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OBJECTIVES

Editorial Policy. The primary purpose of the *JTM* is to serve as a channel for the dissemination of information relevant to the management of transportation and logistics activities in any and all types of organizations. Articles accepted for publication will be of interest to both academicians and practitioners and will specifically address the managerial implications of the subject matter. Articles that are strictly theoretical in nature, with no direct application to the management of transportation and logistics activities, would be inappropriate for the *JTM*.

Acceptable topics for submission include, but are not limited to carrier management, modal and intermodal transportation, international transportation issues, transportation safety, marketing of transportation services, domestic and international transportation policy, transportation economics, customer service, and the changing technology of transportation. Articles from related areas, such as third party logistics and purchasing and materials management are acceptable as long as they are specifically related to the management of transportation and logistics activities.

Submissions from industry practitioners and from practitioners co-authoring with academicians are particularly encouraged in order to increase the interaction between the two groups. Authors considering the submission of an article to the *JTM* are encouraged to contact the editor for help in determining relevance of the topic and material.

The opinions expressed in published articles are those of the authors and do not necessarily reflect the opinions of the Editor, the Editorial Review Board, Delta Nu Alpha Transportation Fraternity, or Georgia Southern University.

PUBLISHING DATA

Manuscripts. Four (4) copies of each manuscript are to be sent to Dr. Jerry W. Wilson, Southern Center for Logistics and Intermodal Transportation, Georgia Southern University, P. O. Box 8154, Statesboro, GA 30460-8154. Manuscripts should be no longer than 25 double-spaced pages. Authors will be required to provide electronic versions of manuscripts accepted for publication. Guidelines for manuscript submission and publication can be found in the back of this issue.

Subscriptions. The *Journal of Transportation Management* is published twice yearly. The current annual subscription rate is $50 domestic and $65 international in U.S. currency. Payments are to be sent to the editor at the above address.

From the Special Edition Editor...

Welcome to the second issue for this year. This issue is the result of work that was originally intended to be a special issue of the *Journal of Transportation Management on Motor Carrier Topics*. Due to the lack of submissions on Motor Carrier Topics we decided to invite three papers to help establish modal research agendas for motor carriers, ocean carriers, and rail carriers.

In addition to the three modal research agenda articles, we have also included an article on logistics faculty salaries and an article that evaluates state highway expenditures.

The lead article by M. Theodore Farris, II, Terrance L. Pohlen, and Jerry W. Wilson surveyed 236 faculty in the first of a longitudinal series of articles planned on salaries of logistics, transportation, and supply chain management faculty. The second article, by Carlo Smith and myself, combines a review of motor carrier research over the past ten years, with input from executives representing common and specialty carrier services, to identify key areas of interest to guide future motor carrier research. David Menachof states that the last five years have been exciting for the world of international liner shipping. Mergers, new larger vessels, charter rates becoming more volatile and demand continuing to increase are just part of this world of liner shipping. In his article he highlights some of the issues that will be affecting international shipping in the forthcoming years. Barton Jennings reviews five major areas; capacity expansion, service standards, safety, security, and data analysis; where academic research could assist the railroad industry. In the final article, Hokey Min and Thomas Lambert develop a meaningful set of benchmarks that will help guide state governments in making wise investment decisions regarding road construction and maintenance. In particular, they propose a data envelopment analysis that is proven to be useful for measuring the operational efficiency of various profit or non-profit organizations.

John L. Kent
Associate Professor - Logistics and Transportation
Special Edition Editor - JTM
Department of Marketing
Missouri State University
901 South National Avenue
Springfield, MO 65897

From the Editor...

As you can easily see, fall came very late this year. I apologize for the delay and hope that you feel the wait was worth it!

Thanks to the Special Editor of this issue, John Kent, of Missouri State University, for a job well done. After 11 years as Editor, this is my first experience with sharing the reins. I can honestly say it has been a pleasure. I hope that John feels the same way!

Please remember that we cannot survive and continue to publish without reader support. Join or renew your membership in Delta Nu Alpha International Transportation Fraternity today and subscribe to the *Journal of Transportation Management.* Remember that, if you join DNA at the Gold level, a subscription to the *JTM* is included in your membership! That is a deal that is hard to beat!

Jerry W. Wilson, Editor
Journal of Transportation Management
Georgia Southern University
Southern Center for Logistics and Intermodal Transportation
P.O. Box 8154
Statesboro, GA 30460-8154
(912) 681-0257(912) 871-1523 FAX
jwwilson@georgiasouthern.edu

Karl Manrodt, Associate Editor
(912) 681-0588
kmanrodt@georgiasouthern.edu

Maciek Nowak, Associate Editor
(912) 681-5310
mnowak@georgiasouthern.edu

Stephen M. Rutner, Associate Editor
(912) 681-0511
srutner@georgiasouthern.edu

And visit our web sites:
Delta Nu Alpha Transportation Fraternity: www.deltanualpha.org
Georgia Southern University Logistics: http://coba.georgiasouthern.edu/centers/lit/

First Annual Logistics Faculty Salary Survey

M. Theodore Farris II
University of North Texas

Terrance L. Pohlen
University of North Texas

Jerry W. Wilson
Georgia Southern University

ABSTRACT

While the Association to Advance Collegiate Schools of Business International (AACSB) conducts an annual survey of business school faculty and administrative salaries, the data do not include salary figures for logistics (and related areas such as transportation and supply chain management) faculty. Since the growth in number of logistics faculty positions has continued to exceed the output of doctoral programs in the field for more than a decade, it is logical to assume that logistics faculty salaries, at all levels, are increasing. However, without factual data, what salary should a new logistics Ph.D. expect, and what should an administrator budget for a logistics faculty position? In order to provide such factual data, the authors developed an electronic salary survey and distributed it to 236 faculty at colleges and universities in the United States. It is the intent of the authors to conduct the salary survey annually, and report the results in the *Journal of Transportation Management.*

INTRODUCTION

For the reader unfamiliar with hiring practices in academia, a brief overview of the process will enhance the understanding of the purpose of this research. The typical business faculty position at most colleges and universities in the United States requires a terminal degree or doctorate as a minimum qualification. Of the 445 business schools/colleges accredited in the United States by the Association to Advance Collegiate Schools of Business (AACSB) International, only 126 (28.31 percent) offer doctoral programs. Of those business schools/colleges offering doctoral programs, only 17 (3.82 percent of the 445 accredited schools/colleges, 13.49 percent of the accredited doctoral granting institutions) offer doctoral programs in logistics, transportation, supply chain management or related fields (Mondello, 2006). The typical well-established business doctoral program, including all functional areas (accounting, management, logistics, etc.) will enroll fewer than ten new students each academic year, with average time

to degree completion in the range of three to five years. The supply of new doctorates to fill all business faculty positions is decidedly small and fixed in the short to intermediate term.

For more than thirty years, logistics-related degree programs have been growing in number and enrollment (Lancioni et al., 2001; Golicic et al., 2004). For the same period of time, staffing the increasing number of programs with qualified faculty has been a continuing problem (Tyworth and Grenoble, 1985; Rutner et al., 1996; Golicic et al., 2004). According to the Graduate Management Admission Council, there were 1.4 openings per doctoral graduate at AACSB member schools in the 1998-1999 academic year, with the number rising to 2.1 the following year (Graduate Management Admission Council, 2001). Further, the Logistics Academic Hiring Survey conducted annually by Dr. Martha Cooper at the Ohio State University directly illustrates the continuing gap between available faculty positions in logistics and the annual supply of new doctoral graduates in the field. In the 2000 survey, of 17 responding universities, there were 16 entry-level positions available, and just 3 logistics Ph.D. graduates that year (Cooper, 2000). In 2003, of 20 responding universities, there were 18 available positions, and only 4 graduates (Cooper, 2003). Note that this survey includes only logistics doctoral-granting universities, indicating that the real gap between supply of qualified new faculty and open positions across all AACSB member schools is much greater than that suggested by the quoted survey results.

The preceding discussion leads directly to the need for and importance of the survey research conducted by the authors. Each year university logistics, transportation and supply chain management programs are faced with the need for salary information when hiring for new and vacant positions, or for justifying salary adjustments for current faculty to remain competitive with other universities. Many fields of specialization utilize data from the annual study of U.S. faculty and administrative personnel salaries conducted by the AACSB International. In 2006, the AACSB conducted the 38th annual survey of U.S. faculty and administrative personnel salaries (Association to Advance Collegiate Schools of Business International, 2006). Responses were received from 485 institutions. Salaries are stated as nine- or 10-month equivalents to allow direct comparability. Salary data were collected in 28 fields of specialization, including Management, Marketing, and Production and Operations Management as shown in Table 1. The category "other" includes general business, health services and hospital administration, hotel, restaurant and tourism, public administration, supply chain management, transportation and logistics, and other not classified.

The logistics and supply chain management discipline is composed of an amalgam of overlapping disciplines, creating a dilemma as to which category should be used to best reflect salaries in the logistics field. For this reason, the authors decided to initiate an annual logistics faculty salary survey in order to provide discipline-specific information of use to both faculty looking for positions and administrators seeking to fill them.

SURVEY METHODOLOGY

The survey methodology emphasized simplicity, ease of response, and confidentiality. The survey instrument is shown in Figure 1. A contact list was compiled from the Council of Supply Chain Management Professionals (CSCMP) annual Educators' Conference registration list for the last five years. The list was reviewed to remove duplicates, adjust for known changes of employment, and to remove faculty members whose primary field was not in logistics, transportation, or supply chain management. The authors added the names of other known logistics faculty members not included in the registration lists.

TABLE 1
2005-2006 AACSB SALARY DATA
(000's)

Rank	Management	Marketing	Production/ Operations Management	Other*
Assistant				
- Private	$ 89.0	$ 93.8	$104.1	$ 78.2
- Public	$ 80.7	$ 88.9	$ 87.9	$ 72.0
Associate				
- Private	$ 93.2	$ 98.7	$100.6	$ 77.4
- Public	$ 83.4	$ 91.0	$ 93.7	$ 77.0
Full				
- Private	$120.2	$110.3	$133.8	$136.4
- Public	$101.1	$137.1	$111.7	$124.9

*Includes General Business, Health Services/Hospital Administration, Hotel/Restaurant/Tourism, Public Administration, Supply Chain Management/Transportation/Logistics, and Other not classified
Source: Association to Advance Collegiate Schools of Business International, *Salary Survey Report 2005-2006.*

After the initial survey was distributed, the list was corrected for any undeliverable addresses, and surveys were sent to the updated addresses. In total 236 surveys were sent. A follow-up survey was sent two weeks later. Due to the number of automated "out-of-office" replies and recognizing responses could be reduced because of the time of year, a third distribution was completed two weeks after the second.

The research employed a process to create an aggregate data set while maintaining the confidentiality of the respondents. Respondents were asked to email their completed surveys to a controlled email address assigned to the University of North Texas Center for Logistics Education and Research or to fax the completed one-page survey to the Center. At that point a research assistant numbered the response (to allow for the ability to confirm or correct data input) and entered the response into a Microsoft Access file. Original completed surveys, which could contain identifying marks such as email addresses or fax numbers, were isolated from the authors. The Access file was then passed to the authors for analysis.

Out of 236 surveys, two respondents requested to be removed from the contact list. Usable responses were received from sixty-four faculty representing a response rate of twenty-seven percent.

ANALYSIS OF RESULTS

Demographics

The demographics in Table 2 reflect a broad mixture of responses. The data allow the survey report to differentiate pay structures in greater detail than the aggregate reports from the AACSB survey. With this information, the authors were able to develop conclusions regarding compensation differences between public and private universities, institution accreditation, type of program, years of service and workload allocation.

FIGURE 1
SURVEY INSTRUMENT

All of us are faced with the need for salary information when hiring for new positions or justifying adjustments to remain competitive in the market. The AACSB salary survey does not include a separate category for logistics faculty. We would appreciate your assistance by filling out this confidential survey and either emailing (logistics@unt.edu) or faxing (940 369-7012) the survey back to us. The results will be available at the CSCMP Educators Conference on October 15 in San Antonio.

Current rank:

O Full
O Associate
O Assistant
O Visiting
O Instructor/Non-PhD./Adjunct
O Other (please specify) _____

Current field (primary):

O Logistics/Transportation/Supply Chain
O Marketing
O Operations Management/Decision Sciences
O Operations Research
O Industrial Engineering
O Other (please specify) _____

_____years Years in present rank

_____years Total years in academic service since Ph.D./D.B.A granted

My current institution is:

O Public
O Private

O AACSB accredited
O Not AACSB accredited

$_____ Base 9 month salary/wages (do not include summer pay, special stipends, professorships, chaired positions, or other non-base remuneration)

$_____ Total wages/salary compensated (including summer pay, special stipends, professorships, chaired positions, or other remuneration)—do not include benefit packages

Current employer:

O Logistics, Transportation, Supply Chain Management, etc. Ph.D granting institution
O Other Ph.D granting institution - with undergraduate and Graduate degrees in logistics fields
O Other Ph.D granting institution - no degrees offered in Logistics fields
O Non-Ph.D granting institution - with undergraduate and graduate degrees in logistics fields
O Non-Ph.D granting institution - no degrees offered in logistics fields
O Other

Present allocation of your workload as your performance is measured (should total 100%):

_____% Teaching
_____% Research
_____% Service
_____% Administration

Email to logistics@unt.edu or Fax to: (940) 369-7012

TABLE 2
RESPONDENT DEMOGRAPHICS

35.9%	Full Professor	67.2%	Public University	34.4%	Logistics Ph.D.
37.5%	Associate	28.1%	Private	31.3%	Other Ph.D. granting
20.3%	Assistant	4.7%	Not Specified	29.7%	Non-Ph.D. granting
6.3%	Not Specified			4.7%	Not Specified/Other
		73.4%	AACSB Accredited		
		26.6%	Not accredited		

Base Salary vs. Total Compensation

Survey respondents were asked to identify their base nine-month salary, as well as the total compensation, which includes such additional incentives as summer pay, special stipends, professorships, chaired positions, administrative positions or remuneration for other activities. Neither figure included benefit packages. Table 3 compares total compensation with base salary.

The nine-month base provides a convenient benchmark of compensation. However, this approach ignores total compensation. Many programs use other income sources as a means to attract and retain their faulty. The nine-month base provides an incomplete measure of compensation. The addition of incentives to base salary represents from sixteen percent (Associate) to twenty-three percent (Full) of total compensation.

Figures 2, 3, and 4 summarize base salary and total compensation at each academic level. These summary figures do not encompass all key differences since total compensation is influenced by factors such as public or private institution, institution accreditation, type of program, years of service and workload allocation.

Public vs. Private Institutions

The first difference is shown in Table 4. Over sixty-seven percent of respondents are employed at public institutions. Contrary to the AACSB data, logistics faculty compensation at public institutions is higher than that from private institutions. This may be due simply to the mix of institutions included in the survey. Many of the private institutions represented in the AACSB data do not offer logistics programs. For example, there are no logistics programs at any of the "Ivy League" universities that are assumed to pay higher than average salaries.

For logistics faculty, compensation is higher from public universities at all levels for both the base salary and total compensation.

A comparison of the survey results with AACSB salary data indicates that logistics and supply chain faculty at public institutions generally receive a higher level of compensation (see Table 5). Logistics and supply chain assistant professors receive over $10,000 more than management, marketing, production and operations management professors in public institutions. They receive over $30,000 more in compensation that the Other category where AACSB reports logistics and supply chain faculty. At the associate level, logistics and supply chain professors receive more than $13,000 per year more in public institutions than their counterparts in related fields and over $30,000 more than reported in the Other category. Full professors in logistics and supply chain management receive over $10,000 more than other areas in public institutions except for Marketing where less than a $2,000 difference exists.

TABLE 3
NINE-MONTH BASE SALARY V. TOTAL COMPENSATION

	Mean Nine-Month Base Salary	Mean Total Compensation	Additional Incentives
Assistant	$ 97,880	$115,226	0.18
Associate	$103,521	$119,666	0.16
Full	$133,254	$164,271	0.23

FIGURE 2
ASSISTANT PROFESSOR COMPENSATION SUMMARY

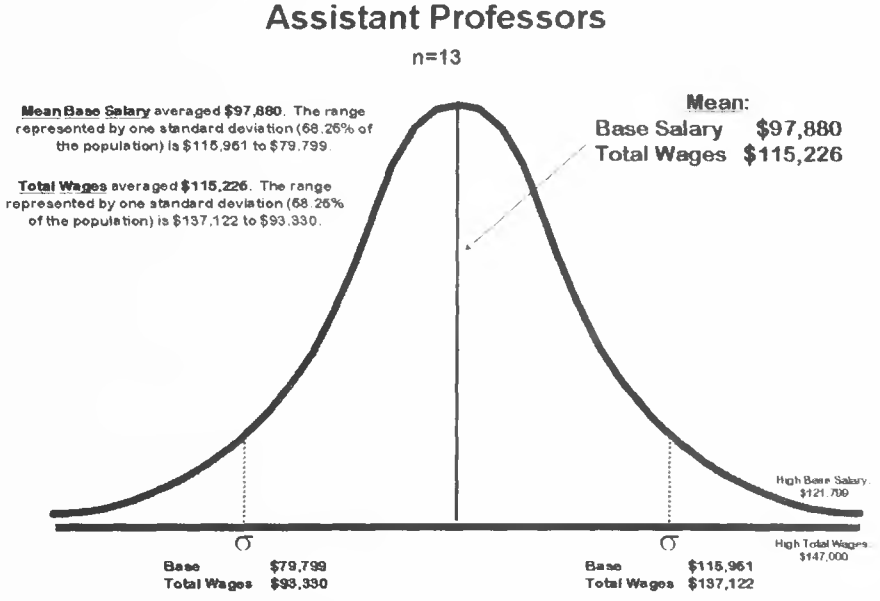


FIGURE 3
ASSOCIATE PROFESSOR COMPENSATION SUMMARY

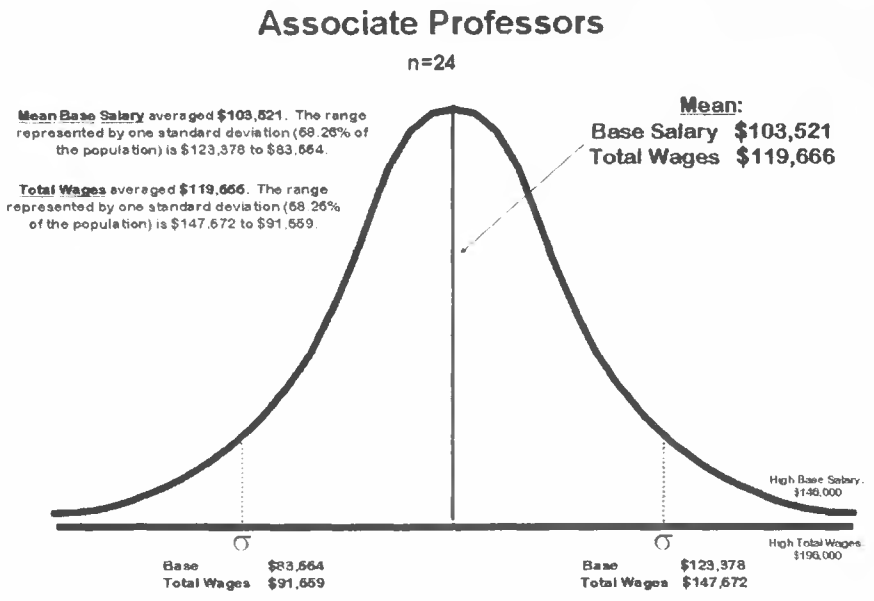


FIGURE 4
FULL PROFESSOR COMPENSATION SUMMARY

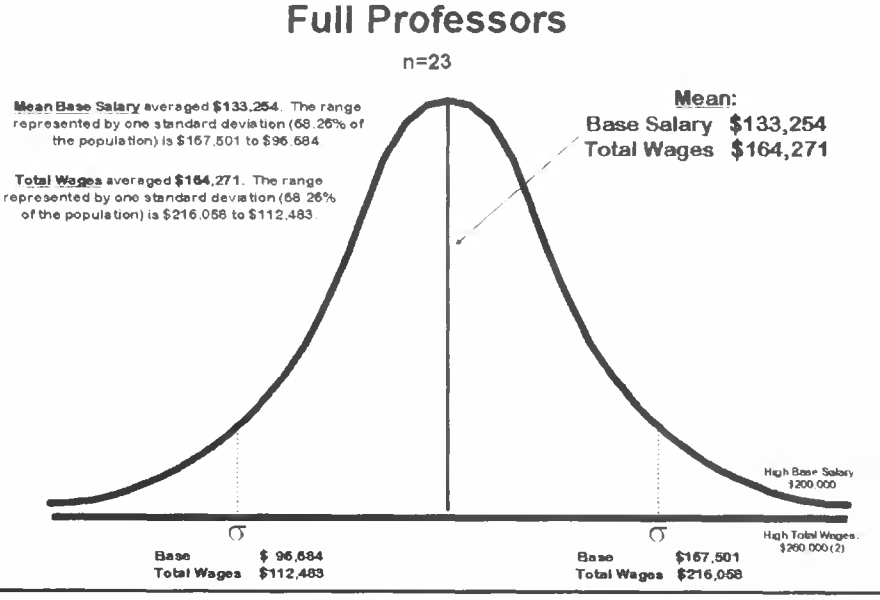


TABLE 4
PUBLIC VS. PRIVATE

	Mean Nine-month Base Salary	Mean Total Compensation	Public Premium
Assistant			
- Public	$102,180	$123,410	0.13
- Private	$ 95,277	$108,949	
Associate			
- Public	$107,422	$121,193	0.05
- Private	$ 91,817	$115,083	
Full			
- Public	$135,520	$167,501	0.17
- Private	$118,900	$142,733	

TABLE 5
COMPARISON OF SURVEY RESULTS WITH 2005-2006 AACSB SALARY DATA
(000's)

Rank	2006 Salary Survey Results	Management	Marketing	Production/ Operations Management	Other*
Assistant					
- Private	$ 95.3	$ 89.0	$ 93.8	$104.1	$ 78.2
- Public	$ 102.2	$ 80.7	$ 88.9	$ 87.9	$ 72.0
Associate					
- Private	$ 91.2	$ 93.2	$ 98.7	$100.6	$ 77.4
- Public	$ 107.4	$ 83.4	$ 91.0	$ 93.7	$ 77.0
Full					
- Private	$ 118.9	$120.2	$110.3	$133.8	$136.4
- Public	$ 135.5	$101.1	$137.1	$111.7	$124.9

*Includes General Business, Health Services/Hospital Administration, Hotel/Restaurant/Tourism, Public Administration, Supply Chain Management/Transportation/Logistics, and Other not classified

Source: Association to Advance Collegiate Schools of Business International, *Salary Survey Report 2005-2006.*

AACSB Accredited Institutions vs. Non-Accredited Institutions

Another key difference is found between the compensation at AACSB accredited institutions and those without accreditation, as illustrated in Table 6.

AACSB accreditation involves adherence to a set of performance criteria and periodic review in

order to promote quality and consistency in collegiate business education. There is a clear difference in compensation at all levels for both the base salary and total compensation. Base salaries are considerably lower at non-accredited institutions. In addition, additional incentives represent a higher percentage of the total compensation package.

Premium for Research

Respondents were asked to allocate their workload based on teaching, research, service, and administrative duties. It was expected that tenure requirements would drive up the research allocation of untenured assistant professors. The actual allocations of workload reported by assistant professors in the respondent group was forty-four percent for research, forty-three percent for teaching, and thirteen percent for service.

Research allocations varied at the associate and full professor levels as shown in Table 7. Analysis reflects a clear compensation premium is paid for both the base salary and total compensation to senior faculty respondents that reported a higher allocation of their workload for research. Faculty at the rank of associate professor with a higher research allocation received forty-eight percent more in total compensation than respondents that emphasized teaching in their allocations. Faculty at the rank of professor with a higher research allocation received twenty-nine percent more in total compensation than respondents that emphasized teaching in their workload allocations.

TABLE 6
AACSB INSTITUTIONS

	Mean Nine-month Base Salary	Mean Total Compensation	Accreditation Premium
Assistant			
- Accredited	$103,357	$121,900	0.13
- Not accredited	$ 91,490	$107,440	
Associate			
- Accredited	$105,732	$121,135	0.17
- Not accredited	$ 79,200	$103,500	
Full			
- Accredited	$138,544	$167,699	0.07
- Not accredited	$119,145	$156,433	

TABLE 7
WORKLOAD ALLOCATION

	Mean Nine-Month Base Salary	Mean Total Compensation	Research Premium
Associate			
50% to 70% research	$121,060	$136,346	0.48
35% to 49% research	$ 98,284	$106,401	
Less than 35% research	$ 92,175	$106,194	
Full			
50% to 70% research	$128,333	$153,971	0.33
35% to 49% research	$117,245	$123,189	
Less than 35% research	$103,000	$119,000	

Administrative Pay

Average workload allocation differences between associate and full professors were somewhat obscured by the diverse mixture of activities, including administrative duties, at each level. The relationship in the sample between compensation and administrative duties was analyzed separately as shown in Table 8.

None of the respondents reported high allocations for both research and administrative duties. While all respondents reporting administrative duties also reported an allocation for research, the results suggest faculty members must choose between focusing on research or on administration in order to increase their total compensation. The average compensation premium for undertaking administrative duties within the sample was six percent for associate professors and forty-eight percent for full professors.

Type of Program

Respondents were also asked to identify the academic level of their respective institutional programs. The reported levels reflected whether their institution granted a Ph.D. in logistics, granted a Ph.D. in other fields, or were non-Ph.D. granting institutions. The results are shown in Table 9. Programs awarding a Ph.D. in logistics accounted for thirty-four percent of the

TABLE 8
ADMINISTRATIVE PAY PREMIUM

	Mean Nine-month Base Salary	Mean Total Compensation	Additional Incentives
Associate			
- Administrative role	$ 97,750	$124,696	0.06
- No administrative role	$105,444	$117,989	
Full			
- Administrative role	$150,568	$204,699	0.48
- No administrative role	$121,267	$138,281	

TABLE 9
PH.D. GRANTING INSTITUTIONS

	Mean Nine-month Base Salary	Mean Total Compensation	Premium
Assistant			
- Logistics PhD. granting	$108,825	$125,012	0.4
- Other PhD. granting	$ 98,100	$118,450	
- Non-PhD. granting	$ 86,660	$101,410	
Associate			
- Logistics PhD. granting	$114,982	$139,210	0.51
- Other PhD. granting	$ 98,630	$112,746	
- Non-PhD. granting	$ 92,863	$100,425	
Full			
- Logistics PhD. granting	$162,929	$210,488	0.72
- Other PhD. granting	$130,038	$151,567	
- Non-PhD. granting	$105,380	$133,451	
- Other	$118,500	$140,000	

respondents. Faculty at Ph.D. granting institutions may face different expectations for research, in the classroom, as well as additional responsibilities, including guiding doctoral candidates, all of which warrant higher salaries. The average compensation premium for working at an institution granting a Ph.D. in logistics was twenty-three percent for assistant professors, thirty-nine percent for associate professors and fifty-eight percent for full professors.

Years of Service

Respondents were asked to identify time in rank and total time in service. Fitting a regression line into total years of service indicates that seniority leads to additional compensation. Longer time in service results in higher pay and does not reflect salary compression. Figures 5, 6 and 7 illustrate compensation differences across academic rank and years of service.

FIGURE 5
TOTAL YEARS OF SERVICE
ALL RANKS

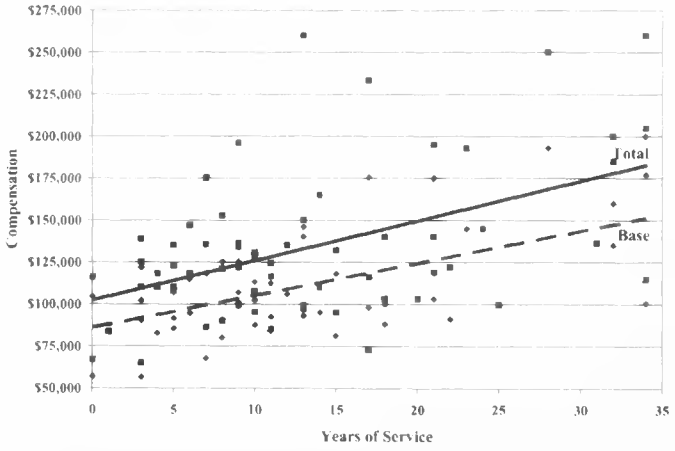
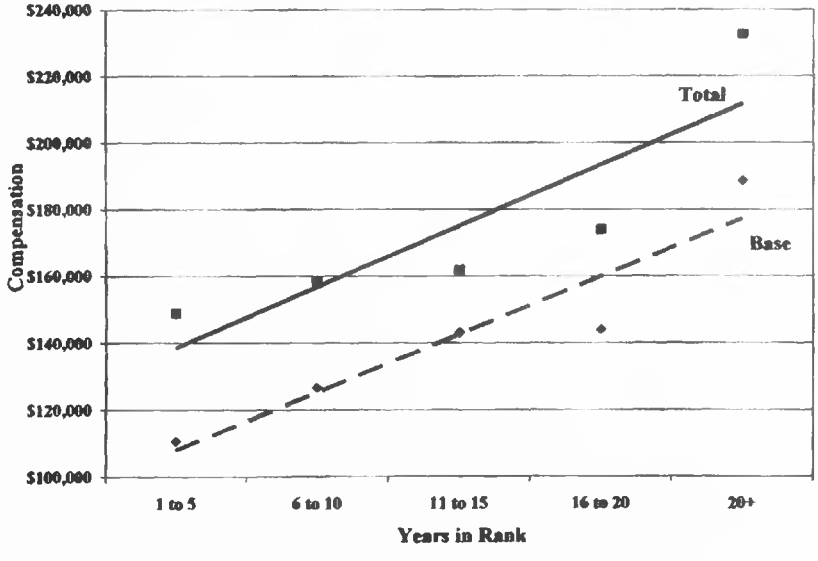


FIGURE 6
RANK OF ASSISTANT PROFESSOR

FIGURE 7
RANK OF FULL PROFESSOR



This relationship appears to hold for both assistant professors and full professors. However, the relationship does not appear to be the same for associate professors (see Figures 8 and 9). This could be the result of "associate purgatory", where some associate professors simply stop seeking to fulfill the requirements for promotion to full professor. As a result, additional incentives taper off.

Further examination of the data for respondents with five or less years of time in rank illustrates an even sharper decline. It is interesting to note that no associate professor with time in rank beyond nine years responded to the survey.

SURVEY LIMITATIONS

This survey has several limitations that could affect the accuracy of the data collected and the analysis.

Self-Reported Data

The data come directly (e.g., self reported) from the faculty members. It is assumed that each respondent accurately reported his/her compensation.

Sampling Error

Not all logistics, transportation and supply chain management faculty attend the CSCMP Educators' Conference or are included in the CSCMP membership roster. The use of the convenience sample excludes some faculty from participation.

Overlapping Disciplines

The academic field of logistics involves overlapping disciplines that may include faculty classified as logistics, transportation, supply chain management, marketing, management, operations and production, or industrial engineering. The population of all faculty in these fields is not known.

Survey Time of Year

The survey was completed in June and July. Many faculty do not teach during the summer

FIGURE 8
ASSOCIATE PROFESSORS ALL YEARS WITHIN RANK

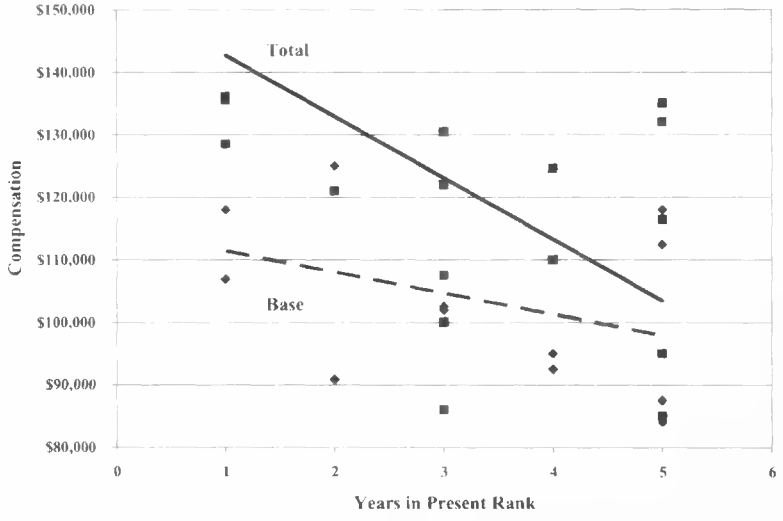
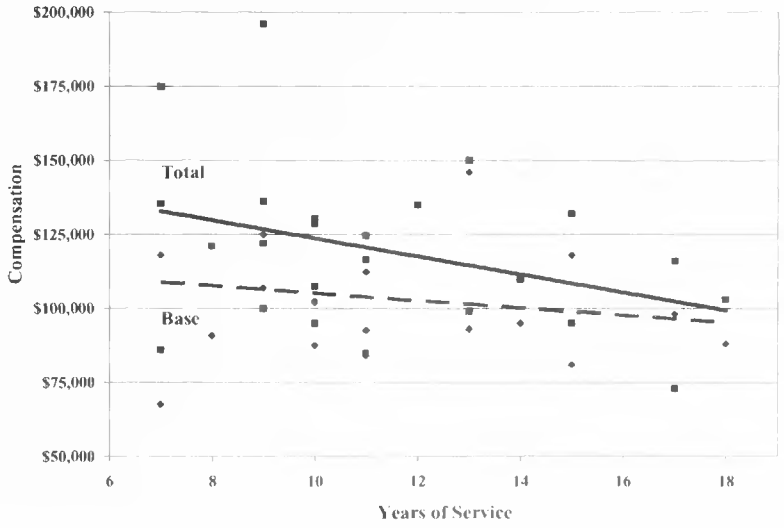


FIGURE 9
ASSOCIATE PROFESSORS FIRST FIVE YEARS IN RANK



months and may not have been available to respond to the survey. Future surveys will be conducted in early May to resolve this potential limitation.

Low Response Rate

Due to the confidential nature of the data collected, some potential respondents may have opted not to participate. It is hoped that as this survey is repeated annually and recognition of its value and importance increase, more faculty will participate.

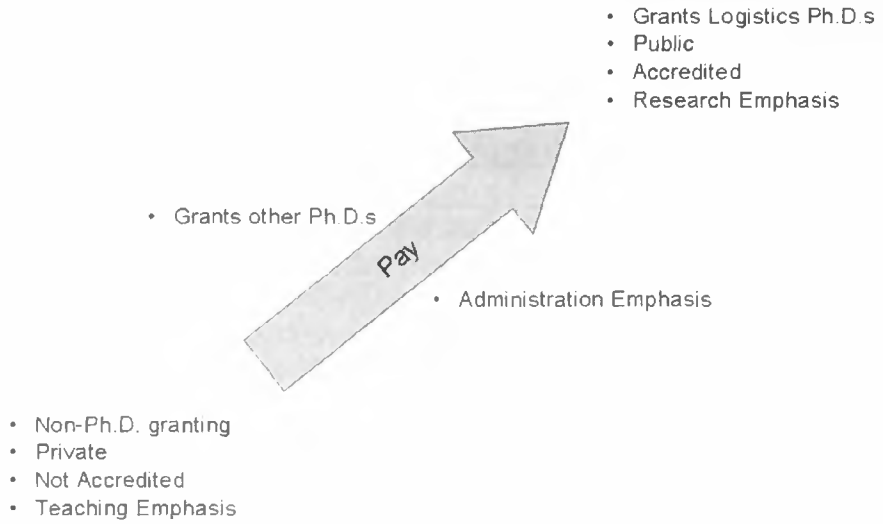
SUMMARY AND CONCLUSIONS

The first annual logistics faculty salary survey offers career guidance for both new and current faculty members, as well as administrators. Salary represents one of the key criteria used in selecting faculty positions, and new career candidates seeking employment will find the highest compensation in accredited public institutions granting Ph.D.s in logistics as shown in Figure 10. Long term career focus should emphasize research first and administration second to increase potential compensation levels.

Care should be taken when utilizing a single overall average salary for a given academic rank. Readers should consider which variables best reflect their situation and interpret the data accordingly.

Finally, it is the expectation of the authors that the logistics faculty salary survey will be conducted annually, and that the results will be published in this journal.

FIGURE 10
COMPENSATION HIERARCHY



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AUTHOR BIOGRAPHY

M. Theodore Farris II, is an associate professor of logistics at the University of North Texas. He holds a Ph.D. in Business Logistics and a M.A.B.A. in Management Information Systems from the Ohio State University, an M.B.A. in Materials Logistics Management from Michigan State University, and a B.S. in Business Administration from Arizona State University. Prior to his academic career, Dr. Farris was employed with IBM Corporation and INTEL Corporation. He holds professional certification status (CTL) with the American Society of Transportation and Logistics. His research interests include cash-to-cash, supply chain mapping, and transportation regulatory policy.

AUTHOR BIOGRAPHY

Terrance L. Pohlen is an associate professor of logistics at the University of North Texas. He holds a Ph.D. in Business Logistics and a M.A. in Business Administration from the Ohio State University, a M.S. in Logistics from the Air Force Institute of Technology, and a B.S. in marketing from Moorhead State University. Dr. Pohlen retired from the United States Air Force with over 20 years of logistics experience. He has published several articles focusing on the costing and financial management of logistics and supply chain performance measurement. He holds the professional certification in transportation and logistics (CTL) from the American Society of Transportation and Logistics (AST&L) and serves on the AST&L Board of Directors and chairperson for the Board of Examiners for the professional certification.

AUTHOR BIOGRAPHY

Jerry W. Wilson is a professor of marketing and logistics at Georgia Southern University. He received the D.B.A. degree in marketing and transportation from Memphis State University and B.S. and M.B.A. degrees from Arkansas State University. He is co-founder of the logistics and intermodal transportation program at Georgia Southern and serves as Editor of the Journal of Transportation Management. Dr. Wilson is a member of the board of directors of Delta Nu Alpha Logistics and Transportation Association and serves on two committees for the Intermodal Association of North America. He also holds the CTL professional certification and is a member of the CTL certification Board of Examiners for the American Society of Transportation and Logistics. His research interests include service process simulation, transportation policy analysis and intermodal connectivity issues.

Establishing a Motor Carrier Research Agenda

Carlo D. Smith
Missouri State University

John L. Kent
Missouri State University

ABSTRACT

The motor carrier industry represents an important linkage in a variety of industry supply chains and accounts for a substantial level of total logistics cost. This article combines a review of motor carrier research over the past 10 years (1996-2006), with input from executives representing common and specialty carrier services, to identify key areas of interest to guide future motor carrier research.

INTRODUCTION

Transportation is an important link supporting the success of supply chain operations in most industries. Of the $736 Billion dollars in domestic transportation cost identified in the 17th Annual State of Logistics Report, fully 79% ($583 Billion) were attributed to motor carrier costs. Motor carrier costs accounted for 49% of total logistics costs and over 4% of the US GDP in 2005 (Wilson 2006).

While supply chain management and logistics as areas of research have received considerable attention over the last decade, the authors sought to investigate the extent of research focused on the motor carrier industry. The purpose of this article is two-fold. First, a review of the past ten years of published research in the area of motor carrier management and operations is presented including topics and extent of coverage. Second, to offer a practical perspective of future research opportunities and interests, the authors' interviewed executives of leading motor carriers including truckload, less-than-truckload, temperature controlled, flatbed, and tank carriers. Combined, the review of research and insights from the professionals interviewed are used to suggest important topics for consideration in an on-going motor carrier research agenda.

The next section reviews research topics specific to the motor carrier industry from logistics and transportation related journals. The review is followed by results from depth interviews with executives from the motor carrier industry. The final section combines these inputs to suggest a topical agenda for consideration in future studies involving motor carrier management and operations.

Motor Carrier Research: 1996-2006

The focus of this study involves management and operational issues in the motor carrier industry. It excludes research concerned with broader economic and federal or state government policy issues as well as issues related to civil and mechanical engineering applications in transportation. Article abstracts were reviewed for the 1996–2006 issues of the logistics and transportation related journals included in Table 1. In addition, an electronic search was conducted in the Emerald and Business Source Premier Databases for studies involving motor carrier management and operations that may be published in other general or topical scholarly publications.

Articles were selected for review if the topic focused on motor carrier management and/or operations. Articles which addressed broader transportation research topics of which motor carriers were one of many transportation alternatives were excluded from the review.

A total of 111 articles were identified with a specific research focus on motor carrier related issues from the journals reviewed. Table 2 identifies the numbers of articles from each of the respective journals. A review of article abstracts revealed 11 categories of research. The articles were each assigned to one of the eleven topical categories. In cases where article content may be associated with more than one category, the assignment was made to that area which appeared to be most predominately addressed in the study. Table 3 identifies each category, as well as the number and percentage of articles assigned to the respective categories.

Thirty two articles focused on research involving the development and testing of modeling algorithms. These studies incorporated methodologies including linear and mixed integer modeling, heuristics, genetic algorithms, game theory, and simulation. The primary area of study involved variations on routing and scheduling algorithms (Pankretz 2005; Zhong and Cole 2005). Studies also considered potential solutions to load optimization and matching problems (Morabito, Morales and Widmer 2000) as well as fleet sizing (List et al. 2003).

Of the fourteen articles identified in the industry structure/competition category, a majority continued to investigate the impact and implications of deregulation on areas such as market structure (Giordano 1997), cost efficiency and profitability (McMullen and Man-Keung 1999; Silverman, Nickerson and Freeman 1997). A few studies considered shifts in strategy (Feitler and Corsi 1997; Feitler, Corsi and Grimm 1998) and market expansion (Hanna and Maltz 1998).

TABLE 1
LOGISTICS AND TRANSPORTATION RELATED JOURNALS INCLUDED IN STUDY

Transportation Science
Journal of Transportation Economics and Policy
Transportation Research A: Policy and Practice
Transportation Research E: Logistics and Transportation Review
Transportation Journal
Journal of Transportation Management
International Journal of Physical Distribution and Logistics Management
Journal of Business Logistics
International Journal of Logistics Management
Transportation Quarterly

TABLE 2

Journal	# Articles	% Articles
Transportation Science	22	19.81
Transportation Research E: Logistics and Transportation Review	19	17.11
Journal of Transportation Management	18	16.22
Transportation Journal	16	14.41
International Journal of Physical Distribution and Logistics Management	11	9.91
Journal of Business Logistics	5	4.50
Transportation Quarterly	4	3.60
Journal of Transportation Economics and Policy	2	1.80
Transportation Research A: Policy and Practice	1	.90
Miscellaneous Journals (12 separate journals)	13	11.12

TABLE 3

Category	# Articles	% Articles
Models/Algorithm Development	32	28.8
Industry Structure/Competition	14	12.6
Information Systems	13	11.7
Organizational Relationships	11	9.91
Human Resources/Employment	10	9.01
Asset Management	9	8.11
Performance Measurement	6	5.41
Operations	5	4.50
Quality Management	4	3.60
Finance/ Economic	4	3.60
Safety	3	2.70

Thirteen articles involving information system related studies were distributed among three primary topics, those involving the implementation and application of electronic data interchange (EDI) technologies for communication between shippers and carriers (Crum, Johnson and Allan 1998; Clarke 2000), the application of mobile communications technologies such as satellite technologies for fleet management (Parker, Kent and Manrodt 2000; Manrodt, Kent and Parker 2003), and the emerging usage models and internet technologies

for promotion, planning and management (Golob and Regan 2003; Kent, Parker and Schaefer 2003)

Studies of buyer/supplier relationships in the motor carrier industry have addressed carrier involvement in relationships (Gentry 1996; Gentry 1996), criteria and differing perceptions regarding criteria used in carrier selection (Premeaux 2002; Kent and Smith 2006), and relationship trends (Crum and Allen 1997).

The majority of studies concerned with human resource issues have focused on driver recruitment and retention. These studies have investigated factors such as the nature of the driver/customer relationship (Keller 2002), the driver/dispatcher relationship (Keller and Ozment 1999), managerial issues (Min 2002) and the impact of regulation (Peoples and Peteraf 1999) and on driver retention.

Asset management issues have focused on life cycle costing and vehicle replacement (Hanna, Stapleton and Zoll 2004), fleet design (Taylor, DuCote and Wicker 2006), terminal layout (Gue 1999; Bartholdi and Gue 2004) and fuel performance (McCarthy and Tay 1998).

The six articles involving performance measurement looked at the role of benchmarking and scorecards as a basis for performance measurement (Poli and Scharage 2003; van Donselaar and Kokke 1998) as well as shipper perceptions regarding LTL carrier performance (Keller 1996).

Areas more specific to operations that were contained in the studies involved the application of routing and scheduling methods (McKinnon and Yongli 2006), the usefulness of traffic information (Golub 2002) and the value of advanced load information (Tjokroamidjojo, Kutanoglu and Taylor 2006).

Quality issues in motor carrier operations addressed issues related to service quality (Crosby and LeMay 1998) and assessments of quality practices and improvement programs (Wisner and Lewis 1996).

Studies involving finance and economics have looked at such issues as rate adjustments (Smith, Campbell and Mundy 2004), firm size (Ellinger, Lynch and Hansen 2003), and asset financing (Zingales 1998).

Finally safety related studies included comparisons of safety performance by commodity (Horrace and Keane 2004), assessing the cost benefit of safety programs (Moses and Savage 1997) and assessing the potential for improved safety processes (Mejza and Corsi 1999).

METHODOLOGY

The primary research component of this study incorporated personal interviews with motor carrier executives. Truckload, less-than-truckload, temperature controlled, flatbed, and tank carriers were represented in the interviews. Each of the interviews was conducted during October 2006. All interviews were conducted in person except one which was conduced via telephone conference call.

The interviews were conducted with the following opening statement: "We'd like an opportunity to get your thoughts regarding issues you feel are most important for future research in the motor carrier industry." Interviewee responses formed a broad foundation from which the interaction then narrowed to areas which appeared to be most significant to the interviewee. Analysis of the accumulated interview responses revealed a grouping into five themes of research interest. Subsequently, the primary research findings were compared to the historical review of motor carrier literature to develop a comprehensive list of topics that may be used to form the bases a research agenda focused on issues relevant to the motor carrier industry. This aspect of a research agenda will be discussed in the *Implications for Future Research* section.

FINDINGS

This section discusses the findings from the personal interviews with motor carrier executives. After completing all the interviews, findings were integrated into five primary themes. The themes include: shipper/carrier collaboration, risk management, driver recruitment and retention, public policy, and fleet management.

Shipper/Carrier Collaboration

The issues identified as part of shipper/carrier collaboration include: 1) information sharing and 2) supply chain management. The electronic sharing of transactional information between shippers and motor carriers via Electronic Data Interchange (EDI) has been a critical component of the shipper/carrier relationship for over two decades. However, as stated by one interviewee, "with the increased functionality of the internet, including extensible markup language (XML) and several extranet type applications currently being used to facilitate the sharing of not only the traditional transactional information but also inquiries regarding forecasting and equipment availability, more research should be done in this area." Another interviewee commented on the carriers' ability to gather and transmit critical shipment information to multiple participants in the supply chain.

In regard to the carriers' role in supply chain management several comments were made implying that the "forgotten" or "ignored" link in supply chain management is the motor carrier. One interviewee stated, "when 3PL's are negotiating on behalf of the actual shipper they seem to forget that collaboration is about long term benefits based on quality and focus much more on negotiation for the lowest price." Another carrier commented, "we are very skeptical when a shipper or 3PL discusses collaboration because we have been drawn in all too often just to find out the bottom line to get the contract is based on rates." When asked if they (the carrier) could identify any examples of a true win-win collaborative relationship only a couple of relationships were identified.

Risk Management

The issues identified as part of risk management include: 1) safety, 2) insurance, and 3) homeland security. Risk Management was the first issue identified by one interviewee. The interviewee stated, "when we make a sales call the first component of our presentation is on safety and the impact of insurability on a carrier's financial stability and their ability to service their customer." Most of the interviewees discussed the importance of risk management for a motor carrier. The two monetary reasons stated for research attention to risk management were to reduce litigation expenses and to reduce insurance costs. One interviewee stated, "this area could bankrupt our company."

In addition to the monetary reasons as justification for a better understanding this aspect of motor carrier operations, homeland security was also mentioned. Specifically related to hiring drivers, training drivers, and dispatching drivers where hazardous materials are concerned. The U.S. Department of Homeland Security has established policies that directly impact a motor carrier with respect to hauling hazardous cargo.

Driver Recruitment and Retention

The issue of driver recruitment and retention has been a persistent concern for the motor carrier industry and its continued importance was reflected in our discussions. One interviewee stated, "a better understanding of the personality characteristics for good drivers should allow motor carriers to more accurately target their recruiting efforts." Also related to recruitment, were discussions regarding the need to better understand advertising strategies. Driver recruitment is an area that all interviewees noted as needing more research attention.

Once the driver is recruited and placed on the payroll then the motor carrier's attention must turn toward retaining the driver. Several minutes of the interviews were spent discussing the need for research to better understand "what works" to retain drivers. Motor carriers currently utilize several strategies directed toward driver retention including various pay incentives, choice of equipment, and preferred routing. Finally, directly related to drivers was a discussion with one interviewee regarding continuing education for truck drivers. Areas of interest included small business management courses for owner operators, GED courses, and even college credit courses for truck drivers.

Public Policy

The issues identified as part of public policy include: 1) infrastructure, 2) sustainability, and 3) hours-of-service (HOS). While not included in our literature review, every interviewee mentioned highway infrastructure as an increasingly important issue for government to address. The importance of gaining a better understanding of infrastructure was explained from two perspectives. First, is the need for improvements in the physical highway infrastructure in the form of smoother, wider, and straighter roads. Second, a means of handling transportation delays caused by existing infrastructure improvements is needed.

Sustainability, or as referred to in several of the interviews, "the cost of being green" is an area which needs more research and was discussed in several of the interviews. From a public policy perspective, sustainability is embodied through EPA emission laws and directly impact equipment costs for the motor carrier. The fuel efficiency perspective on sustainability is discussed in the fleet management section. Finally, as has been well documented in recent years in the popular press, HOS continues to be an area of concern for the motor carrier.

Fleet Management

The issues identified as part of fleet management include: 1) the role of the fleet manager (dispatcher), 2) fuel—including fuel efficiency, alternative fuel sources, and fuel surcharges, and 3) asset utilization. As described by a truckload motor carrier, "The role of the fleet manager in our operations can have tremendous impact on driver retention, customer service, and overall operations efficiency. We need to better understand the levers related to their role and positively enforce them whenever possible. Our company views the fleet manager as a VP of Operations for a small carrier."

The fleet management view of sustainability is more of an efficiency perspective. The combination of more fuel efficient engines, tires, aerodynamics, and alternative power sources to minimize idling were all discussed in the interviews. Additionally, alternative fuel sources were expected to be an area which will need more research.

Asset utilization was the second application area (along with EDI which was already discussed) within the purview of information technology that was described as needing more research. Specifically, the continued integration of mobile communications systems and decision support systems for load solicitation, load planning, and automated dispatch.

IMPLICATIONS FOR FUTURE RESEARCH

The implications for future motor carrier research were deduced primarily from the interviews and secondarily integrated with the extant motor carrier research. Each of the topical areas is listed below. The authors attempted to rank the topics in order of importance; however a limitation was the small number of interviews. This limitation should be explored in future

research via a survey directed to a larger audience of motor carrier managers.

First, as identified in the literature review, safety has been one of the least researched topics. However, risk management (including safety, insurance, and homeland security) was mentioned by most of the interviewees as areas needing more research. This area is listed first due to the relative gap between the level of importance perceived by the interviewees' and the lack of existing research. Certainly, the popular press has published many articles on the impacts of homeland security requirements on transportation.

Second, organizational relationships have received a moderate amount of attention in the existing literature and were frequently mentioned, in the context of supply chain management and collaboration, as needing more clarification regarding the motor carriers' role in each. The interviewees' were clear in stating that they feel their role in both collaboration and supply chain management is misunderstood. Due to the apparent disconnect between the perceptions of the interviewees' and the tremendous attention collaboration and supply chain management have received in academic journals, popular press, and within conference proceedings, the topical area is listed the second most important for future research.

Third, human resources have received a moderate amount of attention in the extant literature and, in the form of driver recruitment and driver retention, received a moderate amount of attention within the interviews. This area appears to be most important for the truckload segment of the motor carrier industry.

Fourth, is the area of public policy. Public policy issues were not examined as a part of the literature review. However, hours-of-service, infrastructure, and sustainability each received a moderate level of attention during the interviews. Due to the relative gap between the literature and the interviewees' perceived importance, the authors included this area as needing additional research.

Finally, receiving a moderate level of attention in the extant literature and moderate to low level of attention in the interviews is the area of asset or fleet management. Specifically, there is a need for more research attention in the area of fuel—including fuel efficiency, alternative fuel sources, and fuel surcharges.

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AUTHOR BIOGRAPHY

Carlo D. Smith is an assistant professor of logistics and supply chain management at Missouri State University. Dr. Smith's research focuses on logistics in the supply chain, inventory management, and forecasting management. His articles have appeared in the *Journal of Business Logistics*, *International Journal of Forecasting*, *Journal of Business Forecasting*, *Journal of Transportation Management*, *Business Horizons*, and the *Journal of Consumer Satisfaction, Dissatisfaction and Complaining Behavior*. Dr. Smith received his undergraduate and masters degrees in business logistics from the Pennsylvania State University and his Ph.D. in marketing and logistics management at the University of Tennessee. He has more than 12 years of industry experience as a logistics consultant and executive educator.

AUTHOR BIOGRAPHY

John L. Kent (Ph.D. University of Tennessee) is an associate professor of logistics and supply chain management at Missouri State University. Dr. Kent's research interests include motor carrier and other modes of transportation, logistics, and supply chain management. He has published in the *International Journal of Physical Distribution and Logistics Management*, *Journal of Business Logistics*, *Defense Transportation Journal*, *Journal of Marketing Management*, and conference proceedings at the Academy of Marketing Science, and Council of Supply Chain Management Professionals.

Smooth Sailing or Rough Seas: The Future of International Liner Shipping

David A. Menachof
City University
London, England

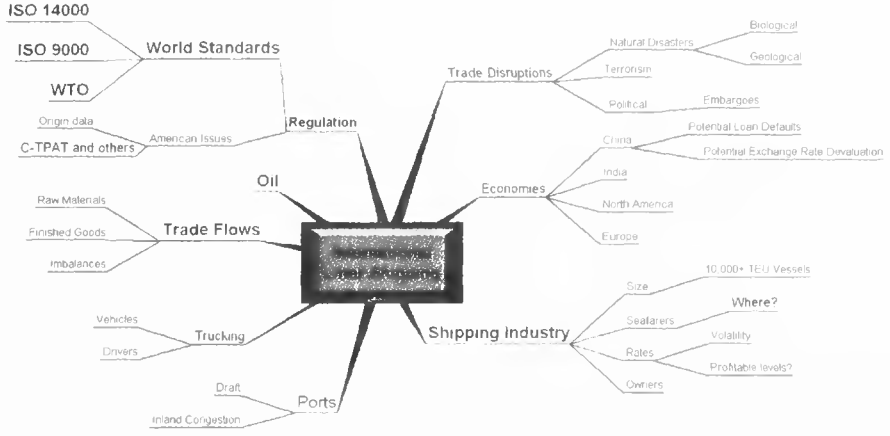
The last 5 years have been exciting for the world of international liner shipping. Mergers, new and larger vessels, charter rates becoming more volatile and demand continuing to increase are just part of this world of liner shipping.

This article is an attempt to highlight some of the issues that will be affecting international shipping in the forthcoming years. At its best, this article will be right on the money. At its worst, readers will look back at this article and wonder how the author could have been so wrong. More likely is that some things will occur as predicted, while others have not even been thought of yet.

THE ISSUES OF CONCERN

There are many influences that affect the liner shipping industry. It is hard to prioritize these influences as at any point in time one or more might have increased importance or relevance compared to others. Figure 1 depicts a Mindmap of the various issues that will have an effect on international transportation in the near future. Mindmapping is associated with Tony Buzan. The technique of mindmapping allows a more freestyle method of organizing your ideas compared to using traditional lined paper. Initially, the mindmap frees the user from assigning importance of ideas over one another.

FIGURE 1
MINDMAP OF ISSUES AFFECTING INTERNATIONAL TRANSPORTATION



For example, at this point, one cannot say whether trade disruptions are more important than changes in regulation in terms of impact for the future. What it does allow is the relationship of the ideas, in this case back to international shipping.

With that caveat, the following issues are offered to be the main ones that will affect international shipping in the next 5-10 years (with more detail in a later section):

The shipping industry includes specific issues such as size of the vessels, the size of the companies (including new mergers and acquisitions), the level of competition, the rates for containers and the rates for chartering vessels, and even the supply of seafarers.

The economies of the world are in flux. Which economies will be the sources of growth, which will be lagging behind? Are there issues with specific countries that need to be taken into account?

Very related to the economies are the trade flows. Where are the goods coming from and to where are they going? Are there imbalances in the imports and exports of various countries? One specific problem is that in many cases, raw materials, which come in bulk form, must be imported on bulk ships which cannot be used to export the finished goods, which tend to use containerized liner shipping services.

Trade disruptions must be taken very seriously now as the last couple of years have seen acts of terrorism, natural disasters such as the Asian Tsunami and Hurricane Katrina, and other political interventions such as embargoes and quotas. Longer supply chains literally mean more chance for disruptions to take place.

Regulation is becoming more encompassing and restrictive. New regulations will certainly add cost, but the cost of non-compliance could be even greater.

The trucking industry will have an effect on the inland delivery of the container to/from the port and along with rail services could have an impact on ocean shipments.

Regulations are continuing to be developed for safety and security reasons. World standards along with U.S. initiatives will need to be satisfied to continue to ply the world's oceans.

Ports have a significant role to play as they are the interface between the ship and shore. An efficient running port is critical to the successful liner shipping firm. The wrong choice of port could make them uncompetitive.

SHIPPING INDUSTRY

Size is the biggest factor that will affect the liner trades in the next few years. Now that the Emma Maersk is up and running, other lines will be competing to bring their next generation of vessels online. These large ships change the pattern of shipping routes, as they must travel on the largest trade lanes, as their economies of scale are only recognized when they are sailing full of cargo. Another related issue of these large vessels is the cascade effect that takes place (Menachof et al., 2004), whereby the previous vessels on a particular route are shifted to the next largest route, causing a cascade effect, and increasing effective capacity on secondary routes as well.

Table 1 shows the 10 largest container vessels currently sailing. The trend is to continue with more vessels breaking the 10,000 TEU barrier, while Table 2 shows the construction trend.

The size of the vessels has already exceeded the Panamax limit, and are closely reaching Suexmax proportions, with a beam of 57 meters considered close to the limit. According to predictions, new vessels could be reaching Malaccamax size in the next 10 years. The size and draft of these vessels will cause problems for ports around the world as well and will be discussed in the port section of the paper.

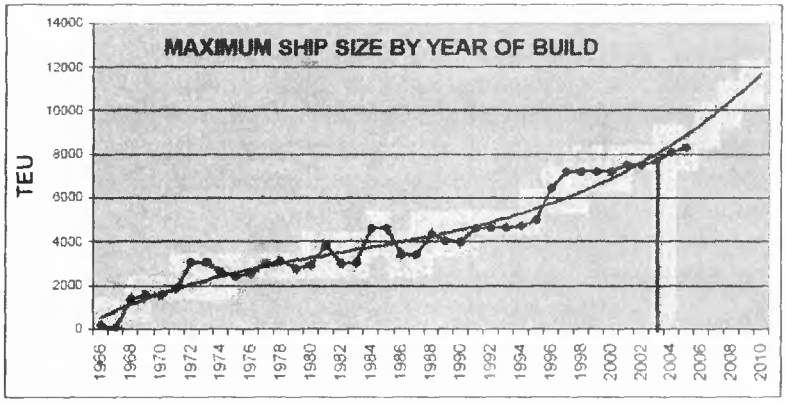
Closely related to the size of the individual vessel is the size of the total container fleet. Table 2 shows that the number of TEU's able to be carried has increased by over 400% since 1992 and by 2009 by an additional 50% to over 12,000,000 TEU's.

TABLE 1
BIGGEST SHIPS IN THE WORLD, LISTED BY TEU CAPACITY

Built	Name	Length o.a.	Beam	TEU	Gross Tons	Owners/Flag
2006	Emma Mærsk	393.0 m	56.4 m	14,500 (maximum TEU)	151,687	Maersk Line/Denmark
2006	Georg Mærsk	367.28 m	42.8 m	10,150	97,933	Maersk Line/Denmark
2006	Gerd Mærsk	367.3 m	42.8 m	10,150	97,933	Maersk Line/Denmark
2005	Gjertrud Mærsk	367.3 m	42.8 m	10,150	97,933	Maersk Line/Denmark
2005	Grete Mærsk	367.3 m	42.8 m	10,150	97,933	Maersk Line/Denmark
2005	Gudrun Mærsk	367.3 m	42.8 m	10,150	97,933	Maersk Line/Denmark
2005	Gunvor Mærsk	367.3 m	42.8 m	10,150	97,933	Maersk Line/Denmark
2006	Xin Los Angeles	336.7 m	45.6 m	9,580	107,200	China Shipping Container Lines (CSCL)/Hong Kong
2006	Cosco Beijing	350.0 m	42.8 m	9,469	99,833	Costamare Shipping/Greece
2006	Cosco Hellas	350.0 m	42.8 m	9,469	99,833	Costamare Shipping/Greece

Source: Wikipedia

FIGURE 2
PREDICTED GROWTH IN CONTAINER SHIPS



Source: Solentwaters.co.uk

TABLE 2

EVOLUTION OF THE CELLULAR FLEET 1988-2009			
Year	**Number**	**Teu**	**Progr.**
1988	1,164	1,496,067	
1989	1,197	1,601,973	7.1%
1990	1,247	1,708,014	6.6%
1991	1,319	1,846,004	8.1%
1992	1,406	2,003,753	8.5%
1993	1,497	2,199,359	9.8%
1994	1,595	2,377,482	8.1%
1995	1,742	2,643,976	11.2%
1996	1,917	2,973,081	12.4%
1997	2,112	3,351,367	12.7%
1998	2,342	3,857,889	15.1%
1999	2,523	4,279,300	10.9%
2000	2,622	4,508,708	5.4%
2001	2,746	4,919,526	9.1%
2002	2,904	5,523,456	12.3%
2003	3,045	6,109,473	10.6%
2004	3,186	6,651,624	8.9%
2005	3,359	7 301,982	9.8%
2006	3,618	8,240,755	12.9%
2007	4,011	9,560,000	16.0%
2008	4,454	10,970,000	14.7%
2009	4,769	12,320,000	12.3%

Figures are given at 1st January of each year
Figures for 2007 to 2009 are derived from the orderbook

Source: BRS-Alphaliner

Like the trucking industry trying to find drivers, the shipping industry is going to have more trouble finding seafarers. There are two major issues that will come into play. Western countries are finding it increasingly difficult to recruit nationals to go to sea. According to Marisec, the Philippines and India are continuing to supply significant numbers of non-officers, but as yet, do not have the quality desired by the fleet owners to move to the officer levels in great numbers. The other issue is the increased paperwork required for security

clearances to get personnel onboard vessels in the first place. Many ships may become short staffed while awaiting replacement crew to be cleared for service.

At the moment, the liner trades are generally profitable, which is part of the reason for the increased investment in the sector. However, like their bulk counterparts, they are increasingly seeing volatility in charter rates for containerships. This volatility in the bulk trades has resulted in boom and bust years, and this should be expected to happen more in the liner trades as well. Figure 3 shows that rates were relatively stable until 2002. Expect this volatility to continue as economic cycles and more tonnage create a fertile space for sale and purchase investors to enter the market.

One should expect to see more mergers in the next couple of years. Figure 4 shows the top 25 global liner shipping operators. Maersk continues to be the world's largest operator after absorbing Sealand and more recently P&O/Nedlloyd.

ECONOMIES OF THE WORLD

The world economy plays a central role for liner shipping. One of the key realizations is that demand for transportation is derived from the demand for the goods themselves. 2003 world merchandise trade grew by 4.5 percent with the most dynamic trading regions being Asia and transition economies. However, U.S. merchandise imports went up by 5.7 percent and EU merchandise imports went up by 2 percent. At the same time, Latin America's exports rose by 4.5 percent, and global trade expanded by 8.5 percent the following year, according to WTO reports. The lag in world reporting means 2005 data is not yet ready, but indications for 2005 and 2006 are positive and growth is expected to continue, but not at the same pace as before. The largest growth in the world is taking place in China, with imports up some 40 percent in 2004. China does have some issues to face and if they do not, there could be an economic bubble bursting. Mandel (2004) reports that a bubble of unprofitable investments and excess capacity is building up in China within the next 5 years. If this happens, imports and exports will be hit. At the same time, the Yuan is considered by many to be undervalued relative to the dollar and any attempts to correct this balance could be 'catastrophic' according to a Chinese central bank advisor, according to Forbes (2006). The result would be an immediate decline in the sale of Chinese manufactured goods, and this decrease would hit the liner industry hard as much of the tonnage currently on order is based on a growing Chinese economy.

In the meantime, we have seen the Indian economy come to life as a production economy. No longer just the place to outsource your telephone call centers and computer programming, manufacturing is quietly growing. If the Chinese economy falters, India will be ready to take its place.

TRADE FLOWS

Closely related to the economies of the world are their effects on the trade flows. The Chinese economy seems to have the most positive trade balance, but is now buying raw materials on the world market and becoming one of the largest importers in the world, as well as the worlds largest exporter.

The trade imbalance with the United States is quite startling to look at in currency value, but focusing on the container trade, the Transpacific trade lane had an eastbound/west-bound ratio of 2:1 in 2001. This meant that twice as many containers were coming to the U.S. than were going back to China. This ratio has worsened to 3:1 by the beginning of 2006 (see Figure 5). Liner companies have to ship containers empty just to stop them piling up in the U.S. With oil prices as high as they are, it might not be cost effective to return the containers empty as the cost to produce them is becoming so inexpensive in China. The U.S. is not the only country with a trade imbalance. According to the Department of Trade and Industry, Britain exported just over £2.8bn of goods to China last year but imported

FIGURE 3

Evolution of charter rates - 1993-2006
Source : BRS-Alphaliner

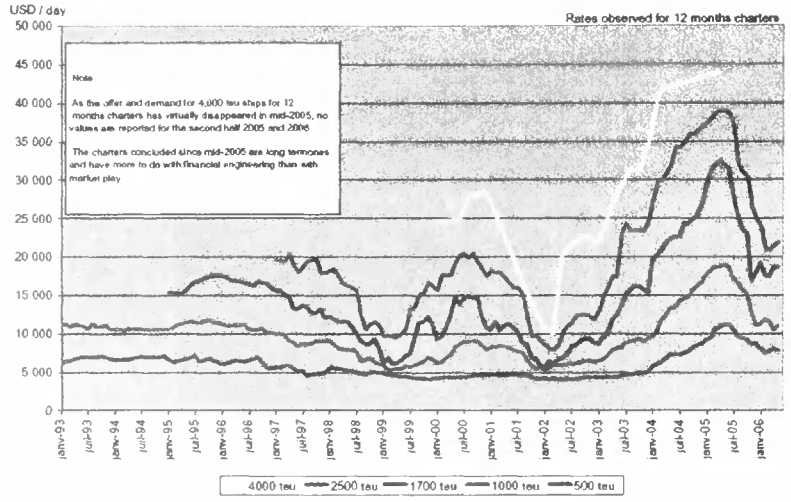


FIGURE 4

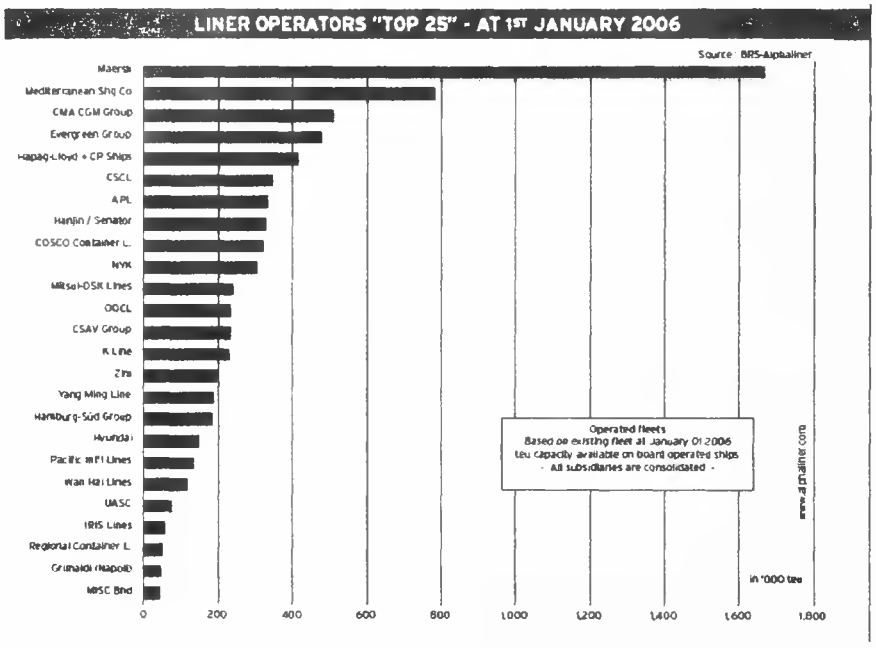
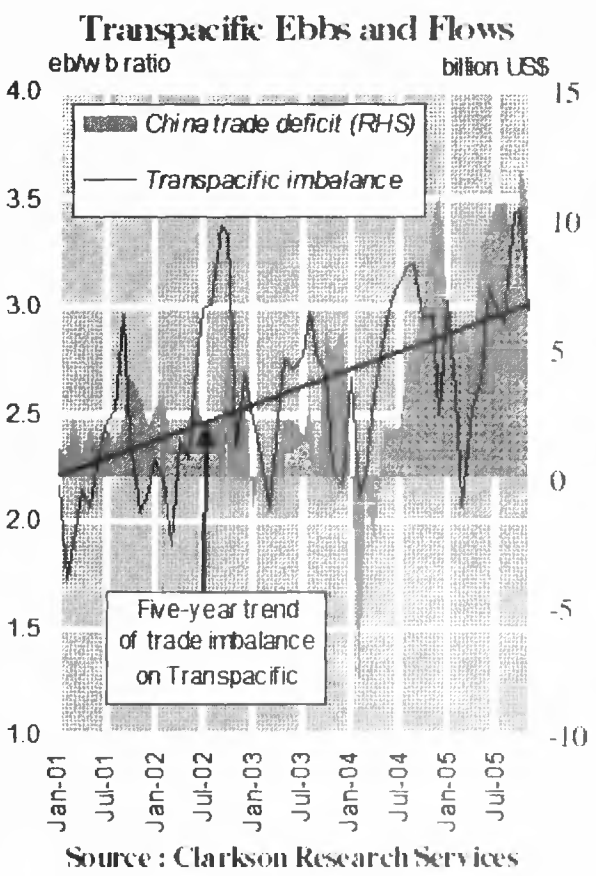


FIGURE 5



nearly £16bn—a 30-fold increase on 1980 (Guardian, 2006).

TRADE DISRUPTIONS

Trade Disruptions have generally taken three major forms: Natural Disasters; Terrorism; and Political.

Recent natural disasters have been Geological, such as the Asian Tsunami, Hurricane Katrina, and the Pakistani Earthquake. Milder disasters have seen major snow storms and flooding hit regions around the world. These are basically unpredictable in their exact location, but more will occur. Other types of natural disasters are Biological. The most recent scare has been the Avian Bird Flu, where according to the World Health Organization, models predicted global deaths in the range 2 million to 7.4 million with a mild form of the disease, but many more with a more virulent form (WHO, 2005). If the response from governments and the population is similar to the SARS outbreak, there could be a decrease in shipments from places affected, as the workforce is kept home. Shipping lines may skip port calls in affected areas.

Terrorism is the main perceived threat to trade in the U.S. 9/11, 7/7 in London, and the Madrid bombings all caused major damage and loss of life. In addition, the response of public

authorities to prevent any further incidents had, as a consequence, delays to the supply chains of firms around the world. To be mentioned in the next section, U.S. regulation has been designed to stop potential threats, such as a dirty bomb being shipped in an ocean container and delivered to the shores of the U.S. In today's marketplace, firms must be seen to be doing everything they can to secure their supply chains against infiltration by terrorists.

Finally, political events have caused trade disruptions both from a governmental level and at a trade union level. Governments have placed embargoes or quotas on other countries goods for various reasons. The recent 'Bra Wars' in the EU-China trade caused hardship for many European retailers as textiles were impounded in EU ports when quotas were filled months before they were expected to.

Trade unions have gone on strike causing major disruptions. The West Coast USA Port Strike was estimated to reduce U.S. earnings by $4.7 Billion (Anderson, 2002).

REGULATION

The International Maritime Organization (IMO) passed the International Ship and Port Facility Security Code (ISPS) in December 2002 which requires detailed security plans from shippers, shipowners and ports. "Under the terms of the Code, shipping companies are required to designate a Company Security Officer for the Company and a Ship Security Officer for each of its ships" (IMO). Additional features for the code are still being developed, but each iteration places additional burdens on all parties involved.

On the American front, there are many new developments. They include

- Cargo Security Risk Assessment—"24 hour rule"—24 hours notice required before loading in foreign port, or no arrival in U.S.
- CSI –Conatiner Security Initiative—Tamper-proof seals, Intelligent RFID tags
- C-TPAT—Customs-Trade Partnership Against Terrorism—via voluntary, non-regulatory agreements
- Sarbanes-Oxley Requirements—Section 404

Much of the recent U.S. legislation is based on an assumption that there is vulnerability in the supply chain, and vulnerability has to be minimized. C-TPAT is of special interest to shippers because it is voluntary (at the moment) but the benefits of membership are great (see Table 3). Shippers who do not become C-TPAT members could see delays at U.S. borders and face additional customs inspections.

In addition to safety and security regulation, the EU is considering a proposal to repeal Council Regulation 4056/86, the block exemption of liner shipping conferences from the EC Treaty competition rules' ban on restrictive business practices. Shipping lines will no longer be able to use conferences to fix prices and capacity on shipping lanes to or from the EU if the exemption is repealed. The effects may create a price war to/from the EU as liner companies try to fill their larger and larger fleets. This would create a clear benefit to shippers in the short term as rates are reduced, but if smaller players are pushed out of the trade, the long term could actually see higher rates with less competition.

TABLE 3
BENEFITS FOR C-TPAT MEMBERS

Benefit	Reduces amount of scrutiny provided for members?
A reduced number of inspections and reduced border wait times	Yes
Reduced selection rate for trade-related compliance examinations	Yes
Self-policing and self-monitoring of security activities	Yes
Access to the expedited cargo processing at designated FAST lanes (for certified highway carriers and certified importers along the Canadian and Mexican borders, as well as for certified Mexican manufacturers)	Yes
Eligible for the Importer Self-Assessment Program and has priority access to participate in other selected customs programs (for certified importers only)	Yes
A C-TPAT supply chain specialist to serve as the CBP liaison for validations	No
Access to the C-TPAT members list	No
Eligible to attend CBP-sponsored antiterrorism training seminars	No

Source: R, Stana Testimony on CBP's C-TPAT Strategic Plan, November 2005.

OIL

No discussion of transportation could be complete without a look at oil. Oil hit record highs of over $75 per barrel only to see prices fall to below $60 in October 2006. At a recent presentation at CSCMP's annual conference, Chuck Taylor, Principal of Awake Consulting, discussed the concept of Peak Oil and said that, "we might have already reached the point of maximum annual production, and if not, it is within the next 10 years." If this is the case, and energy use policy worldwide is not changed, oil prices are expected to remain high and should be expected to increase in the following years. Shipowners will have no choice but to pass on this cost to shippers. Shippers will have to decide if price increases are a sustained trend and if so, at what price level would a change in supply chain sourcing take place.

CONCLUSIONS

The conclusions that one can read from all of these influences on the liner shipping industry is anything but smooth sailing ahead. There will be winners and losers, of course, but all of the firms in the industry and their shippers will continue to see changes to their services.

Shippers should begin to do scenario planning based on plausible events occurring. For example, what would happen to your supply chain if the Suez Canal is closed for an extended period of time? Contingency planning for short-term and long-term effects should be carefully thought out.

There will be trade disruptions. That can be predicted, but where and when is the unknown quantity. The key is preparation and risk management. Firms that take positive steps will have contingencies in place to make quick adjustments and maintain their supply chains functionality.

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AUTHOR BIOGRAPHY

David Menachof is senior lecturer in international logistics and distribution and director of the MSc in Logistics, Trade and Finance degree at City University's Cass Business School in London, England. Dr. Menachof received his doctorate from the University of Tennessee, and was the recipient of the Council of Logistics Management's Doctoral Dissertation Award in 1993.

Suggested Research Agenda for the Railroad Industry

Barton Jennings
Western Illinois University

ABSTRACT

The railroad industry is experiencing a worldwide resurgence. International trade is booming as populations continue to grow and transportation infrastructures are nearing capacity. In the United States, the industry is being pressured to provide more services, while at the same time traffic levels are skyrocketing on a network that is much smaller than it was just fifty years ago. Additionally, security and safety issues are challenging the industry, as well as the regulatory agencies associated with railroading. To help with these problems, the industry is calling for more academic involvement through new degree programs and research initiatives. This paper reviews five major areas where academic research could assist the railroad industry in these challenges: capacity expansion, service standards, safety, security, and data management and analysis.

RAILROADS: A CHANGING INDUSTRY

> The reports of my death have been greatly exaggerated - Mark Twain.

The same can be said for the railroad industry in North America, and in fact, around the world. New rail lines to Tibet, privatization of government-owned systems in various countries, and unprecedented growth in freight and passenger volumes in North America all signal a renewed interest in rail transportation. According to Wick Moorman, President and CEO of Norfolk Southern Railway, "North American railroads are in the fortunate position of facing the challenges of a growth industry (Vantuono 2005, p.23)."

North American railroads are entering what many call a new age of railroading. Railroads are facing the problem of expanding volumes while meeting the needs of thousands of shippers with varying requirements. Many of the products handled are considered to be essential for everyday life in the United States. According to the U.S. Department of Homeland Security, railroads play a vital role, impacting almost all ways of life and business practices in the country (see Table 1). The Department further states that this importance makes it critical that railroads be protected from any outside interference.

TABLE 1
RAILROAD IMPORTANCE TO THE U.S. ECONOMY

Railroads transport
- 42% of intercity ton-miles
- 64% of coal for power plants
- 40% of the grain harvest
- 70% of US made automobiles
- 20% of chemicals

Source: "Cross Sector Interdependencies and Risk Assessment Guidance - Final Report and Recommendations by the Council" National Infrastructure Advisory Council, U.S. Department of Homeland Security, January 2004, p.24.

Nevertheless, for most people, including academics, educators, and researchers, the railroad is simply something that they have to wait for at a railroad crossing or that they take to work in the morning. Very few degree programs in the United States include rail operations education and even fewer regularly research the subject. The issue has become such a concern to the railroad industry that the American Railway Engineering and Maintenance-of-Way Association (AREMA) has started a 10-10 program, aimed at having 10 U.S. universities with railroad programs by the year 2010.

In spite of this seeming lack of educational interest, railroading is a growth industry. Scan the covers of the industry trade magazines and two words keep appearing: growth and capacity. As a result of recent incidents in Europe, the word security has been added to the list. With these new pressures, the question arises: What is the suggested research agenda for the railroad industry?

CURRENT RESEARCH

In spite of a general lack of university interest in the field, a great deal of railroad research is conducted each year. For example, Google Scholar lists 251,000 papers related to the railroad field (compared to more than 500,000 related to highways alone). Much of the North American research was either conducted by the railroad industry, or funded by it through several university centers or through the industry's Pueblo, Colorado, test track. The federal government, through the Federal Railroad Administration and the Transportation Research Board, has also funded significant amounts of research. Additionally, international research is significant, and probably much more common with many countries having universities dedicated to the field.

The vast majority of the railroad research in the United States has traditionally been related to engineering. However, with the growth of rail freight and the ability to be more creative since the Staggers Rail Act of 1980, railroads and their customers have begun to focus much more effort on operational and capacity issues. For example, 39,200 of the 251,000 papers include the term capacity while 18,200 are operational in nature.

For railroads in the United States, the results of this research, and the change in the legal and business environments that encouraged it, have been very positive. As Table 2 demonstrates, the past 25 years have been good for railroad productivity and safety. However, the Association of American Railroads (AAR) states that, "because the most readily attainable productivity gains have already been made, future gains will require significant additional spending on infrastructure and equipment (including substantial new capacity) and new technologies (AAR, p.1).

TABLE 2
CHANGES IN MAJOR U.S. RAILROAD MEASUREMENTS 1980-2005

Rail Employee Productivity	+421%
Locomotive Productivity	+128%
Track Productivity	+171%
Fuel Efficiency	+76%
Train Accident Rate	-65%
Employee Casualty Rate	-79%

Source: AAR website: www.aar.org

SUGGESTED RAILROAD RESEARCH AGENDAS

Based upon personal interviews and a literature review, the railroad industry has a large number of areas in which academic research would provide benefits. These areas include capacity problems, customer service issues, employee and public safety, security, and data management. However, AAR sources say that the previous improvements represent the easy gains and that most future gains will be evolutionary, not revolutionary. This suggests that researchers must understand current practices and sciences before exploring the future. However, this should not limit the topics of such research.

Service and capacity are obvious areas for railroad research. The railroad industry knows that there are improvements to be made. Jack Koraleski, Union Pacific EVP of Sales and Marketing, has stated that, "we know we're not where customers want us to be (Stagl 2006, p.20)." The Policy and Economic Department of the AAR has written that, "there are many opportunities for railroads to achieve further evolutionary gains, including improved track and signaling to allow faster speeds and better track utilization; improved information technology systems to monitor system performance, allow more efficient train operations, and to provide more and better shipment information to customers; more powerful and reliable locomotives; larger freight cars; improved access to ports; enhanced doublestack capability; more efficient yards and switching for interchange and routing; and continued redesign of operations to remove capacity constraints and increase asset utilization (AAR, p.2)."

Safety is an area of major success for the railroad industry. Past and current research has resulted in a number of safety improvements in many areas. For example, Operation Lifesaver states that grade crossing research has resulted in a significant decrease in annual collisions (9295 to 3010), injuries (3293 to 970), and fatalities (728 to 355) between 1981 and 2005. As already mentioned, accident rates for the industry are also down. Much of these improvements are due to better equipment design and practices, generally the result of industry and supplier research.

Security is certainly a research area receiving increased attention. In the first four years after 9/11, rail transit systems in the United States spent more than $2 billion on security. Metro North President Peter Cannito, head of one of two major commuter rail systems serving New York City, stated that security has, "become part of our everyday business (Luczak 2005, p.37)."

A final area of research that appears to interest the railroad industry is better data management. At the September 2006 American Railway Engineering and Maintenance-of-Way Association Annual Conference, there were a number of presentations on improved data collection, but with a number calling for better management of this data. The general concern is that rail management is being overwhelmed with the large amount of data being collected and being made available for decision making.

CAPACITY EXPANSION

Railroads used to brag about their ability to handle more freight. However, the economic deregulation of the 1970's-1980's allowed the railroads to attract new freight movements while eliminating duplicate or unecessary routes and

employees, as shown in Table 3. The result more than twenty years later is an actual shortage of rail capacity on many major routes. This shortage has resulted in railroads turning away business and service issues for those that are accepted.

In response to this capacity issue, railroads have begun to apply many different strategies. Three basic areas of research being used to address the railroad's growth are operational management, engineering, and capacity expansion.

Operational Management

"Today, the demand for rail transportation is growing in almost all sectors of our business. This increased demand for rail transportation is being driven by a convergence of conditions that reflect a fundamentally changed environment in the freight transportation industry (Vantuono 2006, p. 26.)" This statement by Norfolk Southern Vice Chairman and CEO Henry C. Wolf clearly shows the need for a new understanding of rail operational issues and the capacity solutions that they can deliver.

Operations represent the largest expenses within a railroad company, and also provides the service that customers seek. Therefore, it is a logical place to make improvements to create additional capacity. Within the last few years, Union Pacific has begun using a number of supply chain management and Six Sigma strategies. For example, UP has essentially added 50 additional locomotives to their fleet through a program to speed up locomotive repairs as opposed to spending $2 million a piece to buy more locomotives (Stagl 2006, p. 23). Matt Rose, President and CEO of BNSF, also points out that service and capacity are related issues that need more research when he states "improving service through better equipment velocity is one key to our ability to continue to handle volume growth (Vantuono 2005, p.26)."

One of the largest operational management debates in the railroad industry deals with the issue of scheduled railroads. Railroads such as Canadian National claim that scheduling most of their train movements allows them to find capacity and provide better customer service. Others claim that scheduling removes the flexibility needed to respond to changing customer and capacity needs. Research in this area could provide significant benefit to the industry.

TABLE 3
RAILROAD FREIGHT TON-MILE INCREASES VERSUS RAILROAD NETWORK SIZE AND EMPLOYMENT

Year	Ton-miles (BIL)	Miles Operated	Employment
1940	375	364,174	987,943
1960	575	340,000*	850,000*
1980	932	270,623	480,410
2004	1,720	170,071	176,899

*(est.)

Sources: "U.S. Freight Railroad Statistics" by Association of American Railroads—Policy & Economics Department, various editions; and U.S. Railroad Retirement Board.

Engineering

Another way railroads are adding capacity is to increase the hauling capacity of rail cars and the track and bridge structure. The North American railroad industry is in the process of increasing loaded car weights from 263,000 to 286,000 pounds, and in some cases, on to 315,000 pounds. While the larger railroads have generally been able to afford the change, many of the smaller and poorer railroads have failed to make the change due to available funding.

To assist in making the entire rail system compatible, a great deal of research has been conducted since the late 1990's by such organizations as the AAR, AREMA, and the American Shortline & Regional Railroad Association (ASLRRA). While the design issues are generally understood, more research is still required, especially to help find ways for smaller and less well funded railroads to reach the higher weight capacities. In a number of cases, the improvements are funded through various state and federal grant programs, requiring research into various alternative plans.

New Capacity

Often the easiest way to acquire more system capacity is to simply build more infrastructure capacity by adding second and third tracks and new sidings on existing right-of-ways. For example, Railway Track & Structures magazine states that railroads are using capital to buy increased capacity in 2006, such as BNSF adding 18.8 miles of triple track in Wyoming and 40 miles of double track between Chicago and Los Angeles (Railroads loosening purse strings for m/w," 2006, p.18).

The negative of this issue is that railroads have traditionally found it difficult to fund such construction from external sources, and internal sources are generally dedicated to maintenance and repair needs. While Wall Street seems to currently support much of this growth, research into creative financing opportunities, public-private funding programs, and methods to decrease construction costs is important. Also important in this process are more accurate methods to simulate alternatives for planning purposes on a national scale. Large capital programs in rail congested cities such as Chicago and Kansas City have significant local support, but the problem is often demonstrating the benefits to the country as a whole.

SERVICE

The railroads have only one thing to sell: transportation service. Their problem is that many trains may carry the cargo of hundreds of shippers, each with a different service goal and requirement. Additionally, their tracks are being used by all types of trains, from high speed intermodal trains hauling consumer goods to slow coal trains. Many routes must also deal with on-line customers that require trains to stop and pick up or deliver cars. Railroads work to develop service plans that will allow them to serve the many different needs found among their customers while maintaining a fluid transportation system. Research into this problem, associated with the issue of operational management, has the potential for great returns.

SAFETY

> The railroad industry's overall safety record has improved over the last decade and most safety trends are moving in the right direction. However, significant train accidents continue to occur, and the train accident rate has not shown substantive improvement in recent years. Moreover, recent train accidents have highlighted specific issues that need prompt government and industry attention, and the strong growth of rail and highway traffic continue to drive up exposure at highway-rail grade crossings (FRA 2005, p.1).

This is how the Federal Railroad Administration's 2005 accident action plan describes the current safety status of the U.S. railroad industry.

Safety has been a traditional area of research for the railroad industry. During recent years, studies in this area have heavily focused on railroad-highway grade crossing and trespasser safety. Much of this is due to the joint interest by both the Federal Railroad and the Federal Highway Administrations. However, the FRA's 2005 action plan is based upon a statistical analysis of recent safety issues. From this study, the FRA has produced a list of six areas in which safety research initiatives are needed. These areas are:

(1) Human factor-caused train accidents,
(2) Railroad employee fatigue,
(3) Track maintenance,
(4) Hazardous material safety and emergency preparedness,
(5) Better utilization of FRA inspection and enforcement practices, and
(6) Highway-railroad grade crossing issues (FRA 2005, p.2).

Based upon this report, the FRA has accelerated its funded research in these areas, opening up a number of opportunities for academic research in the railroad field.

While the FRA has traditionally focused on its primary responsibilities involving safety, rail transit has not had the same treatment until recently. Within the Department of Transportation, the Federal Transit Administration has had more of a promotional role. However, this is changing. In response to Congressional concern regarding the potential for accidents and incidents on rail transit systems, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) added Section 28 to the Federal Transit Act (codified at 49 U.S.C. Section 5330). This section requires the Federal Transit Administration to issue a regulation creating the first state-managed oversight program for rail transit safety, something finalized in 2005. The requirement that transit systems research and respond to safety concerns on their systems has created the need for a great deal of research in the area.

SECURITY

Railroad security has taken on even more importance since the London and Madrid bombings. However, much of the security plans are internal, relying upon existing railroad security systems and the observation ability of the industry's 180,000 employees, as well as general law enforcement, many of whom have only a minimum understanding of the industry.

Unlike the air industry, railroads operate out in the open, exposed to the general public along their 220,000 miles of track. Because of this, some rail transit systems, as well as Amtrak, have programs that encourage their riders to report suspicious activities. However, on the freight side, only BNSF and the Alaska Railroad have programs to include the general public in some form of community watch effort to protect their rail systems. Additionally, the public is not included in the Railway Alert Network (RAN), the major security planning tool created with the Department of Homeland Security.

But many believe that the nation has too many tracks, bridges, and railroad yards scattered across the country to be patrolled and observed only by railroad workers and law enforcement personnel. Research is needed to provide railroads with additional security strategies and plans that would produce a more secure transportation system.

DATA MANAGEMENT AND ANALYSIS

As the railroad industry works to improve its safety record, new techniques and devices are providing railroad engineering personnel with far more data than in the past. New automated geometry cars, track and ground imaging

devices, automated tie inspection systems, and vehicle-track interaction systems all call for better management of the data to establish forecasts and priorities in the field. Additionally, operating pressures are also placing more emphasis on evaluating various operating practices such as train schedules, crew and equipment availability, loading forecasts, and many other factors related to customer service. According to many industry sources, the data is more available but is harder to manage on a daily basis (Clause 2006, Eby 2006, Judge 2006). Based upon these comments, techniques to better manage and analyze the data would be most welcome to the industry.

CONCLUSION

The railroad industry is a growing, vibrant industry, often constrained by its past practices and designs. This growth provides ample research opportunities in almost every field from engineering to finance to data management. The key to any of this research is an understanding of the field, a field that is currently open to ideas that will assist it in serving the needs of the shipping industry.

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AUTHOR BIOGRAPHY

Dr. Barton Jennings is associate professor of supply chain management at Western Illinois University. He holds a B.S. in construction engineering from the University of Arkansas at Little Rock, an M.S. in civil engineering from the University of Virginia, and a Ph.D. in logistics and transportation from the University of Tennessee. His research areas include carrier operations, intermodal transportation, and transportation regulation and policy. Dr. Jennings' career had included work in both the Class I and shortline railroad industries as well as work with state transportation departments. He has a particular interest in the use of railroads in developing countries and has traveled extensively to explore this subject. He regularly conducts workshops on regulatory compliance for the railroad industry and on many technical issues for the transportation industry. Dr. Jennings has been the author or co-author of a number of reports and journal articles in these and other fields.

Evaluating the Comparative Efficiency of Eleven States' Highway Expenditures

Hokey Min
Bowling Green State University

Thomas Lambert
Indiana University Southeast

ABSTRACT

In an era of budget deficits and financial cutbacks, the efficiency of state highway finances dictates future investment in road construction and maintenance. Considering the significant impact of highway infrastructure on the survival and competitiveness of the logistics industry, this paper aims to develop a meaningful set of benchmarks that will guide the state government authority in making wise investment decisions regarding road construction and maintenance. In particular, we propose a data envelopment analysis that is proven to be useful for measuring the operational efficiency of various profit or non-profit organizations. Using the examples of state highway finances for Kentucky and other comparable states in the United States, this paper illustrates the usefulness of data envelopment analysis for the efficient allocation of financial resources to road construction and maintenance.

INTRODUCTION

As a growing number of state governments in the United States have begun to experience severe budget shortfalls, they often resort to tax increases to balance their budgets. However, during the economic doldrums, tax increases can backfire, because they put more financial burden on businesses that have already suffered from slow revenue growth. Such businesses include the trucking industry that has historically operated on profit margins as low as 3 % of sales after taxes, compared to the 7 to 9% average profit margin experienced by the heavy manufacturing industry (Dun and Bradstreet, 1999; Lambert and Min, 2000; American Trucking Associations Economics and Statistics Group, 2004). Recently, the profit margin of the trucking industry shrank further; for instance, the profit margin declined from 3.08% in 1994 to 2.60% in 1999 (American Trucking Associations Economics and Statistic Group, 2001). With tight profit margins and increasing competition, additional tax hikes for the trucking industry can drive some struggling trucking firms out of business and consequently dwindle future tax bases. Despite such concerns, commercial carriers paid $30.2 billion in federal highway-user taxes in 2002, approximately 40% of all highway user fees (American Trucking Associations Economics and Statistics Group, 2004). In addition, to fund impending $375 billion highway construction and maintenance projects, the trucking industry may need to

absorb a 5-cents-a gallon hike in the gasoline tax (USA Today, 2004). For instance, U.S. diesel fuel prices have risen from approximately $2.00-a-gallon to $3.00-a-gallon from summer of 2004 to summer of 2006 (Energy Information Agency, 2006).

Faced with potential tax hikes coupled with rising gasoline prices and costly road projects, some tax payers including the trucking industry scrutinized how tax revenues had been utilized by state governments. For example, it was recently reported that Jefferson County (the main county of the Louisville Metropolitan Area) in Kentucky received less than $100 million annually after it generated approximately $200 million state and federal transportation revenues (Timmons, 2003). That is to say, Jefferson County lost more than $1 billion of road funds for the past decade due to huge differentials between what tax payers paid for state services and what they actually received. To make matters worse, the lack of road funds may halt or delay indefinitely state road constriction projects (e.g., Kentucky 22 at the interchange with the Gene Snyder Freeway in Jefferson County) and can create prolonged traffic congestion (Associated Press, 2003). Since prolonged traffic congestion negatively affects a truck's on-time delivery services and fuel costs, underutilized transportation tax revenue can hurt the long term competitiveness of trucking firms and the political stability of a state government.

Considering the significant impact of state taxes on the viability of the trucking industry, it may be worth examining the comparative efficiency of state highway finances and then setting a reliable performance standard for state governments. Examples of such a standard are a financial audit, an industry norm, and a benchmark. Since a state government needs to measure its financial performance relative to its peer states to constantly avoid budget shortfalls and then gain a position of "the best of breeds," benchmarking seems to be the most effective way of setting a reliable financial standard and then measuring the operational efficiency of the state government.

In general, benchmarking is a continuous quality improvement process by which an organization can assess its internal strengths and weaknesses, evaluate comparative advantages of leading competitors, identify the best practices of industry functional leaders, and incorporate these findings into a strategic action plan geared to gain a position of superiority (Min and Galle, 1996). The main goals of benchmarking are to

> Identify key performance measures for each function of a business operation; Measure one's own internal performance levels as well as those of the leading competitors; Compare performance levels and identify areas of comparative advantages and disadvantages; Implement programs to close a performance gap between internal operations and the leading competitors (Furey 1987, p.30).

In setting the benchmark, this paper will measure the efficiency of state governments' road finances relative to prior periods and their peers. The relative efficiency measured by input/output ratios can reflect the true overall productivity of state governments better than traditional financial ratios, such as, return on investments and assets that tend to focus on myopic aspects of financial performances. As a way of comparatively assessing the productivity of state governments with multiple inputs and outputs, this paper proposes a data envelopment analysis (DEA) which was successfully explored in measuring the operational efficiency of banks (e.g., Thanassoulis, 1999), hospitals (Valdmanis, 1992), nursing homes (Kleinsorge and Karney, 1992), intergovernmental revenue transfers (Ali et al., 1993), purchasing departments (Murphy et al., 1996), cellular manufacturing (Talluri et al., 1997), travel demand (Nozick et al., 1998), information technology investments (Shafer and Byrd, 2000), customer service performances of less-than-truckload (LTL) motor carriers (Poli and Scheraga, 2000), international ports

(Tongzon, 2001) and trucking firms (Min and Joo, 2003). For further details on other DEA applications, interested readers should refer to Seiford (1990). In general, 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 DMU's. Herein, DMU's 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. DEA is designed to identify the best practice DMU without *a priori* knowledge of which inputs and outputs are most important in determining an efficiency measure (i.e., score) and assess the extent of inefficiency for all other DMU's that are not regarded as the best practice DMU's (e.g., Charnes et al., 1978). Since DEA provides a relative measure, it will only differentiate the least efficient DMU from the set of all DMU's. Thus, the best practice (most efficient) DMU is rated as an efficiency score of one, whereas all other less efficient DMU's are scored somewhere between zero and one. To summarize, DEA determines the following (Sherman and Ladino, 1995):

- The best practice DMU that uses the least resources to provide its products or services at or above the quality standard of other DMU's;
- The less efficient DMU's compared to the best practice DMU;
- The amount of excess resources used by each of the less efficient DMU's;
- The amount of excess capacity or ability to increase outputs for less efficient DMU's without requiring added resources.

In measuring the comparative efficiency of state highway finances, we chose DEA over other alternative techniques, such as Cobb Douglas functions and analytic hierarchy process (AHP), because DEA reflects the multiple aspects of organizational performances, does not require *a priori* weights of performance measures, and provides valuable insights as to how operational efficiency can be improved.

SPECIFICATION OF INPUT AND OUTPUT MEASURES

The assessment of comparative efficiency 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 used by DMU should be included as input, five different metrics were selected as inputs (see Table 1). These are composite index for highway construction costs, total capital outlays, total maintenance costs, motor fuel taxes, and motor vehicle taxes.

Since both federal and state highway revenues are often distributed for the construction and improvement of urban and rural highway systems, highway construction costs can be a key expenditure for road funds and state budgets. Thus, a composite index for highway construction costs is considered a proxy for measuring an efficiency of state budget management and should be chosen as one of the inputs. The composite index includes costs associated with materials (e.g., cement, bituminous surfaces, gravel, sand, slag, steel, concrete pipe, clay pipe, lumber, petroleum), supplies, equipment (including mobilization, fuel and lubricants, licenses, insurances) and with labor needed for highway construction.

Capital outlays are those costs associated with highway improvements, including land acquisition and other right-of-way costs; preliminary construction engineering; reconstruction; resurfacing, rehabilitation and restoration of roadways and structures; and installation of traffic service facilities such as guard rails, fencing, signs, and signals (Larson, 1991). Thus, capital outlays are viewed as expenditures (inputs), because the utilization of capital outlays can increase the efficiency of highway operation and maintenance.

TABLE 1
DESCRIPTIVE STATISTICS FOR INPUT AND OUTPUT MEASURES

	Number of annual reports	Minimum	Maximum	Mean	Standard Deviation	Type
Total receipts	33	442,119*	3,860,474*	1,865,127*	1,025,388*	Output
Composite index for highway construction costs	33	107.27	353.67	157.34	44.41	Input
Total capital outlays	33	235,891*	2,167,981*	984,146*	514,655*	Input
Total maintenance costs	33	52,181*	838,539*	304,549*	185,524*	Input
Motor fuel taxes	33	158,957*	1,425,771*	650,545*	361,083*	Input
Motor vehicle and carrier taxes	33	34,670*	1,020,947*	372,564*	274,874*	Input

* These figures are measured in thousands of dollars.

Also, maintenance costs are considered to be expenditures given that they can prolong the life of highways by preventing early road wear. In general, maintenance costs are those required to keep the highways in usable conditions, such as routine patching repairs, bridge painting, and other maintenance costs; and traffic service costs, such as snow and ice removal, pavement markings, signs, litter cleaning, and toll collection expenses (Larson, 1991).

Since taxes such as motor fuel taxes and motor vehicle taxes are the chief sources of locally generated funds utilized by state governments to finance highway programs, we regarded both motor fuel (e.g., gasoline) taxes and motor vehicle and carrier taxes as key inputs. These taxes are levied on owners and operators of motor vehicles because of their use of public highways and are levied uniformly throughout the state. In particular, motor fuel taxes account for more than 60% of all road user taxes and have become a dominant component of highway funds (Small et al., 1989). However, motor fuel taxes often evoke considerable public debate due to their instability resulting from constant fluctuations of oil prices and due to heavy opposition from the trucking industry to tax hikes. Thus, it is worth investigating whether such taxes are set fairly and efficiently. For a similar reason, the use of motor vehicle and carrier taxes by state governments will be scrutinized.

On the output side, the overall performance of state highway finances can be measured by highway receipts that best reflect the efficiency of state governments in managing highway funds and allocated budgets. Highway receipts represent highway user revenues and all other receipts applied for highway purposes regardless of sources (Larson, 1991). Highway receipts include federal highway trust funds, appropriated general funds, grants-in-aids, registration fees, license fees, toll receipts, parking revenues, interest income, rentals, donations, royalties,

bond proceeds, and profits from the purchase and sale of securities. The input and output data were obtained from a series of highway statistics that were summarized and reported by the Federal Highway Administration (Larson, 1991; Office Highway Policy Information, 2002). This paper analyzed three years of data for 11 state governments made up of Arkansas, Idaho, Indiana, Illinois, Kentucky, Missouri, Ohio, South Carolina, Tennessee, Virginia, and West Virginia.

To maintain comparability and homogeneity among the states, we excluded 40 states that have different geographical, economic, and transportation characteristics than these selected states from the current DEA analysis. A hierarchical cluster analysis using Statistical Package for the Social Sciences for Windows (2004) was used to confirm our choice of peer states listed above. An appropriate grouping of states is critical to the analysis. The Office of Highway Policy Information (2002) noted that the estimation of state maintenance expenditures provided a clear example of difficulty in comparing states. Maintenance expenditures per mile can vary among states depending upon climate, geographic locations, composition of capital expenditures, traffic congestion, the extent of truck traffic, degree of urbanization, pavement roughness, and the level of system responsibility retained by the state versus other levels of government. With this in mind, these variations were controlled in the selection of peer states by using cluster analysis to group states according to their similarities (or Euclidean dissimilarity coefficient matrix) on characteristics such as ratio of urban to rural roadway miles, weather, millions of vehicle miles traveled per year, per capita income, gross state product per capita, and population per square mile.

DATA ENVELOPMENT ANALYSIS MODEL DESIGN AND TESTING

The DEA model, with the inputs and output summarized in Table 1, was adopted for this study. The DEA model is mathematically expressed as

$$\text{Maximize efficiency score } (jp) = \frac{\sum_{r=1}^{t} u_r y_{rjp}}{\sum_{i=1}^{m} v_i x_{ijp}} \quad (1)$$

$$\text{Subject to } \frac{\sum_{r=1}^{t} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \quad j = 1, \ldots, n, \quad (2)$$

$$u_r, v_i \geq \varepsilon, \quad \forall r \text{ and } i, \quad (3)$$

where

y_{rj} = amount of output r produced by DMU j,

x_{ij} = amount of input i used by DMU j,

u_r = the weight given to output r,

v_i = the weight given to input i,

n = the number of DMU's,

t = the number of outputs,

m = the number of inputs,

ε = a small positive number.

To ease computational complexity associated with the fractional nonlinear form of Equations (1), (2), and (3) (above) can be converted into a linear program as follows.

$$\text{Maximize efficiency score } (jp) = \sum_{r=1}^{t} u_r y_{rjp} \quad (4)$$

Subject to $\sum_{i=1}^{m} v_i x_{ijp} = a,$ (5)

$$\sum_{r=1}^{t} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \quad j = 1,\ldots,n, \tag{6}$$

$$-u_r \leq -\varepsilon, \qquad r = 1,\ldots,t, \tag{7}$$

$$-v_i \leq -\varepsilon, \qquad i = 1,\ldots,m, \tag{8}$$

where a = an arbitrarily set constant (e.g., 100). By solving the above equations (4)-(8), the efficiency of DMU (jp) is maximized subject to the efficiencies of all DMU's in the set with an upper bound of 1. The above model is solved n times to evaluate the relative efficiency of each DMU. Notice that the weights u_r and v_i are treated as unknown variables whose values will be optimally determined by maximizing the efficiency of the targeted DMU jp. An efficiency score (jp) of 1 indicates that the DMU under consideration is efficient relative to other DMU's, while an efficiency score of less than 1 indicates the DMU under consideration is inefficient. In a broader sense, an efficiency score represents a state government's ability to transform a set of inputs (given resources) into a set of outputs.

The above model also identifies a peer group (efficient DMU with the same weights) for the inefficient DMU (Boussofiane et al., 1991).

A complete DEA analysis was conducted by applying a non-linear fractional program formulated in equations (1)-(3) to actual data containing a sample of 11 states with three consecutive years of performance measures. The results obtained from the use of Frontier Analyst software (1998) show that Virginia consistently recorded an efficiency score of 1 (100%) in 1999 through 2001. Ohio achieved an efficiency score of 1 (100%) in 1999 and bounced back in 2001 after losing its efficiency in 2000. Arkansas, Indiana, Illinois and South Carolina registered an efficiency score of 1 (100%) once during the three year span (see Table 2). On a year-to-year basis, at least two states are considered efficient every year. However, the average efficiency score of 11 states gradually dipped over the three year span and caused increased concern over their highway finances. In particular, Idaho, Kentucky and Tennessee never rated as efficient and consistently scored below average for the last three years (1999, 2000, and 2001) with respect to efficiency scores for total receipts (Table 2).

TABLE 2
EFFICIENCY SCORES FOR TOTAL RECEIPTS

State	Year			
	1999	2000	2001	Average
Arkansas	85.66%	100.00%	69.10%	84.92%
Idaho	89.45%	86.21%	87.64%	87.77%
Indiana	96.58%	94.22%	100.00%	96.93%
Illinois	97.47%	100.00%	98.15%	98.54%
Kentucky	78.19%	88.44%	79.67%	82.10%
Missouri	83.48%	98.89%	76.02%	86.13%
Ohio	100.00%	89.02%	100.00%	96.34%
South Carolina	100.00%	82.47%	97.62%	93.36%
Tennessee	91.35%	83.14%	84.37%	86.29%
Virginia	100.00%	100.00%	100.00%	100.00%
West Virginia	96.67%	77.48%	80.69%	84.95%
Average	92.62%	91.44%	88.48%	90.85%

For example, Arkansas recorded an efficiency score of only 69.10% in 2001 leaving ample room for improvement. In 2001 it could have improved its efficiency in total receipts by nearly twice as much (see Table 3). Similarly, Kentucky was the worst performer in 1999, and then improved slightly in 2000. However, it still registered one of the lowest efficiency scores (third lowest among the eleven states) in 2001. Overall, Kentucky turned out to be the worst performer among 11 states in terms of its average efficiency score for the three year span.

The input utilization rates summarized in Table 4 show that Kentucky's composite index for highway construction costs are unusually high in comparison to other peer states. Idaho is the only other state that underutilized its construction funds worse than Kentucky (see Table 4). As indicated earlier, Kentucky's struggle with construction cost control may stem from its sole sourcing practice of using a particular contractor and the subsequent high price tag associated with highway construction. On the other hand, Kentucky fully utilized its capital outlays, maintenance funds, and income generated from motor fuel taxes. Another concern is that Kentucky poorly utilized income generated from motor vehicle and carrier taxes. With the exception of 1999, Kentucky ranked lowest in terms of utilizing its income generated by motor vehicle and carrier taxes. This result implied that Kentucky might have levied the higher motor vehicle and carrier taxes on trucking firms than it should, or the income generated by motor vehicle and carrier taxes was not efficiently used. It is also ironic to find that Kentucky received in federal funds more than its residents paid in federal taxes in 2002 (Table 5). That is to say, federal funds received by Kentucky may have not been used efficiently. The further examination of several key tax revenues for Kentucky reveals the following:

1. ***Motor fuel taxes***. The tax on gasoline is 16.4 cents per gallon (of which 1.4 cents goes to insure oil companies for leaking underground storage tanks), and the tax on diesel fuel is 18.4 cents per gallon. Kentucky has not had a gasoline tax increase since 1986, and 40% of the $1.1 billion Kentucky Road Fund comes from motor fuel receipts (Loftus, 2003).

2. ***Motor vehicle usage tax***. Kentucky levies a 6% sales tax on the purchase of a new vehicle in the state, and a usage tax on all vehicles according to their assessed value. This tax accounts for roughly another 40% of Road Fund revenues (Loftus, 2003).

3. ***Debt and bond proceeds***. This totaled $29.1 million for fiscal year 2003. Currently, debt and bond proceeds account for 15% of Road Fund revenue, far exceeding the recommended level of 6% (Kentuckians for Better Transportation, 2003).

The adequacy of the aforementioned revenues has been a subject of debate after the Kentucky state government proposed raising gasoline taxes in 2000 to fund new road construction as part of Kentucky's Six-Year Road Plan for 2002-2008. Although the state legislature rejected tax increase, it approved dozens of new road construction projects. To pay for new projects, the legislature allowed the state government to use cash reserves in the state's Road Fund, which at that time exceeded $700 million. However, those reserves are expected to vanish by the end of 2003, which would force the postponement and delay of many road projects, some of which are already under way. Such delays will eventually drive up construction costs. This vicious cycle of revenue shortfalls have caused highway construction costs to be higher than other peer states (Table 6). To cope with excessive construction costs, the Kentucky legislature mandated that all projects which were 15% over budget be approved by a legislative review committee. Regardless, there were 562 project cost overruns in excess of 15% of estimated costs from 1992 to 1998. These cost overruns totaled $265 million, yet funding for all cost overruns were approved (Stevens, 1998).

Another reason for higher construction costs is an apparent lack of competition among highway road contactors in Kentucky. Loftus (2001)

TABLE 3
POTENTIAL IMPROVEMENTS IN TOTAL RECEIPTS

State	Year		
	1999	2000	2001
Arkansas	16.74%	0%	44.71%
Idaho	11.79%	15.99%	14.11%
Indiana	3.54%	6.13%	0%
Illinois	2.60%	0%	1.88%
Kentucky	27.89%	13.07%	25.52%
Missouri	19.79%	1.12%	31.54%
Ohio	0%	12.34%	0%
South Carolina	0%	21.25%	2.44%
Tennessee	9.47%	20.28%	18.53%
Virginia	0%	0%	0%
West Virginia	3.45%	29.07%	23.94%

TABLE 4
RESOURCE (INPUT) UTILIZATION RATES IN PERCENTAGE

	State	Year		
		1999	*2000*	*2001*
Resources	Arkansas	-18.07%	0%	-33.71%
	Idaho	-86.22%	-78.47%	-86.14%
	Indiana	-29.52%	0%	0%
Composite Index of Highway Construc-tion Costs	Illinois	0%	0%	0%
	Kentucky	-31.11%	-39.17%	-23.96%
	Missouri	0%	0%	-14.78%
	Ohio	0%	0%	0%
	South Carolina	0%	-3.17%	0%
	Tennessee	0%	0%	0%
	Virginia	0%	0%	0%
	West Virginia	-31.81%	0%	0%
Total Capital Outlays	Arkansas	0%	0%	0%
	Idaho	0%	0%	0%
	Indiana	0%	0%	0%
	Illinois	0%	0%	-4.83%
	Kentucky	0%	0%	0%
	Missouri	0%	0%	0%
	Ohio	0%	0%	0%
	South Carolina	0%	0%	0%
	Tennessee	0%	0%	0%
	Virginia	0%	0%	0%
	West Virginia	0%	0%	-0.15%

Table 4
(continued)

	State	Year		
		1999	*2000*	*2001*
Resources	Arkansas	-11.79%	0%	0%
	Idaho	0%	-10.09%	0%
	Indiana	-12.51%	-4.69%	0%
	Illinois	0%	0%	0%
Total Maintenance Costs	Kentucky	0%	0%	0%
	Missouri	-32.40%	-31.88%	0%
	Ohio	0%	0%	0%
	South Carolina	0%	-33.51%	-6.03%
	Tennessee	-21.63%	-12.96%	-23.99%
	Virginia	0%	0%	0%
	West Virginia	-53.62%	-18.20%	-0.69%
Motor Fuel Taxes	Arkansas	-2.45%	0%	-28.96%
	Idaho	0%	0%	0%
	Indiana	-3.05%	-21.77%	0%
	Illinois	0%	0%	0%
	Kentucky	0%	0%	0%
	Missouri	-12.32%	-10.38%	-9.14%
	Ohio	0%	-0.86%	0%
	South Carolina	0%	-38.66%	-75.20%
	Tennessee	-21.87%	-31.10%	-13.31%
	Virginia	0%	0%	0%
	West Virginia	0%	0%	0%
Motor Vehicle and Carrier Taxes	Arkansas	0%	0%	0%
	Idaho	-2.02%	-33.11%	0%
	Indiana	0%	0%	0%
	Illinois	-13.90%	0%	-17.16%
	Kentucky	-43.74%	-59.66%	-48.04%
	Missouri	0%	0%	0%
	Ohio	0%	0%	0%
	South Carolina	0%	0%	0%
	Tennessee	0%	0%	0%
	Virginia	0%	0%	0%
	West Virginia	-84.92%	-22.09%	0%

* Negative values show underutilization of resources and zero values indicate full utilization.

TABLE 5
GOVERNMENT SPENDING PER TAX DOLLAR

State	2002 Spending	2002 Rank	1992 Spending	1992 Rank
Arkansas	$1.55	2	$1.28	4
Idaho	$1.31	6	$1.25	5
Indiana	$1.00	10	$0.83	10
Illinois	$0.77	11	$0.72	11
Kentucky	$1.50	3	$1.20	7
Missouri	$1.34	4	$1.25	5
Ohio	$1.03	9	$0.94	9
South Carolina	$1.34	4	$1.29	3
Tennessee	$1.26	7	$1.11	8
Virginia	$1.13	8	$1.39	2
West Virginia	$1.82	1	$1.44	1

Source: *The Tax Foundation* and *USA Today* (2003)
Note: This table shows how much the federal government spends in each state for every dollar state residents pay in federal taxes. The higher the ranking, the more a state receives in funds than it pays in taxes.

TABLE 6
COST INDICES AND AVERAGES FOR FEDERAL-AID HIGHWAY CONSTRUCTION, 1992-2001

	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	Average
Arkansas	152.7	148.0	135.6	116.6	123.3	109.7	103.8	107.4	96.8	99.8	119.4
Illinois	143.6	132.0	131.6	135.2	123.4	112.2	123.1	115.4	107.3	105.1	122.9
Indiana	176.1	158.4	150.9	149.7	145.4	153.1	141.9	135.9	116.1	109.8	143.7
Kentucky	194.9	195.7	199.7	197.0	156.9	149.8	175.0	103.4	143.8	96.4	161.2
Missouri	353.7	165.9	163.9	96.1	143.3	108.0	129.9	119.6	109.8	108.4	149.8
Ohio	110.9	139.6	117.0	110.5	112.5	115.1	97.8	102.2	86.3	147.6	113.9
S. Carolina	213.7	172.4	178.9	172.8	137.8	124.5	132.7	135.5	100.2	95.9	146.4
Tennessee	134.7	191.0	133.0	159.5	136.0	129.0	125.9	115.4	109.8	118.7	135.3
Virginia	162.6	110.6	120.9	122.8	130.8	114.8	118.8	121.2	99.5	97.1	119.9
W. Virginia	107.3	136.4	147.1	119.1	125.3	147.9	102.5	121.5	84.9	77.7	117.0

Source: Federal Highway Administration
Notes: 1987 is the base year (1987 = 100). Indices are based on information submitted for Federal aid construction contracts over $500,000. The base for each state index is its own particular "market basket" of quantities and costs during the base period. The composite index for each state measure the change in that state's index since base year 1987. (In 1987 each state's index equaled 100).

reported that bidding for state government resurfacing contracts has been marked by a lack of competition in vast regions of Kentucky for decades. For example, from 1988 to 1994, the Kentucky Transportation Cabinet received only one bid for approximately more than half (58%) of the road resurfacing contracts that it awarded. Also, some contractors appeared to have virtual monopolies in certain regions of the state where most, if not all, major projects were done in contiguous counties by the same contractor year after year (Loftus, 2001). With little or no competition, prices for resurfacing contracts are set higher than would be the case in a more competitive market. In such a monopoly situation, the contractor is also likely to build highways of sub-standard quality and subsequently increase maintenance costs.

To summarize, southern states such as Kentucky and Tennessee struggled throughout the sample period, whereas mid-western states such as Ohio, Illinois and Indiana fared better. Both Kentucky and Tennessee significantly underutilized their funds generated by taxes (either motor vehicle tax or motor fuel tax), whereas good performing states such as Ohio, Illinois and Indiana better utilized their tax generated funds. Interestingly, it was discovered that poor performing states such as Kentucky and Tennessee tend to suffer from higher trucking business failure rates than good performing states such as Ohio, Illinois, Indiana and Virginia as shown in Table 7.

In addition, the sensitivity of the results and findings to changes in the specification of DEA input measures was investigated. For instance, the impact of introducing highway administration, research, and planning budget and income generated by law enforcement and safety into the DEA analysis was examined. This model experiment still suggests that the basic findings are relatively robust and do not change significantly when certain input measures are replaced with new input parameters. The only exception may be South Carolina whose efficiency dropped due to the poor utilization of income generated by law enforcement and safety (Tables 8 and 9).

CONCLUSIONS AND MANAGERIAL IMPLICATIONS

In general, good roads not only contribute to quality of life, but also help cities and states develop economically (Chandra and Thompson, 2000). On the other hand, poor road conditions cause 35% of the 43,000 vehicle fatalities in the United States each year, and traffic congestion resulting from poor road conditions costs the United States $70 billion in wasted fuel and productivity (USA Today, 2004). Also, a lack of good roads can increase costs of road construction and maintenance. For example, excessive road construction costs can cause not only the delay of other necessary projects that wait for funding, but also burden state residents

TABLE 7
AVERAGE TRUCKING BUSINESS FAILURE RATES (1984-1995)

State	Failure Rate per 10,000 Firms
Tennessee	456
Kentucky	434
Indiana	423
Illinois	352
Ohio	345
Virginia	340

Source: Dun and Bradstreet, Inc. (1999)

TABLE 8
EFFICIENCY SCORES FOR TOTAL RECEIPTS (ALTERNATIVE MODEL)

State	Year		
	1999	2000	2001
Arkansas	86.00%	100%	74.17%
Idaho	96.25%	86.88%	85.51%
Indiana	100%	94.60%	100%
Illinois	99.27%	100%	92.07%
Kentucky	80.97%	88.49%	84.61%
Missouri	89.03%	99.22%	74.63%
Ohio	100%	96.40%	100%
South Carolina	85.06%	74.69%	85.06%
Tennessee	90.17%	93.62%	82.50%
Virginia	95.32%	99.75%	99.74%
West Virginia	100%	72.48%	74.79%
Average	92.92%	91.47%	86.64%

TABLE 9
POTENTIAL IMPROVEMENTS IN TOTAL RECEIPTS (ALTERNATIVE MODEL)

State	Year		
	1999	2000	2001
Arkansas	16.27%	0%	34.83%
Idaho	3.89%	15.11%	16.95%
Indiana	0%	5.71%	0%
Illinois	0.74%	0%	8.61%
Kentucky	23.50%	13.00%	18.19%
Missouri	12.32%	0.79%	34.00%
Ohio	0%	3.74%	0%
South Carolina	17.56%	33.89%	17.57%
Tennessee	10.90%	6.81%	21.21%
Virginia	4.91%	0.26%	0.26%
West Virginia	0%	37.98%	33.71%
Average	8.19%	10.66%	16.85%

and the trucking industry with additional tax hikes. Consequently, poor road infrastructure can create downward spirals of tax hikes, increased trucking business failures, and the subsequent decrease of tax revenue bases. In other words, state government's road/highway budget and planning policy has long-term consequences for the economic viability of the trucking industry and the political survival of the state government. The best way to minimize the conflict of interest among various stakeholders such as state governments, the trucking industry, and general public is to identify the best practices of managing highway finances and utilizing given highway resources.

In this article, a data envelopment analysis designed to analyze the comparative efficiency of state highway finances, identify potential sources of inefficiency, and provide useful information (hindsight) for the continuous improvement of efficiency was proposed. The DEA analysis revealed four best-practice (benchmark) states: Virginia, Indiana, Illinois and Ohio. Of those four states, three are mid-western states. On the other hand, Kentucky, Tennessee and Idaho were identified as underachievers. Among these three, two are southern states with high trucking business failure rates. By examining these states, one of the culprits for poor performance in managing highway funds turned out to be the relatively high price tag for highway construction or maintenance. For instance, Kentucky has the highest composite price index for highway construction among 11 peer states for the years 1992 through 2001. From 1999 to 2001, Kentucky's average composite price index for highway construction was 38% above the U.S. national average. Thus, Kentucky state government needs to avoid any cost overruns associated with construction. One viable option that Kentucky can exercise is to increase the competition for construction bidding process.

Another viable option is to enhance the efficiency of Kentucky's highway fund management. To elaborate, Kentucky should revise its motor vehicle tax provisions because it performed worst in terms of utilizing motor vehicle and carrier taxes. Indeed, Kentucky generated more than twice as much motor vehicle and carrier tax revenues as Indiana, despite the fact that the former had 55% less registered vehicles than Indiana in 2002. These statistics suggest that Kentucky levied much higher motor vehicle and carrier taxes on its residents and trucking firms than Indiana. Such taxes should be adjusted to the level of other peer states to warrant fair taxation. In other words, tax reforms asking for reduction in motor vehicle and carrier taxes may be needed in the future.

Finally, the five underachiever states (Kentucky, West Virginia, Arkansas, Tennessee, and Idaho) are relatively low income and less populous, whereas the four best performers (Virginia, Ohio, Illinois, Indiana) are higher income and more populous states. This is ironic, because poor income states are supposed to utilize their limited financial resources better than their richer counterparts. This can be partially explained by the fact that richer income and more populous states may have a greater chance to take advantage of their economies of scale (e.g., more lanes per mile) for highway investment, and, therefore, better utilize their resources than poor income and less populous states. Also, all five underachieving states tend to have a higher ratio of rural to urban lane-miles of highways and may experience greater difficulty in building remotely located rural highways on the hills, mountains, and rugged terrains. However, such a finding cannot be generalized because South Carolina performed relatively well despite being a poor income and less populous state. Based on these findings and observations, we suggest the following guidelines for continuous improvement of highway finances are suggested:

- Reassess the transportation needs of a state and develop the performance metric (e.g., traffic volume/capacity ratio) of highways to determine their importance for the long-term economic development of a state;

- Identify traffic corridors and distribution hubs of statewide significance and develop cost-effective investment strategies for those prioritized highways linking traffic corridors and distribution hubs;

- Reexamine the highway construction bidding process for any questionable contracts and compare the composite price index of highway construction bids to that of peer states on a periodic basis;

- Investigate the potential correlation between road thickness (durability) and marginal maintenance cost and then make an optimal tradeoff between highway durability and maintenance cost;

- Eliminate any double taxation by not charging the same highway user both a toll and a fuel tax;

- Create alternative sources of funding rather than relying on traditional tax revenues. These sources may include: investor equity, donated rights-of-way, private development fees, concession rights leasing, fiber optic cable rights leasing and cost sharing with organizations which benefited from a highway improvement.

To conclude, this article differentiates between succeeding and struggling groups of state governments on the basis of DEA efficiency scores. The DEA efficiency score gives state governments a warning signal that the lower the DEA score is, the greater the likelihood a state government has for downward budget spirals. Thus, DEA is very useful for identifying the least efficient state governments which require the closest attention. However, the proposed DEA model can be extended to include multiple outputs (including non-financial measures) and a greater number of state governments in homogeneous socio-economic settings. Also, future DEA studies may explore the decreasing returns to scale for transforming inputs to outputs as opposed to constant returns to scale that this current study assumed. Furthermore, it would be intriguing to examine the correlation between state highway financial efficiency and state tax increases and the subsequent impact on the trucking industry using the exploratory studies. Along the same line, a future area of research could examine how higher fuel prices and the gasoline tax relief would impact future road construction finances.

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AUTHOR BIOGRAPHY

Hokey Min holds the James R. Good chair in Global Supply Chain Strategy in the Department of Management at Bowling Green State University. Dr. Min was professor of supply chain management, distinguished university scholar and founding director of the UPS Center for World-wide Supply Chain Management and the Center for Supply Chain Workforce Development at the University of Louisville. He earned his Ph.D. degree in management sciences and logistics from the Ohio State University. Dr. Min's research interests include global logistics strategy, e-synchronized supply chain, benchmarking, and supply chain modeling. He has published more than 100 articles in various refereed journals including *European Journal of Operational Research*, *Journal of Business Logistics*, *Journal of the Operational Research Society*, *Transportation Journal*, *Journal of Transportation Management*, and *Transportation Research*.

AUTHOR BIOGRAPHY

Thomas Lambert is currently Visiting lecturer in the Department of Economics at Indiana University–Southeast. Prior to the current appointment, Dr. Lambert taught economics, urban and public affairs, and management at both the University of Louisville and Spalding University. He also previously held the position of research manager at the UPS Center for World-wide Supply Chain Management. He received his Ph.D. degree in urban economics from the University of Louisville.

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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 interfirm performance. Existing measures continue to capture intrafirm performance and focus on traditional measures. The lack of a framework to simultaneously measure and translate interfirm 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*, 2001). 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.

$$y = a^2 - 2ax + x^2 \quad (1)$$

REFERENCES

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

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