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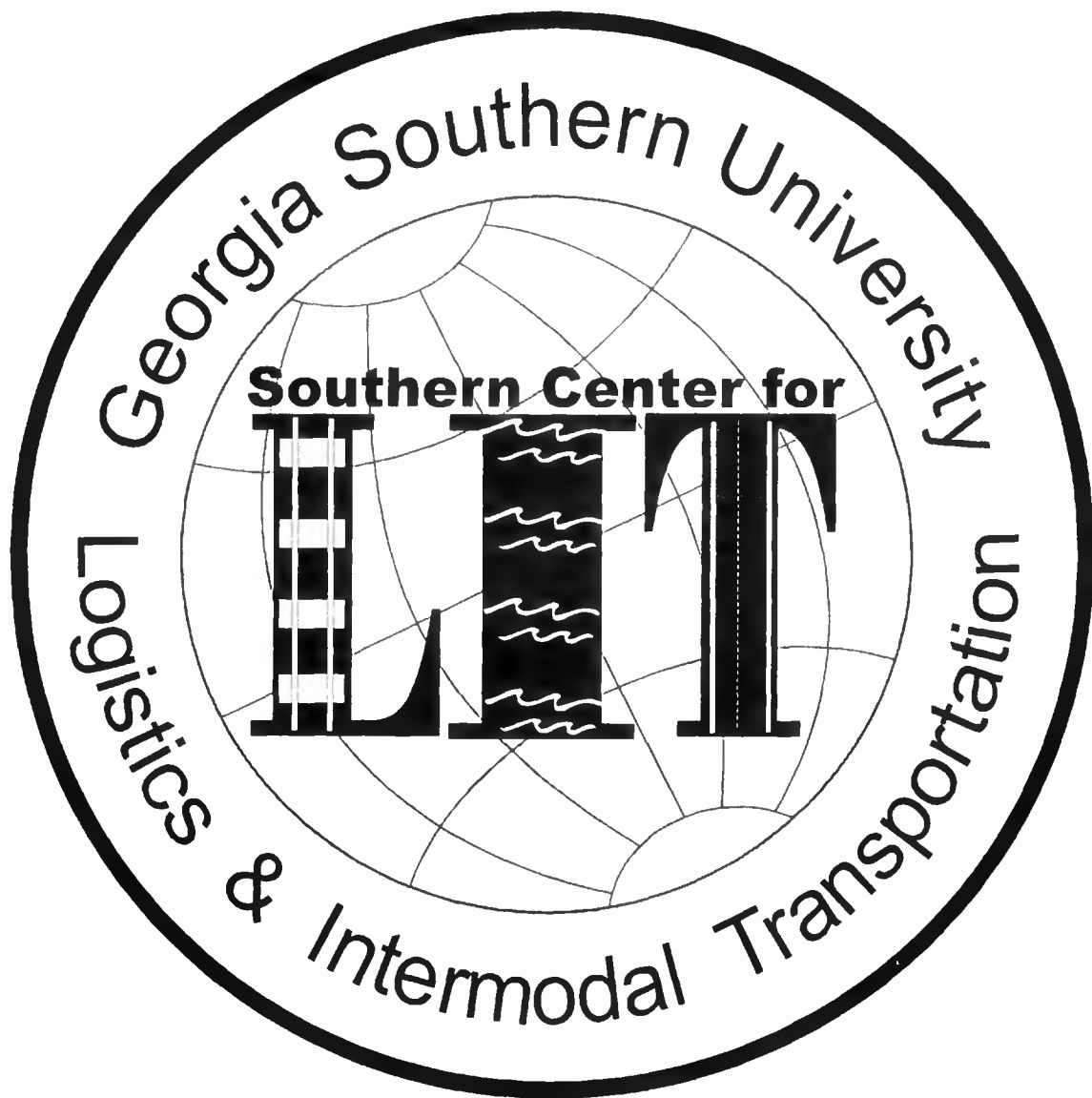
From the Editor...

Better late than never! This issue will be reaching you later than I intended—but it will still be delivered while it is officially spring! Even journal editors have "regular" jobs, and mine has certainly demanded my attention this semester. I hope that, after reading all of the articles in this issue, you will feel that the wait was worth it.

This issue is certainly diverse in content. The topics include carrier rate management, rating carriers, fleet asset management, a new technological tool of the classroom, and saving the Air Force money in a reserve supply chain application. I am very pleased with the variety of topics represented and with the quality of the content. If you like what you find in this issue, please contact me. While I sometimes wish that I could pass it, the "buck" stops on my desk. I welcome your comments and suggestions on this and every issue of *Journal of Transportation Management*.

In the first article, Douglas Smith, James Campbell, and Ray Mundy tackle the complex issue of carrier rate management. They provide a statistical approach to the analysis of rates and customer-specific rate structures that yields both benchmarks for rates and revenues and information for managing "rate relations" with customers. In article two, Brian Gibson and your humble editor [who played a secondary role in bringing this piece to print] use case research to investigate variations in the implementation, operation, and effectiveness of carrier scorecarding programs. Transportation buyers should benefit from the step-by-step model of the scorecarding program development process that is outlined.

Joe Hanna, Drew Stapleton, and Brian Zoll take a look at the considerable problems of equipment management by asset-based carriers in the third article. They present data from three large motor carriers and demonstrate the use of life cycle management and variations in work configuration in achieving better control of equipment maintenance costs. In the fourth article, Steve Rutner [my senior associate editor] describes a new branded technology product that can be used to increase student interaction and participation in the classroom. He tests the effectiveness of the "H-ITT" system with preliminary data obtained from five logistics classes. Finally, Bill Cunningham, Stephen Swartz, and Harold Kahler describe a reverse supply chain employed by the Air Force for reparable assets. They analyze transportation costs and mode selection decisions and recommend alterations to the current system based upon depot-level repair capacity.

Thanks to all of you who had a hand in producing this issue. The authors, obviously, deserve most of the credit. A good portion of the remaining credit goes to members of the *JTM* editorial review board. We would not have a journal without you. Finally, I have failed to credit an extremely valuable asset in recent issues. Carol Waller, of our College of Business Administration Office of Publications & Faculty Research Services, prepares every manuscript for printing. She works wonders in formatting articles and manages to read my scribbled editorial changes—and catches most of my errors. Thanks so much for all that you do, Carol!

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!

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Journal of Transportation Management

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 trans-portation 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.

BASING RATE ADJUSTMENTS FOR MOTOR CARRIERS ON STATISTICAL EVIDENCE

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ABSTRACT

Pricing services of motor carriers is a dynamic process, with continuous pressure from customers to offer competitive rates and discounts. This can lead to a profusion of special arrangements with rates that poorly reflect the services rendered. This article shows how standard database systems and statistical models can be used to extract useful information from bills of lading to assist in the pricing of freight services. Summaries of business performance are produced according to terminal facility, shipping origin, shipping destination, individual shipping lane and individual customer. User-friendly statistical models are constructed to produce benchmarks for rates and revenues considering the services rendered. Differences between actual and benchmark levels of performance help to identify situations that may call for managerial reinforcement or corrective intervention. With illustrations from a major motor carrier, the authors discuss how even small motor carriers can develop such models and use them for planning their rate adjustments and managing customer relationships.

INTRODUCTION

Freight carriers, operating in a deregulated business environment, engage in a form of value-based pricing. They set their base rates and then negotiate individual customer discounts while considering the costs of providing service, com- petitive pressures, and the anticipated value of the customer relationship. They strive to reach different market segments with differentiated service characteristics and with flexible pricing mechanisms, thus deriving revenues from some premium services, capturing business from competitors and achieving a higher utilization of

corporate assets. Airlines, hotels and rental cars engage in a similar form of "yield management" as they set spot rates for restricted fares and offer weekend specials, perhaps with greater consideration to customers' willingness to pay. In such competitive environments with their peculiar pricing mechanisms, freight carriers need periodically to examine the results of their rate structures and discounting practices to determine the net effects of their pricing and service decisions and to adapt corporate strategies accordingly. In doing so, they must systematically address key questions such as:

1. How has the organization's business evolved throughout the transportation network?

2. Are there imbalances in the use of facilities and equipment?

3. How do rates vary throughout the service system? How are they related to market characteristics?

4. Are the effective rates at specific terminal origins, terminal destinations, or for specific customers, commensurate with the services delivered?

5. How should rates be adjusted at certain locations, on particular shipping lanes, or for particular customers or groups of customers?

In this article, the authors describe the development and use of analytical tools that were created to help a motor carrier address such questions. The company provides time-definite delivery services for less-than-truckload (LTL) shipments among a network of terminals located throughout the U.S. and parts of Canada. Although the focus is on the operations of a large North American motor carrier, the basic approaches employed and the issues confronted are relevant to companies in many competitive service industries. The presentation illustrates the use of standard statistical tools to extract information from computer records of bills of lading in order to:

1. Present a comprehensive picture of carrier activities and sources of revenue

2. Establish benchmarks for rates and revenues commensurate with services delivered

3. Identify terminals, shipping lanes and customers that may require managerial attention or intervention

4. Design a program of customer support and rate adjustments to improve corporate performance.

The process represents a form of data mining for pricing decisions. It involves the production of comprehensive statistical summaries that provide overviews of corporate performance in several dimensions, the creation of statistical (regression) models for explaining variation in performance, and the use of the resulting information to develop strategies for rate adjustments. The work can be accomplished with standard statistical software and data management tools.

BACKGROUND

In the two decades since deregulation of the U.S. interstate trucking industry, an array of alternative services has emerged for less-than-truckload (LTL) shipments involving traditional LTL carriers; truckload (TL) carriers who "top-off" partially filled trailers on a contract basis; private carriers who contract for use of backhaul capacity; freight forwarders and consolidators; express package deliverers; railroads and airlines with trucking alliances, etc. (Elzinga, 1994). Shippers weigh numerous characteristics of the terms and quality of service when selecting a carrier (Lambert et al., 1993). On one hand, larger carriers use sophisticated information technology and stronger credit lines to competitive advantage, resulting in greater industrial concentration (Rakowski, 1988; Boyer, 1993). On the other hand, smaller firms find creative market niches by offering services such as time-definite delivery with computerized

tracking, etc., in selected markets under simplified pricing structures (Schulz, 1999).

In this dynamic business environment, freight carriers rely increasingly on information technology to increase efficiency and improve service. Roy (2001) describes analytical tools (including optimization models) used in the trucking industry for tactical planning and operational support. He mentions the need for analytical support that is tailored differently for decisions at the strategic, tactical and operational levels.

In a less grandiose and more tangible frame, Brachman et al. (1996) discuss the concept of knowledge discovery in databases (KDD) and associated tools for data mining. They do so with a view to finding relationships which explain phenomena, identifying deviations from norms, and forecasting. They assert that much of this activity (including data cleaning, model development, testing, verification, interpretation and use) occurs through the use of traditional tools for statistical analysis (e.g., SAS), but also point to the development of proprietary packages which are developed for specific industries (e.g., fraud assessment for financial services, quality control systems for aircraft manufacturers and management of telecommunications networks). They note that general tools have been developed for visualization, query and clustering elements of data (e.g., Clementine, IMACS, MLC++, MOBAL and Recon), but their use is often *ad hoc*, and demanding in terms of technical skills.

In addressing the aforementioned strategic questions, it was desirable to create analytical support that could be employed on a periodic basis by marketing personnel without intensive background in computer information systems or statistics. Further, the authors wished to utilize the power of statistical tools and models, in some instances relying on theoretical underpinnings for development of benchmarks. The scope of analysis ranges from the broadest review of corporate performance (system-wide) to the activity of an individual customer in a specific shipping lane (involving a particular origin-destination pair).

PROVIDING PERSPECTIVE ON CORPORATE PERFORMANCE

The first step in producing tools for analyzing the carrier's effective rate structure (i.e., actual rates net of discounts) is to provide a comprehensive perspective on aggregate corporate performance, with an ability to identify important patterns through time and to drill down to levels of primary managerial attention. At different points in the review cycle, the focus may be system-wide, on a marketing region, on an individual terminal (as an origin, destination or both), on an individual shipping lane (origin-destination combination), or on an individual shipper (customer). There is also the spatial (geographical) element to consider when depicting corporate activity. The focus may be on customers with certain attributes in particular geographical markets (e.g., all large airline companies with business at the JFK freight terminal). It may also involve different time intervals (e.g., a particular reporting period or time following a significant event, such as the opening of a new terminal, establishment of a major competitor, or a catastrophic event such as the destruction of the World Trade Center). Supporting analytical tools must make it easy for managers and analysts to compare performance among entities and groups of entities.

Elemental data for the corporate performance profiles are embedded in bills of lading, which give the weight and revenues associated with individual shipments (roughly 100,000-150,000 shipments per month in this case). Monthly summaries of these transactions are created to serve as the core of a data mart (a mini data warehouse) which incorporates further information about road mileages between terminals, customer attributes, characteristics of cities where terminals were located, number of competitors operating in various markets, etc. A combination of customer number, origin terminal, destination terminal, and month defined the unit of aggregation for the activity dataset. Summaries include the number of shipments in the month, the total weight

shipped, and the total revenue derived from the services. The data mart thus includes

- monthly activity summaries for all combinations of customer number, origin and destination

- cross-references from customer number (which may identify subsets of activity for a company according to organizational structure, product line or geographical area) to company name (name of the customer)

- mileage tables which show driving distances between shipping origins and destinations and allow statistics to be produced which reflect the distance shipped (a critical component of cost and revenue)

- terminal characteristics such as longitude and latitude (to allow computation of spatial distances and identification of direction of traffic flow), size of city, number of competitors, etc.

- geographic data and annotation information to allow the depiction of information on maps.

Corporations often ship under different divisional names, yet wish to receive credit or consideration for the total volumes that they ship when negotiating their discounts. An important activity in connection with creation of the data mart therefore involves the conversion of shippers' names to a common format for consolidation of corporate shipments, and the consolidation of records for the same organization which appear with different spellings (as may be caused, for example, by blanks and special characters in a name, misspellings, upper-case versus lower-case characters, and the inclusion of qualifiers and abbreviations).

The revenues collected and the distribution of fixed and variable costs for a freight carrier depend greatly on the weight of the shipment and the distance involved. Performance must

always be viewed in the context of weight and distance. Accordingly, the key performance statistics for summaries system-wide, by terminal, by origin, by destination and by shipping lane (origin-destination) are:

- number of customers served
- total number of shipments
- total weight of shipments
- total revenue (dollars)
- total ton-miles shipped
- average weight (lbs.) per shipment
- average revenue ($) per pound
- average revenue ($) per ton-mile
- average distance (miles) per shipment
- average revenue ($) per shipment
- average ton-miles per shipment.

The data elements used in creating these statistics were obtained from individual bills of lading and maintained in a Microsoft Access database. The Statistical Analysis System (SAS) was used to create a prototypical data mart and perform the statistical analysis. Analysts can control processing for creating datasets, building models, generating reports, etc., without altering the statistical programs. Selective reporting, performance of ABC analysis (creating cumulative statistics for selected attributes in declining order according to their aggregate contribution to the total), and choice of processing options are controlled through "keyword parameters." The processing parameters also allow the analyst to specify choice of time frame, choice of sorting criteria, naming of summary datasets, selection of screening criteria for exception reports and detailed reports, and restriction of the analysis to focus on an activity for a particular terminal. Large bound copies of summary reports (affectionately known as the "stone tablets") are helpful in providing perspective in periodic reviews of corporate performance and during spontaneous discussions as issues arise. Such summaries should be updated periodically (perhaps quarterly). For particular studies, one can easily produce performance summaries covering a designated time period for chosen groups of entities (e.g., customer categories such

as freight forwarders, major urban terminals, terminals at which a particular competitor has a strong presence, international gateways, etc.). In Table 1, several summaries, which are comprised in the standard reporting options, are illustrated. Maps are also useful in showing imbalances between inbound and outbound traffic, commodity flows, etc. In Figures 1 and 2, maps are used to provide perspective on the geographical configuration of the company's terminal activity in the U.S.

In summary, the presentation of perspective on corporate performance relies on the storage of bill-of-lading data in a "data mart" with complementary data such as mileages, rates, terminal environments, customer characteristics, etc. It includes the periodic production of extensive reports for perusal and reference, the generation of comparable statistics on demand for entities under study, and GIS tools for conveying spatial aspects of the transportation network and business activity.

STUDYING EFFECTIVE RATES AND EVALUATING THE CUSTOMER RELATIONSHIP

The effective rate paid by a customer depends upon the published rate structure, which reflects the industry's basic cost structures, competition and targeted margins, the discount extended to the customer, and the blend of shipments that occurs. The customer's discount is usually negotiated in light of competitive pressures and anticipated volumes, with a greater discount offered to a customer who is expected to ship larger volumes. Sometimes the anticipated volumes fail to materialize. Total weight shipped may fall below expectations, or the resulting business may be primarily short-haul when a substantial amount of long-haul business was anticipated. When revenues (and resulting contributions to profit) fall below expectations, the rates offered to a customer may need to be adjusted. A tool is needed for an objective review that considers the services delivered, related costs, and competitive conditions.

There are various cost elements that should be considered when setting the base rates for a service and negotiating discounts for customers. The main cost drivers are summarized in Table 2. For the basic benchmark, a model that estimates total revenue based upon the number of shipments, weight shipped and distance shipped is employed. The statistical models that are created allow for interdependencies between weight and distance, thus adjusting the impact of weight on expected revenue, in accordance with the distance involved. More complex models are then developed to incorporate details regarding the terminal cities and traffic (for example, city size, geographic region, direction of flow, etc). Surrogate measures such as size of city and general price indices may be employed for the degree of traffic congestion and local factor costs (warehousing space, labor, fuel etc.).

Cost is, of course, not the only consideration. Competitive carriers can put a cap on rates that may be charged in a market. The number of competitors (derived from listings in yellow pages or industry associations) can serve as a surrogate for competitive pressure, which is correlated with city size. The more complex models provide additional explanatory power and help to identify factors other than the basic cost drivers which have impinged on rates. However, they "explain away" some of the differences to which managers should be sensitive. It is therefore valuable to look at the system both ways (first considering the basic cost factors and then considering the additional factors that impinge on rates).

Results for both the basic and complex rate models will depend on the data used to calibrate them. For example, when studying the rates charged at a particular terminal, the model is first calibrated with data involving shipments into or out of that terminal. The model is then calibrated using all shipments system-wide for the same period. This enables the isolation of revenue deficiencies for a particular customer at a terminal (in comparison with other customers, after adjusting for all services delivered at that

TABLE 1
EXCERPTS FROM PERFORMANCE PROFILES

profile of ALL terminal shipments from 12/2000 to 11/2001   11:40 Wednesday, January 23, 2002   1

-- Origin = xxxxx(masked for confidentiality) --

YEAR	MONTH	No. of Cust	Total no. Ship	Total lb Shipped	Dollar Revenue	Total ton-mi	Av. lb per Ship	$ Rev. per ton-mi	$ Rev. per lb	Av. Mi. per Ship	Av. Rev. per Ship	Av. ton-mi per Ship
2000	12	64	232	139,693	25,803	92,700	602	0.278	0.185	1,273	111	400
2001	1	70	283	133,508	25,813	91,740	472	0.281	0.193	1,326	91	324
2001	2	72	277	160,000	29,476	103,228	578	0.286	0.184	1,307	106	373
2001	3	74	332	170,143	32,196	112,866	512	0.285	0.189	1,305	97	340

profile of ALL terminal shipments from 12/2000 to 11/2001   11:40 Wednesday, January 23, 2002   42

-- DEST= xxxxx (masked for confidentiality)--

YEAR	MONTH	No. of Cust	Total no. Ship	Total lb Shipped	Dollar Revenue	Total ton-mi	Av. lb per Ship	$ Rev. per ton-mi	$ Rev. per lb	Av. Mi. per Ship	Av. Rev. per Ship	Av. ton-mi per Ship
2000	12	143	574	304,458	55,035	163,840	530	0.336	0.181	1,088	96	285
2001	1	128	652	406,676	71,073	214,910	624	0.331	0.175	1,086	109	330
2001	2	142	584	325,136	55,961	162,243	557	0.345	0.172	1,083	96	278
2001	3	143	698	412,509	72,996	221,556	591	0.329	0.177	1,101	105	317

profile of ALL customer shipments from 12/2000 to 11/2001   11:40 Wednesday, January 23, 2002   84

OBS	CUSTOMER	No. of origins	Total no. Ship	Dollar Revenue	Total ton-mi	Av. lb per Ship	$ Rev. per ton-mi	$ Rev. per lb	Av. Mi. per Ship	Av. ton-mi per Ship
1	A (masked)	76	89,881	9,073,032	32,445,774	604	0.280	0.167	1,122	361
2	B (masked)	74	91,682	9,007,802	33,978,714	572	0.265	0.172	1,186	371
3	C (masked)	76	55,846	7,556,810	32,069,517	844	0.236	0.160	1,274	574
4	D (masked)	76	76,003	6,691,877	23,481,678	511	0.285	0.172	1,130	309

FIGURE 1
IMBALANCES IN TERMINAL SHIPMENTS

Outbound and Inbound Lbs.
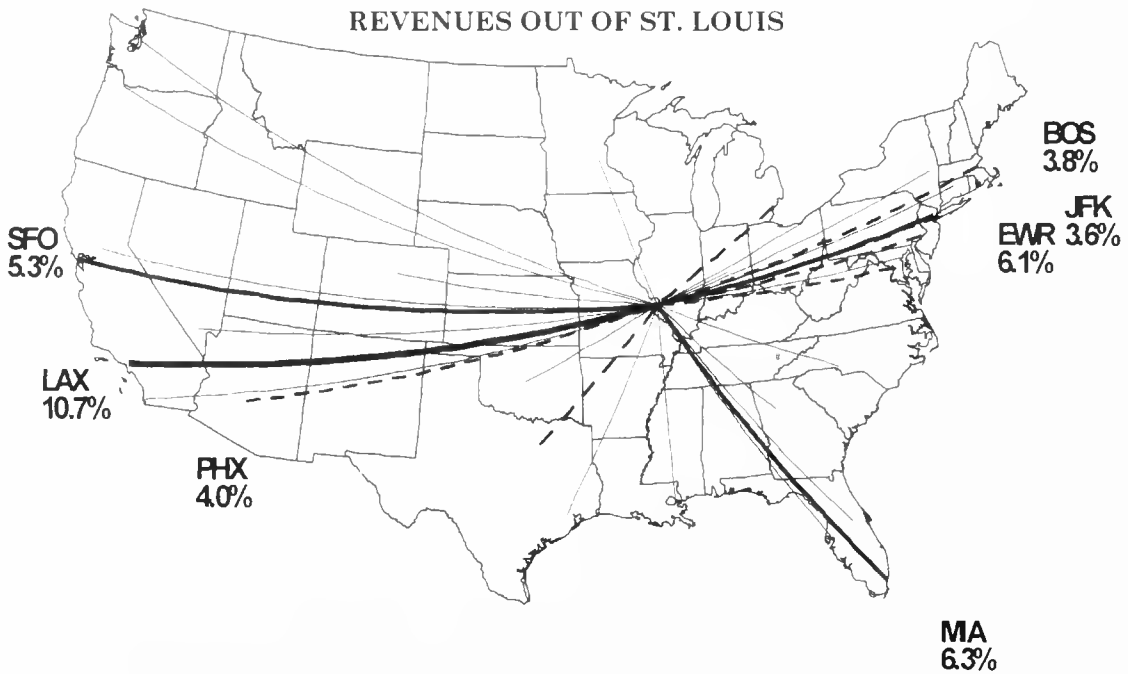(outbound = solid)

FIGURE 2
REVENUES OUT OF ST. LOUIS

BOS
3.8%

JFK
3.6%

EWR
6.1%

SFO
5.3%

LAX
10.7%

PHX
4.0%

MA
6.3%

TABLE 2
MAJOR COST DRIVERS

Cost Category	Cargo Density	No. of Shipments	Weight Shipped	Distance of Shipment	Local Factors	Traffic Congestion	Internat'l Shipment
Labor-Line Haul			X	X		X	X
Labor-Terminal	X	X	X		X		
Fuel	X		X	X	X	X	X
Tractor	X		X	X		X	X
Trailer	X		X	X		X	X
General Admin.		X			X		X
Local Delivery	X	X	X		X	X	
Customs Broker							X

terminal) in light of the customer's business elsewhere on the system. This would help to avoid offending a customer with a rate increase based on analysis only at one location when the customer is paying rates above the norm elsewhere. For example, the model, when calibrated with shipments originating at an individual terminal for a one-year period, comprised 8,362 customer-lane combinations and explained 96% of the variation in $11.6 million of revenue. The model for the entire system for the same year was based upon 146,368 customer-lane combinations and explained 91% of the variation in $193 million of revenue. As mentioned earlier, the results of the model can be aggregated in various ways to produce managerial reports giving benchmark and actual revenues by customer, origin, destination, region, etc.

When the resulting benchmarks were aggregated for the 76 shipping origins with shipments into the chosen terminal, the model explained over 99 percent of the variation in monthly revenues and 79 percent of the variation in revenues per pound. The deviations between expected revenues (generated from the model) and actual revenues (in the raw data used to calibrate the model) depend further on the time frame selected for analysis and upon the section of the network used in calibrating the model. Using data for an entire year avoids seasonal biases. Using the most recent month ensures currency and allows attention to be directed to current developments. It is recommended that the analysis be performed in different ways and further information should be sought to deal with material differences. A system-wide calibration should also be performed and the results compared with those for the chosen geography.

For the system-wide model, the actual and expected (benchmark) revenues that are produced for each customer and lane are aggregated to search for patterns by terminal, size of city served by the terminal, marketing region, and customer type. The results for each customer are also aggregated and material differences between actual and expected revenues are reported. Table 3 presents a comparison of actual and expected (basic benchmark) revenues according to the size of the city in which the terminal was located. The terminal cities were grouped according to the size of their associated metropolitan area (with 10 designating the top percentile—i.e., the 10 percent of cities with largest population). As might be expected, the largest negative deviations (where expected revenues exceed actual revenues) generally occurred at the busiest origins (in largest cities) where competition is thought to be stiffest.

HIGHLIGHTING SITUATIONS THAT MAY CALL FOR RATE ADJUSTMENTS

Revenues and rates from the regression models serve as the benchmark against which actual revenues and rates are judged. Using the expected revenues from the model in conjunction

with actual revenues, weights and distances, the actual effective rates and expected effective rates are compared in terms of revenue per pound and revenue per ton-mile. By analyzing the differences between the actual rates and the expected rates, individual terminals, shipping origins, shipping destinations, shipping lanes, or marketing regions can be identified for which there appear to be systematic deficiencies in revenues. Similarly, areas where business is especially lucrative can be identified (pointing to origins, terminals, shipping lanes, or marketing regions for which the deviations of actual revenues from expected revenues are positive). Finally, guided by these "residual variances" from the statistical models, the model can be used to search for the influence of other factors on corporate performance.

The same principal applies to a review of pricing for an individual customer. To give perspective on the total value of the business relationship, the customer's expected revenues and actual revenues can be accumulated across all lanes and months used for the analysis and compute the difference between the two totals. Customers can be sorted according to the differences between their actual and expected revenues, and a report can be printed showing the summary statistics for all customers whose differences exceed a chosen threshold (defined by a minimum aggregate revenue deviation based on a stated minimum number of shipments). Subtotals by lane can also be produced for a customer to identify significant differences at that level. Lanes where actual revenues are less than expected would be candidates for upward pricing adjustments. Lanes where actual revenues are greater than expected would call for reinforcement of the beneficial customer relationships. The next section discusses how managers might use such information to design pricing experiments for improving corporate performance.

A SYSTEMATIC APPROACH
TO VALUE-BASED PRICING

Models based on cross-sectional analyses of this sort provide some insight about the potential effects of changing general rate structures and service levels. It is impossible, though, to infer the effects of such changes on the behavior of individual customers or customer groups. Additional corporate intelligence is required to estimate how individual customers or customer groups may respond to rate changes. Ultimately, the effects can only be assessed by imposing the changes and observing the results. The differences between the actual and benchmark revenues should be used to guide in the design of marketing experiments for assessing the consequence of altering rates in specific markets or for specific customer groups.

TABLE 3
SYSTEM-WIDE TOTAL REVENUE DEVIATION AGGREGATED BY CITY RANK

City Rank Category	Actual Revenue	Expected Revenue	Deviation (Act. - Exp.)	% Deviation
10	61,313,174	63,356,459	-2,043,285	-3.2
9	37,924,670	39,326,468	-1,401,798	-3.6
6	16,752,318	16,734,710	17,609	0.1
7	19,898,685	19,810,838	87,847	0.4
2	3,241,228	3,121,147	120,081	3.8
3	4,294,813	4,077,087	217,726	5.3
1	2,097,118	1,838,983	258,135	14.0
4	8,588,509	7,690,684	897,825	11.7
5	12,965,521	12,045,443	920,078	7.6
8	25,802,159	24,810,499	991,660	4.0

Consider the case of making rate adjustments at a designated terminal. When reviewing the discounts offered to customers there, it is suggested that the residuals (deviations between actual and expected revenues) from the statistical models be used to cluster the customers into three categories: (1) Low for customers whose actual revenues are materially below the expected values, (2) OK for customers whose actual and expected revenues are essentially equal, and (3) High for customers whose actual revenues exceed expectations by a material amount. This can be done using data for the individual terminal on one hand, and for the entire system on the other hand (thus creating nine possible categories into which the customers could be slotted). Table 4 presents the results of such a categorization for a specific terminal of interest. (In this case, 1 percent and at least $1,000 was used to designate a material difference.) Using these criteria, the 1,023 customers with shipments originating at the illustrative terminal in a one-year period were grouped. The row classifications divide customers using models developed on the basis of monthly shipments for lanes involving that terminal. The column classifications divide customers on the basis of monthly shipments for all lanes system-wide. The right-most column and the bottom row are totals across the columns and rows, respectively. At the terminal alone, the vast majority of customers (850 / 1023 = 83 percent) fell within the OK category, with only 9 percent in the Low category and 8 percent in the High category. System-wide, the distribution was more even, with 43 percent in the Low category, 40

percent in the OK category and 17 percent in the High category. By combining the three groupings from both the individual-terminal and system-wide perspective, it is possible to assign each customer to one of nine composite revenue deviation categories and thus, identify key customers for review. The customers whose revenues fall below the norm at both the terminal level and system-wide (Low-Low customers) are the prime candidates for upward rate adjustments (perhaps by reducing their discounts). The customers whose revenues are above the norm at both the terminal level and system-wide (High-High customers) seem to merit special attention to preserve the business relationship.

In the instance of the chosen terminal, the 68 customers whose revenues fall materially below the norm at the terminal, and also below the norm system-wide, should be scrutinized to assess whether there are other factors (such as special cargo type, tendency to ship on lanes where there is heavy competition, lower level of service rendered on some dimension, or better access to other shipping alternatives for some reason) that can account for their negative deviations. Absent such explanations, these customers would seem to be candidates for a downward adjustment to their discounts. In the spirit of value-based pricing, however, it is recognized that the perceived need for expedited service may not be so great for some of these customers, and that the lower rates may have been necessary to capture their business.

TABLE 4
CUSTOMER GROUPINGS BASED ON ANALYSES OF
CHOSEN TERMINAL AND SYSTEM-WIDE REVENUES

	Low – System	OK – System	High – System	Terminal Total
Low – terminal	68	7	17	92
OK – terminal	361	385	104	850
High – terminal	11	16	54	81
System Total	440	408	175	1,023

Perhaps the discounts for such value-conscious customers could be continued, but with a softer guarantee of service delivery time. Nonetheless, a managerial review of quoted rates for the Low-Low customers should occur in light of the deviation reports, and experiments should be conducted to determine the effect on revenues of raising their rates (reducing their discounts). It is recommended that the Low-Low customers who, after managerial review, seem still to be appropriately categorized, be split into three balanced sub-groups which will receive differential changes in rates as follows.

- Group 1 to receive a designated change in discount in month 1 of the experiment.

- Group 2 to receive a designated change in discount in month 3 of the experiment if the net effect of change of rates for Group 1 customers appears to be beneficial.

- Group 3 to receive a designated change in discount in month 5 of the experiment if the net effect of changes of rates for Groups 1 and 2 appears to be beneficial.

Increasing rates in a recessionary period may pose some risks. In this case, the experimental program may be designed in connection with some volume incentive scheme to reduce the potentially negative impact.

On the other end of the spectrum are the High-High customers whose actual revenues exceed expected revenues based on both the terminal-level analysis and system-wide analysis. Again, these deviations might be due to traffic on lanes where there is little competition, or due to the provision of additional services. Managerial review should occur with these possibilities in mind and the grouping should be validated by management. Programs designed for retention of this business should be designed and administered with a similar experimental format.

- Group 1 to receive attention in month 1 of the experiment.

- Group 2 to receive attention in month 3 of the experiment if the net effect of change in attention for Group 1 customers appears to be cost-justified.

- Group 3 to receive attention in month 5 of the experiment if the net effect of changes in attention for Groups 1 and 2 appears to be cost-justified.

Similar tactics to those described above may be employed for analysis in connection with origin airport, size of city served by the origin airport, marketing region, and customer type. The "rate deviation" analyses on these broader dimensions will point to areas where the basic rate structure (as opposed to individual customer discounts) might potentially be altered to improve profit-ability.

CONCLUSION

Tools can be built economically with standard database and statistical software in order to assist freight carriers in determining appropriate rate adjustments. The analytical approach is hierarchical (top-down) in character, proceeding from broad statistical summaries of corporate performance to detailed summary statistics, to formal statistical models, to the search for further information on related factors (guided by deviations from the norms produced by the statistical models). The utility of regression models to produce benchmarks for this purpose was demonstrated, as well as how the benchmarks from such models, like the results of any statistical analysis, can depend upon the segments of business activity (e.g., time frame or portions of the transportation network) chosen for developing them. Finally, it was shown that differences between actual rates and the benchmark rates from the statistical models

might be used in systematic programs for periodic rate review and customer relationship management. The system prototypes were developed for a large motor carrier with a distribution network covering major cities throughout the United States and parts of Canada. These same systems could readily be implemented by other carriers using desktop computer systems.

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CARRIER SCORECARDING: PURPOSES, PROCESSES, AND BENEFITS

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ABSTRACT

Carrier scorecarding programs (CSP's) provide a formal, quantitative mechanism for use in assessing carrier performance. Such programs provide valuable input for carrier rationalization and contract development initiatives and can also serve as a key component of a Six Sigma program.

In this study, the overall goal was to address three research questions. First, why are organizations adopting CSP's? Second, how are organizations using carrier scorecarding to select and manage carriers? Finally, how does carrier scorecarding impact organizational performance? These questions were used to develop the set of research propositions that formed the basis for the investigation. In-depth case studies of six organizations were conducted to generate the evidence necessary to support or refute the research propositions.

Carrier scorecarding was found to be an objective, process-oriented approach that improves the ability of the transportation buyer to realize significant improvements in customer service while strengthening internal cost control. In the current industry environment of intense competition, narrow margins, pressure for shorter cycle times and improved supply chain efficiency, carrier scorecarding is rapidly gaining recognition as a valuable tool for use in carrier selection, evaluation and retention.

INTRODUCTION

In this era of supply chain management, companies often lose sight of the critical role that transportation plays in the organization. By providing the physical connections in the supply chain, transportation impacts inventory availability, manufacturing performance, sales, and customer satisfaction (Giblin, 2001). Combine these supply chain considerations with

the amount of money spent on freight transportation in the United States ($605 billion in 2002), and it becomes clear that transportation cannot be ignored (Cooke, 2002). Transportation managers must satisfy a wide variety of stakeholders who demand exceptional supply chain support and value in the form of high quality, flexible transportation service at a reasonable cost.

To address this value challenge, transportation managers are employing a wide variety of strategies for the purchase and evaluation of transportation services. Their key initiatives include: stringent carrier selection processes, measurement of key performance indicators (KPI's), and adoption of Six Sigma programs. The popularity and success of these strategies have been widely discussed in the logistics and transportation literature (e.g., Carman, 2000; Richardson, 2001, Premeaux, 2002; Dasgupta, 2003).

Transportation scorecarding is another valuable tool for promoting transportation success (Bowman, 1997). Scorecarding programs provide a formal, quantitative mechanism for assessing the ability of carriers to fulfill a wide array of requirements (Gibson & Mundy, 1998). These programs can highlight the "winners" and "losers" in the transportation "game" much like scoreboards and box scores do in baseball or basketball. The scorecarding process also supplies valuable input for carrier rationalization and contract development initiatives, serves as a key component of a Six Sigma program, and can help transportation managers make more effective use of KPI's (Hannon, 2003; Vitasek & Geary, 2003).

The purpose of this study is to investigate the application of performance scorecarding to the purchase of transportation services. An exploratory study was undertaken to provide insight into the purpose, process, and value of carrier scorecarding. The ultimate objective of the research was to establish a normative model that describes a step-by-step process for building

a carrier scorecarding program (CSP) that can be used to identify and reward premier carriers.

RESEARCH QUESTIONS AND PROPOSITIONS

Given the current strategic focus on transportation purchasing, the overall goal of the research was to address three key questions:

1. Why are organizations adopting CSP's?

2. How are organizations using carrier scorecarding to select and manage carriers?

3. How does carrier scorecarding impact organizational performance?

Since the focus of this research was the investigation of unique processes, and cost-benefit issues, insight was gained by asking open-ended "how" and "why" questions. These questions could not be planned as easily as quantitative "how much" or "how many" questions. Thus, precisely defined hypotheses were not developed. Instead, working propositions were developed to direct attention to the key goals of the study (Yin, 1994). These propositions are outlined in Table 1.

These propositions and related questions allowed a penetrating analysis of carrier scorecarding by studying the development plans, implementation processes, and outcomes experienced by organizations that use this strategic purchasing tool.

METHODOLOGY

Successful investigation of the research propositions required the collection of comprehensive, accurate information from various sources in multiple organizations. Field research, in the form of case studies and document analysis, was the logical methodology. It allowed direct observation of a phenomenon in its natural setting, thus promoting profound, realistic understanding (Babbie, 2003). While other methods may have compiled broad conceptual overviews

TABLE 1
RESEARCH PROPOSITIONS

	Proposition	Implication	Related Research Questions
P₁	A standard set of issues drives the development of CSP's.	This proposition suggests that organizations that have adopted CSP's do so for universal reasons. These reasons could be functionally focused or a common reaction to changing supply chain requirements.	The research questions will help explain why organizations undertake this time and resource intense strategy and what value they expect to receive from it. • Why did you adopt a CSP? • Did a specific trigger event drive your CSP? • What are the goals of your CSP?
P₂	A general framework exists for the development of CSP's.	This proposition suggests that organizations that have adopted CSP's faced common design and implementation issues. These issues include the step-by-step method used, the individuals involved in the process, and the resources required to successfully initiate the CSP.	The research questions related to this proposition focus on how the process is organized and how other organizations should proceed in developing a CSP. • Who developed your CSP? • What was the CSP development and implementation process? • What costs were involved?
P₃	The rewards of CSP's outweigh the risks involved.	This proposition implies that organizations that have adopted CSP's experience significant improvements in carrier performance (e.g., improved on-time performance, reduced claims, lower costs, etc.) while encountering limited problems.	The research questions focus on identifying the value of score-carding and will foster accurate cost-benefit analyses of the scorecarding programs. • What have you gained by initiating a CSP? • Have the results of your CSP met your expectations? • What problems were faced in the implementation of your CSP?

and isolated quantitative facts, case studies combined with document analysis produced rich explanations and illustrative examples that generated great detail of both the process and its implementation in multiple settings (Sommer and Sommer, 1998).

The case study candidates were identified through a purposive sampling effort (Ellram, 1996). An extensive literature review, discussions with transportation professionals, and a relevant database analysis generated a list of 175 potential participants. From this list, case study candidates were identified using the following criteria:

- A well-documented, structured CSP;

- Two to five years of program activity and performance history;

- High annual sales (indicator of substantial transportation spending);

- Industry diversity.

Six organizations participated in the research—enough to generate compelling evidence to support or refute the research propositions (Yin, Bingham & Heald, 1976). The participating organizations had annual sales ranging from $1.4 billion to $24 billion. They represented a variety of manufacturing industries—apparel, building products, chemical, consumer durables, and forest/paper products. The operational profile of the participants was evenly split between corporate and divisional transportation departments.

A research plan and interview guide was developed using CSP documents, information from the literature review, and the research propositions. Half-day site visits were conducted with each organization and interviews were conducted with key personnel. These in-depth interviews involved asking open-ended questions from the interview guide, recording the answers, and posing additional relevant questions to probe in greater depth as necessary. Although straightforward, this process produced a detailed blueprint of each CSP and generated a holistic understanding of the interviewee's views (Patton, 1987).

The semi-structured nature of the interviews allowed participants to initiate their own observations, rather than act strictly as passive respondents. This additional informant role encouraged participants to provide spontaneous insights and increased access to corroborating evidence (Yin, 1994). The dual respondent/ informant role can increase interview clarity and improve the probability of developing accurate, reliable models and theories (Eisenhardt, 1989).

Case study data analysis consisted of examining, categorizing, tabulating, and recombining the evidence to address the research propositions. Each case study was examined independently and a written case study narrative was developed and given to the participants for review, revision, and confirmation. These reports organized key information via matrices (checklists, event listings, and summary tables) and networks (event flow charts and activity records) (Miles & Huberman, 1994).

After the individual case reports were completed and verified, cross-case analyses were conducted. Various meta-matrices (master charts assembling descriptive data from all case studies in a standard format) and graphical displays (scatterplots over time and composite sequence analysis) were developed to promote effective and unbiased comparisons of the case studies. Multiple analytical techniques (pattern-matching, data partitioning and clustering, counting, and building a logical chain of evidence) were used to evaluate the research propositions (Miles & Huberman, 1994).

RESEARCH FINDINGS

The goal of the case studies was to develop insight into CSP adoption goals, implementation processes, and performance results of six large manufacturers. These insights were critical to the development of a normative CSP model. They also hold pragmatic implications for organizations considering CSP's (e.g., the research provides insight into the value of CSP's and suitable processes.).

These goals were addressed through the investigation of three research propositions. The

cross-case analysis of each research proposition is presented below.

P₁ - CSP Purposes

Proposition 1: A standard set of issues drives the development of CSP's. This suggests that organizations adopt CSP's for a universal set of reasons. The key issue is whether these reasons are consistent across organizations or unique to individual organizations. Consistent responses would imply that scorecarding is appropriate for a common, but limited range of applications. On the other hand, diverse responses would indicate that scorecarding is applicable to a wide variety of circumstances. Three research questions were used to analyze P_1.

The initial question, "why did you adopt a CSP?" elicited multiple responses during each case study. Many responses revolved around common organizational, departmental, or external issues. An often cited organizational issue was the need to participate in organizational quality initiatives. A common departmental reason for developing a program was the need to initiate or continue carrier base reductions. The improvement of customer service and satisfaction was a universal external concern. Finding reliable, fast carriers to address transit time pressures and lower customer inventory levels were common reasons for CSP adoption.

The participants also identified unique reasons for adopting CSP's. These reasons are outlined in Table 2.

The second question, "did any specific trigger event drive the development of your CSP?" produced two types of responses. The most commonly cited trigger event was an internal reorganization of the transportation function. Centralization of the transportation function preceded two CSP's, while departmental decentralization triggered two others. Quality agendas spurred the other two CSP's. One was created in response to a company-wide drive while the other CSP was triggered by an industry association effort to improve safety. Table 2 highlights these trigger events.

The third question—"what are the goals of your CSP?"—generated external and internal goals. The external, carrier-oriented goals were consistent, revolving around the issues of performance improvement, supplier reduction, and relationship enhancement (i.e., strategic alliances, volume growth, and exclusive territories). Cost reduction was another goal, although carrier rate reduction was not. The participants indicated that CSP-related reductions in carrier performance variation, improved operational efficiency, and streamlined administrative activities would lead to lower costs. The internal, departmental goals were unique to each organization. They are identified in Table 2.

Enhanced customer satisfaction is the ultimate goal of a CSP, according to the participants. However, they indicated that external and internal goals must be accomplished before customer value and strategic competitive advantage can be achieved.

Given the case study results, it is clear that CSP's have been considered and adopted for much more than a "standard set of concerns". The participants identified a wide variety of reasons for developing a scorecarding program, cited a number of different trigger events, and specified a variety of goals. Thus, P_1 is not supported by the data collected in the current study.

The diversity of responses indicates that carrier scorecarding is not perceived as a narrow transportation management strategy that applies to a limited number of situations. CSP's serve as effective response to departmental needs, organizational initiatives, and external pressures.

The extensive list of program goals also indicates that the potential value of a CSP is not limited to the transportation department. CSP's also

TABLE 2
META-ANALYSIS OF PROPOSITION 1

Organization	Primary Reason for Adoption	Primary Trigger Event	Key CSP Goals
Apparel Manufacturer	Departmental—desire to harmonize service requirements and carrier management procedures.	Reorganization—transition to a regional distribution strategy.	More objectivity in carrier selection and evaluation. Leverage purchasing power.
Building Products Manufacturer	Departmental—desire to be more objective in future carrier reduction initiatives.	Reorganization—shift to division-based logistics departments.	Tailor service priorities to division's customers. Create uniform practices and transparency between divisional facilities.
Chemicals Manufacturer— plastic packaging	Organizational—needed to keep pace with explosive sales growth and customer demands for smaller, more frequent deliveries.	Quality Issue—Company requires development of quality program.	Manage increased volume with current staff. Maintain quality of service while controlling costs.
Chemicals Manufacturer— specialty products	Organizational—needed to reduce company's liability exposure to transportation related chemical incidents.	Quality Issue—participation in Chemical Manufacturers Association Responsible Care initiative.	Eliminate unsafe carriers. Create uniform practices and transparency between divisional facilities.
Consumer Durable Goods Manufacturer	External—address pressures for faster delivery times from retail customer base.	Reorganization—transportation operation absorbed into centralized logistics function.	Establish a more reliable carrier base. Better visibility of carrier activities and performance.
Forest/Paper Products Manufacturer	Departmental—desire to combat the excessive cost of administering 1,100 carriers.	Reorganization—creation of national load control center (that could not handle the volume of carriers used by the company).	Reduce cost of administering carrier base. Manage increased volume with less staff.

provide value to the organization and the customer. These broader benefits prompted the participants to initiate CSP's.

Based upon these findings, the first proposition should be recast to reflect the flexibility and wide applicability of carrier scorecarding. A more appropriate statement of this proposition would be:

P_{1r} A wide-ranging set of departmental, organizational, and external concerns drives the development and implementation of CSP's.

P₂ - Program Processes

Proposition 2: A general framework exists for the development of CSP's. This proposition suggests that organizations have followed a common pattern in designing a scorecarding program. Key issues of investigation included the existence of comparable program development processes and the existence of similar program phases. Three research questions provided insight into the participants and resources involved in CSP implementation. Most importantly, the questions helped explain how the programs work.

The initial question "who developed your program?" produced similar responses from the participants. In all cases, the person with primary responsibility for building the basic structure of the scorecarding program and overseeing the development process was a transportation manager. This person personally chose a team to develop and manage the CSP.

In four cases, individuals outside the transportation department provided CSP development assistance. Purchasing managers, managers from external organizations, and external consultants were involved in most of the development initiatives. Only two organizations developed a program from the ground up without external assistance.

The second question, "what was the CSP development and implementation process?" produced a cohesive set of responses. Although each program employed a varying number of steps, they shared a common platform of four key stages: preliminary preparations, qualification and selection, initiation of operations, and performance analysis.

The first stage involved the task of preparing program guidelines and procedures. Initially, the implementation teams developed a general definition of the program's intentions to ensure that CSP goals were well established, synchronized with the broader organizational mission,

and clearly identified for carriers. Later, attention turned to determining CSP criteria and methods for selecting, evaluating, and categorizing carriers.

In the second stage, candidate carriers were identified and screened according to basic operating capabilities. The remaining carriers were invited to participate in the CSP qualification process. During this process, the candidates' capabilities were thoroughly evaluated. Finally, candidates were evaluated on their ability to provide mutually beneficial long-term relationships. A manageable number of carriers were then chosen to move freight and participate in the CSP.

Attention turned to the development of formal operating agreements in the third stage. Key service criteria were negotiated and the responsibilities of each party were established. When all issues were settled, the carrier was assigned specific lanes and operations commenced.

After a brief break-in period for carrier familiarization and service stabilization, the carriers moved into the final stage of performance analysis. Each program had an established process for collecting performance metrics on a monthly basis for every shipment handled by a particular carrier. Performance reports were distributed to the carriers on a monthly basis. Three organizations used EDI transactions to monitor performance, while the others used paper documents.

After a substantial amount of data was collected on a carrier (usually covering a year), the programs moved into the rating phase. Most programs used a 100-point scale to rate each carrier. This scale consists of both objective performance measurements (e.g., on-time percentages, billing accuracy, etc.) and subjective performance ratings (e.g., customer service response, competitive pricing, etc.). In most programs, the objective component dominated the scale.

Carrier site visits were used in five CSP's for subjective performance evaluation purposes. Facility audits, process reviews, equipment inspections, and personnel interviews were frequent activities in these site visits. The visits also provided an opportunity for the organizations to discuss potential process modifications and develop continuous improvement plans.

These ratings were used to classify the carrier into one of three categories (e.g., Preferred, Approved, Back-up). The top category indicates that the carrier is an outstanding service provider. This level of performance normally results in the assignment of additional lanes to the carrier. The other levels provide less security and can result in a loss of volume if the carrier does not make significant performance improvements by the next rating period.

Of course, the six programs have unique features. The primary difference was found in the weighting factors of individual performance criteria. Each organization stressed one or two issues tied to their initial reason for adopting a CSP. Other unique features dealt with the duration of a program cycle, frequency of reviews, and the potential carrier awards/rewards. Still, these features did not have a material impact on the overall structure of the programs.

The third question, "what costs were involved?" revealed that the unique program features did not significantly influence resource require-ments. The respondents concurred that the primary resources required are management time and a travel budget to visit carrier facilities. Other costs included computer resources and programming expenses, clerical resources to measure performance and develop reports, and management resources to oversee the program. Publication and communication expenses were also identified as minor costs by two organi-zations.

Analysis of the six organizations' responses to these three questions indicates that P_2 is a reasonable and accurate statement. A great deal of consistency existed between the organizations' programs even though they were developed under a wide range of goals. That is, the means to the end were consistent. The programs essentially involved the same group of people, development and implementation stages, and resources.

The acceptance of P_2 is valuable from the standpoint of an organization that wishes to develop a program in the future. The information gathered during the case studies provides insight into the time, effort, and steps they will face. The availability of this type of information can certainly lead to a reduction in CSP implementation time.

The acceptance of P_2 also provides the opportunity to develop a normative model of the carrier scorecarding development and implementation process. Figure 1 provides a flow chart of this process.

P_3 Program Benefits

Proposition 3: The rewards of CSP's outweigh the risks involved. This proposition suggests that organizations gain significant improvements in carrier performance as an outcome of the scorecarding process. Of particular interest was the participants' overall assessment of CSP results. Three questions were used to analyze this proposition.

The initial question, "what have you gained by initiating a CSP?" produced a set of responses that emphasized strong shipper-carrier relationships. All six participants stressed that they had strengthened their relationships with carriers as a result of their scorecarding programs. Improved communications, a mutual understanding of each other's operations, and increased visibility with carriers were widely noted benefits.

Three organizations developed partnerships or strategic alliances with carriers based on their performance in the scorecarding process. Their CSP's facilitated the identification of appropriate partnership/strategic alliance candidates. That

FIGURE 1
SCORECARDING PROCESS FLOW CHART

STAGE 1

Define needs and goals → Select program manager

Gather/review external information ← Assemble scorecarding team → Gather/review internal information

Build program framework

Develop program details → Acceptable? — NO

Eliminate carrier from program

STAGE 2

YES → Present to carriers → Review carrier capabilities → Acceptable? — NO

STAGE 3

Establish roles and reporting structure ← YES

Tender assigned loads to carrier

STAGE 4

Facilities

Carriers

Collect performance data

Create & share service reports → Build performance database

Subjective performance assessment ← Site audit and quality review ← Objective performance assessment

Complete & distribute scorecard → Benchmark scores & rate carrier → Preferred / Approved / Back-up

is, frequent interaction, site visits, and performance evaluations provided an accurate picture of a carrier's capabilities so that effective decisions could be made.

The participants indicated that scorecarding produced a variety of other benefits. Performance gains included a reduction in the number of accidents, a significant increase in customer satisfaction, and notable improvements in on-time deliveries. Departmental gains included greater uniformity between facilities, enhanced buying leverage with carriers, and reduced operating costs.

Overall, these types of benefits helped the organizations develop competitive advantages in their respective industries. The participants also indicated that the benefits are not one sided. Carriers also gained a great deal from the scorecarding process as well. Scorecards clearly lay out what is expected of carriers—the key performance indicators, scoring methods, and service levels are established prior to service provision. Scorecards also provide carriers with benchmarking data that can help determine where to target improvement initiatives. Finally, scorecarding facilitates frequent, structured communication between the carrier and their customers.

Responses to the second question, "Have the results of your CSP met your expectations?" were also positive. All participants stated that their programs performed as anticipated. Three organizations even suggested that their programs exceeded expectations.

The third question, "what problems were faced in the implementation of your CSP?" did not reveal severe complications. Participants indicated that their primary problems revolved around time pressures, capacity pressures, and handling the volume of information generated by the carrier evaluation process. However, none of these seriously impacted the value or performance of the scorecarding programs.

Most of the participants indicated that they were not able to keep their initial project schedules. A few program managers found that the travel requirements and meeting times were more demanding than they expected. These problems tended to delay the first round of performance evaluations and ratings.

Some participants indicated that changing business conditions slowed their progress. Mainly, they found that the programs could not be fully implemented because their best carriers were at full capacity. While the programs intended to replace marginal carriers with preferred carriers, the latter were unable to expand capacity quickly. Thus, these programs were unable to achieve their original carrier reduction goals as rapidly as desired.

The participants indicated that these issues were inconveniences, rather than CSP inhibitors. The participants identified four strategies for avoiding problems:

1. Set realistic dates and targets for implementation,

2. Visit shippers and carriers already involved in CSP's,

3. Use information technology to streamline data collection and performance reporting, and

4. Use common sense when developing and administering a CSP.

The responses to these three questions indicate that P_3 is an acceptable proposition. Overall, the participants widely stated that the benefits of developing a program significantly exceed the risks of doing so, and that the biggest potential risk of all may be choosing not to develop a scorecarding program. They feel that CSP's will become more widely used because they have proven to be successful and easy to implement (with help from existing programs).

Collectively, these cross-case analyses indicated that carrier scorecarding is a practical, value-adding transportation purchasing strategy that can be used by a wide variety of organizations. Scorecarding programs enhance opportunities to improve performance, fortify shipper-carrier relationships and create customer satisfaction, with minimal downside risk.

MANAGERIAL IMPLICATIONS OF THE RESEARCH

Given the applied nature of the research and focus on the current practices of transportation buyers, the primary contributions from the study are managerial in nature.

The basic challenge facing transportation buyers today is the simultaneous achievement of exceptional customer service, equitable carrier compensation, and internal cost control. Many strategies are touted as having the capability to accomplish all three goals. However, most have fallen far short of such "win-win-win" results. This research details a transportation management tool with an established track record of creating customer value, strengthening shipper-carrier relationships, and reducing transportation expenses. That tool is carrier scorecarding.

This research addressed a variety of practical issues that potential CSP users must consider. These pertinent topics focused on program development issues, resources and effort required, and the potential payoff (benefits realized versus risks assumed). Such information can help a transportation buyer answer the question, "would a CSP benefit my organization?"

Finally, this research analyzed the scorecarding program development and implementation process in detail. Using actual scorecarding program information from innovative transportation purchasers, a descriptive step-by-step development and implementation model was established. This knowledge greatly increases the likelihood of establishing a successful program. Thus, the research can help the transportation buyer

confront the ultimate question, "how should my organization proceed in developing a CSP?" with confidence and intelligence.

This research also fills a void in the logistics literature regarding carrier scorecarding. Existing articles provide some anecdotal evidence regarding the purpose and value of CSP's, but little else. This study advances the knowledge base with a normative model of the CSP development and implementation process as well as discussion of its value. Such information can be used as a benchmark for future research initiatives into related topics.

LIMITATIONS OF THE RESEARCH

The primary limitation of the research is that the results may not be representative of all organizations (e.g., smaller companies and industries other than those studied), although steps were taken to promote transferability. At minimum, the results can be viewed as a comparative analysis of the practices among participating firms (Bowersox, et al., 1989). This is not to say that the theories and model produced by the research have no value in other situations. The results provide a great deal of insight into the research questions, produce valuable direction for additional research, and provide a set of general guidelines that other organizations can use. Ultimately, however, future studies must subject the research results to the process of refutation and falsification to prove generalizability (Lynch, 1982).

CONCLUSION

This research was conducted to provide insight into an emerging transportation purchasing tool that has previously received limited exposure in the literature. Through the case study research methodology, three key goals were effectively analyzed. Carrier scorecarding was found be an objective, process-oriented approach that helps the transportation buyer simultaneously achieve exceptional customer service and internal cost control. In the current environment of Six Sigma,

lean operations, compressed cycle times, and supply chain efficiency, carrier scorecarding is an appealing tool that merits additional academic and industry attention.

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USING LIFE-CYCLE COSTING AND THE STRATEGIC PROFIT MODEL TO ENHANCE MOTOR CARRIER CAPITAL EQUIPMENT MANAGEMENT

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ABSTRACT

Participants in the increasingly competitive motor carrier industry are constantly trying to identify ways to enhance customer service levels and/or reduce costs. This research summarized case-based data from three large carriers to examine the use of life-cycle costing as a method to enhance motor carrier equipment management. The financial results of applying the technique are then examined by applying the Strategic Profit Model.

INTRODUCTION AND BACKGROUND

Over the last twenty years, the environment of the U.S. motor carrier industry has changed dramatically (Feitler, Corsi, and Grimm, 1997). Deregulation has been a troublesome event for many in the motor carrier industry as noted by an increase in the number of bankruptcies since deregulation was officially enacted in 1980 (Corsi, Grimm, Smith, and Smith, 1991; Feitler, Corsi, and Grimm, 1998). The free marketplace increased intramodal competition and placed downward pressure on prices, increasing failure rates and changing the strategic focus of many carriers (Silverman, Nickerson, and Freeman, 1997). Couple this with industry consolidation, rising insurance costs, driver turnover, large fluctuations in fuel prices, and a less than robust economy, and carriers are faced with a very difficult operating environment (Ellinger, Lynch and Hansen, 2003; Mejza, Barnard, Corsi, and Keane 2003).

Clearly the large company segment of the industry is under pressure. At the same time shippers are reducing supply bases and asking their remaining logistics providers for higher service levels at competitive prices. Studies confirm that carriers are increasing the variety of services they offer and are attempting to enhance service quality in order to either gain a competitive advantage or merely survive (Crum and Allen 1991; Stock 1988). In part, carriers are making major adjustments to their strategic orientation to counteract the impact the rapid growth of "integrated logistics service providers" has had on the marketplace.

While many motor carriers have made major adjustments to remain competitive in the challenging market environment (Corsi, Grimm, Smith, and Smith, 1991), one area where many continue to struggle is with the acquisition of new equipment. Asset based trucking companies depend on their tractors and trailers to move the freight that generates their revenue. Therefore, it is critical that these companies manage the acquisition, maintenance, and disposition of the equipment in an optimal manner. The entire life-cycle of the equipment must be managed in a way that maximizes reliability and minimizes cost. However, the effective management of capital assets has proven to be a difficult task for many in the highly competitive motor carriage industry.

One approach with promise as a tool designed to aid carriers in the effective management of capital equipment is life-cycle costing. Life-cycle costing is an analytical system that examines how much it actually costs an organization to acquire, use, maintain, and dispose of an asset over its lifetime (Ellram and Siferd, 1993). This method of cost analysis tends to focus primarily on capital or fixed assets (Fernandez, 1990; Jackson and Ostrom, 1980).

PURPOSE OF THE RESEARCH

Motor carriers can range from a one truck operation to an international corporation with thousands of tractors and drivers and millions of dollars tied up in assets. Furthermore, carriers operate in a wide range of diverse markets. However, all asset-based carriers have one challenge in common, how to best acquire and utilize their equipment. Therefore, the purpose of this article is to identify opportunities for motor carriers to improve their competitive position through better life-cycle management.

Data collected from public sources and personal interviews are analyzed to postulate strategies for improved carrier asset management. The first section provides information on study participants, research methodology, and introduces the strategic profit model. This model is used to provide support for the four strategies introduced in the research. Section two describes life-cycle management in general terms and how its concepts can be applied to managing equipment acquisitions. The third section addresses how asset assignment based on work configurations can impact the maintenance program and improve carrier performance and profitability. The last section provides managerial implications, strategies for carrier improvement under different work load scenarios, and suggestions for future research.

RESEARCH METHODOLOGY

The goal of every firm is to succeed. One component of success is to measure increases in shareholder value. A specific way to measure that increase (or decrease) is to calculate the return on net worth (RONW). Managers at DuPont Corporation created the DuPont chart to help them understand how changes in operations impact shareholder value (Shapiro and Kirpalani, 1984). Subsequent research (Lambert and Stock 1993, 2000) formalized the DuPont chart and introduced the strategic profit model (Figure 1). The strategic profit model shows how return on net worth is a function of three factors that can be controlled by management. These three factors are net profit, asset turnover, and financial leverage.

The strategic profit model uses net profit (sales-expenses) as a measure of how efficiently a firm

FIGURE 1
STRATEGIC PROFIT MODEL
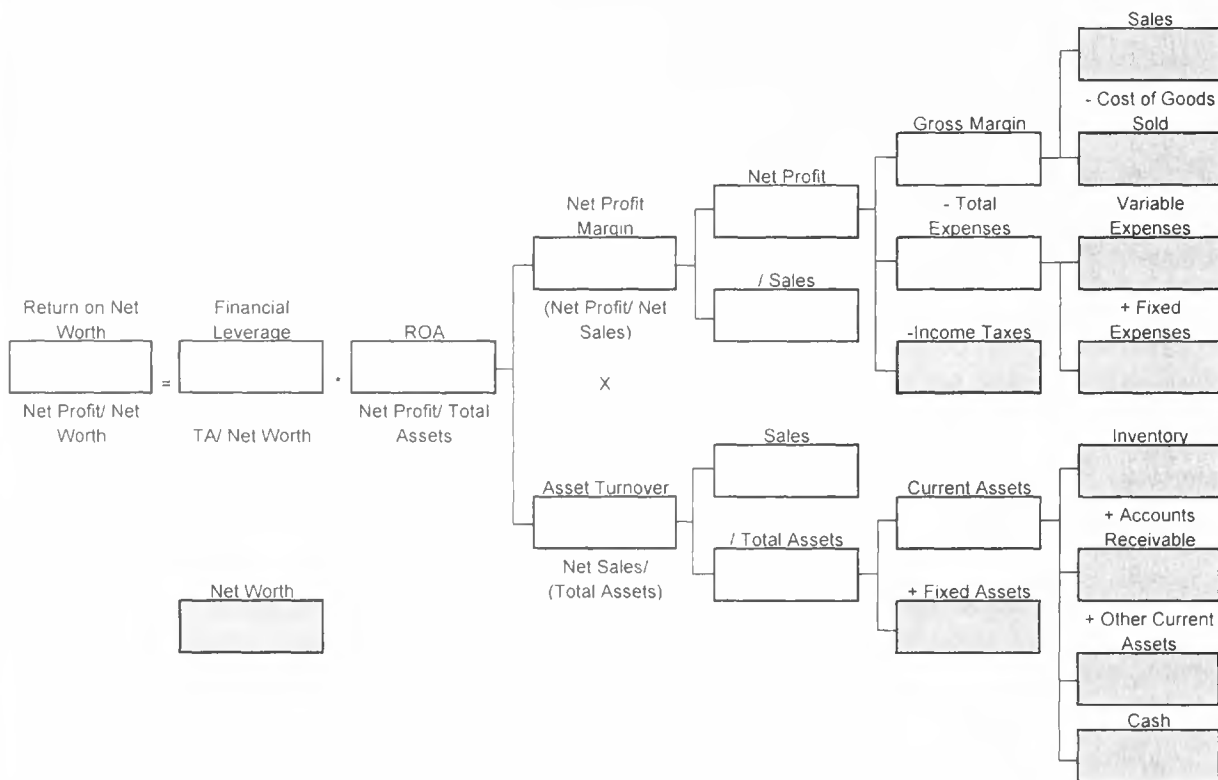
Source: Lambert and Stock (2000), pp. 32-37.

manufactures and sells its products. Asset turnover (sales/total assets) is used as a measure of how efficiently a firm employs its assets. Financial leverage (net worth/total assets) is used as a measure of how effectively management uses outside sources of financing to increase the firm's RONW.

The strategic profit model employs a ratio analysis methodology to determine the return on assets (ROA) and RONW. The model employs two main equations:

$$\text{ROA} = \text{Profit Margin} \times \text{Asset Turnover} \qquad (1)$$

$$\text{RONW} = \text{ROA} \times \text{Equity Muliplier} = \\ \text{Profit Margin} \times \text{Asset Turnover} \times \\ \text{Equity Multiplier} \qquad (2)$$

Sample Firms

This research focused on three large, U.S.-based, cross country, full truckload carriers. The analysis includes: 1) case based observations from three major U.S. Truckload carriers: Swift, J.B. Hunt, and Schneider National, Inc. and 2) a financial based analysis of one of the carriers to illustrate the effectiveness of the methods suggested by the researchers.

The current research takes case-based interview and publicly available data and employs different life cycle costing strategies to the management of maintenance costs. Four strategies for improving maintenance procedures are presented based on a content analysis of the interviews and other information collected from the carriers. The impact of different strategies is then examined by using the strategic profit model to analyze the cost data of one firm in the sample.

Both Swift and J.B. Hunt are publicly held carriers who were selected in part because of the availability of financial and non-financial information. Schneider National was selected based on the research team's intimate knowledge of Schneider National and that Schneider is a privately held firm. The sample allows the researchers to do a case analysis of two publicly traded truckload carriers and one privately held corporation.

Throughout the presentation of the case study results, four strategies for enhanced management of maintenance costs are postulated. Then, the financial details of Swift are entered into the strategic profit model to illustrate the impact of strategic changes on the firms' ROA and RONW. By entering data into a spreadsheet built around the concepts of the strategic profit model, what-if analysis can be done quickly and effectively. The results can be used to help management shape a firm's strategic direction and highlight the possibilities for improvement from applying life-cycle techniques to a carrier's fleet.

EQUIPMENT LIFE-CYCLE MANAGEMENT

Due to low barriers to entry and limited variation in service in the motor carrier industry, it is absolutely critical for carriers to be able to differentiate themselves in terms of price and service levels. Most cross country full truckload carriers operate on small margins. Therefore, they are naturally very cost conscious. However, many carriers often make cost decisions on a very tactical level without considering the overall life-cycle implications. Furthermore, different areas or even different departments have control

over different stages of the life cycle, creating a fragmented approach when applying life-cycle cost analysis techniques to capital assets. The different departments often have conflicting priorities, especially if they operate from independent budgets. In some organizations, some departments are even viewed as their own entity and treated as a profit or cost center. This can require a departmental manager to focus more on cost or profit generated by their segment as opposed to examining the decision from the holistic view of what is best for the overall operation. For example, if maintenance costs are allocated equally across accounts, there is little incentive to practice preventive maintenance. As a result, life-cycle cost management needs to be a strategic approach ingrained throughout the organization by soliciting cross functional input.

The life cycle of a piece of equipment includes its purchase, operation, maintenance, and disposal (Ellram and Siferd, 1998). The purchase is the process of initial acquisition of the asset. Operation costs are those associated with the continued operation of the asset such as fuel. Operation costs can vary based on the work configuration with which the asset is assigned (e.g., solo vs. team driver configurations). Work configuration assignment and its impact on costs will be discussed in greater detail during the analysis section. Maintenance includes warranty, preventive, unplanned, and emergency maintenance. Disposal can include selling to a third party, returning the asset as part of a buy back program or scrapping the asset. Each of these steps presents challenges and opportunities for the carrier to reduce cost and improve service levels.

EQUIPMENT LIFE CYCLE: THE INITIAL STAGE

Equipment purchasing is an important and complicated decision. New equipment can be purchased to replace old equipment or to expand capacity. This type of purchasing decision is often made at the highest levels of the organization. For example, at least one of the carriers in this study has created an "asset team"

of senior vice presidents to determine their purchasing strategy. The purchasing team considers price, quality, expected life, after sale service, maintenance, driver needs, and buy back opportunities when making purchasing decisions.

During the economic boom of the 1990's, trucking firms were locked in fierce competition for drivers (Keller, 2002). At the same time, the demand on trucking was growing with the expanding economy. Increased demands were placed on drivers, creating a demanding work environment which led many drivers to leave the industry for jobs with a different lifestyle. As a result, driver comfort became an increasingly important part of the asset specification process. Based upon discussions with individuals involved with purchasing strategy, one of the main reasons many carriers converted from less expensive Cab-Over-Engine (flat front trucks) to the long nosed conventional tractors was driver preference.

Purchasing assets based upon enhanced driver comfort meant more "creature comforts" in the cab, yielding a more complicated electrical system, and increased maintenance costs. Furthermore, in many cases, the purchase of new tractors requires mechanics to learn the maintenance procedures for a fleet built by an unfamiliar manufacturer. Clearly the strategy used by many carriers was not one of cost minimization but rather one of enhanced driver comfort to improve driver retention rates.

When selecting a supplier, large fleets also need to identify a manufacturer that can supply them with large equipment orders. Large fleets want to use their economies of scale and volume buying power to lower the price per unit. Large carriers seek to find truck manufacturers that can handle large orders of aesthetically pleasing, comfortable tractors, which include a strong warranty program, and a used tractor buy back plan.

Because purchasing is often an executive level decision, front line and mid level managers do not always have a lot of impact on the buying decision. However, once the purchasing decision is made, they have to analyze the entire life cycle of the asset and predict the potential short and long term impacts on their functional area. For example, managers must determine training needs as new and/or improved equipment is introduced. The training may include technical changes as well as warranty filing processes and altering maintenance scheduling and capacity levels. A vital part of the life cycle analysis performed by the managers of each functional unit is the maintenance costs associated with the asset and how those costs impact their functional unit.

Life Cycle-Management: Maintenance

Maintenance considerations play a large role in operations planning in part because maintenance costs make up a large percentage of total life cycle costs. In addition to the actual cost of repairing the equipment, there are opportunity costs whenever equipment is in maintenance. These costs include the impact on service, the under-utilization of the driver while waiting for maintenance, and the under-utilization of the equipment itself.

According to carrier representatives, the key is to minimize both maintenance dollars spent and the opportunity cost. Carriers, typically place maintenance events into one of three categories: planned, unplanned, and emergency. Planned maintenance includes scheduled inspections and preventive maintenance (e.g., changing the oil and filter). Unplanned maintenance occurs when a driver takes equipment to a shop in between scheduled maintenance but not when it will immediately affect service (e.g., getting the air conditioning fixed between loads). Emergency maintenance is categorized as a breakdown that threatens the successful on time delivery or scheduled pickup of a load (e.g., engine failure).

On average, planned maintenance is the lowest cost form of service because it can be scheduled and is predictable. Conversely, emergency maintenance tends to be the highest cost service effort

because it is not scheduled and often requires overtime, emergency service, or expedited parts delivery. According to maintenance professionals interviewed, emergency maintenance is approximately three times as expensive as planned maintenance procedures.

A good maintenance program extends the life of the asset by conducting effective preventive maintenance. When there are unplanned or emergency breakdowns, maintenance determines the best value repair to maintain the highest level of revenue generation for each transportation asset. Maintenance planners must also make a decision as to whether the maintenance will be done internally or outsourced to a third party maintenance provider. These and other decisions contribute heavily to the cost per mile for a carrier and the pricing structure of a carrier.

While maintenance is a very broad subject and a vital component of carrier operations, the focus of this research is on how different work configuration strategies can be used to help optimize revenue generation for a carriers' fleet. While many companies generally do a good job of making maintenance decisions on a case by case basis, many do not focus on controlling the type or frequency of maintenance visits. Most carriers place their equipment in various work configurations to meet the immediate needs of their customers without a thorough knowledge of the impact on the asset or its maintenance requirements. While adhering to customer needs and providing a high level of customer service is essential to carrier success, an underlying maintenance cost minimization strategy could be simultaneously employed to yield a maximum profit level.

Life-Cycle Management: Operations

How a carrier utilizes an asset plays a large role in how costs will accumulate during the asset's life cycle. There are a number of different work configuration strategies a carrier can employ. Different carriers appear to use their own unique variations of the following basic models.

Line haul or system drivers are very common. The driver is dispatched and could travel to any location for any customer. Line haul drivers typically record 2500-3000 miles per week. Since their movements are more or less random, they drive in a number of different weather and terrain conditions.

Team Drivers are line haul drivers. However, there are two drivers which doubles the driving time without violating hours of service regulations. This configuration allows freight to travel very long distances, often coast to coast, in a very short amount of time. This is an ideal work configuration for time sensitive cross country loads. If the team is utilized correctly this can also be the lowest cost model because the carrier can get twice the miles in the same period of time, retaining a high level of asset utilization. From a life-cycle perspective, team drivers put a large number of miles on the tractor so they require different maintenance planning. Additionally, the cost of unplanned and emergency maintenance is much higher because a broken down tractor has two drivers being underutilized.

Dedicated drivers travel to and from the same shipper and consignee location. The weather and terrain conditions are much more predictable. It is also easier to plan maintenance because the location of the asset and the identity of the driver are known. Dedicated drivers often return to their home base at the conclusion of the workday, and no additional costs are incurred for accommodations when the asset requires maintenance.

Local driving is the final common category. Local drivers typically travel in a small radius around their home terminal. Local drivers are often used to shuttle trailers, make "milk runs" to enhance consolidation opportunities, or to serve as a drayage carrier to connect intermodal movements.

Work configuration is important to life-cycle management. Each work configuration places different demands on equipment. As a result, there are considerable opportunities to improve return on assets by closely managing the life cycle of a transportation asset by changing work configurations at predetermined mileage points. There is little evidence that carriers have a focused, cohesive, and systematic effort to enhance maintenance management through work configuration optimization.

Team Driver Assigned Shipments

Under normal circumstances team driving places the greatest strain on the tractor. Teams are often utilized on loads with stringent on-time requirements including Just-In-Time (JIT) logistics shipments. Therefore, a company cannot afford to have a team driven shipment suffer a breakdown. As such, management should consistently place team driven shipments in the most reliable equipment. Teams require living space and comfort features to meet the needs of multiple drivers working together to provide the carrier a significant number of continuous hours of service. These considerations often limit the options a carrier may have when assigning a tractor to a shipment.

Additional considerations must also be examined when using the life-cycle approach. Many manufacturer warranties are based upon age or mileage milestones. The warranty period often ends when either a time period expires or the asset exceeds a predetermined number of miles. Team trucks build up miles roughly twice as fast as a solo truck, greatly reducing the time the tractor is covered under warranty. This can be a costly disadvantage when considering components that are affected more by age than by miles, such as paint, interior components, radios, and some parts of the electrical system.

Retaining truckload line haul drivers has often proven difficult (Stephenson and Fox, 1996). The challenge is particularly apparent when dealing with team driving work configuration assignments designed to maximize continuous hours of service. In fact, turnover rates among all line haul drivers can average 70-80% with some estimates for team drivers as high as 100-300% (Ruriani, 1995).

The financial costs associated with losing drivers and then hiring and training new drivers is considerable. New drivers are also more expensive because their inexperience can lead to more accidents and service failures. However, financial cost is not the only consideration. It is not rare for a driver to simply resign his/her position in route, causing service disruptions and potentially causing a negative impact on customer service levels. Not only is customer service impacted by the specific event, but the event reduces the asset utilization rate and can add to the cost of providing a replacement driver to transport the shipment to its final destination.

Strategy #1. Carriers may wish to assign team drivers a new tractor and upgrade their equipment relatively early in the warranty period. Based upon the three carriers in this study, this strategy would result in an upgrade to a new tractor by team drivers approximately every eight months. Use of this strategy would simultaneously extend the length of time the tractor is under warranty and reduce the time the tractor is in the shop for maintenance. Furthermore, receiving a new tractor every eight months could be used as a good recruiting incentive for team drivers. This is important because team drivers typically carry relatively high profit margin per load items, but tend to be difficult to recruit and retain because of lifestyle issues.

Solo Line Haul Driven Shipments

Solo line haul drivers and their equipment face many of the same conditions as team driven equipment. However, solo line haul equipment incurs fewer miles per week and drivers tend to be somewhat easier to recruit when compared to a team driving configuration assignment.

Based upon the interviews conducted, it appears to be common for a carrier to place their more

experienced drivers in newer equipment. This is in spite of the fact that, from the perspective of a maintenance cost strategy, it would make more sense to place seasoned drivers in older equipment. Experienced drivers tend to have more of an appreciation for their equipment, have fewer service emergencies, and are better equipped to handle a breakdown in the most cost effective manner. Solo line haul drivers require reliable and comfortable tractors. They are similar to team drivers except that there is only one driver responsible for delivering the shipment to its destination.

Strategy #2. Solo line haul drivers should receive tractors less than one year old and could include the tractors from which team drivers are upgrading. Unfortunately, most large fleets do not have the luxury of having as many team driven units as solo driven units. Therefore, this strategy would leave some solo line haul drivers without relatively new and reliable replacement equipment.

Dedicated Shipments

Dedicated tractors present a challenge to managers implementing life cycle planning strategies. Given that a dedicated asset is often assigned to a particular customer, the demands placed on the asset can vary greatly. Different dedicated customers have varying service expectations and requirements. To generalize all dedicated accounts into a single configuration model is not possible. Some dedicated accounts require precise on time delivery for Just-In-Time shipments and, therefore, require highly reliable equipment. Other customers are more flexible and have less rigid demands.

Regarding dedicated tractors, the consensus of those interviewed is that the original haul and back haul freight often have different service requirements. For example, a company may move finished product to a customer with Just-in-Time requirements at a premium price, then return with a load of scrap for recycling or send empty packing crates and pallets back to the manufacturer.

Dedicated freight is often considered more desirable by drivers because the drivers on dedicated accounts have consistent schedules and spend less time away from their home base. Therefore, it is easier for the company to assign older, less "comfortable" equipment to these drivers in exchange for the better life style.

Strategy #3. Dedicated account tractor assignments must be made on an account by account basis. The account manager should play a major role in requesting equipment that fulfills the customer service level requirements at the lowest possible cost. If an account manager is going to be judged on his/her profit and loss (P&L) statement for each account, he/she should have some input into how equipment is assigned to the account.

However, account managers should avoid making the mistake of trying to improve their P&L by exchanging newer equipment for older equipment that has a lower annual depreciation charge. Managers do this because maintenance costs are arbitrarily allocated as opposed to being assigned by activity based costing techniques which try to match the cost with the activity driving the cost. Depreciation is a non-cash cost to the company, so it represents only an estimate of the reduction in the value of the asset. When making decisions based upon depreciation figures, the account manager's incremental increase in maintenance costs more than offsets any gain achieved by changing equipment to reduce the depreciation expense. Furthermore, this negatively impacts cash flow since depreciation is a non-cash expense while maintenance is a cash expense and increased maintenance time reduces the utilization rate of the asset. Therefore, a tactical decision at the account manager level results in a negative impact on the overall organization.

Decision-making based upon this type of cost strategy can result in an account being priced incorrectly and not properly reflecting the underlying costs of servicing the account. All of the major carriers studied are involved in projects to evaluate dedicated accounts for

profitability. Each is seeking to expand business in their most profitable accounts and eliminate accounts with the lowest profit potential.

However, if the right equipment mix is not used to service each account, managers could be making bad decisions as a result of a failure to fully appreciate the true cost picture. Manipulating equipment to change the amount of non-cash depreciation charges reflected on the income statement of a particular customer account can lead to poor decision making. The income and expense numbers provided for each customer account may actually distort true profit per account and lead managers to drop a more profitable customer for a less profitable customer.

Locally Driven Shipments

Equipment driven by local drivers is generally exposed to harsher treatment than any of the other three categories discussed. Local drivers are constantly in slow moving, congested traffic requiring heavy loads on the engine, transmission, and braking systems. Furthermore, poor yard conditions at railroad loading/unloading locations and ports and/or trailer drop off locations can be punishing to tractors. Therefore, it generally does not pay to assign good equipment to shipments requiring a local shipment configuration. Furthermore, local drivers tend to spend less time in the tractor and spend virtually every night at their home base. As such, it is relatively easy to schedule a tractor for overnight maintenance to be repaired and ready for use the next morning. If a breakdown prevents a local tractor from completing its workday, it is comparatively easy to find a substitute asset to complete the job.

Strategy #4. Utilize old equipment near the end of its life cycle for local shipments. Local fleet managers serve the organization well by using old, fully depreciated equipment for local shipments. However, caution must be exercised to ensure the maintenance costs and related idletime of the asset do not exceed the value of having the equipment. One drawback to this

strategy is that using a tractor for local shipments will often diminish its resale value. The carriers involved in this research indicated that trucks assigned to local shipments often end their life cycles by being scrapped for salvage value versus being sold in the used truck market.

One alternative to running former line haul tractors in a local configuration is to purchase tractors specifically designed for this type of work. These tractors are lower cost because they do not need the sleeper berth and storage space. The local tractors also do not need the weight and engine power of a larger tractor. In fact, many local drivers prefer the smaller and more maneuverable truck.

The decision to run former line haul tractors in a local configuration or to buy specialty equipment depends largely upon the used truck market, truck manufacturer buy back plans, and the company's capital budget. Since the decision to buy specialty equipment is usually a five to seven year commitment, many companies choose to run a majority of their local fleet using former line haul tractors, and occasionally buy specialty equipment when they perceive conditions are favorable. Favorable conditions often occur when a company frequently running local shipment equipment experiences a liquidation of assets. The individual or team that makes the decision to add equipment must fully understand the cost structure of the account the equipment will be assigned to, the long term projections of the business, the reaction of drivers, pricing of the business, and how the local business relates to the overall portfolio of services offered by the company.

Life-Cycle Management: Disposal

Disposal is an important part of the life cycle strategy. There are four disposal options: trade in, trade out, salvage, and scrap. Trade in involves selling the truck to a new tractor manufacturer. Trade in terms and conditions are set at the time of purchase of a new truck. There is often cost associated with trade in. This can

include mileage penalties and the cost of bringing the tractor to an acceptable standard to be traded. When conducting life cycle planning, if a trade in option exists, it is important to select tractors for the trade in process that will recoup the maximum amount of money. The goal is to trade the tractor at a higher cost than it could be sold for on the wholesale used truck market. A hidden cost to be aware of is the opportunity cost of having maintenance resources dedicated to preparing trucks for trade in when they could be servicing active equipment.

Trade out is selling the truck on the used truck market. Most large trucking companies do not have the time or expertise to sell individual trucks retail, therefore they sell to wholesale buyers. The advantage of trade out is that it is quick, and does not require a lot of preparation time. The disadvantage is that the wholesale price is usually lower than a trade in price. Furthermore, the used truck market fluctuates whereas the trade in price is contractually set at the time of new truck purchase.

Salvage of a tractor is cutting it up for parts. The parts are then sold or put into maintenance inventory. This is a good option when a newer tractor is involved in an accident, such as a rollover, that destroys the cab and frame of the truck, but the engine, tires and drive train remain in good shape.

The fourth option is to scrap the asset. Scrapping a truck is simple, management either sells the tractor to a scrap yard or strips the parts it desires to keep and then sells the remaining portion of the asset to a scrap yard. This obviously has the lowest return and is only used when the truck is so badly worn or damaged is has little or no value.

The ideal scenario is to get the maximum amount of use of a tractor with acceptable maintenance costs, then sell it at a competitive price. This involves making sound predictions of when major components like the engine,

transmission, and frame will fail. A strategy of avoiding the position of having to rebuild an engine or other significant components shortly before the sale date is essential since the sales price of the asset will not make up for the recently incurred maintenance and repair costs. According to one of the interviewees, one of the keys to effective disposal planning is being able to "predict failures that can be predicted, prevent failures that can be prevented, run to failure when safe and economical to do so, and to recognize the difference." In some configurations (e.g., local shipments) it makes sense to run the tractor to failure, and when the failures become too expensive to repair, scrap or salvage the unit (see Figure 2).

To illustrate the potential gains associated with employing a life cycle maintenance strategy, Figure 2 illustrates the estimated annual maintenance cost by age of tractor in each configuration. Team trucks have a higher annual cost and steeper slope as the age increases because they run roughly twice the miles. This results in more maintenance and the rapid expiration of the warrant period. As previously discussed, the opportunity cost for a team truck in any kind of maintenance is also considerably higher than the other configurations. Not only are maintenance occurrences more likely as a team truck ages, but breakdowns are more costly when compared to other configurations.
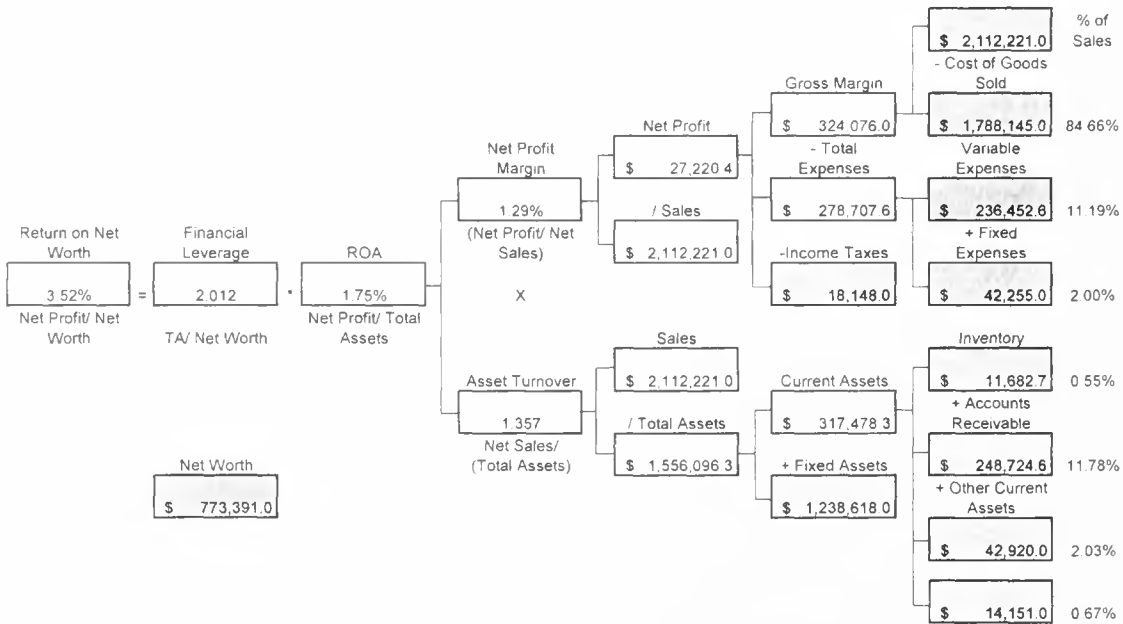

FIGURE 2
**ANNUAL MAINTENANCE COSTS FOR VARIOUS WORK CONFIGURATIONS**
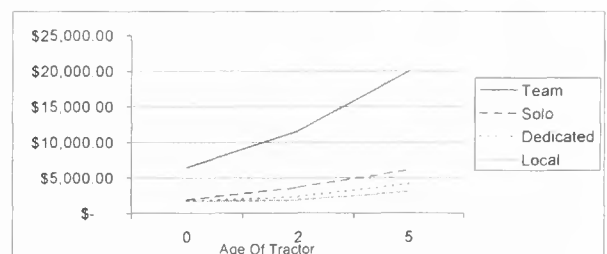
According to the data, for an asset utilized by a team driver configuration, the annual maintenance cost difference for a new truck versus a two-year-old truck is about $5,200. This cost difference expands to approximately $6,750 when comparing a new piece of equipment to a three-year-old asset. If the same truck was moved to a solo configuration after one year, the total maintenance cost would be approximately $3,200. This is a significant annual savings per tractor which could result in savings into the millions if assets were more appropriately assigned to a particular work configuration. Hopefully, life cycle cost analysis will aid carriers in their pursuit of enhanced asset scheduling and reduced maintenance costs.

Use of the strategic profit model to estimate cost savings for Swift Transportation illustrates the potential impact possible by employing such a strategy. The researchers used 2001 annual report data, estimated the potential cost savings of optimizing work configurations and applied the savings across the total number of assets owned by Swift. The profit model (See Figures 3 and 4) yielded an estimated savings of roughly $6 million in maintenance costs. As illustrated by the model, the reduction in total operating costs will lead to a significant increase in the company's return on assets measure. The results obtained by using the strategic profit model illustrate how the cumulative affect of closely managing work configuration can dramatically impact maintenance costs.

FIGURE 3
SWIFT TRANSPORTATION MODEL RESULTS
BEFORE WORK CONFIGURATION OPTIMIZATION

FIGURE 4
SWIFT TRANSPORTATION MODEL RESULTS
AFTER WORK CONFIGURATION OPTIMIZATION
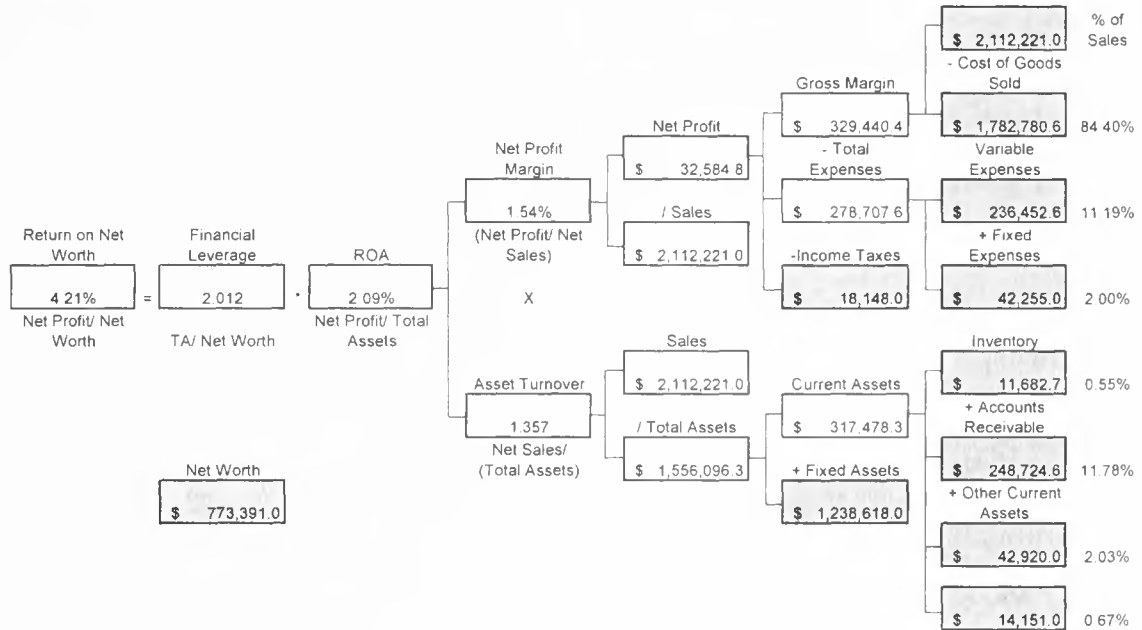
MANAGERIAL IMPLICATIONS AND CONCLUSIONS

Transportation providers have many decisions to make. Several of those decisions are based upon asset investment. Carriers must address what level of asset investment will be required to supply the customer's needs. Furthermore, once an asset is acquired, there are strategic decisions to be made on how to best maintain or dispose of an asset.

Shippers are shrinking their carrier bases and asking for more integrated services. Carriers must attempt to balance the need to remain price competitive in the marketplace with their asset acquisition and maintenance strategies. Acqui-ring too many assets too often can increase capital equipment acquisition costs, forcing the carrier to raise the price charged to customers. Conversely, carriers failing to acquire new or

updated equipment frequently enough may experience low asset utilization rates, high maintenance costs, and frequent service failures.

Life-cycle costing techniques provide some unique opportunities for carriers to effectively manage maintenance costs by assigning assets to various work configurations in a systematic method. Life-cycle costing provides its best results when both art and science are merged with good judgement. There are many aspects of life-cycle management that provide opportunities to reduce cost. One under-appreciated cost saving opportunity is better assignment of assets to particular work configurations. Placing the right trucks in the right configurations will enhance the efforts of carriers to make the right purchasing, maintenance, and disposal decisions.

Cutting costs without sacrificing service is critical to competing in the trucking industry.

Work configuration life-cycle management is an untapped source of cost reduction for many companies. The result of such an implementation could yield positive results and provide a carrier with an inherent advantage in a highly competitive industry.

Managers wishing to apply life-cycle management to the maintenance function must get accurate maintenance costs for various ages and configurations. The data used in this research are based upon relatively small samples and approximations from three truckload carriers. Each carrier will have slightly different data on configurations and maintenance costs. Once obtained, a detailed analysis should be done to determine the optimum mileage or timing of when to shift an asset from one work configuration to another.

Furthermore, to create a highly precise, predictive model, better information on the predictable failure time of the asset needs to be incorporated. Managers must also undertake an analysis of warranty recovery to determine the amount of the disadvantage of reaching the mileage warranty target before the age warranty target. Accurate weekly mileage estimates for the organization implementing the suggested strategies must also be made for each work configuration in order to verify significant differences.

Finally, the manager must also examine cost-per-repair on similar repairs for assets assigned to different configurations in order to confirm that there is a significant difference. Once these variables are examined, a good mathematical model for the organization's work configurations and related maintenance costs can be created. The results of the model can be utilized to aid management in the planning for effective asset rotation between workforce configurations for large and complex fleets.

Life-cycle management has been introduced as a way to effectively manage the asset acquisition, assignment, and disposal process. The researchers applied life-cycle techniques to maintenance costs and examined the impact of various work configurations on the total maintenance costs of a carrier. While additional research needs to be conducted, this technique shows promise as a tool to assist carriers in reducing maintenance costs through efficient asset work configuration assignments.

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AN EXPLORATORY STUDY INTO THE USE OF HYPER-INTERACTIVE TEACHING TECHNOLOGY IN THE LOGISTICS AND TRANSPORTATION CLASSROOM

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ABSTRACT

New technologies are being developed that can assist professors in the classroom. One is the Hyper-Interactive Teaching Technology or H-ITT. This is a system that allows instructors to gather instantaneous feedback from students for a variety of topics. The article examines the benefits and disadvantages of using H-ITT in the classroom and presents some initial findings.

INTRODUCTION

New technology is introduced into society on a daily basis. Some of this technology is generating new tools for the classroom. In many cases, the classrooms of today differ greatly from those of a few years ago. In the last ten years, faculty have incorporated the Internet, various computer applications (i.e., PowerPoint, Access, Excel, Supply Chain Pro, etc.), computer labs, smart boards and other items into the learning process. While none of these are designed to replace the traditional learning process, students have come to expect a technologically enhanced educational experience (Day, 1996). To meet student expectations, faculty should try to identify additional new technologies that can be applied in the classroom that continue to support and improve learning.

One of these emerging technology tools for the classroom is Hyper-Interactive Teaching Technology (H-ITT). H-ITT is an excellent example of using new technology to improve on sound, existing teaching techniques. H-ITT does not change any fundamental methodologies in the classroom. It does improve tested methods and improves the timeliness of feedback for both the instructor and students.

This article provides a detailed description the H-ITT system, an examination of the strengths and weaknesses of H-ITT, the areas of teaching supported by H-ITT, and finally some exploratory data from business logistics and global logistics classes. Finally, some conclusions concerning the effectiveness of technology in the logistics and transportation classroom are presented.

H-ITT TECHNOLOGY

Consider the television show, "Who Wants to be a Millionaire?" At some point, the contestant may decide to use a lifeline and asks the audience for help. The studio audience votes on the four possible answers to the question and the responses are instantly presented to the contestant. The contestant has immediate feedback to make a better choice. The H-ITT uses the same basic idea, but with many additional pedagogical tools incorporated into its system.

Hyper-Interactive Teaching Technology (H-ITT) is a system designed to collect information from respondents in a real-time setting. Each student is required to purchase a H-ITT device (Figure 1). The device costs about $30, has an "On/*" button and five response buttons: A through E. The H-ITT device uses an infra-red light to transmit the letter response (A-E) and its unique five or six digit identification code (Figure 2). This data is collected by receivers positioned within the classroom. The company recommends one receiver per 25 transmitters. Each receiver costs about $180. Finally, the data is sent to any computer that is connected through a communications port. There are two software programs that come from the company: H-ITT Acquisition and H-ITT Analyzer. The end result is an accurate, real-time collection method that identifies each individual user's response by question.

The H-ITT Acquisition program is used to collect the students' responses. By using Microsoft PowerPoint to prepare the question slides prior to class, the H-ITT Acquisition software displays the questions in sequence. The instructor can incorporate most types of media that can be placed on a PowerPoint slide into the question (i.e., text, graphics, pictures, etc.) Next, the professor can set up a number of options about the data collection. These options include the length of time that the question will be displayed, use of a H-ITT transmitter to identify the correct answer, point values of correct and incorrect responses, display of response histograms, and a host of minor options.

An example of the H-ITT Acquisition software is provided from a traditional introductory logistics course (Figure 3). A simple calculation is required from the students. Each student then sends his or her answer to the system. As they respond, their individual number is displayed at the bottom of the screen (an option). Also, this example is set to "memorize location." Therefore, the students' numbers will be in the same location each time. Also, a student may change his or her answer. A count is shown after the student's identification number for each answer change (see student number 396 on the bottom row).

Once the preset time period is over or when the instructor chooses to end the question, the results of the question can be displayed. This is an available option and would not make sense in a traditional testing format. However, if the goal is to improve interaction, feedback and effective learning, it can be a useful tool. Figure 4 presents the results for the actual question given in a business logistics class. Eighty-one percent of the students correctly choose "D" as their answer. This allows the instructor to assess whether the students understand the issue, or in this case, whether they are able to calculate a simple days-of-inventory type problem. Had a much larger number of students missed the question (e.g., greater than 50%), it would have been an indication that the class was not adequately prepared for the question. In that case, the professor could take immediate steps to correct the learning deficiency.

The H-ITT system supports interaction in a number of ways in the classroom. The second portion of the process is to use the H-ITT as an evaluation tool. It is possible to collect various types of data from the students using this system. A simple example is to take a number of questions as demonstrated in Figures 3 and 4 and have quizzes at various times during a course. Also, some mass lecture sections in the physical sciences are giving exams using the H-ITT devices. They have chosen this strategy due to the large number of students per section and the relative ease of grade entry.

FIGURE 1
H-ITT TRANSMITTER
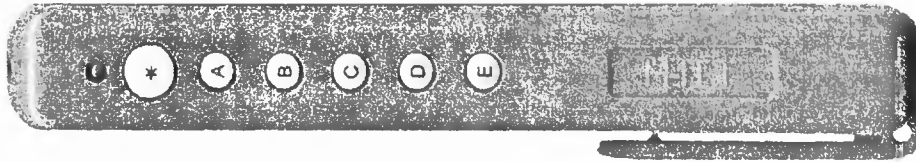
(Source: www.h-itt.com)

FIGURE 2
TYPICAL CLASS DATA COLLECTION
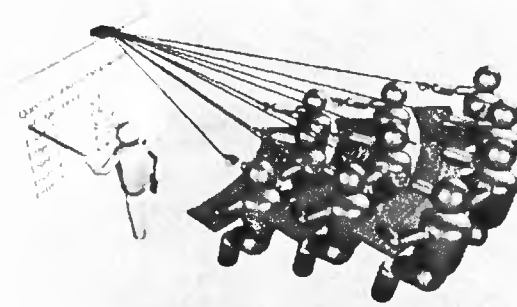
(Source: www.h-itt.com)

FIGURE 3
EXAMPLE BUSINESS LOGISTICS H-ITT QUIZ QUESTION

FIGURE 4
EXAMPLE BUSINESS LOGISTICS H-ITT QUIZ RESULTS

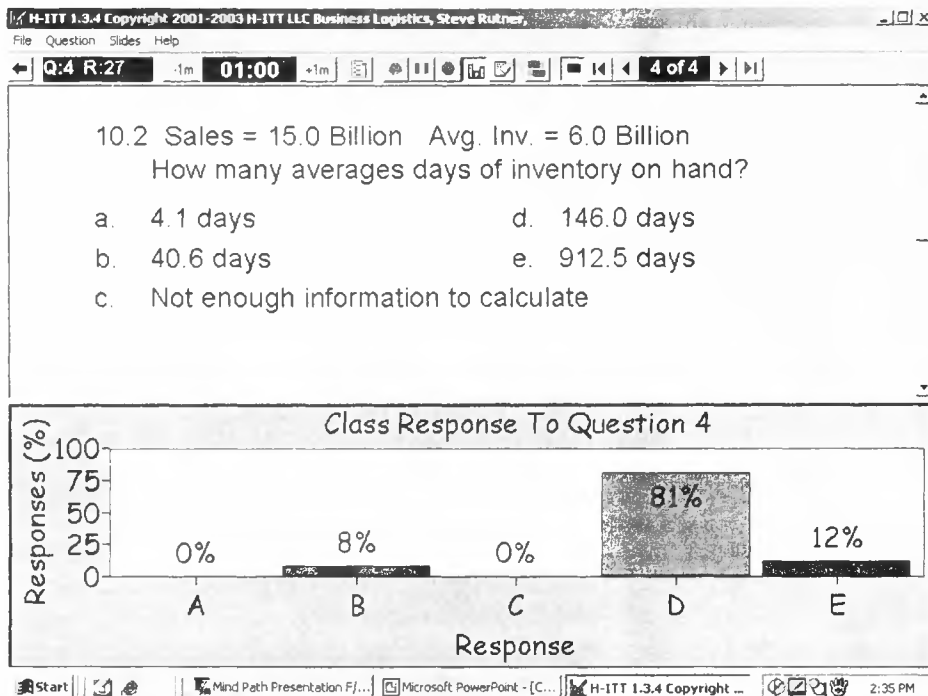The H-ITT Analyzer software provides a good tool to evaluate various items about an individual student's responses. Figure 5 presents a hypothetical set of results from students to maintain grade confidentiality. It demonstrates that every response by every student is recorded and stored. This data is easily converted to a traditional spreadsheet format such as Excel. Figure 6 also gives an additional example of the usefulness of the H-ITT system by showing how responses to an individual question can be analyzed. With this type of software, the professor may choose to make adjustments to the point values of individual questions.

Therefore, the H-ITT devices and software provide a sound system to use in the classroom to gather data from students. The collection software provides instantaneous feedback to both students and professors using a number of methods. It provides a tool that can be used to support various teaching techniques to improve learning.

PEDAGOGICAL FRAMEWORK

While the H-ITT system provides multiple opportunities for use in the classroom, the key criteria for success center on the specific pedagogical areas that H-ITT could improve or support. The evolution of today's classroom is from traditional professor-led lectures to a more interactive experience. In many cases, this changing learning environment is based upon improved technologies (Smith, 1996). This is further supported by students' increased expectations

FIGURE 5
EXAMPLE RESULTS

(Source: www.h-itt.com)

FIGURE 6
EXAMPLE RESULTS
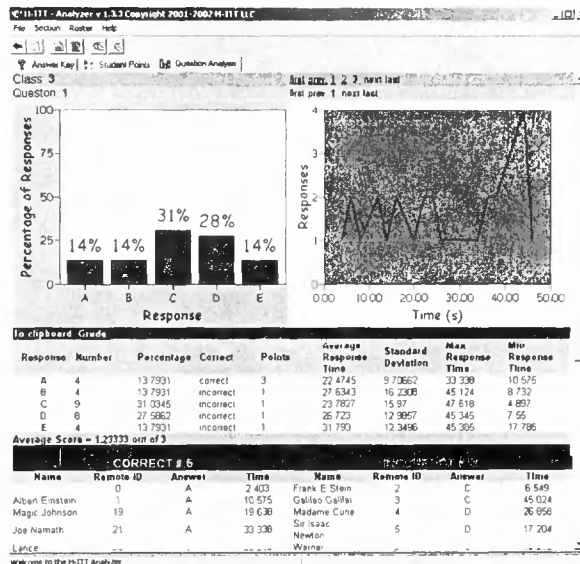
(Source: www.h-itt.com)

that the learning process include other methods beyond the traditional lecture format to help maintain interest in the subject material (Smart, Kelley and Conant, 1999). The H-ITT system does an excellent job of supporting these basic tenets. It is a relatively new and unique method to employ technology in the classroom.

The next major question to consider is whether the H-ITT is an effective tool to improve the learning process, or merely a "cool gadget" to amuse the students. The first important step in an improved learning experience is that it is interactive (Egemen, Edwards, and Nirmalakhandan, 1998). The H-ITT requires each student to participate with each question. Furthermore, the technology must support the learning objectives and be integrated into the curriculum (Zeon et al., 1999). The H-ITT device provides a tool that can support the curriculum if used properly. However, the instructor's choice of how the H-ITT is applied within the course will determine its success.

The final major pedagogical issue deals with the implementation of technology as a testing tool in class. There are numerous studies on the value of short quizzes in the classroom. However, there are two studies that specifically address short quizzes and using technology similar to the H-ITT. The first was performed using students in Georgia and Tennessee. Slough and Lane (1995) used a keypad system to gather responses from students. They found that both students' interest in subject matter and grades improved. The second study suggested that the use of "on-the-fly" questions with immediate feedback worked with various levels of students including MBA's (Marien, 1995). This study also suggested that the implementation of technology in the classroom improved learning when used for non-quiz type interaction.

An additional pedagogical point is the appropriateness of using a H-ITT like system in a university setting and specifically a logistics or transportation class. Previous studies had success with both undergraduate and graduate students. However, none of the studies applied the

learning methodology in a logistics classroom. The closest example was a study performed on international marketing students (undergraduate and graduate). The results included a statistically significant improvement on test scores for students using the interactive technology. Also, the students enjoyed using the interactive tools (Ueltschy, 2001). Ueltschy's study supported the concept of using "fun" tools in a marketing course. The H-ITT technology is similarly used to create "edutainment" as a learning tool in logistics and transportation classes (Rutner et al., 1997).

In summary, the concept of interactive technology does not create a new learning paradigm. Rather, it supports a number of proven, traditional pedagogical methodologies. The H-ITT system can be used to improve the effectiveness of quizzes, interactive surveys, etc.

H-ITT STRENGTHS AND WEAKNESSES

Given that the H-ITT system supports traditional learning models, it is appropriate to examine both the benefits and disadvantages of the technology. As with any new technology, there are a number of shortcomings with the current system. The first disadvantage is the capacity of the system to capture responses. The largest complaint students have is that they "cannot get their answer in (sic)." In other words, often the large number of responses to the system in a short period of time causes students to be unable to immediately input their answer into the system. There are three solutions to this problem. First, the instructor can limit responses to one side of the class at a time. Also, by lengthening the response time, students are less likely to all respond at one time. The final solution is to add response receivers in rooms with large numbers of students.

Adding receivers to the classroom highlights a second potential problem with the H-ITT system. There is a financial cost to implement this system. Each receiver costs approximately $180. A typical classroom (approx. 50 students) will require a minimum of two receivers and a

number of support items. Therefore, a college will spend about $500-$1,000 per classroom depending upon size. This assumes that the class is already equipped with a PC. Each student also needs to purchase a H-ITT transmitter. Although the cost is approximately $30, this is in addition to textbook, materials, etc. that a student must bear. However, this cost can be reduced. After two semesters in use at one university, on and off campus bookstores began to buy back H-ITT transmitters and resell them at a reduced price. Also, MBA students at this same university set up a secondary market for the H-ITT transmitters among the graduate students. A final point is that a student can use one H-ITT transmitter in multiple courses during a term and across terms. The best analogy is that the transmitter is much like a calculator. It can be used in many classes, but only by one student at a time. Although it is not possible for students in a given class to share a transmitter, it is possible to share across different classes during a term.

Another disadvantage to this system is the requirement that the student bring the transmitter to class each day. It is very likely that some students may lose their transmitter during the term. This adds to the individual's cost for the course. However, the collection software is able to assign multiple transmitter numbers to a single student. Therefore, a student will retain all of his or her points when multiple transmitters are used during a semester. Beside the permanent loss of a transmitter, the instructor can expect one or more students in each class to forget to bring the transmitter on any given day. The H-ITT program has an option for a "loaner" transmitter for students for a single class period.

The final disadvantage of the H-ITT system is the investment of time needed to use the system. The instructor should expect to have two to three hours of training before implementing the system in the classroom. Furthermore, it requires approximately five additional minutes per question to prepare quiz questions using H-ITT and PowerPoint. Finally, the quizzes take approximately one minute per question.

However, these times are relatively low given the benefits of the system. The collection of individual scores removes any grading requirements for the instructor. Therefore, the time needed before class for question preparation is more than offset in reduced grading time.

While there are some disadvantages, the H-ITT system has many positive attributes. The first is the ability to provide instantaneous, interactive feedback. As identified in the previous section, there are positive learning outcomes from instantaneous feedback. The H-ITT gives both the students and professor important information at the end of each question. The students learn the correct answer and the instructor learns if students have understood the concept or problem. For example, Figure 4 suggests that the students understood the relevant material, since over 80 percent were able to correctly answer the question. The professor can then move on to another topic or problem. However, if only 20 percent of the students had answered the question correctly, the instructor could choose to return to the previous material.

Another benefit of the H-ITT is in supporting the idea of in-class quizzes. The students appear to be more attentive throughout the class, since a quiz may occur at any time over any subject.

A hidden benefit of the H-ITT system can be an increase in class attendance. Students quickly become aware of the H-ITT process and expect it in each class. They know that they must be present to participate in a daily quiz and that there is a penalty for missing a quiz. However, instructors must be aware that it is possible for a student to operate a second H-ITT for a student not present. This is not a problem in a smaller classroom. However, in large, mass lecture types of classes, the professor must be careful to ensure that each student only uses one H-ITT device.

An additional benefit of the H-ITT system is that it provides an alternative method for evaluating in-class participation. Every professor recognizes

that soft-spoken, shy student that always comes to class, does well on tests and assignments, but rarely answers questions. The H-ITT provides students with another method for participating in the classroom. The quizzes are a form of participation and the results are recorded. Also, depending on how an instructor uses the H-ITT, it can help to draw out students for discussion. For example, the H-ITT can be used to gather opinion type data that can then be used to foster discussion between various factions of students in the class.

There are a number of minor benefits of using the H-ITT system as well. One is that students appear to enjoy using the devices. However, this may be a temporary response that dissipates once the technology becomes commonplace. Another minor benefit is the ability to collect other types of feedback in class. The most common can be collecting accurate "votes" on various issues (i.e., what type of test would you like? or what is the best date to make up a class period?) The only limit to the use of the H-ITT appears to be the creativity of the instructor.

A basic evaluation of the H-ITT system highlights a number of benefits and disadvantages. Table 1 presents a summary of these items given in the academic literature and the company's website.

INITIAL STUDY

Based on the potential benefits of using an interactive system in the classroom, it seemed appropriate to collect exploratory data for use in evaluating the H-ITT system. The data were collected on both student opinions and actual examination results. Both groups of data can be used to provide insight into the value of using the H-ITT in logistics and transportation classes.

Student Opinions

To evaluate the students' views of the H-ITT system, a few simple questions about the system were asked of two groups. One group of students

TABLE 1
SUMMARY OF H-ITT

Advantages
Instantaneous Feedback
Improved Attendance
Increased Attention
Alternative Method to Evaluate Participation
Student Enjoyment

Disadvantages
Cost – Student and University
Preparation Time – Primary Daily
In Class Time and Distraction
Technological Problems – Too Many Inputs, System Crash, etc.

Source: Leidner, 1995; Rutner, et al., 1997; Slough & Lane, 1995; www.h-itt.com, 2003

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was a class of undergraduates taking an introductory course in business logistics. The second group consisted of graduate students taking a course in global logistics. These two groups represent a good cross section of potential users of the H-ITT. The two classes were asked a number of basic questions about the H-ITT system. The demographics of the sample appear in Table 2.

The students were asked to give their opinions on a number of issues about the H-ITT system. The first group contained a series of 5-point scale questions from "loved" to "hated" or "strongly agree" to "strongly disagree." For reporting purposes, all the responses have been converted to $1 =$ the most negative finding to $5 =$ the most positive response. Table 3 summarizes the overall responses to these questions grouped by class level. Also, the table identifies statistically significant differences at the .05 level between the two groups.

The students do not appear to feel strongly about the use of the H-ITT. Most of the responses were

TABLE 2
STUDENT DEMOGRAPHICS

Variable	Responses
Male	65.8%
Female	34.2%
Undergraduate	60.5%
Graduate	39.5%
Major	
Logistics & Trans	42.1%
Other Business	42.1%
Non-Business	15.8%
1st Time H-ITT User	
Yes	44.7%
No	55.3%

grade higher on examinations. For that question, the undergraduates were much more supportive of the H-ITT than the graduate students (i.e., undergraduates may be much more grade focused.) The other area of significant difference between graduates and undergraduates concerned the belief that the H-ITT system had improved their understanding of class material. Again, the undergraduates had a much higher perception of the value of the H-ITT as an instructional tool.

There appeared to be no major differences between genders for any of the survey items. Also, there were no differences between first time users and students who had used the H-ITT in a previous class. The results imply that effectiveness of the H-ITT system is not affected by either gender or previous experience with the device. The instructor can be fairly confident that the H-ITT will not create a bias in any data gathered.

in the middle ranges of the 5 point scale. One interesting difference was between the undergraduate and graduate students when considering additional information about the system. Both groups were told that past classes using the H-ITT had scored approximately one-half letter

Two other questions focused on the specific strengths and weaknesses of the H-ITT system. The questions asked the students to identify the best and worst things about the H-ITT system. Tables 4 and 5 provide the results of these questions.

TABLE 3
STUDENT REACTIONS TO H-ITT SYSTEM

Question	Graduate	Under-Graduate	Sig.
How do you feel about the H-ITT system?	2.40	2.77	–
How do you feel about the H-ITT system with the knowledge that it improved previous students' grades?	2.47	3.22	.008
I think the H-ITT was fun to use.	3.33	3.22	–
The H-ITT helped me to better understand the class material.	2.53	3.91	.000
Recommend the instructor use the H-ITT in this and other classes.	3.33	3.65	–

TABLE 4
STRENGTHS OF THE H-ITT

What was the best thing about the H-ITT?	%
Reviewed material/questions	39.5
Increased class participation	23.7
Made me come to class	13.2
Nothing	13.2
Fun	10.5

TABLE 5
WEAKNESSES OF THE H-ITT

What was the worst thing about the H-ITT?	%
Too expensive	55.3
Forget to bring to class	23.7
Did not work in class	10.5
Too many people trying to enter results at once	7.9
It was just stupid	2.6

The students were pleased with the ability to review their knowledge of the subject material. Another recognized benefit was the system helped them to remain more involved in the class and improved their participation.

The students identified cost as the overwhelming weakness of the system. This is based on a price of $30 for the transmitter at the university bookstore. The cost of the H-ITT transmitter is actually higher, given that approximately five to ten percent of the students lose the transmitters each semester. These students must purchase a second device.

There are a number of solutions to the cost issue. As identified previously, a secondary market between graduate students helped to reduce the cost (approximately $15). Also, after two semesters in use, the off campus bookstores were buying used H-ITT devices and selling them at a reduced price. Finally, students in different class sections have shared a single transmitter. Therefore, while cost will always be a key issue with students, it is not an insurmountable obstacle.

There were a few open-ended comments that are useful in summarizing students' opinions. Also, they helped to shape the author's views on the value and future use of this technology in the classroom.

- "I liked the instant feedback, but there might be a better use of it than for a quiz."

- "I don't like giving or getting instant feedback from the class."

- "May we have more time to answer the questions? Forty seconds is not enough."

- "The Hitt Stick is a very efficient method."

- "It doesn't always work on the first try."

- "I would utilize it to motivate class discussion."

Examination Results

The H-ITT system was also evaluated upon student examination results. One instructor's introductory logistics courses provided the data set. The current and previous two semesters of classes had used the H-ITT system. The data set included raw test scores by exam for three classes using the H-ITT system and two classes without the system. Scores on each exam for classes with H-ITT were compared to scores on the same exam for classes without H-ITT.

Although not a perfect comparison, the choice of one instructor's classes did hold most of the possible variables constant: little change in material, same instructor, same style, same university, same textbook, same assignments, etc. Also, students were not allowed to keep the tests. Therefore, each current examination

included approximately 80 to 90 percent of the previous term's questions. This provided a useful dataset for comparison. Finally, all of the classes included four examinations and each exam covered the same material in the same period. Given this set of data, four t-tests were performed to evaluate any differences based upon the usage of the H-ITT system.

The first examination covered some of the basic principles and concepts of logistics, materials management, outbound logistics and supply chain management. The comparison of the raw test scores included three sets of students using the H-ITT and two sets that had not. The results indicate significantly higher scores for the students that used the H-ITT (Table 6).

The second examination covered the concepts of inventory carrying costs, EOQ, total annual costs, changes in the number of distribution centers and warehouse design. The material in this section is very quantitative and the exam involves a large number of calculations. The results of the t-test produced a surprising finding (Table 6). There is a negative relationship between H-ITT use and test scores. The implication is that the H-ITT works well in conceptual applications (Exam 1), but not when quantitative skills are involved (Exam 2). This may have been partly due to the fact that the H-

ITT questions used in class were focused toward qualitative issues and very few of the in-class questions required calculation.

The third test was similar to the first exam. It was conceptually based and covered topics such as international logistics, logistics information systems, and transportation management. In this section of the course, the H-ITT system appeared to have a positive impact (Table 6). Once again, the classes using the H-ITT system scored significantly higher on the exam. While all the differences appear small, the result is a measured three to five percentage change in the overall class average.

The final exam was non-comprehensive, covering both quantitative (i.e., facility location) and qualitative (i.e., SCM, 3PL, etc.) topics. Unfortunately, some of the material in this section of the course was changed during the most recent term, limiting the usefulness of the comparison. However, the results mirror the previous three findings. There is some improvement in test scores (Table 6), but the change is not statistically significant. This can be partially explained by the change in course material. Also, there were some calculation-type problems on this exam which appear not to benefit from using the H-ITT system as it was being applied at that time.

TABLE 6
SUMMARY OF T-TEST FOR EXAMS 1 THROUGH 4

	Exam 1		Exam 2		Exam 3		Exam 4	
	HITT	WO/HITT	HITT	WO/HITT	HITT	WO/HITT	HITT	WO/HITT
Mean	26.340	25.311	29.416	30.741	25.406	24.090	23.796	23.367
Variance	16.404	14.934	25.365	14.671	10.797	8.9341	17.371	17.720
t Stat	1.763		-1.821		2.513		0.606	
P (T < = t)	0.039		0.035		0.007		0.273	

The overall findings support the claim that the H-ITT system can positively impact interactive learning in the classroom. The H-ITT is popular with students and provides opportunities for increased learning in some cases. However, the negative results from Exam 2 suggest a need for more research and multiple samples.

CONCLUSIONS

The findings generated in this study provided some valuable insights into the use of the H-ITT system. While much of the literature strongly supports the benefits of various interactive teaching tools, the findings reported here suggest strong support in some areas and cautious interpretation in others. The negative results on the second examination and comments from the graduate students caused the instructor to carefully consider future H-ITT use. The results indicate that H-ITT is not a "magic bullet" that can cure all instructional problems. The H-ITT system must be applied like any other instructional tool. It has strengths and weaknesses. The H-ITT system can be a valuable tool when applied properly.

Based upon the findings of this study, the subject instructor will make the following changes in the

logistics and transportation courses. For undergraduates, there will be little change in the process. The H-ITT system will remain a method to check learning progress and understanding with review-type questions on a daily basis. However, in the highly quantitative sections of the course, more problems will be included as H-ITT questions. Also, fewer H-ITT quizzes will be used in the quantitative sections and more traditional teaching tools will be emphasized.

For graduate students, there will be a dramatic change in how the H-ITT is employed in the classroom. It will be used more to facilitate discussion. For example, based upon homework readings concerning a controversial subject, H-ITT quizzes will be used at the beginning of the class to assess student opinions on the issues. This can then be used to generate discussion of that topic. It will help to integrate reading assignments and improve class participation.

With these and other minor refinements, the H-ITT system can evolve into an excellent tool to help both students and instructors. The key to successful integration in the curriculum is the methods that instructors use to implement the technology in the classroom.

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DEPOT REPAIR CAPACITY AS A CRITERION FOR TRANSPORTATION MODE SELECTION IN THE RETROGRADE MOVEMENT OF REPARABLE ASSETS

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ABSTRACT

To support smaller reparable asset inventories, current Air Force logistics policies direct the "expedited evacuation of reparables ... to the source of repair." Mode selection is based on the asset. Focusing on the asset is an efficient and effective method of getting assets to where they are needed in a timely manner in the forward portion of the supply pipeline. However, in the reverse portion of the pipeline, the demand for an asset may no longer be critical to how it is transported. The quantity of the asset at the depot may already exceed repair capacity. In this instance, rapid movement results in the asset being added to the backlog already awaiting repair, thus retrograde modal selection focus should shift to repair capacity. Since the depots face budget and manning constraints and do not operate on a continuous basis, their repair capacity is limited. With finite repair resources, the question of when an asset can be repaired should be involved in mode determination. A stock-point modeling approach was used, with depot production requirements as a surrogate for demand in calculating shipping priority. Using Warner Robins Air Logistics Center reparable asset production data, this article illustrates potential savings in transportation that are possible utilizing an alternative factor in modal choice decision for the retrograde or reverse portion of the pipeline.

INTRODUCTION

Air Force guidance on management and direction of the reparable item pipeline is primarily found in AFPD 20-3, *Air Force Weapon System Reparable Asset Management* (Department of the Air Force, 1998) and the Air Force instruction which implements this policy directive, AFI 21-129, *Two Level Maintenance and Regional Repair of Air Force Weapon Systems and Equipment* (Department of the Air Force, 1998). This guidance provides the scope of the reverse pipeline which,

> begins when a weapons system reparable asset is removed from an end item, repaired or declared as NRTS (Not Repairable This Station) and concludes when the item has returned to the serviceable inventory (Department of the Air Force, 1998, p. 3).

This is a slightly expanded view of reverse logistics than is normally discussed, which ends when the item is returned to its point of origin. In AFPD 20-3, the Air Force expands the scope of retrograde logistics to include the repositioning of a newly-repaired asset. This guidance provides the basis for the reparable pipeline:

> The objective of Air Force logistics is to maximize operational capability by using high velocity, time definite processes to manage mission and logistics uncertainty in lieu of large inventory levels— resulting in shorter cycle times, reduced inventories and cost, and a smaller mobility footprint (Department of the Air Force, 1998, p. 1).

The policy directive goes on to direct the "expedited evacuation of reparables by bases…to the source of repair" (Department of the Air Force, 1998, p. 1).

The most significant aspect of this guidance is that the Air Force pipeline is transportation-based. Air Force logistics relies on a time definite and expedited means of transportation instead of inventory to counter variability. An Air Force Logistics Management Agency (AFLMA) study described the rationale for this policy:

> Air Force supply policies are closely linked to the use of premium transportation. The logic for these policies is based on the classic tradeoff between inventory investment and transportation costs…Air Force inventory policies are sensitive to transportation or pipeline times because inventory costs tend to be relatively high and transportation costs low (Masciulli, Boone, and Lyle, 2002, p. 2).

The Air Force's transportation guidance, AFI 24-201, *Cargo Movement*, also reinforces this notion:

> Increased transportation costs are offset by reduced inventory levels resulting in overall logistics savings and mission sustainment (Department of the Air Force, 1999, p. 9).

Transportation Mode Selection

Reliance on transportation to support lower inventory levels and faster cycle times places a premium on transportation mode selection. Various authors have stated that the importance of transportation mode selection lays in its impact on a firm's total logistics system (Stock and Lambert, 2001; Coyle, Bardi, and Novak, 2000; Liberatore and Miller, 1995; Sheffi, Eskandari, and Koutsopoulos, 1988). But more than that, it is the interaction and synergy between logistics activities that drive costs. Stock and Lambert state,

> Effective management and real cost savings can be accomplished only by viewing logistics as an integrated system and minimizing its total cost given the firm's customer service level (2001, p. 28).

The customer service level provided by a mode of transportation is the preeminent factor involved in mode choice. This is not to say that the goal is the highest level of service available. It is the

optimal level of service that is desired, once other trade-offs have been considered. Stock and Lalonde, in a pre-deregulation study, found that service related variables, such as reliability, loss/damage, and total transit time, were most important (Stock and Lalonde, 1977, p. 57). For pre-deregulation this would have to be true, since price was not allowed to be utilized as a competitive weapon.

Other studies (McGinnis, 1990; Murphy and Hall, 1995) have shown this to be true after deregulation. Confirming this and broadening the scope to post-deregulation, McGinnis found that,

> While post-deregulation literature suggests that shippers have placed greater emphasis on costs since 1980, shipper priorities have not changed fundamentally... (McGinnis, 1990, p. 17).

Murphy and Hill (1995), in their analysis using studies published in the early 1990's demonstrated that customer service was still the preeminent factor. However, costs have grown in importance during post-deregulation:

> Shippers in the U.S. value reliability more highly than cost and other service variables in the freight transportation choice process... (Murphy and Hill, 1995, p. 37).

The goal in modal choice decisions is to use the lowest cost transportation *consistent with a given service level.* The overwhelming driver of mode choice cited was customer service first, followed by an optimization of costs (Giese, 1995; Rautenberg, 1995; Coyle, et al, 2001; Stock and Lambert, 2001). However, costs must be considered. Quite a few authors make this point:

> Freight rates are an important variable that should not be ignored... (McGinnis, 1990, p. 17).

> Economic and resource constraints mandate that organizations make the most

efficient and productive mode and carrier choice decisions possible (Stock and Lambert, 2001, p. 355).

When costs are considered, freight cost should not be analyzed in isolation. Coyle, Bardi, and Novak (2001) note that failure to consider the total picture is hazardous. Simply selecting a low cost mode, while lowering transportation costs, may raise inventory or warehousing costs, and reduce customer service.

Air Force Transportation Mode Selection

The Air Force logistics system is transportation-based and relies on a time definite and expedited means of transportation instead of inventory to counter variability. This places a premium on effective mode selection. The applicable transportation guidance in this area is found in three publications. The first is the *Defense Transportation Regulation* (DTR), Part 2 (Department of Defense, 2000). This document sets time standards and allows for expedited movement of cargo when needed. Second, AFI 24-201, *Cargo Movement* (Department of the Air Force, 1999), is the overarching Air Force transportation regulation. Finally, *Air Mobility Command Freight Traffic Rules,* Publication Number 5 (AMC, 1999), applies DoD transportation rules to all carriers hauling freight for the DoD. These three regulations cover the span of the movement of freight within the DoD and the Air Force. In addition to the transportation guidance, AFI 21-129, *Two-level Maintenance and Regional Repair of Air Force Weapons Systems and Equipment* (Department of the Air Force, 1998) states the following:

> Traffic managers must ensure that reparable 2LM [two-level maintenance] items are evacuated as quickly as possible for shipment to repair activities. Shipment planners must make every effort to ship those assets the same day they are received from Supply or Maintenance organizations (Department of the Air Force, 1998, p. 11).

From the guidance on reparable maintenance, instructions require that the NRTS asset be transported off base as quickly as possible. Further, regulations state that the reparable assets should be "moved using fast, time-definite best value transportation…" (Department of the Air Force, 1998, p. 11).

However, as one study of Air Force shipping policies states, "the definitive word comes from AFI 24-201" (Masciulli and Cunningham, 2001, p. 4). This transportation instruction provides Air Force transportation managers with the direct guidance on selecting the mode of transportation for a NRTS asset. Chapter 2 of AFI 24-201 provides the concept of operations for transportation managers.

According to this document, all reparable items will be shipped using commercial express. Explicitly, the directive states:

> Commercial air express small-package delivery service… is the norm for Agile Logistics/2LM/Rapid Parts Movement shipments to meet Air Force sustainment goals (Department of the Air Force, 1999, p. 9-10).

It also sets a rigorous and compressed time standard of 24 hours from the time an item is declared NRTS by maintenance until it is processed through supply to transportation and picked up by the carrier (Department of the Air Force, 1999, p. 10). AFI 24-201 also states that the DoD is a mandatory user of the General Services Administration small package express program. In other words, any item shipped by the DoD (and thus the Air Force), must be sent by express air. The exceptions to this are provided in paragraphs 6.1.1 through 6.1.5 of the instruction (Department of the Air Force, 1999, p. 22). Three of the major exceptions include distances under 500 miles, contingency operations, and shipments over 151 pounds.

The overall Air Force policy on transportation mode selection (for forward or retrograde movement of assets) is a fast, time-definite,

traceable means. Mode is not dictated (see also Kossow, 2003; Masciulli, et al., 2002; and Masciulli and Cunningham, 2001). However, as is seen in AFI 24-201, it may be specified in certain instances. For example, an individual shipment under 151 pounds and over 500 miles distant from origin will be sent via express air under the terms of the GSA small package express contract.

Masciulli and Cunningham (2001) analyzed Air Force Mission Capable (MICAP) part shipping policies and examined MICAP shipment data. They found that current Air Force shipping policies are less than optimal from a cost standpoint (Masciulli and Cunningham, 2001, p. 4). Of particular interest is the heavy reliance on the use of premium, overnight air to ship items. The data used in this study had several examples of misuse of premium, overnight air, including a shipment that traveled a total of 11.4 miles. They raised the following question regarding this issue:

> …is the use of FedEx so ingrained in the Air Force and DoD corporate culture [that] it is automatically … used as the carrier for MICAP items and other time-critical shipments without regard to cost, distance or other factors? (Masciulli and Cunningham, 2001, p. 7)

The problem with the current Air Force policies is that they seek to optimize the entire logistics pipeline by optimizing each individual segment in terms of transportation times. The reasoning is, if the part is shipped by the fastest mode in each segment, this will result in the fastest overall order cycle time. However, this view ignores the effects of bottlenecks in one segment that might affect other decisions in that segment or other segments, and is the antithesis of the systems approach to logistics management. Current Air Force reparable asset management policy calls for the expedited movement of reparables,

> …using high velocity, time definite processes to manage mission and logistics

uncertainty in lieu of large inventory levels... (Department of the Air Force, 1998, p. 1).

In addition, Air Force transportation policy, while not dictating mode, further calls for the fast movement of reparable items (Department of the Air Force, 1999). This policy may focus inappropriately on the asset, rather than being contingent upon what is happening at the repair depot. The quantity of the asset at the depot may already exceed the depot repair capacity. In this instance, the rapid movement of an asset to the depot would result in the asset arriving and being added to the backlog of items awaiting repair. This would be an inefficient use of transportation resources.

ANALYSIS

This article examines the use of depot capacity as a determinant of retrograde mode selection. No previous studies were found that incorporated the use of receiver capacity to process (by repairing or otherwise modifying) the item shipped as a determinant in mode selection. In this study, the required transportation service level will be determined by what is occurring at the depot. The quantity of assets at the depot and the depot repair capacity are used to determine what service level is required and, where this level could be provided by a lower cost mode, potential cost savings are calculated.

Supply Data

The supply data were obtained from the depot wholesale and retail receiving and shipping database. The data include two measurements per month from January to July 2002. The depot pipeline data needed from these measurements are the quantities of each national shipping number (NSN) that are in the depot pipeline and are physically at the depot.

Also needed is depot capacity. However, depot capacity data could not be obtained from the air logistics centers (ALC). The Oklahoma City ALC

responded to a request for capacity data with the following:

> As we operate today, capacity is a very, very rough cut determination ... capacity requirements planning at the rough cut level may indicate sufficient capacity exists to execute a master production schedule only to find at the micro level (close to or at the time of production) that capacity is insufficient ... there are too many variables surrounding the determination of shop capacity to make any kind of reliable statement concerning the mode of shipment based on capacity data (Oklahoma City, ALC, 2004).

The other depots confirmed this, describing shop capacity as a "floating" or "running" figure based upon budget, manning, and equipment. Therefore, a surrogate measure for depot capacity was developed.

Depot Capacity and Induction Requirements

In order to determine the shipment priority of a reparable item back to the depot repair station, the time sensitivity of the shipment must be established. The repair schedule, a combination of depot capacity and funded repair authorizations, determines the monthly requirement for the numbers of items to be inducted for repair. A stock point model approach was used to determine time sensitivity. The sensitivity is based upon shipping mode selection in order to prevent "stocking out" of items for induction.

The stock point model approach is based upon maintaining sufficient stocks of an item of inventory in order to ensure an acceptable level of risk of having insufficient inventory to meet demand. In this application, demand is the need for reparable assets to induct for a given production cycle. If the number of such items at the beginning of a production period is already sufficient to meet all of the induction needs for that period, then no shipment is required. If there are insufficient

items to meet the production need, then shipments must be scheduled in order to provide items ahead of need in order to assume a limited risk of stocking out.

In this research, the induction needs of the depot repair shop were treated as the "customer demands" for the stock point model. Actual depot capacity sets an upper bound for the number of items that could be repaired in any monthly period. While the lower bound for any period is zero, the funded allocation of repairs per month over the annual budget cycle would set a practical average level of induction in any period. While information on actual depot capacity (upper bound) was not available, actual production counts (demands) were available from historical records.

Depot production data were acquired from Warner Robins ALC. Actual monthly production quantities of national shipping numbers (NSN's) produced by repair shops at Warner Robins from October 2000 to December 2003 (less missing data for April 2002) for approximately 5,500 NSN's were obtained from historical records. Using Microsoft Access, these files were joined together to yield a sample of NSN's with non-zero production counts in each month. Descriptive statistics were calculated for these items to compare against depot stock. While all data samples did not strictly adhere to a theoretical normal distribution, the data were sufficiently symmetrical and mound-shaped, and the samples large enough, to apply the central limit theorem. Under the application of the stock point modeling technique, this data represented "customer demand" for the purpose of calculating risk of stockout and time sensitivity of resupply.

Transportation Data

Transportation data came from Headquarters, Air Force Materiel Command's Logistic Support Office (LSO), and the D087T, "Tracker" database. The transportation data required consisted of the trip information and cost data. In addition to actual transportation data, information on an alternate transportation mode is needed to evaluate the effectiveness of mode selection.

Methodology

Since only Warner Robins ALC provided production data, the pool of NSN's is limited to those for which this center is either the source of repair (SOR) or source of supply (SOS). To ensure 30 or more observations, only those NSN's that were in all three years of the monthly production data were used. These NSN's serve as a filter for the transportation data. NSN's having fewer than two shipments (air or ground) were also excluded. Of the NSN's remaining, only those with eleven or more shipments were used in this study.

Once the sample was obtained, the methodology became fairly simple in nature. The intent was to evaluate the efficacy of the modal choice made. Throughout the analysis, it involved comparing the depot stock (consisting of condition code F reparable items in depot supply and those in transit to the depot repair shop from depot supply) with the depot production averages calculated from the Warner Robins ALC production data. For this model, if the depot stock is greater than the average monthly production, plus three standard deviations for a given reparable asset, the asset can be sent by the least cost method. This test was performed on all 3,189 NSN's. Because 14 different production data files were available, each NSN was evaluated for efficiency of modal selection 14 times.

The use of $\mu + 3\sigma$ was decided upon because 99.7 percent of all measurements fall within three standard deviations of the mean. Since, for the purposes of this study, only the right tail of the distribution is relevant, 99.85 percent (virtually all occurrences) of the time the depot repair shop production rate will be less than $\mu + 3\sigma$.

The final step is to calculate a potential savings figure using an alternate mode (in this study FedEx ground shipments) for shipments that passed the above mentioned test ($\mu + 3\sigma$). Of the

NSN's remaining after the paring is accomplished, a random sample of 35 NSN's were selected to calculate this cost saving. In Microsoft Access, the results of the modal tests and the transportation data were linked in a query that filtered for shipments of the 35 randomly selected NSN's and for the given date of the production data file, then screened out those that failed the test.

A significant number of transportation records were missing the actual cost data. Due to this fact, the 2004 FedEx government domestic express rate for standard overnight shipments was used for the cost of the shipments. The 2004 FedEx government rates for two and three day rates and the FedEx standard commercial ground shipment rates were used to calculate the savings gained by going with a slower mode, and the percentage saved over standard overnight rates was also calculated. The difference in cost between the mode used and the alternate mode, multiplied by the number that could be shipped using a least cost approach, gives the total potential savings. In order to ascertain what these savings might constitute when projected over the entire set of repaired NSN's, the savings from the random sample to the population were extrapolated.

Transportation Mode Evaluation

Once the sample was obtained, the ability to ship via a slower or lower cost mode was evaluated. The depot stock figure, consisting of the sum of condition code F items in depot supply, and those in transit from depot supply to the repair shop, was calculated for all 3,189 NSN's for all 14 of the production data files and compared with the average monthly production, plus three standard deviations. Table 1 displays the results of this comparison by sample size.

Potential Savings

After obtaining the results of the modal evaluation analysis, the data were filtered for those shipments on the dates of the production data files from the 35 NSN's whose depot stock

allowed for slower transportation. A total of 34 of the 35 sample NSN's had at least one occasion of depot stock exceeding the production rate. These NSN's had a total of 114 shipments on the dates of the 14 data files. The calculation of savings is provided in Table 2.

Calculating what that savings might constitute when extrapolated over the entire set of repaired NSN's was accomplished by assuming that the savings of a larger sample is proportional to the relative sizes of the two samples. Table 3 shows the results of this extrapolation.

Recall that this figure is only for 14 days, assuming the ratios hold throughout. Annual savings would be derived by dividing the savings figure by the ratio of 14/250 (assuming no shipments on weekends or federal holidays). Annualized extrapolation would yield savings of $102,055,053.87 for all NSN's and $38,771,413.33 for those managed by Warner Robins ALC. A simple "back of the napkin" sensitivity analysis

Table 1
Results of Modal Evaluation

Sample	Trials	Success	%
35	490	410	83.7
213	2,982	2,585	86.7
593	8,302	6,283	75.7
3,189	44,646	24,189	54.2

TABLE 2
SAVINGS FROM ALTERNATIVE MODE

	Cost	Savings	% of SO
Standard Overnight (SO)	2,577.96		
2 day	2,202.36	375.6	14.57%
3 day	2,071.88	506.08	19.63%
Ground	1,080.05	1,497.91	58.10%

TABLE 3
EXTRAPOLATION OF SAVINGS*

	Sample Size	Ratio	Savings ($)
Total Repair NSN's	133,538		5,715,083.02
WR ALC NSN's	50,732	0.380	2,171,199.15
NSN's with Production Data	3,189	0.063	136,481.00
NSN's with Activity	593	0.186	25,378.88
213 > 11 ships	213	0.359	9,115.85
Random Sample	35	0.164	1,497.91

*This assumes the ratios hold throughout

illustrates that, even if the results of the interpolation were off by 90 percent, substantial savings would result from a modal selection process that utilized depot capacity and on-hand inventory as decision criteria.

RESULTS

This research addressed the basis for Air Force transportation mode selection in the retrograde movement of reparable assets. Air Force inventory policy is transportation-based, offsetting the increased transportation costs with lower inventory expenses. Overall policy directs shipment by a fast, time-definite and traceable means. While in general mode is not directed, in the review of Air Force policy, it was shown that certain supply and transportation policies, such as Agile Logistics, Two-Level Maintenance and Rapid Parts Movement required fast movement of reparable items in those categories. According to one study of this process, most often this means that an NRTS asset is shipped via premium air transportation (Masciulli, Boone, and Lyle, 2002).

The literature review has shown the focus of Air Force modal selection to be on the asset, its type and the current demand for it. While these are important in mode selection, in the reverse portion of the logistics pipeline, using these to determine the shipment mode omits a critical factor affecting this decision. This factor is the

limited or finite repair capacity at repair depots. The fact that there is a finite repair capacity should be the major determinant in how an asset is shipped. Otherwise, if the depot has a sufficient quantity to work on (for this study a one month supply was considered sufficient), after express shipping the asset to the depot, it will just sit and await repair. This produces a situation analogous to our military's notorious penchant for "hurry up and wait." In addition, this also results in the over-expenditure of a significant amount of resources for premium air when a slower, cheaper mode would have sufficed.

CONCLUSIONS

The U.S. Transportation Command's Strategic Distribution program guidance states,

> Improved retrograde of valuable, repairable stock to service maintenance depots, synchronized with depot repair schedules, has enormous potential in areas of readiness, reduced inventories, and long-term cost savings (USTRANSCOM, 2003, p. 15).

While reverse logistics and synchronization may not seem directly germane to transportation mode selection, it is essential that mode selection not be made in a vacuum. The entire system must be considered. As Stock and Lambert put it,

effective management and real cost savings can be accomplished only by viewing logistics as an integrated system and minimizing its total cost given the firm's customer service level (2001, p. 29).

Part of this systemic view entails taking into account what is happening upstream at the source of supply and repair. This research queried whether depot repair capacity should be a factor in retrograde transportation mode selection. The results make the answer to this question an emphatic yes. The high percentage of "passes" (incidences of depot stock being greater than depot production) indicates that the depot has more than enough to work on. For these items, shipment by premium air (standard overnight service) will not result in efficient induction, repair and return to using bases. Rather it will mean their addition to the assets already awaiting induction for repair.

Implicit in Air Force reliance on fast transportation to offset smaller inventories is that this tradeoff has to be made. It should follow that the depot should be dependent upon fast shipment to maintain production. While this methodology presented depot stock as being greater than production rate as a "pass" or "success," it actually represents a failure of the logistics system to successfully make the tradeoff between inventory and transportation. In those instances, a part was either sent too fast or a point where the Air Force possessed too much inventory was identi-

fied. This research illustrated that it is possible to switch modes without relaxing service level (in many instances, ground can match air in next day service) and, with the 83.7 percent pass rate of depot stock greater than depot production, the service level can be reduced without impacting production.

Furthermore, this research was conservative in the determination of situations in which assets could be shipped slower without impacting production. Under the methodology used in this analysis, even shipping the items back via ground (with the worst case transit time being a five day trip from the Pacific Northwest) would still result in those items awaiting repair, at reduced transportation cost. This analysis has not approached the point of synchronization of transportation with repair production scheduling. It was assumed, regardless of mode selected, that the items would still ship. However, because the production rate used was a monthly figure, the "passing" of the depot stock test could also produce a hold signal for the transportation coordinator. This could allow for further efficiencies and savings to be attained through shipment consolidation (perhaps even at the truck load level). Finer production rate data (at the weekly level) would further enhance the ability of this test to determine mode and get closer to synchronization. The closer the Air Force can get to synchronization of transportation with repair schedules, the more efficient transportation modal decisions will become.

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Journal of Transportation Management

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Book:

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

MANUSCRIPT SAMPLE

A FRAMEWORK FOR EVALUATING SUPPLY CHAIN PERFORMANCE

Terrance L. Pohlen, University of North Texas

ABSTRACT

Managers require measures spanning multiple enterprises to increase supply chain competitiveness and to increase the value delivered to the end-customer. Despite the need for supply chain metrics, there is little evidence that any firms are successfully measuring and evaluating 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.

$$y = a^2 - 2ax + x^2 \tag{1}$$

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