could benefit the ultimate customers and drive service competency. And as pointed out earlier, the logistics and purchasing departments must work together with other departments to help deliver this potential value. By sharing such information with logistics, an innovative solution can be developed to create superior value to the customer which may be in the form of a JIT system for those customers that look to minimize inventory costs or an EDI system for those that require more accurate sales forecasts. These innovations in turn are expected to improve the customer's perceptions of the firm's operational performance. The relational performance, however, can only be fostered by motivated and qualified employees who are in contact with customers. Therefore,

P4: Logistics service's external market orientation is positively associated (a) directly with the operational aspect and (b) indirectly (mediated through logistics service's internal market orientation) with the relational aspect of the logistics service performance.

Internal market orientation focuses on increasing employee productivity by developing an understanding of employees' needs and

satisfying them appropriately. Motivated employees would perform their jobs more efficiently and the attained efficiency in operations may be reflected in customers' perceptions of such operational performance variables as order quality, timeliness, and procedures. The relational aspect of the business, on the other hand, can be handled by proper employee motivation (Richey and Bachrach 2004). Such expectations as frontline employee (drivers, salespeople, etc.) courtesy and honesty; service representative's care, attention, and knowledgeability; and warehouse employees' responsiveness depends on the employees' attitudes towards their jobs. To enhance such job-related attitudes and motivate employees, firms should adopt an internal market orientation toward its logistics service. Therefore,

> **P5:** Logistics service's internal market orientation is positively associated directly with both (a) the operational aspect and (b) the relational aspect of the logistics service performance.

Most interesting is the synergistic impact of logistics service's external and internal market orientations on logistics service performance. These two strategic orientations are components of logistics service orientation and complement each other. Firms that rely only on external market orientation would have a better grasp of customer's needs and can take joint interdepartmental actions to satisfy those needs by making their order receiving and handling procedures more efficient and/or effective. However, optimal logistics service competency would not be achieved unless the employees are motivated to develop and use such order receiving and handling procedures. Even though a firm may have acquired and/or developed all the right procedures and technologies to satisfy the customer needs that are identified through logistics service's external market orientation, customers' satisfaction may still be dampened by rude, dishonest, unmotivated, and/or unproven

employees. Similarly, firms that depend solely on internal market orientation toward logistics service may have a better grasp of employees' needs and can take joint interdepartmental actions to satisfy those needs by fostering innovative rewarding and/or training methods to recruit, develop, and motivate qualified employees. However, logistics service competency would not be achieved unless the employees are equipped with the necessary procedures and technology to serve their customers better than the competitors would. By adopting both strategies simultaneously, i.e. logistics service orientation, firms can bundle their superior service procedures and technologies with their superior service employees, and bundling of superior resources would lead to competitive advantage (Hunt and Morgan, 1995) – in this case, to logistics service competency. Thus,

> **P6:** Logistics service orientation, when both internal and external market orientation are perfectly aligned, is positively associated with both (a) the operational aspect and (b) the relational aspect of the logistics service performance.

One other key factor for building core competency in logistics services is the firm's ability to follow the market orientation procedure in logistics service. As discussed earlier, both logistics service's internal and external market orientations involve three procedural components: generation of intelligence, dissemination of intelligence, and preparation of a collaborative response. Firms need to excel in all three dimensions of market orientation to create a bigger impact on logistics service performance (Kohli and Jaworski, 1990). For instance, the marketing department may gather a myriad of information on customer needs but unless the information is shared with the logistics department, the response developed without a key department's input would be less effective. Similarly, human resource and

logistics departments may attempt to develop joint solutions to increase employee motivation, but such efforts would be less effective unless the solutions are based on disseminated intelligence gathered from employees. Therefore, firms should focus on all three dimensions of market orientation in order to build logistics service competency.

> **P7a:** Firms that excel in all three dimensions of external market orientation would have a superior logistics service performance over those that overlook at least one of the components.

> **P7b:** Firms that excel in all three dimensions of internal market orientation would have a superior logistics service performance over those that overlook at least one of the components.

IMPLICATIONS AND FUTURE RESEARCH

The objective of this manuscript was to develop a conceptualization of logistics service orientation by integrating the external and internal market orientation views by illustrating the synergy between the two schools of thoughts. Research in logistics service performance posits that service competency can be achieved either through customer/competitive focused (i.e. external market oriented) strategies (e.g. Zhao, Droge, and Stank, 2001) or employee focused (i.e. internal market oriented) (e.g. Keller, 2002) strategies. In our conceptual framework, we suggest that firms that are truly committed to building a logistics service competency should adopt both an internal and external market orientation – rather than choosing one or the other – in order to take advantage of the synergies between the two strategic views. It is obviously very unlikely that marketing, purchasing, and logistics will be able to operate independently over time and remain effective.

This is supported by the plain fact that logistics cannot create customer value without marketing creating sales and marketing cannot complete sales nor retain customers without logistics filling those orders consistently and correctly. It is truly unfortunate that — in this new service driven economy – research and practice in marketing and logistics still remain very much in functional silos. It is our hope and belief that adoption of a unified vision of *logistics service orientation* and strategy will assist in integrating both research and organizational practice with a goal of superior performance.

Being externally market oriented means paying attention to customer needs and demands – a normal claim in most mission statements. Being internally market oriented means hiring, motivating, and retaining qualified employees as a mechanism for driving superiority in logistics service performance. Human resource managers recognize that external market orientation cannot survive without internal market orientation. Logistics strategists know that external market orientation will not happen if operations managers and employees have not bought into the concept. Yet researchers neglect the connection as imminent in developing logistics service orientation.

Also, while we argue that logistics service orientation has direct impacts on logistics service competency, we also suggest that this relationship can be mediated with internal process integration. The inclusion of an internal process integration concept presents a more complete and robust framework to explain the proposed relationships.

As an exploratory study on logistics service orientation, the current paper provides many opportunities for future research. First of all, due to the conceptual nature of the current study, future research is needed to empirically test, validate, modify, or reject the proposed conceptualization of logistics service orientation and related relationships. While we have proposed a theoretical conceptualization of

logistics service orientation, future research on operationalizing this construct is warranted.

As stated previously, the scope of the current study is limited to a single firm. In reality, supply chain management involves more than one firm. Therefore, future research should build upon the current study and expand discussion to multiple parties in the supply chain. Similarly, only internal process integration is considered in this paper, but future research could incorporate and examine the relationships between external process integration and logistics service orientation and logistics service competency.

Furthermore, future research can extend the boundaries of the discussion presented in this paper by integrating it with the concept of supply chain orientation. Mentzer et al. (2001, p.11) define supply chain orientation "as the recognition by an organization of the systemic, strategic implications of the tactical activities involved in managing the various flows in a supply chain." Integrating supply chain orientation with the current discussion not only extends the focus of external market orientation from mere downstream customers to focusing on both upstream suppliers and downstream buyers, but also expands the outcomes beyond logistics service performance to include other outcomes.

Logistics and supply chain managers have known for years that customer service goals will not be met if frontline employees are not hired, trained, and motivated to meet and exceed customer firm expectations (Richey and Bachrach, 2004). For a firm to be a truly superior performer, executives must develop a strong logistics service orientation and commit to external market orientation supported by consistent internal market orientation. Unfortunately, the strategic management focus of many firms respects external market orientation with little attention paid to internal market orientation in most logistics/supply chain scenarios.

Twenty-first century logistics management philosophy is transitioning from an operational focus on transactional cost reduction and service trade-offs to a more long-term relational perspective. More and more emphasis is being placed on supply chain partners and supply chain competitive positioning based on both consistent operational and relational performance outcomes. Leading firms will adapt to reflect market orientation across internal/operational and external/strategic levels. Failure to do so will result in a strategic misfit between top management teams and operations management/frontline employees. What will the results of this misfit be? We expect unattainable or misunderstood corporate missions, subpar performance, and eventual divesture vs. market dominance! Therefore, we propose an integrative approach to developing a strong logistics service orientation and achieving logistics service competency.

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THE SELECTION OF TRANSSHIPMENT PORTS USING A HYBRID DATA ENVELOPMENT ANALYSIS/ANALYTIC HIERARCHY PROCESS

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ABSTRACT

The accelerated globalization of logistics activities over the last several decades has spurred a rapid expansion of port facilities all cross the world. However, the recent slowdown of international trade, coupled with a global financial crisis, has created an on-going glut of international port facilities throughout the world. Although the abundance of port facilities provides more transshipment options for carriers and shippers, it makes the port selection decision more complex and difficult. To cope with this new set of challenges, this paper proposes a hybrid data envelopment analysis (DEA)/ analytic hierarchy process (AHP) model that is designed to identify factors specifically influencing transshipment port selection, evaluates the extent of influence of those factors on a transshipment port selection decision, and then determines the most critical ones among various factors. To illustrate the usefulness of the proposed hybrid DEA/AHP model, major container hub ports in Far-East Asia were analyzed.

INTRODUCTION

As a severe public debt crisis in developed economies including the Unites States, Great Britain, Spain, Portugal, and Greece continues, the global economy has struggled to slip out of ongoing recession. Impacted by this slumping global economy, international trade in 2009 experienced the sharpest decline in more than 70 years. Although international trade grew somewhat in 2010, that growth has been slow-paced relative to the recent past. Slow growth in international trade has far reaching impacts on the maritime logistics industry, and most notably ports serving the ocean shipping industry (Toth, 2009). To make matters worse, many major ports across the world substantially expanded their capacity in the recent past with an expectation of a demand surge. For example, the port of Qingdao in China recently invested 1.4 billion dollars in its harbor, including 10 deep-water berths and expansion of the total dock length to 3,408 meters (DredgingToday.Com, 2010). Similarly, the Port of Tianjin in China

and the Port of Mundra in India poured billions of dollars of investment into capacity expansion.

On the surface, the above port capacity expansion sounds beneficial for shippers and carriers because the surplus of port capacity can lower port charges for ocean carriers. However, the reduced port charges may increase the number of vessels anchored at the port and can considerably slow the loading/unloading process at the port. A delay at the port caused by an excessibe number of vessels will lead to an increase in lead time and the subsequent deterioration of services for shippers. Considering this dilemma, the ocean shipping industry needs to develop an efficient and effective port selection strategy that will help carriers and shippers cope with the misalignment of port demand and supply.

Generally, a port selection decision is extremely challenging due to a multitude of influencing factors. These factors include (Murphy et al., 1992 and Chang et al., 2008), geographical location, terminal handling charges, port dues, feeder connections, inland intermodal connections, port

reputation, water draft, information technology capabilities, convenience of customs processes, and labor-management relationships. Factors often conflict with each other thereby complicating the goal of selecting the most desirable port. For instance, a port in an ideal location may incur higher costs due to high terminal charges and port dues or vice versa. Also, since the comparative performance of ports relative to other competing ports can influence the port selection decision, the relative attractiveness of ports should be factored into the port selection decision. This attractiveness, in turn, is influenced by the relative importance of port selection factors. Considering this complexity of the port selection decision, this paper develops a systematic decision tool for selecting the most desirable port in dynamic business environments. More specifically, the main objectives of this paper are to:

1. Identify key determinants that significantly influence the transshipment port selection decision from the perspective of both port users (carriers) and port service providers (port authorities and operating companies);
2. Determine the relative importance of those determinants to the port selection decision;
3. Analyze the trade-offs among those determinants;
4. Evaluate the extent of influence of each determinant on port selection;
5. Develop a port competitive strategy or port policy that can attract more carriers to the port and then strengthen port competitiveness under various what-if decision scenarios.

PRIOR LITERATURE

A transshipment port plays an important role in linking the global supply chain, since it is often used as a point of transfer from international (open-sea) to domestic (inland) transportation or from one mode of transportation to another. The transshipment port is also regarded as a collection center for cargoes moving from a feeder port to an inland destination. Due to its critical role in a global supply chain, the choice of a transshipment port has a long lasting impact on supply chain efficiency. Despite its significance, relatively few studies have been conducted to address the issue of how a port is selected and who selected the port given the conflicting interests of multiple-stakeholders (i.e., port authority, carriers, and shippers). Some of the prior works on transshipment port selection include studies performed by Lim (2003, 2004), Ng (2006), and Park and Sung (2008). All of these studies built upon the findings of earlier pioneering studies (Bardi, 1973; Willingale, 1981; Murphy et al., 1992; and Malchow and Kanafani, 2001) on generic port selection which attempted to identify key determinants for port selection from the perspectives of multiple stakeholders. The following subsections elaborate on the key objectives, findings, and methodologies of these prior studies.

Generic Port Selection

Earlier studies on port selection were primarily concerned with the identification of port selection criteria/factors using empirical surveys of carriers and/or shippers. Examples of these studies include Willingale (1981), Branch (1986), Browne et al. (1989), and Murphy et al. (1988, 1989). They identified port infrastructure, cargo safety, port service quality, and port charges as the key influencing factors for port selection. Following up on these studies, Murphy et al. (1992), Hayuth (1995), Thomas (1998), and Villalon (1998) continued to examine which factors significantly affect port selection. In particular, they examined whether socio-political stability, geographical location, and cargo (including bulk cargo and odd-sized cargo) handling capability affect port selection decisions. Their findings indicated that port services, lead time (including loading/ unloading time), equipment availability, and information technology support were considered most important for selecting a port. These exploratory studies, however, are not designed to analyze trade-offs among a host of conflicting factors and help the policy/decision maker to

choose the best available port among alternative ports.

To overcome such an inherent shortcoming of exploratory studies based on survey questionnaires, a series of fairly recent studies on port selection proposed mathematical techniques. One of the most popular techniques is an analytic hierarchy process (AHP) which is helpful for selecting the best available port among a set of alternatives with various pros and cons. Examples of the studies which used AHP for port selection include Brooks (2000), Cullinance and Toy (2000), Song and Yeo (2004), Kim (2005), Guy and Urli (2006), and Lee et al. (2007). To summarize, these earlier studies on port selection revealed that port infrastructure, port capacity, port service quality, port charges, information technology support, and geographical location are key influencing factors, although their perceived relative importance may differ from one stakeholder to another (see Table 1). It is also noted that, with the increasing automation of port handling processes and electronic transmission of port-related data, the information technology capability of a port seems to have gained more importance for port selection.

Transshipment Port Selection

Generally, ports are points of convergence between two domains of freight circulation; the *land* and *maritime* domains. In a broad sense, key roles of the port include the provision of: (1) *maritime access* to navigational waters, (2) *maritime interface* to support maritime access through

TABLE 1
A SUMMARY OF THE SELECTED PORT LITERATURE

Problem scope		Author (year of publication)	Survey respondents or methodologies	Key determinants
Transshipment port selection		Lim et al. (2003, 2004)	Experts and carriers	Port/freight charge, port infrastructure, geographical location
		Ng (2006)	Carriers	
		Park & Sung (2008)	Carriers and port authorities	
Generic port selection	1980's	Willingale (1981)	Carriers	Port facility, docking frequency, port safety, port service, port/freight charge,
		Branch (1986)	Literature reviews	
		Browne et al. (1989)	Literature reviews	
		Murphy et al. (1988, 1989)	Carriers and port authorities	
	1990's	Murphy et al. (1992)	Carriers, shippers, forwarders, port authorities	Port service, lead time, equipment availability, shipment information technology
		Hayuth (1995)	Literature reviews	
		Thomas (1998)	Literature reviews	
		Villalon (1998)	Carriers	
	21st	Cullinane and Toy (2000)	Literature reviews	Port location, port/freight charge, port size, port facility, port management
		Brooks (2000)	Literature reviews	
		Song and Yeo (2004)	Experts	
		Kim (2005)	Carriers	
		Guy and Urli (2006)	Literature reviews	
		Lee et al (2007)	Carriers and shippers	

dedicated space (capacity), (3) *infrastructure* (e.g., piers, basins, stacking or storage areas, warehouses, terminals) and *equipment* (e.g., cranes), and (4) *land access* to inland transportation (e.g., rail, trcusk) (Rodrigue et al., 2009). In addition, one of the emerging roles of the large ports includes the transshipment of cargoes from one port to another. A port that plays the role of a transshipment point is often considered a hub port where cargoes are either consolidated or break-bulked for a final leg of the journey (Min and Guo, 2004). In this type of port, a multiple array of commodities including dry or liquid bulks are handled with a link to a wide variety of transportation modes and containers. Examples of well-known transshipment ports are: Rotterdam, Netherlands; Singapore; Hong Kong; Shanghai, China; Kaoshung, Taiwan; Busan, Korea; Yokohama, Japan. Although factors influencing transshipment ports may be similar to those affecting typical ports, a transshipment port selection decision is more complex than a generic port selection decision due to its expanded roles. Recongnizing such added complexity, Lirn et al. (2003, 2004), Ng (2006) and Park and Sung (2008) initiated studies focusing on transshipment port selection from the perspectives of either carriers or port authorities as recapitulated in Table 1.

To elaborate, Lirn et al (2003) identified a total of 47 factors affecting a choice of Taiwan's transshipment ports using two rounds of "Delphi" surveys of port experts. Among these, they discovered that geographical location was the most important determinant for transshipment port selection. They also proposed an AHP model for final selection of the most desirable port. A year later, Lirn et al. (2004) extended their study to include transshipment ports across the globe. They found that both geographical location and port charges were two dominant factors for transshipment port selection. Built upon the earlier studies of Lirn et al. (2003, 2004), Ng (2006) identified 46 different factors influencing transshipment port selection using a survey questionnaire. Among these, he observed that lead time turned out to be most important factor. More recently, Park and Sung (2008) further extended these earlier works by soliciting feedback from multiple stakeholders including the port authority for identifying transshipment port selection criteria in Far Eastern countries. Their study revealed that port/freight charges and the subsequent port operating expenses were considered most important for transshipment port selection.

As the review of this prior literature reveals, the perception of key factors, and their relative importance, seems to vary from one study to another due in part to the conflicting interests of multiple stakeholders. This indicates that a majority of the prior studies summarized in Table 1 failed to reflect the differing views of multiple stakeholders such as carriers, port authorities, shippers, port operating companies, and forwarders. To overcome this drawback, the current study attempts to solicit feedback from both carriers and port operators (port authorities/ operating companies) and identify differences in their perception of key determinants and their relative importance. Also, none of the prior studies measures the extent of influence of port selection determinants on a port selection decision relative to other determinants. Thus, this paper attempts to not only identify key determinants of transshipment port selection, but also evaluates the extent of contribution of each determinant to a port selection decision. In other words, this paper helps port policy makers understand how carriers arrive at the final port selection decision in the presence of multiple port selection determinants and alternative ports.

RESEARCH METHODOLOGY

The primary database for this study came from a survey questinnaure of both carriers (e.g., ocean carriers) and port operators (e.g., container operating companies, port authorities). A sample of carriers were targeted as survey respondents from a list of the top 30 carriers designated by *Containerization International* 2009 and 2010 as well as other major carriers serving shippers globally. Also, a sample of 50 carriers and 30 port

operators in Far-East Asia were targeted for a survey. During the period of March 2009 through June 2009, the questionnaire was sent to this sample of carriers and port operators. Since the initial survey produced a total of only 20 valid responses, a second wave of questionnaires was sent to these target respondents with a reminder during the periods of December 2009 and February of 2010. Overall, 39 valid responses from the carriers and 9 valid responses from port operators were received. These responses represent a 78% response rate for the carriers and a 30% response rate for the port operators. Comparing early and late responses, a non-reponse bias error was checked for but no such error was found.

Based on these survey results and a review of prior literature, we identified a total of 46 different factors which may influence a transshipment port selection decision. These fators are summarized in Table 2. Since the simultaneous consideration of all of these factors can overwhelm the decision maker and some of these factors may be redundant with each other, we broke down these factors into 13 different categories and then these categores were aggregated into four distinctive groups: (1) port infrastrucre; (2) port location; (3) port management; and (4) carrier operating expenses as summarized in Table 3. The grouping of these factors was based on Lim et al. and input from a panel of experts comprised of three university professors in the maritime logistics fields, three port administrators in the Ports of Busan and Gwangyang, and five executives representing liner shipping companies.

These grouped factors were re-organized as a hierarchical structure shown in Figure 1 for an application of analytical hierarchy process (AHP) techniques. AHP is a systematic scoring method that was designed to synthesize the perceived degree of importance of each port selection criterion/category into an overall evaluation of each candidate port with respect to such a criterion/category (see Saaty, 1980 for the conceptual foundation of AHP). Accordingly, AHP helps the carrier assess the strengths and weaknesses of candidate ports relative to competiting ports, but also helps the carrier identify the most viable alternative port in the port selection process. Furthermore, AHP can enhance the carrier's ability to make tradeoffs among various quantitative (port charges, container handling cost, ship turnaround time, a proximity/distance to a feeder port, quick response time) and qualitative port selection categories (port service quality, port security, cargo safety) for port selection (Saaty, 1988; Min and Min, 1996). In addition, data envelopment analysis (DEA) was employed to assess the extent of contribution of each category to the port selection decision so that the most essential categories would be identified. In measuring the extent of influence of transshipment port selection categories, we chose DEA over other alternative techniques, such as Cobb Douglas functions, because DEA does not require an explicit *a priori* determination of input and output functional relationships and provides valuable insights as to comparative "influence efficiency" (extent of influence) of each port selection category relative to other categories. Generally, DEA is referred to as a linear programming (non-parametric) technique that converts multiple incommensurable inputs and outputs of each decision-making unit (DMU) into a scalar measure of operational efficiency, relative to its competing DMUs. Put simply, DEA examines the resources available to each DMU and monitors the "conversion" of these resources into desired outputs (Cook and Zhu, 2008). Herein, DMUs refer to the collection of private firms, non-profit organizations, departments, administrative units, and groups with the same (or similar) goals, functions, *standards* and market segments (Charnes et al., 1978). Though uncommon, transshipment port selection categories are considered DMUs in our study because they represent port selection *standards*. Combining the complementary traits of both AHP and DEA, the application of hybrid DEA/AHP to transshipment port selection involves four major steps:

(1) Break down the port selection process into a manageable set of criteria (e.g., four criteria in this study) and categories and

TABLE 2
A LIST OF TRANSSHIPMENT PORT SELECTION FACTORS

Factors	M(89)	M(92)	T(98)	V(98)	B(00)	C(00)	L(3,4)	S(04)	Yeo(04)	Kim(05)	G(06)	N(06)	L(07)
Water depth				o			o		o	o	o		o
Port size	o	o	o			o	o	o	o	o	o		o
Port infrastructure			o	o			o			o		o	o
Port information technology	o	o				o	o	o	o	o		o	o
Quality of port superstructure	o	o	o		o	o	o	o		o	o	o	
Inland transporation cost						o	o	o	o	o			o
Port access							o	o	o	o			
Port service range					o		o					o	
The size of local/regional market							o	o	o	o	o		o
Intermodal links/networks				o			o	o	o	o	o		o
Cargo handling capacity	o			o		o	o	o	o				
Container cargo rate			o				o						
Geographical location				o	o		o			o		o	
Container hub				o			o			o			
Feeder frequency				o			o						o
Routing diversity									o				o
Port competitiveness							o	o					
Access to alternate ports							o			o		o	
Access to major shipping routes					o		o	o	o	o	o		o
Short transshipment time					o		o			o	o		
Socio-political stability							o	o	o	o			o
Port organization							o	o					
Customs procedure							o		o			o	
Port policy and regulation							o		o			o	
Container handling efficiency				o			o					o	
Operational flexibility							o	o					
Port operating time	o	o	o			o	o	o	o	o			
Shipment schedule	o	o				o	o	o	o				
Port marketing										o		o	o
Cargo safety						o			o	o		o	o
Feeder service							o		o				
A length of port berthing time			o				o						o
Port productivity							o		o		o		o
Port security	o	o				o	o	o		o			
Port labor quality									o	o		o	o
Port reputation									o	o		o	o
Immediate user service									o			o	o
Supporting service									o			o	
Government support				o			o						
Port exspense	o	o	o	o	o	o	o	o		o		o	o
Free dwell time on the terminal							o			o			
Related business operations							o						
Privileged ownership contract for carriers							o					o	o
Cargo balancing													o
Alliance member's calling													o
Competitor's calling													o

Note: M(89)-Murphy et al.(1989), M(92)-Murphy et al.(1992), T(98)-Thomas(1998), V(98)-Villalon(1998), B(00)-Brooks(2000), C(00)-Cullinane & Toy(2000),

L(3,4)-Lim et al.(2003,2004), S(04)-Song & Yeo (2004), Yeo(04)-Yeo et al.(2004), Kim(05)-Kim(2005), G(06)-Guy & Urli(2006), N(06)-Ng(2006), L(07)-Lee

TABLE 3
GROUPING OF TRANSSHIPMENT PORT SELECTION FACTORS

Criteria	Categories	Examples of detailed factors
Port infrastructure	Basic infrastructure	Depth space of the port,size of port and terminal(quay length, no. of berths, container yards and CFS area), container handling capacity
	Information technology infrastructure infrastructure	information system (system integration, VTS, vessel/cargo information), port EDI, port RFID
	Intermodal links	Access to inland transportation, port service coverage (e.g., pilotage, towing and mooring), rail sidings, intermodal terminal access, competitiveness and diversity of other modes,
Port location	Proximity to import/export businesses	Traffic volume and throughput, containerized cargo proportion, geographical advantage (to the manufacturer), availability of free trade zones
	Feeder service access	Frequency and network of feeder service, variety of service routes, proximity to alternative port
	Access to major shipping routes	Deviation to trunk routes, short transit time
Port management	Port management efficiency	National stability (politics, society, labor, etc.), port reputation, quality of customs handling, port authority policy and regulations, container handling efficiency (delays), port operating / working hours, reliability of berth scheduling and cargo handling, port marketing, cargo handling safety & flexibility
	Ship turn-around time	Idle time (e.g., no congestion), length of berthing time, loading/unloading time
	Port security	Port physical security (CCTV systems, fences), personal security (security guards, employee background checks), information security (privacy, hacking prevention)
	Port service quality	Quality and availability of staff, port recognition and reputation, prompt response to claim and request, Supporting services (e.g. warehousing, insurance, fresh water, fuel oil and ship's stores provision, etc.)
Carriers operating expenses	Container handling cost	State aided incentives, cost for handling & storage of containers, free dwell time
	Terminal contract cost	Related business operating expenses, privileged ownership contract for carriers
	Carriers bargaining opportunity	Cargo balancing, alliance member's calling, competitor's calling

then structure these into a hierarchical form as displayed in Figure 1;

(2) Make a series of pairwise comparisons among the criteria and categories according to the survey respondent's perceived importance of each criterion and category;

(3) Estimate the relative weights of service criteria and categories based on the panel of experts' perceived importance of those criteria and categories. Also, determine the local priority scores of the respective transshipment port selection categories using AHP;

(4) Aggregate these local priority scores and synthesize them for the overall evaluation of each port selection category. Then, identify the most influencial port selection categoties among various determinants using DEA.

FIGURE 1
A HIERARCHICAL STRUCTURE OF THE TRANSSHIPMENT PORT SELECTION CRITERIA
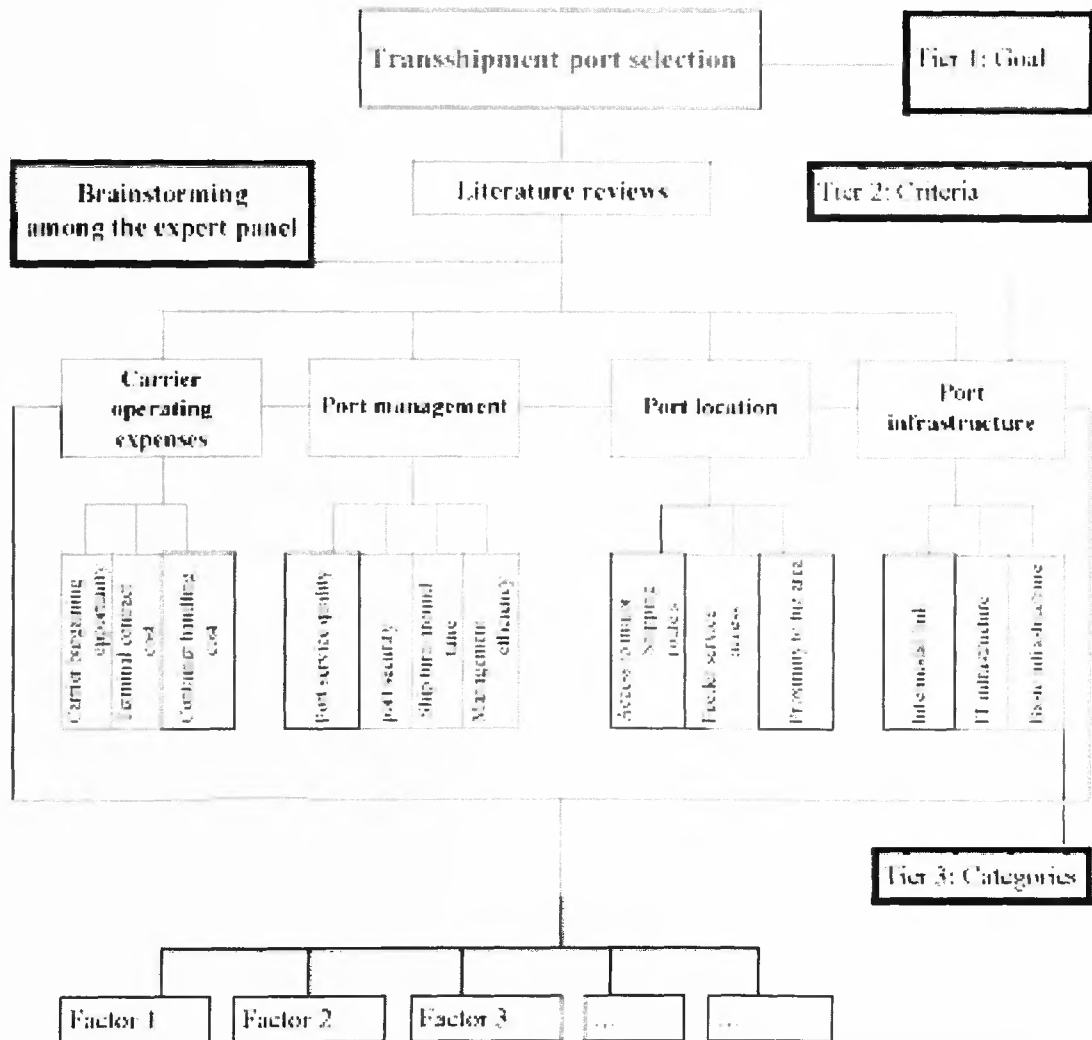
RESULTS AND DISCUSSION

To deteremine both the carriers's and the port operators' perceived importance of transshipment port criteria and categories, their relative weights and priority scores were first calculated through a series of pairwaise comparisons made by a panel of experts and survey respondents. Using the Expert Choice program (2009), the weights and priority scores were derived. These scores, however, are not absolute measures (raw scores), but relative measures that represent the relative importance or priority of each criterion and category. Thus, pairwise comparisons were intended to derive numerical values (relative measures) from a set of experts and survey respondents' judgments, rather than arbitrarily assigning numerical values to criteria and categories. These pairwise comparisons produced

relative weights of the four transshipment port selection cariteria summarized in Table 4. As shown in Table 4, port operating expenses turned out to be most important in selecting a transshipment port. Overall, the second most important cariteria is port infrastructure. However, there is a marked difference in its relative importance between the carrier and the port operator. Indeed, the port operators regarded port infrastructure as the least important criterion, whereas the carriers valued port infrastructure almost as much as port operating expenses. Especially, the port operators did not seem to fully understand how much the carriers appreciate good basic infrastructure (port size, water depth) and convenient access to intermodal links (piggybacks, rails, barges). This result indicates that port operators should invest more in the improvement of port infrastructure to attract more carriers and

TABLE 4
RELATIVE IMPORTANCE OF PORT SELECTION CRITERIA/CATEGORIES

Criteria Categories	Overall	Carriers	Port Operators
Port infrastructure	0.271	0.304	0.128
Basic infrastructure	0.384	0.381	0.417
Information tech. infrastructure	0.212	0.208	0.253
Intermodal links	0.404	0.412	0.330
Sub-total	1.000	1.000	1.000
Port location	0.240	0.231	0.275
Proximity to imp/exp. businesses	0.291	0.306	0.236
Feeder service access	0.226	0.235	0.192
Access to major shipping routes	0.483	0.459	0.572
Sub-total	1.000	1.000	1.000
Port management	0.140	0.143	0.130
Management efficiency	0.332	0.350	0.248
Ship turnaround time	0.267	0.253	0.335
Port security	0.122	0.120	0.131
Port service quality	0.279	0.277	0.286
Sub-total	1.000	1.000	1.000
Port operating expenses	0.349	0.322	0.467
Container handling cost	0.540	0.518	0.606
Terminal contract cost	0.182	0.189	0.160
Carrier bargaining opportunity	0.278	0.293	0.234
Sub-total	1.000	1.000	1.000
Total	1.000	1.000	1.000

TABLE 5
TRANSSHIPMENT PORTS UNDER EVALUATION

Port	2009		2008		Country
	1,000 TEU	Ranking	1,000 TEU	Ranking	
Shanghai	25,000	2	27,980	2	China
Hong Kong	20,980	3	24,490	3	China
Busan	11,950	5	13,480	5	Korea
Tianjin	8,700	11	8,500	14	China
Kaohsiung	8,580	12	9,680	12	Taiwan
Tokyo	3,740	26	4,160	24	Japan
Gwangyang	1,810	53	1,810	65	Korea

Source: CI Yearbook, 2010

subsequently generate more revenue. Another noticeable discrepancy between the opinions of the carriers and the port operators is the relative importance of port management efficiency. As shown in Table 4, the carriers are more concerned with port management efficiency than the port operators. However, in a competitive environment, the measure of port management efficiency should be relative rather than absolute. In other words, to properly factor port management efficiency into a port selection decision, we should compare its relative importance to that of other port selection categories. The same analolgy can be made regarding the comparative evaluation of other port selection categories. Such evaluation called for the use of DEA, since a standalone AHP is not designed to assess the comparative efficiency. Thus, there is a need to combine AHP with DEA.

For illustrative purposes, we considered seven major transshipment/hub ports in Far-East Asia: (1) Shanghai; (2) Hong Kong; (3) Busan; (4) Tianjin; (5) Kaohsiung; (6) Tokyo; (7) Gwangyang for comparative evaluation. All but Gwangyang were listed on top 30 ports in the world in terms of their cargo handling volume (see Table 5). Although Gwangyang is relatively young and unknown, it is growing rapidly thanks to heavy investment in the development of large-scale free economic zones due for completion in 2011. Therefore, we included it in the DEA evaluation.

Prior to DEA applications, we solicted the opinions of both carriers and port operators regarding their perceived importance of 13 port selection categories identified earlier. Their combined and respective opinions are summarized in Tables 6, 7, and 8. These raw data were later fed into the DEA model for comparative evaluation of these categories for port selection. With respect to all of these categories, larger and sourthen location hub ports such as Busan, Shanghai, and Hong Kong are considered more favorable whereas smaller or northern location ports such as Tianjin and Tokyo are considered less favorable. However, as shown in Tables 7 and 8, opinions between the carriers and the port operators somewhat differ in that the carriers tend to favor southern location ports whereas the port operators tend to favor larger ports.

A careful identification of inputs and outputs is critical to the successful application of DEA to any decision-making process (Yeh, 1996; Thanassoulis, 2001). Thus, the assessment of the extent of influence of port selection categories using DEA begins with the selection of appropriate input and output measures that can be aggregated into a composite index of overall performance standards. Although any resources utilized by DMU could be included as input, we selected the performance rating (1: the least favorable scale, 5: the most favorable scale) of each transshipment

TABLE 6
TRANSSHIPMENT PORT EVALUATION SCORES WITH
RESPECT TO OVERALL CATEGORIES

Data	(O) Overall priority score	(I) Gwangyang	(I) Busan	(I) Tokyo	(I) Shanghai	(I) HongKong	(I) Kaohsiung	(I) Tianjin	Average
Basic infrastructure	0.104	3.4	3.8	3.4	3.9	3.9	3.2	3.1	3.5
Information tech. infrastructure	0.057	3.4	3.8	3.6	3.7	3.9	3.4	3.0	3.5
Intermodal link	0.110	2.9	4.0	3.3	3.6	3.8	3.2	3.0	3.4
Proximity to businesses	0.070	2.9	4.1	3.3	3.9	3.8	3.2	3.2	3.5
Feeder service access	0.054	2.9	4.1	3.2	3.6	3.8	3.2	2.9	3.4
Access to major shipping routes	0.116	3.1	4.1	3.3	3.8	4.0	3.5	3.0	3.5
Management efficiency	0.047	3.4	3.7	3.4	3.6	3.8	3.4	3.1	3.5
Ship turnaround time	0.037	3.3	3.8	3.3	3.6	3.8	3.4	3.0	3.5
Port security	0.017	3.6	3.8	3.8	3.6	3.8	3.5	3.2	3.6
Port service quality	0.039	3.4	3.8	3.5	3.6	4.0	3.5	3.1	3.6
Container handling cost	0.189	3.7	3.6	2.8	3.7	3.3	3.2	3.4	3.4
Terminal contract cost	0.063	3.2	3.4	3.1	3.7	3.5	3.3	3.0	3.3
Carrier bargaining opportunity	0.097	3.0	3.7	3.1	3.9	3.9	3.2	3.1	3.4
Port evaluation score	Average	3.26	3.84	3.22	3.74	3.73	3.28	3.11	3.45
	Ranking	5	1	6	3	2	4	7	

TABLE 7

THE TRANSSHIPMENT PORT EVALUATION SCORE WITH RESPECT TO CATEGORIES

(CARRIER'S OPINIONS)

Data	(O) Carriers	(I) Gwangyang	(I) Busan	(I) Tokyo	(I) Shanghai	(I) HongKong	(I) Kaohsiung	(I) Tianjin	Average
Basic infrastructure	0.116	3.5	3.8	3.3	3.9	3.9	3.1	3.0	3.5
Information tech. infrastructure	0.063	3.5	3.8	3.5	3.6	3.8	3.3	3.0	3.5
Intermodal link	0.125	3.1	3.9	3.3	3.5	3.7	3.2	2.9	3.4
Proximity to businesses	0.071	3.1	4.1	3.1	3.7	3.7	3.1	3.2	3.4
Feeder service access	0.054	3.1	4.2	3.2	3.6	3.7	3.1	2.8	3.4
Access to major shipping routes	0.106	3.1	4.1	3.2	3.7	3.9	3.3	3.0	3.5
Management efficiency	0.050	3.5	3.7	3.4	3.6	3.7	3.2	2.9	3.4
Ship turnaround time	0.036	3.4	3.9	3.3	3.6	3.8	3.3	2.9	3.5
Port security	0.017	3.6	3.7	3.7	3.4	3.7	3.4	3.0	3.5
Port service quality	0.040	3.6	3.7	3.5	3.4	3.9	3.4	3.0	3.5
Container handling cost	0.167	3.7	3.7	2.8	3.6	3.4	3.1	3.3	3.4
Terminal contract cost	0.061	3.3	3.4	3.0	3.5	3.4	3.2	3.0	3.2
Carrier bargaining opportunity	0.094	3.1	3.8	3.1	3.9	3.8	3.1	3.1	3.4
Port evaluation score	Average	3.33	3.84	3.18	3.65	3.71	3.18	3.04	3.42
	Ranking	4	1	6	3	2	5	7	

TABLE 8
THE TRANSSHIPMENT PORT EVALUATION SCORE WITH RESPECT TO CATEGORIES
(OPERATOR'S OPINION)

Data	(O) Operators	(I) Gwangyang	(I) Busan	(I) Tokyo	(I) Shanghai	(I) HongKong	(I) Kaohsiung	(I) Tianjin	Average
Basic infrastructure	0.053	3.1	3.8	3.6	4.0	3.8	3.4	3.6	3.6
Information tech. infrastructure	0.032	3.0	3.9	3.6	4.3	4.3	3.5	3.1	3.7
Intermodal link	0.042	2.1	4.5	3.6	4.0	3.9	3.3	3.5	3.6
Proximity to businesses	0.065	2.3	4.4	3.9	4.6	4.1	3.8	3.5	3.8
Feeder service access	0.053	1.9	4.1	3.3	4.0	4.0	3.8	3.3	3.5
Access to major shipping routes	0.157	3.3	4.4	3.6	4.0	4.5	4.3	3.0	3.9
Management efficiency	0.032	2.8	3.4	3.4	4.0	4.0	4.1	3.5	3.6
Ship turnaround time	0.044	2.9	3.5	3.5	3.6	3.8	4.3	3.5	3.6
Port security	0.017	3.6	4.1	4.1	4.1	3.9	4.0	3.8	3.9
Port service quality	0.037	2.9	4.0	3.5	4.6	4.4	3.9	3.6	3.8
Container handling cost	0.283	3.9	3.3	3.0	3.9	3.0	3.8	3.8	3.5
Terminal contract cost	0.075	3.0	3.5	3.3	4.4	4.0	3.6	3.4	3.6
Carrier bargaining opportunity	0.109	2.4	3.4	3.5	4.1	4.0	3.5	3.1	3.4
Port evaluation score	Average	3.07	3.74	3.39	4.06	3.79	3.79	3.43	3.61
	Ranking	7	4	6	1	2	3	5	

Note 1: Likert scale of 1: Least favorable, 5: Most favorable

Note 2: Port evaluation score = Perceived importance of category × Port performance rating

Note 3: (O) Operators = Operators' priority scores based on AHP

port as input. Since the port performance rating with respect to each port selection category reflects the port efficiency and subsequently increases the chance of a particular port being selected, it can be regarded as input. Given seven different ports to evaluate, there were a total of seven inputs. On the output side, the overall performance of the port can be measured by its diverse service offerings weighed by each port selection category. Thus, the priority score of each port selection category was used as the output. As indicated earlier, this priority score ranging from a small fractional value to a maximum of 1.0 was generated by AHP. By calculating a ratio of the priority score of each port selection category to each port performance rating relative to other priority scores, an estimate of the extent of contribution of each port selection category to port attractiveness and the subsequent port selection can be developed.

Overall, nine different port selection categories that affected the port selection decision "significantly" (using the threshold value of 95% for a DEA model with varying returns to scale - BCC) were found. As shown in Table 9, these categories are: (1) basic port infrastructure; (2) intermodal links; (3) feeder service access; (4) access to major shipping routes; (5) ship turnaround time; (6) port security; (7) container handling cost; (8) terminal contract cost; and (9) carrier bargaining opportunity. Among these, four categories (intermodal links, a proximity to major shipping routes, container handling cost, and carrier bargaining opportunity) are considered primary port selection factors with 100% DEA scores ("full" efficiency"), while five others (basic port infrastructure, feeder service access, ship turnaround time, port security, and terminal contract cost) are considered secondary port selection factors with less than 100% DEA scores. However, the results differ somewhat in that the carriers' port selection decision was affected by ten different categories including the port's proximity to import/export businesses, whereas the operators factored nine categories into the port selection decision. The most striking differences in the extent of impact of categories on port selection happen to be the port's proximity to businesses involved in import/export activities (carriers' 99.98% versus operators' 67.63%), port security (carriers' 99.66% versus operators' 6.70%), port service quality (carriers' 99.72% versus operators' 22.14%), and port management

TABLE 9
SUMMARY OF FINAL DEA RESULTS

	Overall		Carriers		Operators	
	CCR	BCC	CCR	BCC	CCR	BCC
Basic infrastructure	60.04%	99.98%	76.55%	100.00%	23.39%	99.94%
Information technology infrastructure	34.36%	68.49%	42.10%	53.27%	14.78%	29.63%
Intermodal link	73.25%	100.00%	87.93%	100.00%	27.22%	99.98%
Proximity to businesses	47.20%	99.93%	50.99%	99.98%	39.50%	67.63%
Feeder service access	37.25%	99.98%	38.82%	99.98%	38.56%	100.00%
Access to major shipping routes	73.28%	100.00%	76.02%	100.00%	69.48%	100.00%
Management efficiency	27.31%	57.47%	33.35%	49.24%	16.05%	98.31%
Ship turnaround time	22.33%	99.83%	24.63%	99.79%	20.74%	99.96%
Port security	9.69%	99.64%	11.17%	99.66%	6.43%	6.70%
Port service quality	22.50%	33.97%	26.07%	99.92%	17.71%	22.14%
Container handling cost	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Terminal contract cost	38.85%	38.85%	41.06%	99.98%	34.10%	99.70%
Carrier bargaining opportunity	63.97%	63.97%	66.36%	100.00%	63.00%	100.00%

efficiency (carriers' 49.24% versus operators' 98.31%). These discrepancies illustrate significant gaps between the opinions of carriers and that of operators in the perceived importance and the extent of influence of port selection categories. From a port policy standpoint, these gaps may be the sources of port failure in attracting more carriers to a particular port.

CONCLUSSIONS AND MANAGERIAL IMPLICATIONS

In increasingly fierce port competition, port attractiveness is playing a pivotal role in sustaining the competitiveness of transshipment ports serving carriers (liner ships) all across the world. Also, from a carrier's viewpoint, the selection of a particular transshipment port has a long-lasting impact on its global supply chain links and subsequent supply chain efficiency. Thus, port attractiveness and selection are intricately interwoven. The common premise is that port operating cost single-handedly dictates the port attractiveness and subsequently becomes a dominant factor for influencing the carrier's port selection decision. Although cost turned out to be one of the most influential factors for port selection according to many prior studies and this study, it is not the only one significantly influencing the carrier's port selection decision. To identify other factors for port selection, we conducted a three-stage research process involving (1) an empirical study based on a survey identifying a host of port selection factors; (2) an AHP model determing the relative weights (importances) of port selection factors; (3) and a DEA model assessing the extent of contribution of each factor to port selection. Unlike prior studies that focused on the identification of port selection factors, this study not only identified port selection factors, but also assesses the extent of influence of those factors on port attractiveness and the subsequent port selection decision. In other words, this paper is one of the first to propose a hybrid DEA/AHP model that is useful for evaluating the extent of impact of each port selection factor. From a practical standpoint, some findings of this study are noteworthy.

First, port operating cost such as container handling cost is not the only factor which significantly influences port selection. That is to say, the port authority's attempt to offer volume discounts and monetary incentives alone may not increase port attractiveness. As observed by Bennathan and Walters (1979), non-monetary qualitative factors such as intermodal links and feeder service access could play a significant role in increasing port attractiveness.

Second, we found substantial discrepancies in the perceived importance of some port selection factors such as a port's proximity to import/export businesses, port service quality, port security, and port management efficiency between the carriers (port users) and the operators (port service providers). Disregarding these discrepancies may have contributed to the failure of port strategy to attract more liner ships to a particular port. In particular, it is somewhat surprising to find that the port operators (authority) tended to overlook the growing importance of port security to the carriers' port selection decision in the wake of 9/11 events. Also, the port operators did not seem to take port service quality and the port's proximity to import/export businesses as seriously as their customers (carriers). On the other hand, the port operators tended to think that port management efficiency would attract carriers to their port, whereas the carriers did not consider it to be a major factor for choosing their port. As such, the port operators need to change their port policy and strategy in accordance with changing preferences of the carriers.

Finally, despite the increasing use of advanced information technology such as RFID and EDI among carriers and port operators, neither carriers nor port operators regarded information technology infrastructure as an essential element for port selection. The possible explanation for this tendency is that information technology infrastructure is almost considered a necessity for

every port and thus may not be considered a differentiator.

To summarize, this paper intended to help carriers develop a wise port selection strategy, while aiding port operators in formulating more user-friendly and effective port competitive strategy using novel hybrid DEA/AHP techniques. Despite its merits, this paper has some limitations. These limitations include the consideration of seven transshipment ports located in the Far East Asian region only. Also, this study is confined to a cross-sectional study targeting both carriers and port operators. Appropriate platforms for further research include:

- Consideration of other major hub ports in Europe and North American regions and comparisons of these ports in terms of their attractiveness and competitiveness;
- Extension of the current study to include shippers' perspectives;
- Development of multi-year databases for a longitudinal study with a DEA window analysis.

Acknowledgments

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MICHIGAN PASSENGER RAIL:
AN ANALYSIS OF COMMUNITY BENEFITS

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ABSTRACT

Passenger rail service is perceived to provide important benefits to Michigan communities. However, the extent of these benefits has never been quantified in a systematic way. The study reported on here involved the performance of a broad based assessment of the community level benefits of passenger rail service. The main objective of the research project was to estimate the full range of these benefits at the community level, as opposed to at the state level. Benefits were estimated for individual travelers, Amtrak expenditures, and local businesses. This research indicates local communities currently realize $62.0 million annually in benefits. Additional benefits accrue to the region, state, and nation in the form of congestion relief, air quality improvement, energy conservation, and safety.

INTRODUCTION

Passenger rail service is perceived to provide important benefits to Michigan communities. The objective of this article is to report on the results of research which sought to estimate the full range of direct, indirect, and induced benefits at the community level. In addition to community benefits, passenger rail may provide statewide macro benefits related to reductions in congestion, air quality improvement, and energy conservation. This article focuses on community benefits such as individual traveler savings, Amtrak expenditures, and local business benefits, but does not address statewide macro benefits. The individual benefits focus on the savings to the passenger by choosing a mode of transportation less expensive than driving or flying. The Amtrak expenditure benefits quantify the amount of money Amtrak expends in employee wages and goods and services. The final benefit measured, local business benefits; quantifies the economic impact of a person accessing a community where they will spend money on goods and services, such as restaurants and taxi fares. These benefits are

assigned to the community where the rail station is located. In cases where more than one train station serves one metropolitan area, the benefits are added together to quantify a reasonable representation of the benefits for the metropolitan area. These benefits were analyzed using ridership data from 2007 and costs from 2008.

OVERVIEW OF MICHIGAN SYSTEM

Passenger rail services have been provided in Michigan for over 170 years. The first passenger train operated between Toledo and Adrian in 1836. By 1909, a 9000-mile network of railroad lines provided passenger service to nearly every city, town, and village in the state. The railway depot provided the doorway to the community and stations ranged from small wooden shelters to massive and distinguished buildings.

Railroads provided virtually all of the intercity transportation until the second decade of the 20th Century when automobiles and improved roads began to siphon off local rail traffic. This trend accelerated over the decades as roads were improved and longer distance traffic shifted to

air. By the early 1960's, the construction of the Interstate Highway System and massive investments in airports and airways dealt an almost fatal blow to the passenger rail industry. As ridership declined and losses grew, many passenger trains were discontinued by their private railroad operators and it became apparent that government must become involved if any passenger rail service was to survive.

In response to this crisis, in 1970, the federal government passed the National Railway Passenger Service Act that created the National Railroad Passenger Corporation known as Amtrak. This Act provided for private freight railroads to turn over passenger equipment and assets to Amtrak and, in return, they were relieved of their passenger service obligations. On May 1, 1971, virtually every privately operated intercity passenger train in the country was discontinued and most remaining services were assumed by Amtrak under a nationwide system.

In Michigan, about a dozen daily round trips on seven routes operated on April 30, 1971. The next day, May 1, only two round trips operated between Detroit and Chicago. Since that time Amtrak has been the sole operator of intercity passenger rail services in Michigan and, with minor exceptions, the entire U.S. These services receive financial assistance from the federal government and from many states including Michigan. Additional routes were added at the request of the State of Michigan between Port Huron and Chicago in 1974 and between Grand Rapids and Chicago in 1984.

Michigan Routes

In 2009, three routes provided passenger rail service in Michigan as shown in Figure 1 below.

MICHIGAN AMTRAK ROUTES

These Amtrak services have generally been in place for many years. The first of these services is the Wolverine. The Wolverine Service

provided by Amtrak began with two round trips on May 1, 1971 between Detroit and Chicago. A third round trip was added in 1975 and service was extended to Pontiac in 1994. Between 1980 and 1995, one of the round trips was extended to and from Toledo while continuing to serve Detroit and all other stations to the west.

The second route is The Blue Water Service started in 1974 between Port Huron and Chicago. From 1982-2004, the service operated as an international route from Toronto and Port Huron to Chicago. The international component to Toronto was discontinued in 2004 and service again originated and terminated in Port Huron. The Pere Marquette Service is the third route. This service was started in 1984 between Grand Rapids and Chicago and has operated continuously since that time. Table 1 summarizes ridership on these services and ridership (MDOT, 2007).

The three corridors are operated by Amtrak with financial support for the Blue Water and Pere Marquette services coming from the State of Michigan. The Wolverine service is part of Amtrak's basic national system and does not receive State support for operations.

The three corridors primarily operate over rail lines owned by Michigan's major freight railroads—Canadian National Railway, Norfolk Southern, CSX Transportation plus portions of the Conrail Shared Assets territory in metropolitan Detroit. This is typical of all Amtrak operations throughout the nation. An important exception is the railroad between Kalamazoo, Michigan and Porter, Indiana that is directly owned and operated by Amtrak. This line has been improved for service at speeds up to 110 mph, although the current allowable passenger train speed is 95 mph. This line segment is used by both the Wolverine and Blue Water trains.

The freight railroads used by Amtrak typically allow Amtrak operations at maximum speeds of 65-79 mph. Freight railroad ownership of the

FIGURE 1

MICHIGAN'S INTERCITY
PASSENGER RAIL SYSTEM
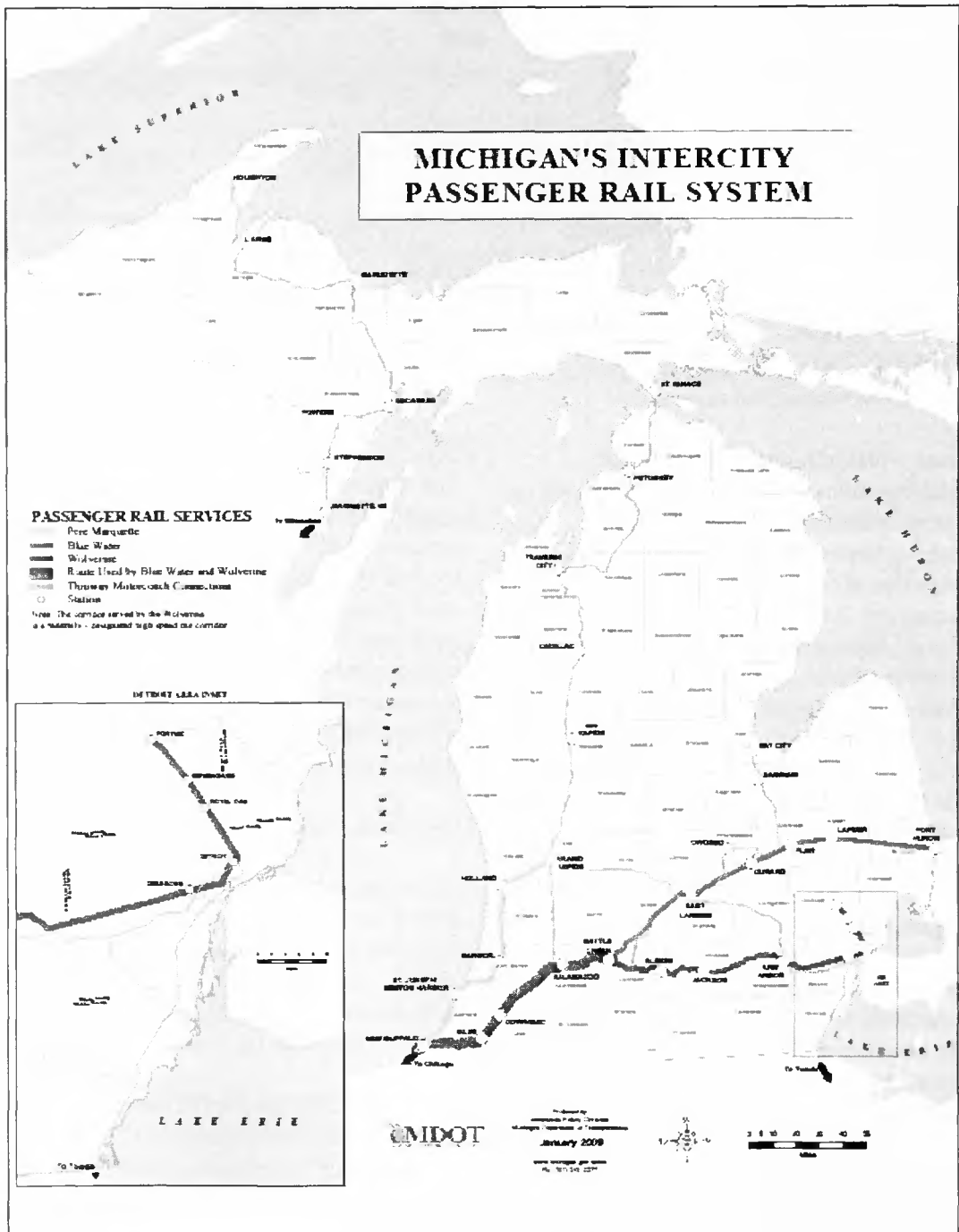
PASSENGER RAIL SERVICES

Route	Name of Service	Daily Round Trips	2007 Ridership	2008 Ridership
Pontiac-Detroit-Chicago	Wolverine	3*	455,020	474,479
Port Huron-Chicago	Blue Water	1*	130,063	138,604
Grand Rapids-Chicago	Pere Marquette	1	106,462	111,575
Statewide			691,545	724,658

* The Blue Water service operates on the Wolverine route from Battle Creek to Chicago resulting in 4 round trips on that segment.

rail lines with the resulting control of dispatching duties has caused problems with on-time performance of passenger trains. Some of the line segments have heavy freight train volumes that often delay passenger trains, producing persistent on-time performance problems. However, the State of Michigan has recently received federal funding to allow for purchasing and upgrading the Amtrak used Norfolk Southern line between Dearborn and Kalamazoo. This will allow for faster train speeds on this segment, and more importantly, for more reliable service with fewer "slow" orders.

Michigan Stations

There are 22 station communities associated with the three passenger routes. Thirteen of the twenty two stations are city owned, five are owned by Amtrak and one each is owned by a local travel agency, Michigan State University, MDOT and a private owner. These stations vary greatly in age, architecture, staffing models and operation. Ten of the 22 stations are staffed by employees, while the remaining ones require passengers to purchase tickets from a ticket machine or Amtrak's website. The variability in station type and staffing models has resulted in an inconsistent operating model, and impacts some of the community level benefits.

The Amtrak stations that serve the passenger rail community all vary significantly in size, structure, and services offered. In general, there are four types of Amtrak stations in Michigan; basic, historical, modern and other. The station types vary by community served and do not offer common services of each type. Since the stations are under different ownership models, the employment and maintenance models for each station vary.

Ridership Levels

Ridership on Michigan passenger trains has grew by over 50 % between 2000 and 2008 – and from 481,223 passengers in year 2000 to 724,658 passengers in 2008. Current ridership is, by a wide margin, the highest ridership level since the inception of Amtrak in 1971.

Recent increases are part of nationwide increases in Amtrak ridership primarily caused by higher fuel and other transportation costs. In addition, state, local, and national marketing efforts have increased awareness of the advantages of train travel. In Michigan, anecdotal evidence suggests that the ridership would be even higher if more passenger cars were available and if on-time performance were more reliable. Ticket agents and others told the research team that

TABLE 2
MICHIGAN RIDERSHIP TRENDS
1994-2008

Year	Wolverine	Blue Water	Pere Marquette	Statewide
2008	474,479	138,604	111,575	724,658
2007	455,020	130,063	106,462	691,545
2006	444,319	124,953	103,912	673,184
2005	411,092	115,741	98,299	625,132
2004	379,677	98,356	90,522	568,555
2003	344,107	88,530	75,606	503,243
2002	295,550	88,045	63,596	447,191
2001	294,570	103,197	59,437	457,204
2000	313,255	106,866	61,102	481,223
1999	334,946	113,864	69,934	518,744
1998	365,143	112,168	65,788	543,099
1997	414,601	125,126	65,065	604,792
1996	383,426	111,348	58,516	553,290
1995	366,365	111,773	45,159	523,297
1994	402,461	117,100	70,995	589,142

many trains are sold out and potential passengers are unable to purchase tickets on the days that they prefer to travel. Table 2 provides information on ridership by route since 1994 (Amtrak, 2008).

ANALYSIS OF BENEFITS

The research team surveyed individuals associated with each of the stations and found that in each community there was at least one person who had some knowledge or responsibility for the station. Although the research team was able to identify at least one person with knowledge of the station, it is important to note that the actual responsibility for operating the station may have been with the city, transit agency, regional planning agency, Amtrak, or some combination of these agencies. As a result, the person surveyed may or may not

have been able to provide substantive information about the operation, care and upkeep of the station. This results from each community operating the station in a way that suits their particular needs. The surveys revealed that the community generally supports the stations, and would likely support increased ridership and investment in the stations if the ridership levels supported the additional investments. The business benefits of the Amtrak stations are generally acknowledged in the community, but little data is available to support the notion that there is additional business resulting from station traffic.

The benefit associated with development and investment in new or improved stations is driven by overall ridership levels. Ridership levels are influenced by the services offered at the station as well as train service such as frequency of service, price, train capacity and perceived benefit. Surveys conducted with Amtrak personnel indicated that there is a need to increase the frequency of routes. Due to increases in gas prices, and the perceived value of train travel, certain routes have been selling out at peak times. To support this growth, there are several initiatives underway such as the Midwest Regional Rail Initiative. This initiative proposes the operation of a "hub and spoke" system of transportation to and through Chicago and other cities in the Midwest. Initially, Michigan would see an increase of 3 additional daily trains, and eventually there would be 10 total trips between Detroit and Chicago. In addition to the Detroit-Chicago routes, there would be four trains between Chicago and Kalamazoo. The additional frequency of routes, and speed/reliability improvements in the Dearborn-Kalamazoo corridor discussed earlier, are expected to greatly increase the ridership, and overall economic benefits in station communities. The station community benefits would also be enhanced by the infrastructure improvements needed to support such an increase in ridership.

The benefits of passenger rail to a community can be classified as individual station benefits, Amtrak expenditures, and local business benefits. These benefits vary by community, Amtrak station type, number of daily routes, and overall ridership. Overall ridership tends to be the largest driver of quantifiable benefits.

Individual Station Benefits

The first type of benefit a station community receives is the individual passenger benefit. This benefit exists because trains offer an economical mode of transportation that is generally less expensive than air and automobile travel. Quantifying this benefit involves analyzing the costs that would be incurred if there was no passenger rail service in a community and alternative modes were used, or the trip were not taken all together. To quantify the benefit, ridership data was obtained for each Michigan passenger rail station from MDOTs Transportation Management System (TMS) (MDOT, 2007). This information is provided directly from Amtrak, and is available by station. For the purposes of this study, 2007 data was used and data was complied for the Wolverine, Pere Marquette and Blue Water Corridors. Once the data was obtained from TMS, the research team determined the mode of transportation that would be used if Amtrak was not available. This determination was made by surveying riders on the Amtrak routes and captured not only the alternate mode that would have been used, but also data points as to whether or not a trip would have been taken in the absence of an Amtrak route. To supplement the survey results, the research team leveraged a similar study conducted in 2000 by the University of Michigan (2000). This survey captured additional data points such as duration of the trip, number of travelers in the party, and the percentage of travelers using hotels. The multiple surveys were conducted during different time periods, the 2000 survey in December and the 2007 in spring. The difference in the time periods allowed the

research team to capture data that is more representative of passenger travel.

Once this data was compiled, the team was tasked with determining the cost of alternate modes of transportation. These costs were gathered by internet searches of bus routes and airline prices for the same O-D pairs. There is a considerable amount of variability in the alternate modes of transportation as pricing on a particular route can vary based on the frequency, day of week traveled and seasonality. To help normalize the data, a 14-day advance round trip ticket was used for the analysis. The round trip ticket was then divided in half to estimate the cost to compare to a one way Amtrak ticket. When a traveler indicated that they would drive rather than take the train, the 2008 IRS rate of $.505 per mile divided by 1.8 persons per vehicle was used. The IRS rate per mile was used because this rate factors in gas, depreciation or lease payment, maintenance costs, insurance, tires, oil, and license and registration. The IRS rate is the most widely accepted measure of an automobile cost. In addition to the IRS rate and ticket costs, parking, tolls and any other fees from a particular mode we factored into the savings calculation.

In addition to traveler benefit, the team quantified non traveler benefits by using a complex procedure where numerous tables and data points were analyzed. Non traveler benefits were quantified because some travelers were unwilling to take the trip if a less expensive alternative was available. Knowing that a person was willing to spend money on a train ticket, but not on the next most expensive alternative mode of transportation allows for the calculation of a consumer surplus. This estimate of non-traveler benefit assumes that if the money was not spent on a ticket, it would be spent on something else, but they do not get any additional benefit beyond the price of the ticket. The non traveler savings represent a small piece of the total benefit.

Table 3 below shows that across the state of Michigan, there was a total of $22.7M in savings generated by the availability of an Amtrak station. This table is supported by a number of more detailed analysis spreadsheets that are too long to show here.

Local Business Benefits

A traveler may use the train to travel to and from a community where they stay in a hotel, use a taxi, shop or eat in a restaurant. Although the level of these activities may vary from community to community, these types of expenditures send a stream of benefits to the station community. To quantify these benefits, the research team relied heavily on the 2000 and 2007 surveys. The survey captured the mode of transportation used to get to and from the Amtrak, as well as the length of stay. Respondents were also asked their primary

TABLE 3
STATION INDIVIDUAL TRAVELLER BENEFITS

	Pere Marquette Corridor	Blue Water Corridor	Wolverine Corridor	Total
Traveler Savings with Amtrak	$2.8M	$4.3M	$12.9M	$20.0M
Non-Traveler Savings	$.3M	$.5M	$1.8M	$2.7M
Total	$3.1M	$4.8M	$14.7M	$22.7M

purpose for the trip. With this information estimates for expenditures were developed. Since many of the routes involve travel to and from Chicago, expenditures were isolated to the state of Michigan. With the heavy travel volume to Chicago, only an estimated 7% of Amtrak travelers in Michigan were expected to use hotels for business, convention, shopping or other purposes. This approach is considered conservative since there are likely some Michigan residents who would stay and shop in state. A fair set of cost estimates were used based on the 2008 State of Michigan government travel rates. These rates are $65/night for hotels and a $38.50 daily per diem for meals with an average stay of four days.

Table 4 indicates that local communities receive annual benefits of $25.7M due to Amtrak passengers using stations and surrounding businesses. Again, a number of more detailed spreadsheets support these values. These benefits include $15.7 million of direct benefits, and indirect benefits of $9.9 million.

The $15.7M equates to approximately $23 per passenger using the Amtrak stations in Michigan. This estimate was developed using conservative cost estimates, and takes into consideration the fact that some smaller communities may not attract the same level of business travelers as more diverse metropolitan areas. As a result, the station types were classified as Category 1, 2 or 3 stations. The category 1 stations have a metropolitan area station with multiple daily service frequencies and yield a per passenger benefit of $25. The category 2 stations have a metropolitan area with single daily service, and yield a per passenger benefit of $20. The category 3 stations are defined as smaller community stations and yield a per passenger benefit of $15. Total passenger value was estimated and then adjustments were made to estimated benefits based on station type. This results in a reduction of $200,000 in annual expected benefits from the $28/passenger estimate. In addition to the station type

adjustments, the multiplier effects of direct expenditures in a community were quantified. These multipliers were obtained through the Bureau of Economic Analysis for (2006) at the county level. Different multiplier sets were obtained for the five regions served by Amtrak. The sets contained multipliers for retail related expenditures ranging from 1.426 to 1.5817 and rail related expenditures ranging from 1.5591 to 1.8081.

AMTRAK Expenditure Benefits

Amtrak is the operator of all passenger rail services in Michigan. As a result, Amtrak spends a significant amount of money in station communities in the form of wages, supplies, and stations. These expenditures provide benefits to the local communities where employees live and work or where the stations are located.

To quantify the benefits from direct Amtrak Expenditures, Amtrak provided information on employee residence location and procurement expenses in Michigan. Employees were assigned to station locations based on discussions with Amtrak officials and review of material provided by Amtrak. Procurement expenditures were assigned to stations if they had a relationship to a particular station. Procurement expenses that support system wide operations outside of Michigan were excluded from the benefits analysis.

A large portion of direct Amtrak expenditure benefits comes from employee wages. For the purpose of this analysis, employees were classified as operating employees, station service employees and engineering department employees. The operating employees, primarily based in Pontiac, Port Huron and Grand Rapids, include the train conductors, engineers, assistant conductors and train maintenance personnel. There are 48 operating employees. The station service employees sell tickets, clean and provide information, and also provide some security services. There are 27 service employees distributed among 10 Michigan Amtrak stations.

TABLE 4
LOCAL BUSINESS BENEFITS

Access	% Using	Trip Universe (000's)	Total Trips (000's)	Average Cost	Total Cost (000's $)	Cost/Passenger
Access						
Taxi	8.5	692	59	$10	$ 587	$0.85
Transit	2.4	692	17	$ 1	$ 17	$0.02
Rental Car	.01	692	.7	$50	$ 35	$0.05
Personal Vehicle	81.7	692	565	$2.80	$1,582	$2.29
Total					$2,221	$3.21
Lodging Materials						
Hotels	7.42	346	26	$260	$6,671	$9.65
Meals	7.42	346	26	$154	$3,951	$5.71
Total					$10, 622	$15.36
Incidentals						
Shopping	5.00	346	17	$100	$1,728	$ 2.50
Incidental Meals	10.00	692	69	$ 10	$ 692	$ 1.00
Misc	100.0	692	692	$ 1	$ 692	$ 1.00
Total					$3,112	$ 4.50
Passenger Total					$15,955	$23.07
Station Adjustment					$15,722	
Indirect					$ 9,953	
Grand Total					$25,675	

The engineering department employees maintain track and signal systems on the 97 mile rail line between Kalamazoo and Porter, Indiana. There are 40 employees in this category. Expenditures on wages added up to $7,150,000.

In addition to employee wages and direct expenditures, Amtrak spends a significant amount of money procuring diesel fuel in Pontiac. The value of the fuel was excluded from the study, but an estimate of the cost of direct labor and vendor profit was assigned as a benefit. Costs for items such as landscaping, office supplies, trash pickup and other expenses associated with station maintenance were estimated and included in the study. In addition, costs for Amtrak expenditures associated with crew layovers such as taxi fares, hotels and meals were estimated and included in the analysis. Costs associated with the materials and suppliers related to maintaining the rail lines between Kalamazoo and Porter Indiana we estimated and included in the analysis.

The analysis of the direct Amtrak expenditures resulted in over $9M in direct benefit assigned to station communities. The values in the Table 5 are subject to economic multipliers, as the expenditures will flow throughout the community. The application of these multipliers results in $13M of Amtrak direct and induced expenditures in Michigan.

While the station communities receive significant economic benefit from the Amtrak stations, it is important to take into consideration that the communities incur certain costs. These costs may vary from community to community but in general include staff time to coordinate with Amtrak, MDOT or others involved with the station, staff time to coordinate with local volunteers or to arrange for necessary maintenance, and routine station operating costs. Since only six of the 22 stations are owned by Amtrak, maintenance of the remaining 16 stations is the responsibility of the local

TABLE 5
AMTRAK EXPENDITURE BENEFITS

Type of Expenditure	Expenditure
Direct Employee Wages	$7,150,000
Employee Layover Costs	$242,000
Miscellaneous Expenses	$300,000
Pontiac Refueling Costs- Direct Vendor Labor and Profit	$700,000
Amtrak Line Equipment and Materials	$485,000
Amtrak Owned Station Operations	$150,000
Total Expenditures Before Multipliers	$9,027,000
Impact of Economic Multipliers	$4,606,80
Total Community Benefit	$13,633,680

community. The annual expense for maintaining these stations is an estimated $10,000-$60,000 annually, depending on station size. The total local community expenditures for the Amtrak stations are estimated at $510,000 statewide. In addition to the $510,000, Amtrak spends an additional $150,000 maintaining the stations it owns.

Total Benefits

The total benefits associated with the 22 station communities are estimated at $62M annually. These quantifiable benefits are associated with passenger rail service. The benefits are summarized in Table 6. As expected, the benefits are highest in the "Wolverine Corridor". This corridor has the most ridership and the greatest population. The Wolverine Corridor receives $45M, the Blue Water Corridor receives $9.7M, and the Pere Marquette Corridor receives $7.3M in annual benefit. It is important to note that the $62M in total benefits are the quantifiable benefits associated with passenger rail. There may be additional benefits that exist, but are more difficult to quantify. These benefits relate to how the existence of passenger rail service enhances its image as a place to live or do business. There are also significant benefits that accrue to the entire state related to relief in traffic congestion, energy conservation and environmental impact. The quantifiable benefits and the macro benefits should be taken into consideration when determining the overall benefit of Amtrak service in a community.

Other Benefits

The benefits associated with passenger rail are highly impacted by ridership levels. Enhancing stations or building new stations could increase the benefits associated with passenger rail. In order to accurately estimate the benefits, ridership levels must be accurately estimated. Estimating these levels typically involves use of complex models. These models take into consideration service frequency, travel time, fare pricing, on board amenities and other factors. The models factor in the number of city pairs serviced by a particular station. As evidenced by the $62M in annual community benefit, there may be a business case to expand passenger rail service in the state of Michigan. The quantified benefits of the existing rail stations may be increased by developing new stations or relocating stations to more strategic locations. There are several projects underway throughout the state where local communities are trying to increase the value of the station to their community.

TABLE 6
TOTAL BENEFITS

	Pere Marq. Corridor	Blue Water Corridor	Wolverine Corridor	Total Statewide
Traveler Savings	$2,808,380	$4,283,972	$12,872,105	$19,964,456
Non Traveler Savings	$345,737	$545,449	$1,848,575	$2,739,761
Local Business Benefits	$3,572,199	$2,942,865	$19,159,480	$25,674,544
Amtrak Expenditures	$551,035	$1,949,089	$11,133,556	$13,633,680
Total Community Benefits	$7,277,351	$9,721,374	$45,013,716	$62,012,441

There are many direct and indirect benefits resulting from the passenger rail services provided at existing rail stations. These benefits can be enhanced and expanded through investment in a new station or relocating an existing station. When considering whether or not to add a new station to a community or relocate and existing station, the numerous economic opportunities must be quantified. These economic opportunities may include local job creation, increased property values, new residential and commercial construction, and creation of new business in and around the station. The analysis of these economic benefits comes primarily from studies of Transportation Oriented Development (TOD) throughout the U.S. While these studies typically focus on commuter rail service in densely populated communities, many of the benefits discussed could accrue to Michigan Amtrak services through enhancements to station locations and levels of service.

One of the major economic benefits associated with building or relocating a station comes from the construction costs. There is an increase in both direct jobs and spinoff jobs in the local economy. The construction of a station with a cost of $10M will result in the creation of 90-140 new jobs and contribute $5M to the local economy. These conservative estimates of job creation and economic stimulation focus only on direct construction impact and do not include future development based on business stimulation.

In addition to the direct economic impact, property values near the station may increase. TOD studies reveal a wide variation in property value increases across the country. Property value may increase 2-45% for residential properties and 1-167% for office/retail space. As property values increase, there is also an opportunity for the station community to generate additional property tax revenue. The situation for Amtrak stations is somewhat different from light rail systems since Amtrak generally operates on freight lines. This may make residential proximity somewhat less desirable, but creative land planning and the increased availability of public transportation can increase the desirability and value of adjacent land. Expanding a station could bring in more tourists, which in turn increases the value of land for some areas. In Michigan, St. Joseph is planning a major expansion of their current station. This will increase the area's reputation as a Michigan tourist destination which may increase the value of the adjacent land as there will be an increased customer base for some businesses.

Creating a transportation focal point can be a stimulus for various types of development in the station community. The location of the land and effective use of surrounding property is a key driver of economic benefits. A site surrounded by public land has the potential for development by both the municipality and private developers. In contrast, stations with little available vacant land or with land incompatible with development will have limited development potential. In order to maximize benefits and increase the effectiveness of land use, the municipalities should work with the developers throughout the station development process. An example of a study currently underway analyzing the benefits of repurposing land for light rail use is the Birmingham/Troy relocation study. This study is looking at the benefits of relocating a station from Birmingham to Troy. The current site is a shelter type station, and would be converted into a multimodal transportation hub. The proposed parcel used for this project is approximately 3.5 acres. Current estimates state that the development of a multi modal station development under optimal conditions could generate up to 300,000 square feet of retail development and 290 new residential units.

CONCLUSSIONS

Significant local economic benefits are associated with Amtrak service in Michigan. The research indicates that local communities

currently realize $62M in annual benefits in the form of individual traveler benefits, local business benefits, and direct Amtrak expenditures. In addition to the direct benefits, additional benefits accrue at the regional, state and national level in the form of traffic congestion relief, air quality improvements, energy conservation and safety. The benefits identified through this research accrue at the local level even though ridership in Michigan is quite low. Most of these stations provide only a single roundtrip route. This severely limits the potential for economic development and its associated benefit. Since ridership is a major driver in station community benefits, implementation of greatly improved service levels and train speeds such as those in the proposed high speed Midwest Regional Rail System could dramatically change the station area dynamics and overall benefit levels for local communities.

Acknowledgements

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IDENTIFYING TRAFF IC COUNT POSTS FOR ORIGIN-DESTINATION MATRIX ADJUSTMENTS: AN APPROACH TO ACTUAL SIZE NETWORKS

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ABSTRACT

For transportation planners, the use of Origin-Destination (OD) matrix adjustment, is receiving considerable attention. However, there are concerns about the validity of results, primarily related to the number and location of traffic count posts. This leads to the question "What would be the best set of traffic count posts to use in OD matrix adjustment modules?" It has been proved that solving this problem is cumbersome. There have been several attempts (either exact or heuristic approaches) to address this problem. But due to the inherent complexities, there is no efficient and easy-to-use methodology able to address situations on the scale of actual cases. This study demonstrates a simple way of identifying traffic count posts tailored to deal with real-size cases. The proposed methodology is based on a maximum matrix coverage criterion. Using a limited number of incremental trials, a set of links whose traffic flows give maximum coverage of the demand and maximum fitness to the corresponding traffic count rates are identified as traffic count posts. The results show that more traffic count posts do not necessarily yield a better result. This article reports on a project conducted for the public works ministry of the UAE city of Sharjah.

INTRODUCTION

In transportation problems, the use of Origin-Destination Matrix Adjustment (OD-MA) based on traffic count data is receiving considerable attention from practitioners. This is due to the fact that the approach provides a cost efficient alternative to the time consuming and expensive traffic surveys required to develop OD matrices. In addition, after a couple decades of research, most transportation planning software provides this application. However, the extensive utilization of the OD-MA has faced some obstacles largely dealing with the number and location of the traffic count posts.

There are various methodologies which provide solutions to the OD-MA problem such as Spiess (Spiess, 1990; Nguyen, 1984; Cascetta, 1984;

and Yang, 1994). Most of these approaches formulate a convex optimization problem in which some sort of distance function $Z(\hat{D}, D)$ between an initial demand matrix $\hat{D}$ and adjusted demand D is developed. In order to achieve assigned volumes v_a relatively close to observed volumes $\bar{v}_a$ on the count posts (links) $a \in \bar{A} \subset A$ (A is set of network's link), some constraints are embedded in the formulation. In all, the primary input after the initial matrix is the traffic counts. Intuitively, the set of traffic counts must observe some considerations such as:

·   The traffic count rates must be consistent.

·   Traffic count posts must be independent.

- In general, traffic count posts must represent as much travel demand as possible. Yang et. al. *(1998)* has defined this consideration with three rules.

- Apart from the above items, from a technical perspective, there are some other considerations such as: (a) the count posts should not capture a lot of intra-zonal trips since these trips will not be accounted for in the traffic assignment. (b) The count posts should not be placed close to zone connectors, because, to achieve a better fitness to the traffic count rates, the corresponding zones would be biased to observed volumes of the corresponding count posts.

Due to the nature of the OD-MA procedure (simply in terms of the unbalanced number of unknown variables and equations); the outcome solution may not be unique. This fact, together with the considerations listed above, has raised a substantial concern about possible perturbations consequently being imposed on the initial matrix (in terms of trip distribution pattern, total number of trips, etc.).

The initial matrix is typically developed from an elaborate and expensive survey (such as home or road side interviews …) which contains substantial structural information on the origin-destination movements. Therefore the final adjusted solution (out of so many solutions) must not vary significantly from the initial matrix. This is a very strong criterion in which no compromise is tolerable. There have been some studies addressing the uniqueness of solution by introducing more constraints and criteria or a secondary objective function to select the most desirable solutions. Yang et. al. *(1998)* and Chootinan et. al. (2005) set up some rules, such as an OD covering rule, maximal flow fraction rule, maximal flow-intercepting rule and link independence rule, and proposed integer linear programming models *(*Yang et al, 1998*)* or a bi-objective problem (Chootinana, Chena, and Yang, 2005). They developed heuristic solution methods to determine the counting links satisfying the established rules. Their methodologies were not, however, tested by a real case study. LeBlanc et. al. *(1982)* proposed a partial Lagrangian method to choose the nearest solution (OD matrix) to the initial matrix among all feasible solutions. Computational results from the application to a small network in Sioux Falls, South Dakota with 76 links were presented. Spiess *(1990)* made a great effort by introducing a relative version of gradient method in which the adjusted matrix would be proportional to the initial matrix so as not to deviate dramatically from the initial matrix.

It is worth noting that, in contrast to Spiess approach, most of the developed methodologies (Nielsen, 1998); Ortuzar and Willumsen; 1990; and Willumsen, 1981) and commercial planning software applications (TransCAD, 1996) yield an adjusted non-zero matrix with a good fitness to the traffic count rates on the basis of a zero-out initial matrix. Also, the implication of Yang et. al.'s *(1994) work,* wherein the OD-MA problem can be greatly simplified under certain conditions, shows that the OD-MA applications are very fragile. This may result in many good solutions being discarded. In this regard, the importance of adopting a proper OD-MA module associated with proper traffic count posts deserves more attention so as not to deteriorate the initial matrix.

There may be various interpretations of the traffic count post problem. For instance, given that conducting traffic count surveys is not free of charge (and budget always is limited), one may want to know the location of the minimum number of link count posts in order to determine the traffic volume of the entire network. This problem in math and computer science is called a Sensor Location Problem or Dominating Path Problem. To provide a sense of the complexity of these kind of problems, Bianco et. al. *(2006)* proved that the problem is in the complexity order of NP-complete.

In this study, without getting overly absorbed in the problem's complexity, a practical version of the problem is addressed as follows: "There is a set of traffic count rates produced from junction and corridor analysis (as part of regular activities in a Traffic Impact Study -TIS project); but what is the best subset to feed into the OD-MA module in order to have a reliable adjusted model?" The members of the traffic count rates are henceforth referred to as "Candidate Traffic Count Posts" (or CTCP).

This study presents an approach to deal with real size cases using an actual project conducted for the UAE's public works ministry. First CTCPs are prioritized and sorted according to their demand coverage. Second, through an iterative and incremental process, starting from the top prioritized CTCPs, a subset of CTCPs is "fed" into the OD-MA module. Spiess' algorithm (via demadj.mac; macro feature of EMME3 (Spiess, 1990)) based on least error between counts and volumes is then engaged to carry out OD-MA. Next, the fitness (R^2-index) of the assignment volumes to the corresponding CTCPs would be a key parameter to decide which subset of the CTCPs must be chosen as the "traffic count posts." Application to the case study showed there was an optimum number of a CTCPs with maximum R^2-index (i.e. feeding the OD-MA module with more CTCPs does not necessarily yield better result).

METHODOLOGY

From a practical perspective, given a traffic network and a set of traffic count rates (usually collected during TIS projects) adjusting outdated OD matrixes to the traffic counts is desirable. Practitioners' and researchers' experiences reveal that feeding the OD-MA module with all the counts might have adverse effects by deteriorating the number and distribution of trips. Thus, in simple language this question arises: "Given a set of traffic count rates - should all the counts serve as inputs for the module? If not, which count rates should be used?" This study answers the question for a real size case.

In order to select a subset of CTCPs, Yang et. al. (1998) proposed some rules that they derived from empirical observations and common sense as follows:

- Rule-1: The OD Covering rule - some fraction of the trip for each OD pair must be covered.

- Rule-2: The Maximal Flow Fraction rule - for a given OD pair, the count post should be identified in a way that, the largest fraction of flow for that OD pair is obtained.

- Rule-3: The Maximal Flow Intercept rule - given a set of candidate posts, choose the ones that have the greatest number of OD pairs traversing them.

In principle, these rules are all good, however, in practice; rules 2 and 3 often come into conflict with each other. In addition, as discussed before with respect to the complexity of the problem, the proposed solution methodologies are not able to tackle real size cases (Yang and Zhou, 1998; Chootinana, Chena and Yang, 2005). Since the primary objective of this study is to ensure its applicability to the real world, even if this involves compromising some purely mathematical aspects of the problem, this study adopted "more matrix demand coverage" (which can be interpreted as a general aggregation of the triple rules) as a benchmark to prioritize and then select the best collection of count posts.

Our approach then is carried out as follows. Initially, the original (initial) demand matrix is assigned to the network so that the traffic volumes of all the links are saved. Also, travel time emanating from assigning the initial matrix on the network is saved and the times on all the links of the network are preserved. Then a candidate count post with maximum traffic volumes is labeled as the first prioritized candidate posts. In order to find the next one, the previous prioritized candidate post is removed from the candidate post set. Thus the

part of the demand matrix corresponding to the prioritized candidate is removed from the matrix as well. The consequent matrix could be called a "truncated matrix". The truncated matrix is assigned on the network while the travel time has been preserved as it was for the initial assignment. By doing so, the resulting traffic flow simply is the original traffic flow minus the flow corresponding to the previous prioritized post(s). Again a candidate post with maximum current flow is labeled as the next prioritized candidate posts. This process may be repeated until a sorted and prioritized set of CTCPs is identified.

This heuristic approach to addressing the problem has some significant advantages. First, executing this concept even for practitioners is very easy. Commercial planning software provides useful procedures called "Select Link Analysis" in which an OD matrix corresponding to desirable links can be distinguished from the original matrix. Furthermore, Emme3 provides an easy way to conduct the prioritization process through a macro called cntposts.mac (INRO Consultant, Inc., 2010) in which additional options of auto assignment are used. The user simply enters the initial matrix and the set of candidate posts. Within a very efficient computing time, the macro computes and tags the amount of demand coverage for the candidate posts (i.e. more coverage means higher priority).

Secondly, if the initial matrix and the network are "reliable," the results would respect all of Yang's rules in one way or another (reliability taken here to mean observing consideration-4

presented earlier). Third, the magnitude of the last traffic flow on each count post is an indication of how important the count posts (prioritization of importance) are. This property can be important since some algorithms, such as Spiess, are able to accept some sort of the weights for count rates. Thus the adjusted matrix would be biased to those count rates with more weights. For instance one may want to have the adjusted matrix more closely reflect count rates along highways and expressways rather than local and access roads. By having the set of traffic count posts, the OD-MA module is executed.

Spiess' methodology based on the gradient method to minimize distance between counts and assigned volumes as a convex minimization problem is:

$$\min_{D} \ Z(\hat{D}, D) = \frac{1}{2} * \sum_{a \in A} (v_a - \bar{v}_a)^2 \qquad (1)$$

Subject to
$$v_a = assign(D) \qquad for \ \ \forall a \in A \qquad (2)$$

Wherein $assign(D)$ indicates that v_as are the volumes emanating from a traffic assignment in which an equilibrium traffic flow results. Since the expressed problem is highly undetermined, an infinite number of solutions (all yielding a close fit to the observed volumes) are expected. Due to the substantial structural information of the initial matrix; the proximity of the solution to the initial matrix must be noted. Thus Spiess has proposed a transformed gradient method to solve the problem (1-2) in which the gradient is based on the relative change to the demand as follows:

$$D_i^{\ell+1} = \begin{cases} \hat{D}_i & for \ \ell = 0 \\ \\ D_i^{\ell}(1 - \lambda^{\ell} \left[\dfrac{\partial Z(\hat{D}, D)}{\partial D_i} \right] D_i^{\ell}) & for \ \ell = 1,2,3,... \end{cases} \qquad (3)$$

Where λ^ℓ is the size of the move along the steepest descent $\left[\dfrac{\partial Z(\hat{D}, D)}{\partial D_i} \right] D_i^\ell$

at iteration ℓ. By using relative gradients, the solution algorithm becomes multiplicative in initial demand $\hat{D}_i$ so a change in demand is proportional to the initial demand. This module has been implemented in Emme3 and is called demadj.mac (Spiess, 1990). Finally, the R^2-index between all the survey counts, including those fed into the module, versus the assigned volumes is used as a measure to identify which set of CTCPs gives the better result.

Out of all the initial survey count posts, 10% are prioritized by executing cntpost.mac and designated to be fed into demadj.mac. Through an incremental process, for each next attempt a further 5% are added to the already fed CTCPs. This process continues until all the survey is taken as count posts. In the end, the attempt with the maximum R^2-index, along with some other considerations, can be chosen as the updated model.

UAE CASE STUDY

A model of the city of Sharjah, UAE comprises 481 zones, 10,426 nodes and 26,294 links. There are total trips of 182,128 and 182,908 for the AM and PM peak hours respectively. A traffic survey which was carried out over 18 junctions plus 8 roads accumulated up to 281 movements. Figure 1 depicts the traffic survey locations. The algorithm ran 9 times starting with 10% of all traffic surveyed (28 candidate posts) and then up to 50% (at which no more improvement in the R^2-index was observed).

The Spiess module provides the facility to weight specific count posts in order to attain a more desirable pattern. For instance, one may want to get a conservative pattern in which the results guarantee higher rates of traffic counts. Thus a logistic function varying from 1.00 for low rates up to 2.0 for the highest volume is adopted here as follows:

$$link's\,Weight = 2.\dfrac{100}{100 + 100 * e^{5.\frac{traffic\ count\ rate}{maximum\ observed\ traffic\ count\ rate}}}$$

(4)

In every attempt, the Spiess module is set for 8 iterations so as to guarantee fitness of $R^2 = 0.95$ or above for the (only) fed counts and corresponding assigned volumes. At the end of each attempt the R^2-index for all the 281 CTCPs (including non-fed and fed count posts) against the corresponding assigned volumes is calculated. Table 1 indicates results of the incremental tries.

In Table 1 the introduced indices are:

- An R^2-index: an index for overall performance of the methodology

- Total travel demand and average travel time: shows how the adjusted matrix differs from the initial matrix are.

Figure 3 depicts the changes of the listed above indices over incremental numbers of traffic count posts.

Figure 3a clearly shows that there is an optimum collection of CTCPs to be utilized since feeding the algorithm with more posts only results in deterioration in the overall convergence of the algorithm. For both AM and PM; using 40% of CTCPs (112 count posts) has achieved around 80% overall fitness. Figures 3b and 3c indicate that in terms of closeness to the initial matrix for a low number of traffic count posts the algorithm behaves chaotically and is not reliable. As the number of count posts increases the results assume a monotone shape. Provided the initial matrix is accepted, an adjusted matrix close to the initial matrix in terms of average travel time and total amount of trips may be taken. For

FIGURE 1
SHARJAH, UAE TRAFFIC SURVEY LOCATIONS

**FIGURE 2**
LINKS WEIGHT FACTORS

AM Peak Hour
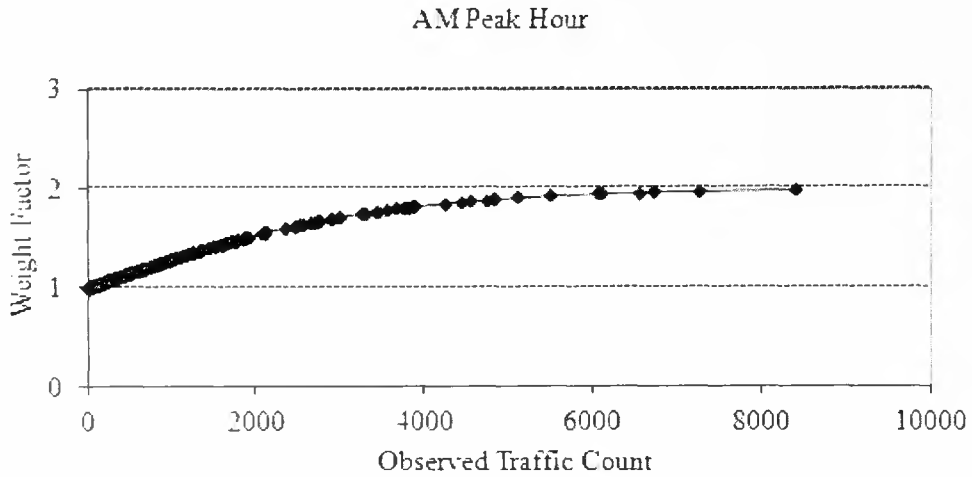
TABLE 1
MODEL'S RESULTS FOR INCREMENTAL PERCENTAGE
OF TRAFFIC COUNT POSTS

Try No	Percentage of Fed Traffic Count Posts	Number of Fed Count Posts	AM			PM		
			R^2 Index	Total Travel Demand	Average Travel Time (minute)	R^2 Index	Total Travel Demand	Average Travel Time (minute)
0	0	0	0.5766	182,128	18.342	0.4783	182,908	17.392
1	10%	28	0.6690	168,695	18.981	0.6784	180,276	18.642
2	15%	42	0.7171	168,837	18.402	0.7284	180,228	18.537
3	20%	56	0.7294	168,194	18.519	0.7463	179,007	18.056
4	25%	70	0.7746	171,946	18.125	0.7618	181,609	18.420
5	30%	84	0.7787	170,979	18.106	0.7730	177,456	17.912
6	35%	98	0.7899	172,150	17.957	0.7760	179,570	18.147
7	40%	112	0.8086	173,612	17.980	0.7871	178,851	18.023
8	45%	126	0.8018	172,193	17.949	0.7689	178,138	17.968
9	50%	140	0.7976	171,468	17.676	0.7623	177,743	17.895

FIGURE 3
ALGORITHM RESPONSES OVER NUMBER OF FED COUNT POSTS
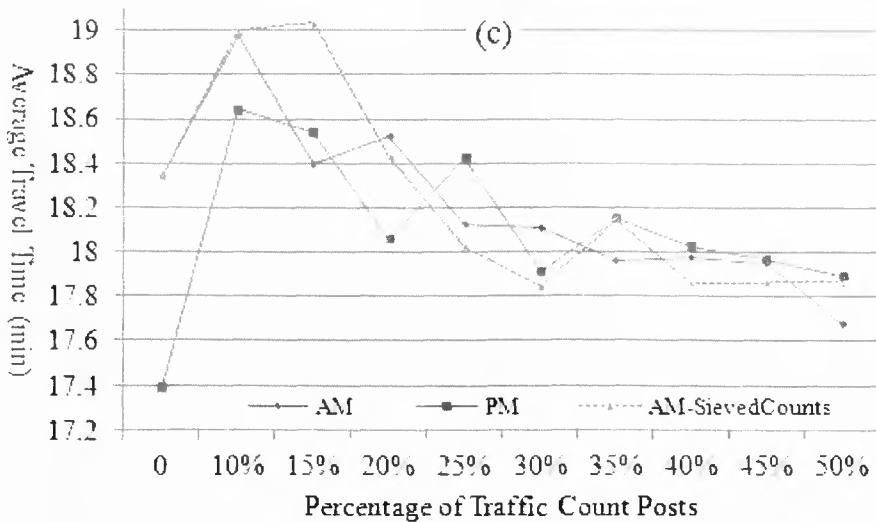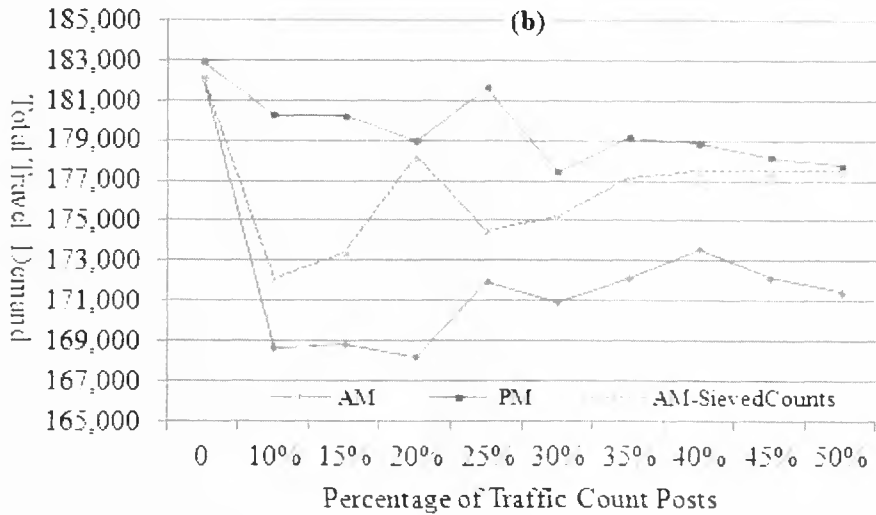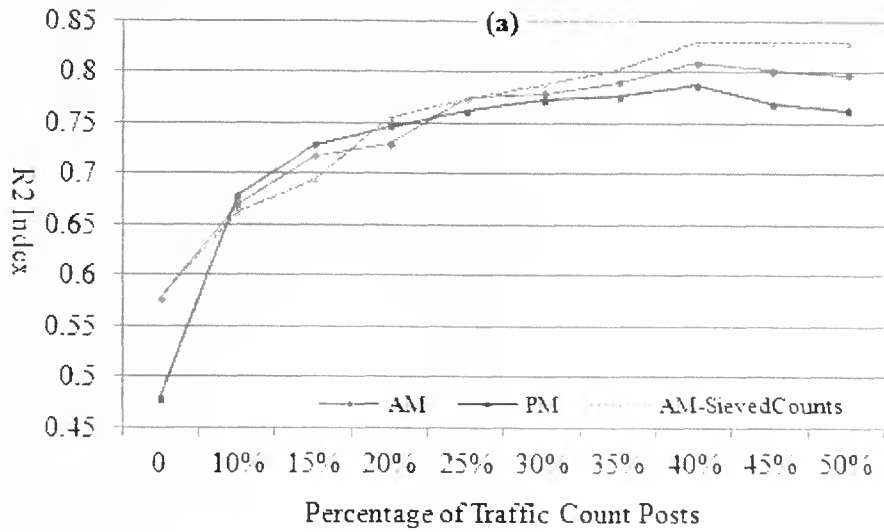
instance in the AM, the maximum R^2-index occurred at 40% of traffic count posts and at which point the total trip is at the nearest distance to the initial matrix.

Number of Count Posts

It is useful to consider why, counter-intuitively, more count posts do not necessarily provide better results (higher R^2). It is possible that beyond the optimum set of traffic count posts, the additional traffic count posts convey no additional information. Generally speaking this may be due to installing count posts at some linearly dependent locations with the optimum posts, survey errors or selecting unimportant locations such as seldom used local roads. In order to demonstrate that the poor count posts have adverse effects a new run is conducted on a selected set of counts posts rather than the initial set for the AM peak hour. We set up some thresholds to discard the poor posts from the initial set in order to have a selective set of count posts before launching the methodology. First we calculate the traffic survey rates-per capacity ratio (known as V/C in transportation literature) for all the candidate posts. To avoid major survey errors and low-profile local roads, the candidate posts with a V/C ratio greater than 20% or with traffic survey rates greater than 360 are used as the selective count posts set and the remainder discarded. This selective set simply is called AM-SievedCount which contains 161 count posts out of 286 initial count posts. The threshold of 20% for V/C is an arbitrary parameter embedded to exempt the methodology from fitting low profile count posts. Similarly the minimum traffic survey of 360 can be seen as passing at least 1 car every 10 seconds.

The methodology as described was run on AM-SievedCount. The result is shown in Figure 3. Figure 3(a) demonstrates that during successive tries the algorithm steadily rises to a saturated level (7st attempt) at which maximum (possible) fitness is achieved. Beyond this level no more candidate traffic posts belonging to AM-SievedCount would be selected due to linearly

located count posts. Figure 3(b) demonstrates that adopting a sieved set of count posts may produce a reliable result in the sense of closeness to the initial matrix. The above discussion once again highlights the importance of properly and carefully identifying the traffic count posts. These results lead us to the point that OD-MA is not always predictable or straightforward and should therefore not be used as an alternative to standard procedures for developing trip tables. This situation is exacerbated further if great care has not been taken in identifying the count posts. In addition, and counter-intuitively, more count posts do not yield a better result.

CONCLUSION

This paper introduces an easy and efficient approach to the problem of selecting the best set of traffic count posts for the purpose of the OD Matrix Adjustment (OD-MA), applicable to real networks. From a traffic survey conducted for the Traffic Impact Studies (TIS) a set of traffic count rates (called candidate traffic count posts or CTCPs) is available. First, CTCPs are prioritized and sorted according to their demand coverage. Second, through an iterative and incremental process, starting from an initial number of top prioritized CTCPs (10%) and incremental rates (5%) up to an endpoint, a subset of CTCPs is designated and "fed" into the Spiess' OD-MA module. Then the fitness (R^2-index) of the assignment volumes to the corresponding CTCPs would be a key parameter to decide which subset of the CTCPs must be chosen as the "traffic count posts". Application to the case study showed there was an optimum number of CTCPs with a maximum R^2-index. Feeding the OD-MA module with more CTCPs does not necessarily yield better result).

During the case study an important observation was achieved: counter-intuitively, by feeding more traffic counts the module achieved a better fit, but overall, it deteriorated in the size and distribution of trips. For instance, in the case of Sharjah, UAE, 112 count posts (40% of all the traffic count) yields a maximum R^2-index for all

the traffic count posts versus corresponding assigned volumes. This study has an important implication: before using the OD adjustment modules it is necessary to first identify which links should be taken as traffic count posts.

No matter how reliable the count posts are, even by accommodating relative versions of gradient methods so as to have an adjusted matrix close to the initial matrix; great care must be taken when the OD-MA application is used. A visible discrepancy between the final adjusted matrix at the highest overall fitness (maximum of R^2-index) and the initial matrix in terms of total trip rates and average travel time was observed.

Acknowledgement

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2. Second Page - A brief biographical sketch of each author including name, degree(s) held, title or position, organization or institution, previous publications and research interests. Include each author's email address at end. Maximum of 90 words per author. Times New Roman with 12 point font.

3. Third Page - Title of the paper without author name(s) and a brief abstract of no more than 125 words summarizing the article in Times New Roman 12 point font. The abstract serves to generate reader interest in the full article.

FORMATTING

1. Manuscripts should be typed, double-spaced (body of text only).

2. The entire manuscript should have 1" margins on all sides.

3. Text body font should be Times New Roman 12 point.

4. The entire manuscript must be typed LEFT-JUSTIFIED, with the exception of tables and figures.

TITLE PAGE AND ABSTRACT PAGE (after 3 pages of Front Matter)

1. The manuscript title should be printed in Times New Roman 12 point and in all capital letters and bold print.

2. Author(s) and affiliation(s) are to be printed in upper and lower case letters below the title. Author(s) are to be listed with affiliation(s) only. Times New Roman 12 point.

3. The abstract should be 125 words or less on a separate Abstract Page. Title should be repeated as in 1) followed by ABSTRACT in caps, bolded and 12 point also. The abstract should be in 12 point font.

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3. Second level headings are 12 point upper/lower case.

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5. A full blank line should be left between all headings and paragraphs.

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1. ONLY Tables and Figures are to appear in camera-ready format! Each table or figure should be numbered in Arabic style (i.e., Table 1, Figure 2).

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EQUATIONS, CITATIONS, REFERENCES, ENDNOTES, APPENDIXES, ETC.

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$y = c + ax + bx$
$y = a + 1x + 2x + 3x + ax$

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3. Endnotes may be used when necessary. Create endnotes in 10-point font and place them in a separate section at the end of the text before References. (1, 2, etc.). Note: Endnotes should be explanatory in nature and not for reference purposes. Endnotes should NOT be created in Microsoft Insert Footnotes/ Endnotes system. The Endnotes section should be titled in 12 point, uppercase and bolded.

4. All references should be in block style. Hanging indents are not to be used.

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7. All references to journals, books, etc., are *italicized,* NOT underlined. Examples are as follows:

Journal Article:
Pohlen, Terrance L. (2003), "A Framework for Evaluating Supply Chain Performance," *Journal of Transportation Management,* 14(2): 1-21.

Book Chapter:
Manrodt, Karl (2003), "Drivers of Logistics Excellence: Implications for Carriers," In J. W. Wilson (Ed.), *Logistics and Transportation Research Yearbook 2003* (pp. 126-154) Englewood Cliffs, NJ: Prentice-Hall, Inc.

Book:
Coyle, John J., Bardi, Edward J., and Novack, RobertA. (2004), *Transportation,* 6th ed., Cincinnati, OH: South-Western College Publishing.

Website:
Wilson, J. W. (2003), "Adapting to the Threat of Global Terrorism: Reinventing Your Supply Chain," [On-line]. Available: http//:georgiasouthern.edu/coba/centers/lit/threat.doc. Created: 11/01/02, Accessed: 11/12/03.

MANUSCRIPT SAMPLE

A FRAMEWORK FOR EVALUATING SUPPLY CHAIN PERFORMANCE

Terrance L. Pohlen, University of North Texas

ABSTRACT

Managers require measures spanning multiple enterprises to increase supply chain competitiveness and to increase the value delivered to the end-customer. Despite the need for supply chain metrics, there is little evidence that any firms are successfully measuring and evaluating inter-firm performance. Existing measures continue to capture intrafirm performance and focus on traditional measures. The lack of a framework to simultaneously measure and translate inter-firm performance into value creation has largely contributed to this situation. This article presents a framework that overcomes these shortcomings by measuring performance across multiple firms and translating supply chain performance into shareholder value.

INTRODUCTION

The ability to measure supply chain performance remains an elusive goal for managers in most companies. Few have implemented supply chain management or have visibility of performance across multiple companies (Supply Chain Solutions, 1998; Keeler et al., 1999; Simatupang and

Sridharan, 2002). Supply chain management itself lacks a widely accepted definition (Akkermans, 1999), and many managers substitute the term for logistics or supplier management (Lambert and Pohlen, 2001). As a result, performance measurement tends to be functionally or internally focused and does not capture supply chain performance (Gilmour, 1999; *Supply Chain Management,* 200 I) . At best, existing measures only capture how immediate upstream suppliers and downstream customers drive performance within a single firm.

Table 1 about here

Developing and Costing Performance Measures

ABC is a technique for assigning the direct and indirect resources of a firm to the activities consuming the resources and subsequently tracing the cost of performing these activities to the products, customers, or supply chains consuming the activities (La Londe and Pohlen, 1996). An activity-based approach increases costing accuracy by using multiple drivers to assign costs whereas traditional cost accounting frequently relies on a very limited number of allocation bases.

$y = a^2 - 2ax - x^2$

REFERENCES

Manrodt, Karl (2003), "Drivers of Logistics Excellence: Implications for Carriers," In 1. W. Wilson (Ed.), *Logistics and Transportation Yearbook 2003* (pp. 126-154) Englewood Cliffs, NJ: Prentice-Hall, Inc.

Coyle, John J., Bardi, Edward J. , and Novack, Robert A. (2004), *Transportation,* 6th ed., Cincinnati, OH: South-Western College Publishing.

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