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From the Editor...

It has been a "late" spring here in the South! It seems that every time I think I will be able to get an issue of the *JTM* to the printer early, I end up being punished for my optimism. Such is the case with Volume 17, Number 1! After you read the included articles, I hope you feel that they were worth the wait.

The lead article in this issue, by Harry Sink, employs data from a mail survey to determine the benefits that are sought by purchasers of third party logistics services. Cluster analysis is then used to identify viable market segments for 3PL services. In the second article, Michael Mongold and Alan Johnson describe the use of "pure pallets" (user-specific pallets), rather than traditional break-bulk methods, to move military cargo. They compare the two with respect to requisition wait time, cargo throughput and revenue performance. In the third article, Michael Maloni provides the most comprehensive review and summary of the literature on third party logistics that I have seen. He has produced a reference work that will be valuable to researchers and practitioners for years to come. The fourth article is radically different from those that precede it. Jennifer and James Pope describe their experience in analyzing a circular queueing system for a manufacturer of peanut butter! They developed a simulation model of the rail supply system in use, and evaluated a number of potential variations in an attempt to improve system efficiency. In the final article of this issue, Carol Johnson, Lidiya Sokhnich and Charles Ng investigate the impact of several supply chain dimensions on overall firm performance. Lidiya and Charles, both undergraduate students working with Carol, build on a research stream initiated by Carol. Their work is impressive!

In the last issue of the *Journal*, I reported that John Kent would be serving as Special Editor for this issue. Due to time constraints, that did not happen. However, I am pleased to report that John, Associate Professor of Logistics and Transportation at Missouri State University, will be the "Special Editor" for the Fall 2006 issue. If you have a manuscript that you would like John to consider, send it directly to him at the following address:

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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 transportation and logistics activities, would be inappropriate for the *JTM*.

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

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

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

PUBLISHING DATA

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

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

WHAT DO THIRD PARTY LOGISTICS BUYERS REALLY WANT? AN EMPIRICAL ANALYSIS UTILIZING BENEFIT BASED MARKET SEGMENTATION

Harry L. Sink
North Carolina A & T State University

During the last decade the third party logistics market has grown significantly in the United States. While a degree of uncertainty continues regarding the definition of third-party logistics, a reasonable consensus of the concept has been described as

> a relationship between a shipper and third party which, compared with basic services, has more customized offerings, encompasses a broader number of functions and is characterized by a longer-term, more mutually beneficial relationship (Afrik and Calkins, 1994).

Competitive conditions have forced many firms to revise their priorities and focus resources on a limited number of key activities. Business process redesign has revealed the in-house provision of logistical services to be less than critical in the creation of customer value for a growing number of organizations. Thus, the U.S. third party logistics market now accounts for $85 billion of the $1.015 trillion total market for transportation, warehousing, and related support services (Langley, van Dort, Ang, and Sykes, 2005). The level of interest in logistics outsourcing can be further gauged by recent survey responses from chief logistics executives of the 500 largest American manufacturers. The participants currently reported spending 40 percent, on average, of their entire annual logistics budget with third party logistics providers. A consensus of the respondents indicated an expectation to increase this amount to 46 percent within three years (Lieb and Bentz, 2005).

Currently there exists a paucity of empirical research concerning the intrinsic drivers underlying the purchase of third party logistics services. The identification of market segments and the design of successful marketing strategies rely on understanding the benefits desired by existing and potential customers. Past research has found the benefits derived from products and services to be prominent discriminatory variables in market segmentation (Haley, 1968; Wind, 1978). The principle underlying benefit-based segmentation is that buyers are not seeking a product or service per se, but the value represented by the acquisition. In other words, how does the product help meet needs or provide benefits?

The present literature does not reveal an attempt to empirically determine the benefits sought by firms seeking to outsource logistics or whether homogeneous buyer segments exist in this market. Further, suppliers appear deficient in their understanding of the inherent value industrial buyers are seeking from the acquisition of third party logistics services. Current marketing strategies use broad based approaches in an attempt to reach potential customers based upon traditional measures of industrial segmentation, i.e., geographical location, decision making process, SIC code or industry, etc. Thus, these shortcomings highlight the need to determine the benefits desired by the purchase of third party logistics services and whether the buyers of these services can be segmented into homogeneous groups based on the unique benefits sought by each group. Further, third party logistics firms may gain a sustainable competitive advantage via innovative industrial buyer market segmentation.

STRUCTURAL UNDERPINNING FROM EXISTING LITERATURE

Segmentation is a process that subdivides markets into potential customers with similar traits likely to exhibit comparable purchasing behavior. Most firms cannot pursue each and every market opportunity, as resources are routinely limited. However, in practice, many organizations ignore this fact and treat the entire market as potential customers for their products or services. This approach to marketing is known as aggregation and employs an undifferentiated strategy. Aggregation is akin to a shotgun approach to marketing while segmentation can be likened to a rifle shot methodology (Weinstein, 1987).

There are a number of requirements surrounding effective market segmentation. Chief among these are the need for measurability (segment size, purchasing power, customer profile), accessibility (ability to reach and serve), and size (large enough to warrant a tailored marketing program). Other segmentation requirements include differentiability (market segment must be distinguishable and respond differently to elements of the marketing mix) and actionable (effective marketing programs may be derived to attract and serve the segment) (Armstrong and Kotler, 2000).

Numerous methods have been employed to identify market segments, e.g., by geographic regions, by demographics, via product usage, by the decision process employed in purchasing, using firmgraphic variables such as SIC codes, revenue and number of employees, by adoption propensity (early vs. late), and by the meeting of needs or the provision of benefits (Market Vision Research, 1998). However, segmentation via the meeting of needs or benefits derived from a purchase is the only method based on buyers' underlying motives. Meeting needs provides benefits and is the genesis of purchasing behavior. Benefits are the sum of advantages derived or satisfaction resulting from the fulfillment of perceived needs or desires (Weinstein, 1987). For example, logistics mangers do not buy freight transportation to merely transfer their firm's goods; they complete this transaction as a means of providing customer service.

Industrial markets are more difficult to segment than consumer markets as industrial products are often employed in multiple applications or different products may be used in similar applications. Also, industrial purchasers differ greatly and it is arduous to determine which differences are meaningful and those that are trivial when developing a marketing strategy. Researchers have identified five general segmentation criteria, arranged in a nested hierarchy, as bases for industrial market segmentation. These are demographics, operating variables, purchasing approaches, situational factors, and personal characteristics. Variables that are more easily observed, such as demographics or operating variables, compose the outer nests while criteria that are more specific and difficult to determine constitute the inner nests. Outer nest variables are usually held to be inadequate for industrial segmentation in all but the most simple or homogenous markets, as they do not consider the differences among industrial buyers or their purchasing motivations (Shapiro and Bonoma, 1984).

Once market segments are identified they must be evaluated to determine whether they are viable. Prior research has revealed three factors critical in the evaluation of market segments. These are (1) the overall size of the segment and its propensity for growth, (2) the structural attractiveness of the segment regarding revenue and profit and (3) the selling organization's long-run objectives and resources. Firms are cautioned to enter only segments in which they are likely to develop sustainable competitive advantages (Armstrong and Kotler, 2000).

While the existing literature includes much previous work concerning the segmentation of consumer markets, research involving industrial applications is limited. This is likely because industrial purchasing often involves a team approach and results in a much more challenging arena for investigation. Also, the use of benefit-based approaches to industrial market segmentation, as described in existing literature, is scarce probably due to the rigor associated with these methodologies. However, the advantage of industrial market segmentation using benefit-based methods is potentially more beneficial than other techniques routinely employed.

The advantages associated with benefit-based segmentation methods include the identification of market segments based on causal factors, a revealing of opportunities for new product/service development, an effective approach to reaching homogenous buyer groups, and an efficient use of marketing resources (Kerin and Peterson, 2004). Benefit-based market segmentation can provide the above referenced advantages to third-party logistics firms seeking to differentiate themselves by meeting the specific needs of industrial buyers. This strategy may also lead to a sustainable competitive advantage in a significant and growing industrial market.

RESEARCH APPROACH

The nature of this study should be considered exploratory since there has been no previous published research regarding benefit based segmentation of the third party logistics market. The methodology employed to address the questions of desired benefits and the potential segmentation is an adaptation of the approach used by Moriarty in his study of the potential for buyer segmentation in the data terminal market (Moriarty, 1983). This design was particularly appropriate as third party logistics services, like data terminals, are purchased for a wide variety of industrial applications.

The initial research phase involved the use of a focus group to generate constructs and provide pre-scientific knowledge. Insights from the focus group were used to prepare a cross-industry mail survey of experienced third party logistics buyers. Focus group participants were recruited from a group of senior logistics, purchasing, financial, manufacturing and human resource managers. Candidates were identified using three sources, i.e., recommendations from a major U. S. based supplier of third party logistics services, an experienced logistics academic, and several industrial directories.

Structure for the focus group interview was provided by a topical outline developed from a literature review and preliminary interviews with experienced third party logistics buyers. Interview questions examined the perceived need for third party logistics services, the advantages and disadvantages of logistics outsourcing, benefits resulting from successful logistics outsourcing, buyer perceptions of current providers and the procurement process. The focus group was conducted by an experienced moderator at the facilities of a professional marketing company located in a large mid-western city. Analysis of the recorded focus group data followed the method prescribed by

Krueger (Krueger 1988). An interpretative summary derived from a synthesis of the focus group data was used in the development of a mail survey.

The second phase of the research utilized supplier selection data obtained from a nationwide, cross-industry mail survey of experienced third party logistics buyers. In an effort to obtain responses reflective of a broad spectrum of third party logistics buyers, three sources were used to construct a potential participant database. The first entailed a recent review of well-known logistics popular press articles. The second relied on promotional material distributed by third party logistics providers. The final source entailed the membership roster of a very large industry association composed of transportation / logistics and supply chain professionals, consultants and academics. This database was modified to include only the most senior logistics or supply chain managers representing U.S. manufacturing and merchandising firms. A total of 1,279 potential respondents were identified from the three sources.

A pilot test of the survey instrument was conducted to ensure relevance, clarity and completeness of questions. The pretest involved a number of experienced third party logistics buyers representing large and small manufacturing and merchandising firms. The refined questionnaire was used to obtain quantitative measurements on thirty supplier selection variables. As presented in Table 1, survey participants were asked to rate the importance of each supplier selection criterion and the amount of perceived variability associated with said criterion.

A final set of determinant variables was constructed across all respondents by multiplying each importance rating by its variability rating. The new variables were created to ascertain the criteria most determinant in third party logistics supplier selection decisions. Research has revealed that a selection variable is determinant only when it is perceived to be important and variability, surrounding the variable, is acknowledged (Kerlinger, 1986). The thirty determinant variables served as surrogates for the benefits sought in the procurement of third party logistics services. The determinant variables were analyzed via two multivariate statistical techniques, i.e., factor and cluster analysis.

Factor analysis was used to examine the relationships among the determinants for each of the thirty supplier selection benefits across all survey respondents. The principal components model was used to extract factors and the Scree Test (Cattell, 1966) was employed to identify the number of non-trivial factors. The principal components method was chosen as it yields a mathematically unique solution to a factor problem (Kerlinger, 1986). The Scree Test was selected as it provides the minimum number of factors accounting for the maximum amount of variance (Gorsuch, 1974).

The principal components method requires an unrotated solution to determine the starting point for factor rotation. Factor (axes) rotation facilitates the derivation of simple structure, i.e., a condition in which each variable "loads" on as few factors as possible. This step assists in the interpretation of factor analytic results. A varimax rotation was selected for use in this study as it provides the best means of reaching a simple structure solution and is usually regarded as the optimum orthogonal rotation technique (Rummel, 1970).

TABLE 1
MAIL SURVEY INSTRUMENT—IMPORTANCE AND VARIABILITY QUESTIONS

Variable	Importance Rating	Variability Rating
	Please rate the importance of each of the following selection criteria to you during the time you were making your most recent third party logistics acquisition decision. *(Circle a number from 1 to 7 to show how important each factor was to you personally.)*	Also, please rate your opinion of how much difference there is among suppliers in the industry. *(Circle a number from 1 to 7 to show huch much difference you think there is among suppliers in the industry on each factor.)*
	Importance to You	**Suppliers in the Industry**
	Not Important ... Very Important	All about the Same ... Differ Widely
Provision of integrated logistics services	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Single contact point	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Continuous improvement	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Direct control of all services provided	1 2 3 4 5 6 7	1 2 3 4 5 6 7
International capabilities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Breadth of service	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Required services at lowest price	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Quality of service	1 2 3 4 5 6 7	1 2 3 4 5 6 7
EDI capabilities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Confidentiality during negotiations	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Warehouse mgmt. system	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Software/systems capability	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Proven track record of experience	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Financial strength	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Asset ownership	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Depth of management expertise	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Experience in your industry	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Time in business	1 2 3 4 5 6 7	1 2 3 4 5 6 7
References from current customers	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Strategic partner potential	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Variable	Importance Rating	Variability Rating
	Please rate the importance of each of the following selection criteria to you during the time you were making your most recent third party logistics acquisition decision. *(Circle a number from 1 to 7 to show how important each factor was to you personally.)*	Also, please rate your opinion of how much difference there is among suppliers in the industry. *(Circle a number from 1 to 7 to show huch much difference you think there is among suppliers in the industry on each factor.)*
	Importance to You	**Suppliers in the Industry**
	Not Important — Very Important	**All about the Same — Differ Widely**
ISO 9000 certification	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Gain sharing from productivity improvements	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Compatible culture	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Skill level of workers	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Quick response to customer requests	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Non-union work force	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Contract/pricing flexibility	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Willingness to assume existing assets	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Overall cost of service	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Operational flexibility	1 2 3 4 5 6 7	1 2 3 4 5 6 7

To investigate the existence of benefit based buyer groups, the determinants composing the non-trivial factors served as input to a cluster analysis algorithm. Cluster analysis is a multivariate statistical method similar to factor analysis. In essence both of these techniques assist in identifying groups in data, especially when more than three dimensions are considered. Whereas factor analysis is routinely used to group variables, cluster analysis is more commonly used to combine cases.

The purpose of cluster analysis is to classify a group of objects or variables into a mutually exclusive assembly based on some statistical rule. Discriminant analysis is another technique used to differentiate between groups. However, this procedure differs from cluster analysis in that it identifies differences between groups on an a priori basis. Cluster analysis does not assume any previous knowledge concerning the number and/or types of groups existing in a dataset. It is a technique used to initially identify groups.

There is no universally accepted definition of a cluster. The term usually refers to a group of objects that are similar in some manner. However, research has revealed that clusters have identifiable characteristics, the most significant of which are density, variance, dimension, shape and separation (Sneath and Sokal, 1973). Numerous cluster analysis techniques exist and the selection of an appropriate model is an important decision in classification research.

A number of simulation studies have been conducted to determine which clustering algorithms are better at recovering known clusters in a dataset (see Milligan, 1981; Kuiper and Fisher, 1975; Blashfield, 1976). A synthesis of these tests revealed that Ward's minimum-variance clustering method is highly accurate and provides above average performance. This method was also used successfully in previous research to identify benefit based market segments (Moriarty, 1983). As a result of the validation tests and evidence of successful use in the identification of buyer segments, Ward's method was chosen for this research.

Ward's minimum-variance model is an agglomerative hierarchical method of cluster analysis. It is based on the premise that the most accurate representation of a dataset, i.e., the one containing the least error, exists when each object forms a cluster. Therefore, as the number of clusters decreases from k, k-1, k-2 ...1, the groupings of increasingly dissimilar objects yield less precise information. At each level of the clustering process the objective is to create a group such that the sum of squared within-group deviations about the group mean, for each object, is minimized for all objects at the same time. The value of the objective function is expressed as the error sum of squares, i.e., the within-group sum of squares. Each reduction in the number of clusters is accomplished by considering all possible N(N-1)/2 object pairs and selecting the pair for which the increase in the error sum of squares is the least. As the clusters are combined they are treated as one unit, i.e., a new cluster (Lorr, 1983).

When the complete hierarchical solution has been attained and only one cluster remains, the error sum of squares history may be examined to determine the relative homogeneity of the clusters formed. This progression may be visualized by plotting the increase in the sum of squares at each iteration of the clustering process against the number of clusters formed. A sharp increase in the error sum of squares indicates that accuracy has been significantly compromised and the clustering process should be terminated (Lorr, 1983). The "natural" number of groups for the dataset is identified in this manner.

RESULTS OF THE RESEARCH

Data from the mail survey were used to determine the benefits desired by individuals involved in third party logistics services procurement process. Market segments were derived by combining buyers seeking similar benefits. A total of 263 completed surveys were return by the designated research deadline. A list of respondents by industry is presented in Table 2. The completed questionnaires provided an overall response rate of 21.3 percent.

The respondents to the mail survey were not required to identify themselves. This was done to ensure respondent anonymity and encourage participation in the study. However, this practice precluded a comparison of those electing to complete the questionnaire and the population from which they were drawn. This fact has implications for the findings drawn from this research.

In essence, the results must be considered representative of the industrial buyers completing the survey and not necessarily reflective of general practice for all third party logistics buyers.

Factor analysis was used to derive the benefits desired by the industrial buyers participating in this study. A correlation matrix of the thirty determinant variables served as input to the principal components model. The Kaiser-Meyer-Olin (KMO) test was used to ascertain the applicability of factor analysis to the correlation matrix (Kaiser,n.d.). KMO values in the 0.90's are considered exceptional and values in the 0.80's as very good. The KMO statistic calculated for the correlation matrix employed in this study was 0.875; therefore, factor analysis was considered appropriate for the dataset.

TABLE 2
MAIL SURVEY RESPONDENTS BY INDUSTRY

Industry	Percentage of Respondents
Appliances	0.80
Automotive and Transport Equipment	9.90
Building Materials/Lumber Products	1.90
Chemicals and Plastics	11.40
Clothing and Textiles	5.70
Computer Hardware and Equipment	8.00
Construction and Farm Equipment	2.70
Department Store / General Merchandise	2.70
Electronics and Related Instruments	10.60
Electrical Machinery	3.00
Food and Beverage	18.60
Furniture	0.00
Hardware	0.80
Machine Tools and Machinery	3.40
Fabricated Metal Products	0.80
Mining and Minerals	0.00
Office Equipment and Supplies	3.00
Paper and Related Products	3.80
Petroleum and Petrochemicals	0.00
Pharmaceuticals	11.40
Primary Metals	0.00
Rubber Products	1.10
Other	0.40
Total	**100.0**

TABLE 3
VARIMAX ROTATION: INITIAL CORRELATION MATRIX

Variable	Factor 1 "Reliability"	Factor 2 "Synergy"	Factor 3 "Economy"
Track Record	.73097		
Time in Business	.69073		
Industry Experience	.66845		
Financial Strength	.61583		.33222
Management Expertise	.58735		.52092
Skilled Work Force	.54815		.44948
EDI Capabilities	.53826		
Software/Systems	.52170	.44107	
Customer References	.48049	.42501	
Quality of Services	.47789		.34105
Integrated Services		.74548	
ISO 9000		.69708	
Breadth of Services		.67042	
International Capabilities		.59826	
Assume Assets		.57012	
Asset Ownership	.35148	.52592	
Strategic Partner	.31626	.48673	
Continuous Improvement		.45420	.34485
Warehouse Mgmt. System	.41308	.41408	
Direct Control	.40696		
Confidentiality		.36113	.30032
Total Cost			.72569
Operating Flexibility			.70288
Contract Flexibility			.67287
Lowest Price			.59087
Non-union Operation			.57243
Quick Response	.42363		.52075
Compatible Culture	.35729		.46483
Gain Sharing		.36580	.46201
Single Contact Point		.38614	.40400

The thirty determinants were standardized about a mean of 1.0 before application of factor analysis to simplify interpretation. The principal components method was employed for factor extraction. A Scree plot was used to determine the number of non-trivial factors for the dataset. The Scree Test results revealed a three-factor model to be appropriate. The results of applying the principal components model while specifying the extraction of three factors, followed by a varimax rotation, are presented in Table 3. Coefficients below 0.30 are not displayed, as any loading less that 0.30 was not considered salient to a factor in this study.

The three factors accounted for 44.2 percent of the total variance. The communalities for the variables indicated the three factors did not fully explain the variance related to some of the variables. While higher communality values were desired, the level of resolved variance reported here is not uncommon in exploratory research. The unexplained variance my be unique to specific variables and caused by measurement error or due to chance, i.e. random error.

Fifteen of the selection determinants experienced cross loadings greater than 0.30. Significant cross loadings inhibit meaningful factor interpretation. In an effort to improve interpretation and obtain a simpler structure, all determinants loading on two or more factors at a level greater than 0.30 were removed. The revised fifteen variable correlation matrix was subjected to the KMO test. The results of this test confirmed that factor analysis was appropriate for the revised matrix. An application of the principal components model followed by a varimax rotation yielded a much simpler structure. However, one variable displayed a cross loading greater than 0.30. After eliminating this variable, the revised fourteen variable matrix was tested for sampling adequacy and the KMO index was revealed to be 0.80. Thus, the revised matrix was subjected to factor analysis as outlined above.

Simple structure was accomplished at this point as no variable loaded on more than one factor with a coefficient greater than 0.30. The rotated factor matrix appears as Table 4. The three extracted factors resolved or explained 53.1 percent of the total variance and the communalities were slightly improved from the first two iterations of factor analysis.

TABLE 4
VARIMAX ROTATION: FINAL CORRELATION MATRIX

Variable	Factor 1 "Economy"	Factor 2 "Synergy"	Factor 3 "Reliability"
Total Cost	.80560		
Operating Flexibility	.73550		
Lowest Price	.69435		
Contract Flexibility	.66791		
Non-union Operation	.56452		
Integrated Services		.75390	
Breadth of Services		.72378	
International		.70030	
ISO 9000		.68511	
Assume Assets		.54348	
Time in Business			.81945
Track Record			.75195
Experience			.70608
EDI Capabilities			.53571

The first factor was noted to describe the cost and flexibility associated with logistics outsourcing and was renamed "Economy." It explained 31 percent of the total variance and was composed of the linear combination of five variables. The second factor, labeled "Synergy" was also composed of five variables and resolved 12.6 percent of the total variance. This factor was observed to reflect buyers' perceptions regarding the provision of multiple or integrated services by a single provider. The final factor, entitled Reliability, was made up of four variables and accounted for 9.6 percent of the total variance. This factor was found to relate to supplier longevity and proven competence.

An internal consistency test, Cronbach's Alpha, was performed on the determinants constituting the three factors. This test was conducted to determine the reliability of the variables composing each factor. A Cronbach Alpha score of 0.70 is considered satisfactory for basic research (Nunnally, 1978). The tests resulted in scores of 0.77 for the Economy factor, 0.75 for the Synergy factor and 0.72 for the Reliability factor. These results provided a satisfactory level of assurance concerning the use of the fourteen determinants as input to the cluster analysis algorithm.

The final research step employed the reduced set of fourteen variables to determine whether benefit based market segments could be identified from the dataset. While component scores may have been calculated for the three factors and used as input to cluster analysis, a decision was made to employ the original fourteen determinants. This decision was predicated on the knowledge that component scores are not easily interpreted and the correlation matrix of the fourteen original determinants was more suitable to cluster analysis.

Ward's minimum-variance agglomerative method was used to cluster the third party logistics buyers with respect to their ratings of the fourteen determinant variables composing the Economy, Synergy and Reliability factors. Ward's algorithm requires that the correlation matrix be transformed into a dissimilarity matrix before submittal to the model. Further, a method must also be specified to calculate dissimilarities among the objects. Squared Euclidean distance was the method selected for use in this research.

The object of cluster analysis is to find some intermediate stage in the grouping process resulting in a meaningful number of clusters. An agglomeration schedule may be used to assist in locating this point. The coefficients appearing in this schedule may be examined to determine the initial point at which the increase between two adjacent agglomeration stages becomes large. In Ward's method this increase indicates that the members of the joined clusters are no longer similar since a substantial increase in the overall sum of the squared within-cluster distances has occurred. Statistics from the final ten stages of the clustering process for the industrial buyers are presented in Table 5.

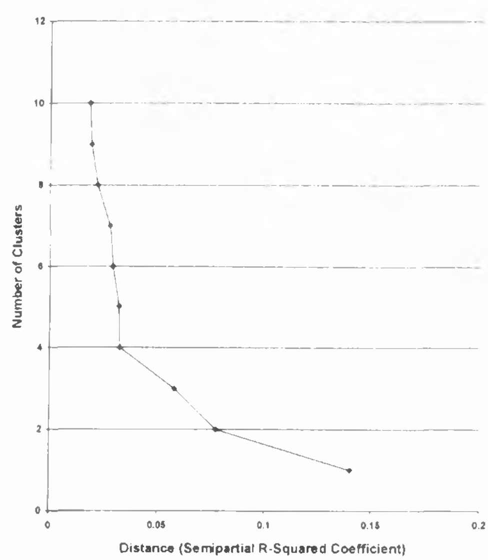
One method of detecting the appropriate cluster stopping point is to plot distance levels (Semi-partial R-Squared coefficients) against the number of clusters formed at each stage in the grouping process. This method was first set forth by Thorndike and later addressed by Kowalski and Bender (See Thorndike, Kowalski and Bender). Using this procedure, a four-cluster configuration was noted to produce the most "natural" number of groups for the buyer dataset. These four clusters represent third party logistics buyer segments.

Figure 1 displays a plot of the data appearing in Table 5, in accordance with the procedure described immediately above. The goal of this procedure is to identify the clustering stage at which the curve initially changes slope or radically "flattens out." The plot reveals a "break" or flattening of the curve at the point between the formation of the fourth and third clusters. As can be observed from the values of the semipartial R-squared coefficients appearing

TABLE 5
ABBREVIATED CLUSTER ANALYSIS AGGLOMERATION SCHEDULE
THIRD PARTY LOGISTICS BUYERS

Number of Clusters	Cluster (CL) Joined	Semipartial R-Squared
.	.	.
.	.	.
.	.	.
10	CL 18 & CL 13	.017889
9	CL 20 & CL 16	.018827
8	CL 12 & CL 27	.022178
7	CL 15 & 9	.027775
6	CL 10 & CL 17	.028859
5	CL 8 & 14	.031825
4	CL 11 & CL 6	.032520
3	CL 4 & CL 7	.057917
2	CL 3 & CL 28	.077395
1	CL 5 & CL 2	.139972

FIGURE 1
PLOT OF THE DISTANCE REQUIRED TO FUSE CLUSTERS FOR THE SAMPLE POPULATION
WARD'S MINIMUM SQUARED ERROR CLUSTERING OF THIRD PARTY LOGISTICS BUYERS



on the X-axis, it is apparent that a significant increase in distance was required to form the three cluster configuration.

The dataset was also clustered using the Average Linkage Between Groups method to validate the four-segment configuration. The results of applying this model also revealed a four-cluster configuration to be appropriate for the data. The groups formed by the Average Linkage method were also found to be very similar to those formed by Ward's minimum-variance method.

The reliability of the four-cluster configuration was tested. The sample population was randomly split in half and the resulting datasets were clustered via Ward's algorithm. The results of these groupings revealed that a four-cluster grouping was appropriate for both of the randomly formed buyer datasets. The buyers grouped in the split-half analyses were also noted to possess characteristics, e.g., mean evaluations of the supplier selection determinants, similar to those combined in the original clustering of the sample population.

The four clusters derived via the Ward algorithm varied in size. The last two groups formed (CL 5 & CL 2) consisted of 39 percent and 61 percent of the respondents respectively. These two clusters defined the two major market segments appearing in the dataset. The remaining two clusters were found to be subdivisions of the largest buyer group (CL 2). Behavioral profiles of the buyers forming each of the four segments were developed and compared to determine how the clusters differed. Differentiation between the two major and two minor market segments was examined by comparing mean determinacy scores for each group across the fourteen purchasing attributes. Table 6 displays this comparison for the two major market segments.

Buyers in both major markets segments ranked operating flexibility, a supplier's track record of experience and overall cost as their top three selection variables. These rankings implied that a supplier desiring to participate in both markets must, at a minimum, provide the benefits of Economy and Reliability. However, Segment 2 buyers, composing 61 percent of the sample population considered EDI capabilities, a supplier's willingness to assume assets and the provision of integrated services to be more determinant in their third party supplier selection decisions. Thus, the buyers in Segment 1 can be characterized as "traditional" buyers." They are concerned primarily with efficiency and dependability. Whereas Segment 2 buyers may be more appropriately considered "innovative" purchasers as they are seeking more synergistic benefits from logistics outsourcing.

The two minor market segments were also compared in the manner described above. These two groups were noted to be sub-groups of the largest major market segment, i.e., Segment 2. One sub-segment was very small, containing only 4.4 percent of the total sample population. It is highly unlikely that a marketer would develop a separate strategy for a segment this small unless it represented an unusually high profit opportunity. Buyers in the second minor market segment represented 14.4 percent of the total sample population. They differed from Segment 2 buyers in their ratings of the following determinants: use of a non-union workforce, overall cost of services, and contract and operating flexibility. Thus, buyers in this subgroup placed more importance on the determinants relating to the Economy factor. The individuals in this group may most appropriately be considered "Cost-Sensitive" buyers.

FINDINGS AND IMPLICATIONS

This research provides third party logistics marketers with a methodology for identifying customer segments based on benefits rather than descriptive measures. It applied the concept of benefit segmentation first posited by Russell Haley to the third party logistics market and identified two major and two minor market segments. Benefit based segmentation is an effective method of segregating customers as it yields a substantive basis for the existence of

TABLE 6
COMPARISON OF MEAN DETERMINACY SCORES
ACROSS THE FOURTEEN SERVICE ATTRIBUTES
MAJOR MARKET SEGMENTS NO. 1 AND NO. 2

Service Attribute	Overall Sample Stack Ranking	Sample Mean	Segment 1 Mean	Segment 2 Mean
		100%	39%	61%
Track Record	3	29.4	24.0	32.8
Time in Business	9	22.0	17.3	25.0
Experience	4	28.3	24.0	31.0
EDI Capabilities	7	24.6	16.2	29.9
Integrated Services	8	22.8	16.4	26.8
ISO 9000	12	14.9	12.7	16.4
Breadth of Services	6 **	24.8	20.5	27.6
Int'l. Capabilities	11	20.4	20.3	20.5
Assume Assets	13	14.7	10.1	17.6
Overall Cost	2	29.6	25.3	32.4
Operating Flexibility	1	30.5	23.8	34.7
Contract Flexibility	5	25.4	19.8	29.0
Low Price	6 **	24.8	21.5	26.9
Non-Union	10	20.8	18.1	22.6

* Mean Index = Segment mean divided by sample mean.
** Tie

customer groups. This type of customer aggregation provides the springboard for successful marketing strategy development and the efficient use of resources. The research results revealed that suppliers cannot consider all third party logistics buyers similar when formulating their service offerings and marketing strategies.

The two market segments identified were based on the bundle of service attributes desired by third party logistics buyers. Fourteen selection criteria were found to be critical in supplier choice. The criteria were condensed, using factor analysis, into three major benefit areas (Economy, Reliability and Synergy). Both of the major market segments were found to highly value benefits relating to Economy and Reliability. However, buyers in the largest segment, constituting 61 percent of the total population, were found to differentiate among third party logistics suppler candidates by selecting suppliers that provided integrated services. The results reveal that suppliers cannot consider all third party logistics buyers homogeneous regarding desired benefits. Providers attempting to serve both market segments must offer economy and reliability at a minimum. However, when it is time to make the final purchasing decision, many industrial buyers appear to favor suppliers that offer synergistic benefits in addition to economy and reliability.

The two minor market segments were found to be sub-segments of the largest major market segment. One of these segments was very small, representing only 4.4 percent of the total population. It is highly unlikely a third party logistics supplier would target a market this small unless the potential for profit was extremely high. However, the buyers in this small group were noted to differentiate among potential suppliers regarding benefits relating to financial stability and international service capabilities. The largest sub-group, constituting 14.4 percent of the buyer dataset, highly valued low price and supplier flexibility in their choice of a third party logistics supplier. Obviously, marketers must emphasize these two attributes to appeal to this segment.

An ongoing "shakeout" continues among third party logistics suppliers in the United States. However, competition is likely to be rigorous for the foreseeable future. Third party suppliers must become adept at matching their service offerings to customer needs to gain a competitive advantage. This research provides insight into the purchasing preferences of industrial buyers regarding desired benefits and critical supplier selection factors. This insight may be used by industrial buyers to more effectively and efficiently select third party logistics providers. It can also assist suppliers in their efforts to segment the overall market, target clients, successfully formulate strategy, and properly allocate their resources.

The purchase of third party logistics services involves multiple representatives from buyer and seller organizations. A dyadic or network relationship exists. The perspective of the seller was not evaluated in this research. It is important to broaden the research to include this viewpoint to more fully characterize the purchasing process. Also, the benefit factors derived from this research resolved approximately one-half of the variance represented by the supplier selection variables. This is not uncommon in an exploratory study; however, future research is needed to substantiate the results. Measurement error may have served to limit the explanatory ability of the factors and additional supplier selection criteria and benefit factors likely exist. The provision of additional benefit factors may also assist in refining or expanding the market segments identified in this research.

Additional empirical research is needed to more fully characterize the true "drivers" underlying the ongoing demand for third party logistics services. Much of the existing work has been descriptive and based on subjective information. The third party logistics market continues in the growth stage of its "product" life cycle. It has been described as a dominant trend at the very least and perhaps a "megatrend" (Murphy and Poist, 2000). Further study is needed, as proper market segmentation is the basis of loyalty focused, customer relationship marketing. This is a salient point as mutually beneficial relationships are critical in the provision and ongoing use of third party logistics services.

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PURE PALLETS: EFFECTIVENESS AND EFFICIENCY IMPACTS ON THE DEFENSE TRANSPORTATION SYSTEM

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ABSTRACT

The military supply chain must explore initiatives to improve its ability to meet warfighter needs. One initiative, developed during operations in Afghanistan and Iraq is the *pure* pallet process—by consolidating material early in the supply chain into user-specific pallets, these pallets are able to transit the defense transportation system without being broken down en route, theoretically arriving to the warfighter in less time than prior break-bulk methods required. The pure pallet initiative's effectiveness and efficiency was assessed by measuring customer requisition wait time, cargo throughput, and revenue performance. It was found that effectiveness increased, without corresponding losses in efficiency.

BACKGROUND

Initial analyses show that the defense transportation system has not yet fully learned the logistics lessons of the 1991 Gulf War. A December 2003 Government Accountability Office (GAO) report investigating the preliminary effectiveness of Operation Enduring Freedom identified what it termed as "substantial logistics support problems" (Solis 2003). In particular, the GAO identified "[i]nsufficient and ineffective theater distribution capability" as a major problem. They state "[t]he distribution of supplies was also delayed because cargo arriving in shipping containers and pallets had to be separated and repackaged several times for delivery to multiple units in different locations" (Solis, 2003, p. 3).

In 1993, the defense transportation system stakeholders also recognized that improvements to the supply chain were critical to expedite the flow of material to the warfighter and to relieve congestion at the aerial ports of debarkation during Operation Iraqi Freedom (Kuntz, 2004). Prior to Operation Iraqi Freedom, improvements in the supply chain focused primarily on the link between the factory and the ports of debarkation. The rapid movements by combat forces during the Iraq war taught military logisticians the critical need to streamline the flow from the debarkation ports to the warfighter—"the last tactical mile" as well (Bivona et al., 2004, p. 76).

Establishing the Pure Pallet Process

In July 2003, a Defense Distribution Center representative visited Kuwait to review Central Command's distribution system and assist in identifying areas of improvement. It was discovered that the method employed to consolidate material and build pallets in the U.S.-based consolidation and containerization points was creating a substantial backlog of pallets upon arrival at the debarkation ports and theater distribution center due to the high volume of material and excessive handling requirements of pallets arriving into the theater. An important consequence of the saturation was the substantial increase in the warfighter's wait time for supplies at the "point of the spear" (Hornung, 2004). A more alarming concern was that soldiers were unnecessarily being placed in harm's way—the process of breaking down, sorting, and rebuilding pallets made soldiers vulnerable to attack (Diamond, 2004; Imberi, 2004; Merriweather, 2005).

In October 2003, Defense Distribution Center staff sponsored a meeting among the defense transportation system supply chain stakeholders. The team determined that requisitioned material should be held as far back in the supply chain as possible where the infrastructure was in place to efficiently hold and consolidate it. The ideal locations to position the cargo were determined to be the U.S.-based containerization points: the Defense Distribution Depot Susquehanna, the Defense Distribution Depot Red River, and the Defense Distribution Depot San Joaquin (Hornung, 2004).

The team also elected to build the consolidated material at the containerization points into end-user specific pallets called *pure* pallets. By consolidating material into pure pallets, the material would flow to the warfighter without being broken-down en route. This is unlike the historical process, which was based on break-bulk pallets that were broken down in-theater and the material sorted and re-palletized before being moved forward to the warfighter (Kuntz, 2004). This new approach seemed logical—the open desert environment and chronic lack of personnel certified to build air pallets made the theater distribution centers better suited for pallet cross-docking than for break-bulk activities and pallet construction.

Air Mobility Command's Air Transportation Division planners then defined a pure pallet as "...a pallet, which contains only shipments for the end-users at a single military destination. They also realized that certain low-volume destinations would be inefficient. Therefore they stipulated that in some instances the historical approach could be used, by combining specific users with a designated single or lead destination. Pallets constructed in this way are said to be *mixed* pallets. Pallets were to be capped when sufficient cargo was available to fill the pallet, or when the oldest piece of cargo reached a hold time of 48 hours.

In November 2003 the pure pallet process was placed into action at the Susquehanna depot. In support of Central Command's route plan, Susquehanna established 47 pure pallet build lanes to service 47 associated destinations. In addition, the Army's maximum allowable cargo hold time was increased from 48 hours to 120 hours and the Marine Corps' cargo hold time was increased from 48 hours to 72 hours (Hornung, 2004). It was assumed that the increased cargo collection time would allow a sufficient volume of cargo to flow into the consolidation points to enable the pure pallets to meet or exceed the ideal 1.5 ton pallet weight previously established by regulations (Air Mobility Command, 2001).

In February 2004, the pure pallet process was expanded to include pure pallet construction at Charleston and Dover Air Force bases (Hornung, 2004). These aerial ports were ideal due to their location in the defense transportation system supply chain, which allowed them to collect and consolidate Central Command-destined material that had bypassed the containerization points. This initiative is still new and is continuing to evolve rapidly. While the initial assessments were positive, they were largely based on opinion. The research goal was therefore to objectively study the process, using specific criteria for effectiveness (requisition wait time) and for efficiency (monthly tonnage and transportation revenue performance).

DEFENSE TRANSPORTATION VS. COMMERCIAL PRACTICE

When considering the challenges facing the defense transportation system, it is easy to assume that it should operate much like its commercial counterparts. Upon closer investigation, several key differences are readily identifiable. A paper by the University of Pennsylvania's Wharton School notes that the military supply chain can be categorized as three distinct chains, involving commodities, major components and people (Wharton, 2003). The Wharton paper also highlights the seriousness of military supply—a retail outlet may suffer lost sales if supply runs out but in the military, soldiers can be killed if their on-hand stocks of fuel or munitions are exhausted. Some principal differences between commercial transportation and its defense counterpart follow.

Scale and Size

In Fiscal Year 2004, Air Mobility Command moved approximately 1.15 billion pounds (Derick, 2005), while FedEx shipped 1.2 billion packages amounting to more than 3.9 billion pounds during the same timeframe (Federal Express, 2004). Where the average FedEx package weighs approximately 3 pounds, Air Mobility Command often moves much heavier items. Furthermore, commercial companies such as FedEx and UPS limit their maximum pallet weights to approximately 2,200 pounds (Federal Express, 2004), while the Air Mobility Command Weekly Summary Reports indicate that their average pallet weighs between 3,000 and 5,000 pounds. Finally, Air Mobility Command must be equally adept at moving non-palletized cargo such as rolling stock, where the commercial companies need not be.

Predictability and Volatility

The defense transportation system challenge is not one of volume as much as of being able to meet the unpredictability and volatility brought about by global events. Companies such as FedEx and UPS are concerned with steady growth and profitability as goals that are realized by increasing efficiency, productivity, and market share (Robbins et al., 2004, p. 11). While the defense transportation system is also concerned with efficiency, it is more important that the system be able to respond to a large uncertainty of demand and be able to meet the needs of the warfighters, regardless of profitability. Robbins and his colleagues note that "The defense distribution system must deliver to places that profit-maximizing commercial firms might never visit, and it must procure and hold low-demand items that would never be cost-justified in the commercial sector" (Robbins et al., 2004, p. 12).

Commercial "Rainbow" Pallets vs. the Military Pure Pallet

The commercial mixed pallet, also known as a *rainbow* pallet, provides multiple products to a single customer on a single pallet (Schultz, 2003, p. 2). Rainbow pallets were developed because merchandisers demanded more frequent deliveries and bought smaller quantities, delivered to their door on a just-in-time basis. This requirement has become more widespread to include most industries serving the retail trades, resulting in intense pressure to "do or die" (Hammond, 1999, p. 2).

By purchasing "the right amount of goods", which is usually less than a full pallet, the merchandiser customer is not required to maintain additional warehouse space to store excess product. Their challenge is to determine whether the increased transportation cost of more frequent deliveries outweighs the cost of excessive inventory and warehousing if rainbow pallets are not used. In contrast, the pure pallet process designers must consider more than just the velocity at which material reaches the warfighter. The pure pallet process must also accommodate the proper balance between process effectiveness (i.e., velocity), and process efficiency (i.e., acceptable use of scarce transportation assets). For example, standard commercial shipping pallets are typically low cost wooden items that can be easily obtained. Furthermore, the transportation assets themselves—typically trucks—are also widely available. Distributors can secure additional trucking if necessary, and the customer needs only to accept the additional cost as a tradeoff for velocity. In contrast, military airlift aircraft and pallets are scarce, and wartime pallet attrition is significant. Peterson notes that of the more than 180,000 standard "463-L" military airlift pallets available prior to September 2001, only about 85,000 were accounted for by December 2004. The pallets themselves are costly to buy and maintain: the Air Force spent almost $24 million for 463-L pallet repairs in 2004 (Peterson, 2005, p. 31).

The pure pallet concept is similar to the commercial industry's rainbow pallet, in that the defense transportation system must also balance tradeoffs of velocity versus transportation cost, warehousing space, and inventory. The key difference is that the pure pallet process is made considerably more complicated by the additional constraints of limited airlift assets.

Before explaining the research methodology, a brief discussion of effectiveness and efficiency metrics is necessary. To measure defense transportation system effectiveness, requisition wait time—the time that elapses from an item's order to the date it is received—was a clear choice (see e.g., Solis, 2005, p. 19). To assess efficiency, the measure used is cargo throughput, in terms of both pallet loading and aircraft usage. The hypothesis was that the time criterion for capping pure pallets would lead to lighter average pallet loads, which in turn would lead to lighter, less efficient aircraft loads. Pallet weight computations would be straightforward due to the standard 463-L pallet specification, but a corresponding aircraft usage metric was needed that could be readily applied across the multiple aircraft types used by Air Mobility Command. Fortunately, Air Mobility Command already uses precisely such an efficiency measure: the percent Transportation Working Capital Fund (% TWCF) goal.

The Transportation Working Capital Fund (TWCF)

Title IV, Section 405, of the National Security Act of 1947, *Working Capital Funds,* authorizes the use of revolving accounts to finance certain commercial-type activities in the Department of Defense. Airlift services reimbursement is received by the TWCF from authorized airlift customers by charging tariffs based on the type of airlift service provided. These tariffs are developed by U.S. Transportation Command planners and approved by the Undersecretary of Defense, Comptroller, through the President's Budget Cycle. Revenues earned by the TWCF recoup direct and indirect costs, general and administrative support provided by others, depreciation, and amortization costs incurred by Air Mobility Command in providing airlift services (Air Mobility Command, 2004, p. 7).

TWCF airlift tariffs for routine passengers and cargo are set annually based on commercial competition or a standard rate per mile. As a result, the TWCF doesn't recover full costs due to Air Mobility Command's requirement to maintain the wartime capacity of the airlift system. The difference between the revenue that the TWCF receives and the costs incurred for these airlift services is offset by an Air Force operations and maintenance-funded readiness account (Air Mobility Command, 2004, p. 8).

Air Mobility Command's Financial Management and Comptroller division determines the standard aircraft usage level for passengers and cargo to meet the Transportation Working Fund Goal. The goal is for the Air Force to provide a service to the customer cheaper than they can buy it commercially. In order to remain competitive the Air Force accepts some financial loss on each flight. The TWCF goal is set to defer most, but not all of the cost (Hobin, 2005). For example, in March 2005 the percent TWCF goal was 49.8% for passengers and 63.3% for cargo (Hobin, 2005). Therefore in March 2005, if an airlift aircraft was loaded to 63.3% of its cargo capacity, then it met its TWCF goal. When Air Mobility Command exceeds the TWCF goal, then they are operating cheaper than their commercial competition and they are operating efficiently by exceeding the expected TWCF input (Hobin, 2005).

METHODOLOGY AND ANALYSIS

To examine pure pallet impacts to defense transportation system efficiency and effectiveness, a case study of airlift-based material support to Central Command was conducted, comparing pre-pure pallet throughput (denoted as "historical" throughput) versus pure pallet throughput into the Central Command theater. Requisition wait time, average pallet weight and percent Transportation Capital Working Fund (%TWCF) goal-per-mission metrics were used to compare historical (March 2003–February 2004) pallet data to pure pallet (March 2004–January 2005) data.

Qualitative sources included published interviews and communications with military personnel involved in pure pallet implementation. Quantitative data sources included the RAND DOD-wide distribution database (for requisition wait time), Air Mobility Command's Weekly Summaries for the Charleston and Dover Air Force Base aerial ports (for pallet weights), and Air Mobility Command's Tanker Airlift Control Center end-of-month reports for Charleston and Dover Air Force Bases (for % TWCF goal). This article focused on the Dover and Charleston aerial ports because virtually all Central Command-designated pure pallets transit these two ports.

Requisition Wait Time

Figure 1 shows how the monthly pure pallet mean requisition wait times compare to the historical method, for cargo palletized at Dover or Charleston (denoted as "MILAIR" pallets). Figure 2 depicts the same information, for cargo palletized by the Defense Logistics Agency at the Susquehanna, Red River, or San Joaquin depots (denoted as "MILALOC" pallets). To ensure an accurate picture is presented, the tonnage of material transported into the Central Command theater is also shown in each figure, as is the Army's maximum 20-day requisition wait time goal. The associated data is shown in the Appendix. Note that for the Central Command MILAIR requisition wait times, the historical mean and median were 35.2 days and 30.1 days, respectively, while the pure pallet initiative mean and median values were 31.3 and 25.5 days, respectively. Using a two-sample t-test assuming unequal variance, it was found that the difference in mean requisition wait times is statistically significant ($p = 0.048$). Average monthly cargo throughput was about 10,500 tons across both timeframes.

Figure 2 shows that the historical mean and median Central Command MILALOC requisition wait times were 27.6 days and 23 days, respectively, while the corresponding pure pallet initiative mean and median values decreased to 23.5 and 19.8 days. The difference in mean requisition wait times is statistically significant ($p = 0.006$). Average monthly volume was again about 10,500 tons across the entire period. Similar findings were reported in a GAO report by Solis from data collected since February 2005 (Solis, 2005). These trends suggest that the pure pallet initiative is helping to reduce Central Command customer wait time.

FIGURE 1
REQUISITION WAIT TIME, PALLETS BUILT AT DOVER OR CHARLESTON

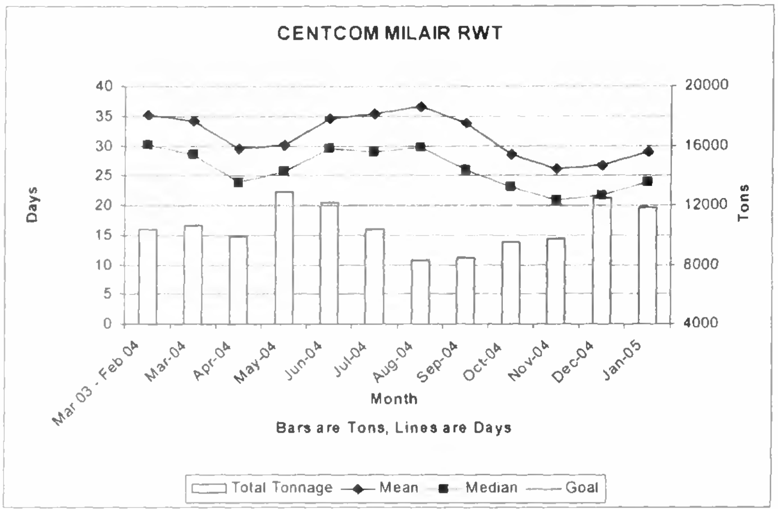
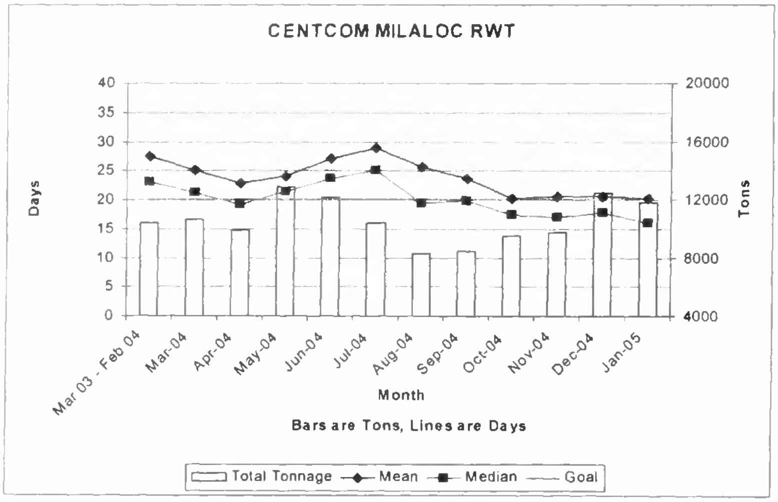


FIGURE 2
REQUISITION WAIT TIME,
PALLETS BUILT BY SUSQUEHANNA, RED RIVER, OR SAN JOAQUIN DEPOTS



Pure Pallet Weight

Figure 3 compares the average pallet tonnage for Dover AFB both before and after pure pallet implementation. The Missions numbers were generated from the reported data for the three primary airlift assets, the C-5, C-17, and the B747 as shown in the Appendix, records 1 through 4, 9 and 10. Figure 4 provides similar insights for Charleston AFB—the associated data is in the Appendix, records 5 through 8, 11 and 12.

Dover Throughput. The historical average Dover AFB pallet weighed 1.4 tons, but increased to an average of 1.76 tons for port-built (MILAIR) pure pallets. The MILALOC pure pallets transiting Dover averaged 1.6 tons. Taken together, Dover MILAIR and MILALOC pure pallets averaged 1.68 tons. The difference in mean tonnage, historical versus combined MILAIR and MILALOC pallets, is statistically significant ($p = 0.0004$). The average number of airlift missions through Dover AFB was 107 per month during the historical period, but decreased slightly to 102 per month during the pure pallet period.

Charleston Throughput. MILAIR pallets built at Charleston increased from 1.9 tons average weight to 2.13 tons after pure pallet implementation. The MILALOC pure pallet weight averaged 1.73 tons. Overall, MILAIR and MILALOC pure pallets together averaged 1.93 tons per pallet. Charleston averaged about 139 Central Command airlift missions per month during the historical period, but dropped to 105 per month during the pure pallet timeframe. Note that while the difference in mean tonnage, historical versus MILAIR pallets is statistically significant ($p = 0.017$), the difference in mean tonnage, historical versus combined MILAIR and MILALOC pallets is not ($p = 0.33$).

In summary, the pure pallet process appears to be helping increase average pallet weight—at the least, average pallet weight has not declined since the process was adopted. One might argue that the pure pallet initiative is affecting the number of monthly airlift missions, given their decrease during the study period, but this is unlikely. Too many other factors are also involved, such as competition for airlift aircraft for other missions, poor weather, and customer demand.

Percent TWCF Revenue Performance

Figures 5 and 6 compare the average %TWCF per month for Dover and Charleston Air Force Bases before and after pure pallet implementation. Both the missions and the %TWCF were generated from the reported data for the three primary airlift assets, the C-5, C-17, and the B747. The Appendix contains the applicable statistical measurements: refer to records 9, 10, 13, and 14 for Figure 5, and records 11, 12, 15, and 16 for Figure 6.

FIGURE 3
AVERAGE PALLET WEIGHT, DOVER AIR FORCE BASE

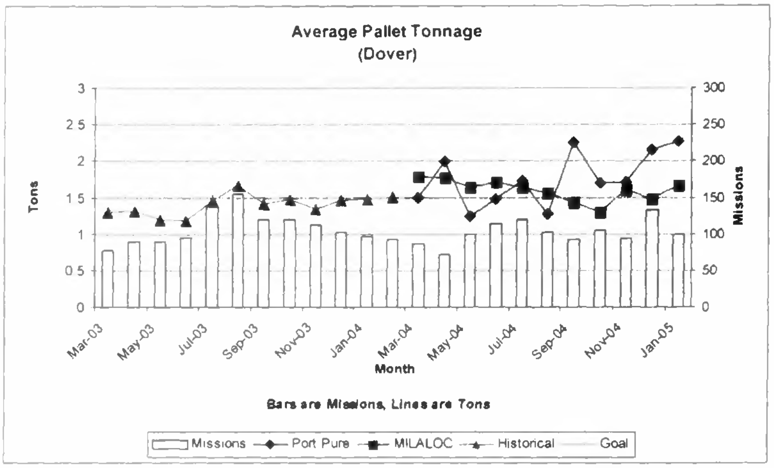


FIGURE 4
AVERAGE PALLET WEIGHT, CHARLESTON AIR FORCE BASE

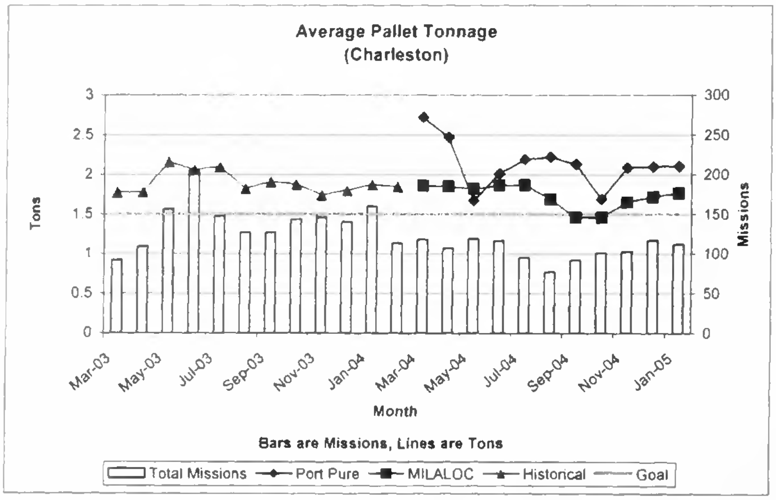


FIGURE 5
AVERAGE PERCENT TRANSPORTATION WORKING CAPITAL FUND REVENUES, DOVER AIR FORCE BASE

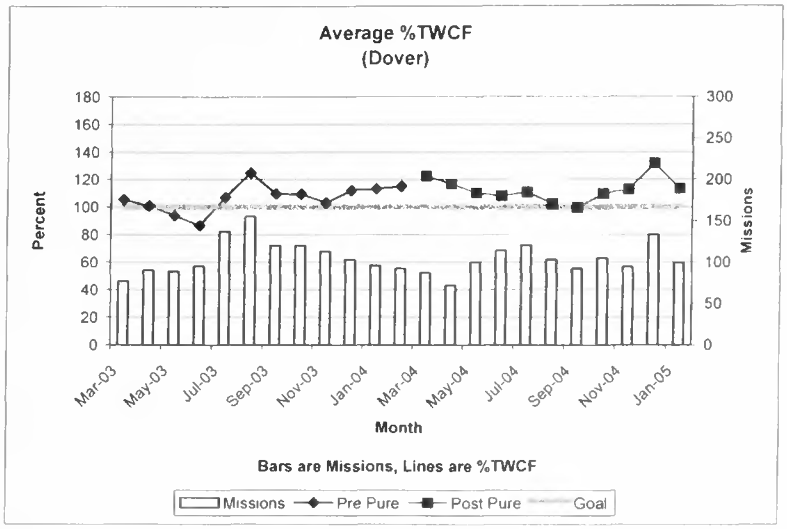
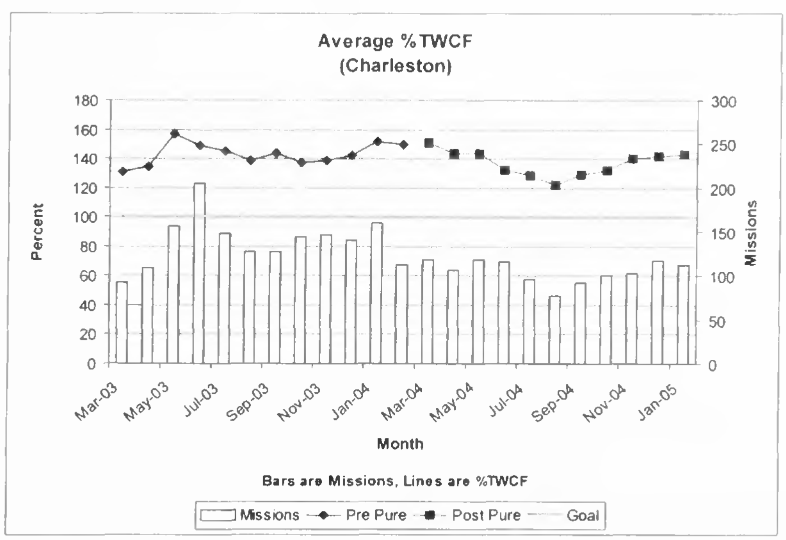


FIGURE 6
AVERAGE PERCENT TRANSPORTATION WORKING CAPITAL FUND REVENUES, CHARLESTON AIR FORCE BASE



During the March 2003–February 2004 historical period, Dover AFB averaged 106.7 percent TWCF revenues per month, but increased to an average 112.5 percent after pure pallet implementation. The statistical significance between the historical versus pure pallet %TWCF revenue performance is somewhat weak ($p = 0.076$). In contrast, Charleston AFB averaged 143.1% TWCF during the historical period, but declined slightly to 137% TWCF after the pure pallet process was initiated. This difference is statistically significant ($p = 0.045$). Overall, there appears to be a mild negative impact on the %TWCF revenue per mission. However, the %TWCF revenue continued to easily exceed the Air Mobility Command goal after the pure pallet process was implemented.

CONCLUSIONS

Pure pallet process implementation appears not to have reduced the defense transportation system's efficiency in the Central Command area of responsibility and in most circumstances is correlated with improved system effectiveness. The defense transportation system might never be fully optimized, but by continuing to implement ground-breaking initiatives along with lessons learned from commercial industry, the Department of Defense is making strides toward becoming a truly seamless end-to-end supply chain.

This research has shown that the pure pallet concept is correlated with increased velocity of material to Central Command warfighters, at minimal impact to transportation system efficiency. However, pure pallets are probably not a panacea for all military material distribution situations. For example, pure pallets increase the workload in the earlier stages of the supply chain (Robb, 2004, p. 22). Therefore, in situations such as a stable theater with a mature logistics system in a non-combat environment, the trade-off between velocity and increased workload may not be acceptable, such as in non-military sectors. It does, however, have potential application in disaster response situations.

Future research will investigate pallet attrition and retrograde issues, which was a significant challenge before the pure pallet concept was initiated. The pure pallet concept may be exacerbating the problem—during historical breakbulk pallet operations, the pallets would be broken down at the points of debarkation and the material loaded on trucks for delivery to the warfighters, leaving the 463-L airlift pallets and associated netting for return to the U.S. In contrast, the pure pallet concept pushes the airlift pallets much closer to the warfighter, rendering pallet retrograde more difficult.

Other research will address the 72 and 120-hour hold times that were established early in the pure pallet process formation, with little or no available data. Sufficient data now exists to determine optimal hold times. Hopefully, these hold times can be reduced without system efficiency impacts.

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APPENDIX
STATISTICAL SUMMARIES

# 1	Pallet Tonnage Historical (DOV Mar 03 - Feb 04)
Mean	1.40
Standard Error	0.04
Median	1.44
Mode	#N/A
Standard Deviation	0.14
Sample Variance	0.02
Kurtosis	0.05
Skewness	0.06
Range	0.49
Minimum	1.19
Maximum	1.67
Sum	16.85
Count	12

# 2	Pallet Tonnage Port Pure (DOV Mar 04 - Jan 05)
Mean	1.76
Standard Error	0.11
Median	1.71
Mode	#N/A
Standard Deviation	0.37
Sample Variance	0.14
Kurtosis	-1.30
Skewness	0.14
Range	1.02
Minimum	1.25
Maximum	2.27
Sum	19.31
Count	11

# 3	Pallet Tonnage MILALOC (DOV Mar 04 - Jan 05)
Mean	1.60
Standard Error	0.04
Median	1.64
Mode	1.64
Standard Deviation	0.15
Sample Variance	0.02
Kurtosis	0.24
Skewness	-0.81
Range	0.48
Minimum	1.30
Maximum	1.78
Sum	17.60
Count	11

# 4	Average Pure Pallet Tonnage (DOV Mar 04 - Jan 05)
Mean	1.68
Standard Error	0.06
Median	1.66
Mode	1.48
Standard Deviation	0.29
Sample Variance	0.08
Kurtosis	0.19
Skewness	0.68
Range	1.02
Minimum	1.25
Maximum	2.27
Sum	36.91

# 5	Pallet Tonnage Historical (CHS Mar 03 - Feb 04)
Mean	1.90
Standard Error	0.04
Median	1.86
Mode	#N/A
Standard Deviation	0.14
Sample Variance	0.02
Kurtosis	-0.36
Skewness	0.96
Range	0.41
Minimum	1.74
Maximum	2.16
Sum	22.76
Count	12

# 6	Pallet Tonnage Port Built Pure (CHS Mar 04 - Jan 05)
Mean	2.13
Standard Error	0.09
Median	2.11
Mode	#N/A
Standard Deviation	0.30
Sample Variance	0.09
Kurtosis	0.79
Skewness	0.31
Range	1.05
Minimum	1.67
Maximum	2.72
Sum	23.40
Count	11

# 7	Pallet Tonnage MILALOC (CHS Mar 04 - Jan 05)
Mean	1.73
Standard Error	0.05
Median	1.77
Mode	1.86
Standard Deviation	0.15
Sample Variance	0.02
Kurtosis	-0.16
Skewness	-1.01
Range	0.41
Minimum	1.46
Maximum	1.87
Sum	19.01
Count	11

# 8	Average Pure Pallet Tonange (CHS Mar 04 - Jan 05)
Mean	1.93
Standard Error	0.07
Median	1.86
Mode	1.69
Standard Deviation	0.31
Sample Variance	0.10
Kurtosis	0.78
Skewness	0.78
Range	1.26
Minimum	1.46
Maximum	2.72
Sum	42.41

# 9	Missions Pre-Pure Pallet (DOV Mar 03 - Feb 04)
Mean	107
Standard Error	7
Median	100
Mode	120
Standard Deviation	23
Sample Variance	509
Kurtosis	0
Skewness	1
Range	78
Minimum	77
Maximum	155
Sum	1287
Count	12

# 10	Missions Post-Pure Pallet (DOV Mar 04 - Jan 05)
Mean	102
Standard Error	5
Median	100
Mode	#N/A
Standard Deviation	17
Sample Variance	274
Kurtosis	1
Skewness	0
Range	61
Minimum	72
Maximum	133
Sum	1119
Count	11

# 11	Missions Pre-Pure Pallet (CHS Mar 03 - Feb 04)
Mean	139
Standard Error	8
Median	142
Mode	127
Standard Deviation	29
Sample Variance	847
Kurtosis	2
Skewness	1
Range	113
Minimum	92
Maximum	205
Sum	1667
Count	12

# 12	Missions Post-Pure Pallet (CHS Mar 04 - Jan 05)
Mean	105
Standard Error	4
Median	107
Mode	#N/A
Standard Deviation	13
Sample Variance	176
Kurtosis	0
Skewness	-1
Range	42
Minimum	77
Maximum	119
Sum	1157

# 13	% TWCF Pre-Pure Pallet (DOV Mar 03 - Feb 04)
Mean	106.7
Standard Error	2.9
Median	108.1
Mode	#N/A
Standard Deviation	10.0
Sample Variance	99.9
Kurtosis	0.8
Skewness	-0.4
Range	38.2
Minimum	86.6
Maximum	124.7
Sum	1280.2
Count	12

# 14	%TWCF Post-Pure Pallet (DOV Mar 04 - Jan 05)
Mean	112.5
Standard Error	2.7
Median	110.9
Mode	#N/A
Standard Deviation	8.9
Sample Variance	79.0
Kurtosis	1.2
Skewness	0.8
Range	32.0
Minimum	99.6
Maximum	131.6
Sum	1237.7
Count	11

# 15	% TWCF Pre-Pure Pallet (CHS Mar 03 - Feb 04)
Mean	143.1
Standard Error	2.2
Median	142.8
Mode	#N/A
Standard Deviation	7.7
Sample Variance	58.7
Kurtosis	-0.6
Skewness	0.2
Range	26.2
Minimum	130.8
Maximum	157.0
Sum	1717.2
Count	12

# 16	%TWCF Post-Pure Pallet (CHS Mar 04 - Jan 05)
Mean	137.0
Standard Error	2.6
Median	139.8
Mode	#N/A
Standard Deviation	8.7
Sample Variance	75.6
Kurtosis	-0.7
Skewness	-0.2
Range	29.2
Minimum	121.7
Maximum	150.9
Sum	1507.0

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MANAGEMENT GUIDELINES FOR THIRD-PARTY LOGISTICS

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ABSTRACT

There is a significant amount of useful yet fragmented research in third-party logistics (3PL). This article seeks to review, summarize, and structure this 3PL research to provide a reference guide for managers interested in exploring, building, or improving logistics outsourcing opportunities. Topics covered include reasons to outsource, functions to outsource, 3PL provider evaluation, implementation and relationship success factors, contracts, and performance measures.

INTRODUCTION

Third-party logistics (3PL) has become an effective tool for supply chain management. Synonymous with logistics outsourcing, 3PL involves external providers supplying multiple logistics functions to a user (Capgemini, Langley, and FedEx Supply Chain Services, 2003). Since its emergence in the 1980's, the concept has continued to grow as companies constantly seek to drive greater value from logistics in the form of lower costs and improved service levels (Lynch, 2004). Capgemini et al. (2004) indicate significant benefits from logistics outsourcing, including average reductions of 15 percent in costs, 16 percent in fixed assets, 7 percent in inventory, 5.4 days (from 12.2) in order cycle times, and 2.4 days (from 22.2) in cash cycles.

The 3PL industry is still rapidly expanding and maturing. Recent estimates put the North American 3PL market at around $65-$70 billion annually ("The North American 3PL Market," 2004). Multiple surveys indicate that approximately 80 percent of companies outsource at least some logistics functions, averaging 40 percent of their logistics expenditures (Capgemini et al., 2004; Lieb and Bentz, 2004a). It is clear that 3PL has established a strong foothold in industry.

Academic research in 3PL has also expanded over the last few decades, providing contributions across key topics of logistics outsourcing including drivers, services, success factors, and performance measurement. Despite this wealth of 3PL research, it is not easy to navigate, accumulate, and summarize the findings. 3PL relationships are too multi-faceted and complex to completely survey in a single study, so research projects tend to examine individual pieces of the 3PL puzzle. Some papers address reasons to outsource (Rao and Young, 1994; Bienstock and Mentzer, 1999), while others will investigate success factors or performance measures (Tate, 1996; Knemeyer and Murphy, 2004). Some examine service provider (i.e., seller) perspectives (Leahy, Murphy, and Poist, 1995; van Hoek, 2000), while others concentrate on user (i.e., buyer) views (Daugherty, Stank, and Rogers, 1996; Boyson, Corsi, Dresner, and Rabinovich, 1999). Even works that align in research focus do not always address the same variables due to the extent of potential considerations.

OBJECTIVES AND METHODOLOGY

Given the breadth and fragmentation of the 3PL literature, it is difficult to gain comprehensive insight into 3PL without a rigorous literature review. This potentially compromises the impact and usability of the 3PL research and may not effectively serve the needs of industry practitioners who look to the literature for assistance with exploring, building, or improving 3PL opportunities. To address this problem, this article reviews and organizes more than 75 3PL published articles. It provides a structured summary of this previous research, organizing it by focus and findings to provide logistics managers with a centralized guide for exploratory consideration of key outsourcing topics.

The author has reviewed supply chain, logistics, and operations academic journals for 3PL related literature dating back to the origins of 3PL research in the early 1990's. The results are summarized relative to key 3PL topics (Table 1)

TABLE 1
DESCRIPTION OF TOPICS ASSESSED IN 3PL RESEARCH

Topic	Description	Sample Research Questions/Hypotheses
Reasons to Outsource	Motivations, drivers, and deterrents for outsourcing logistics functions	▸ Why should (and should not) a 3PL user consider outsourcing logistics functions? ▸ What are the expected benefits of outsourcing logistics functions?
Services to Outsource	Logistics functions (e.g., transportation, warehousing, freight payment, etc.) that a 3PL user outsources	▸ Which logistics functions could a 3PL user outsource? ▸ Which logistics functions do 3PLs offer? ▸ Which logistics functions are bundled together in outsourcing solutions?
Provider Evaluation	Process and criteria for selecting 3PL providers	▸ Which factors should a 3PL user use to assess and select 3PL providers? ▸ How should a 3PL user assess and select 3PL providers?
Contracts	Important elements of 3PL contracts	▸ What elements are critical to 3PL contracts? ▸ How should 3PL contracts be structured (e.g., duration, pricing, etc.)?
Success Factors (Implementation and Relationship)	Factors that affect the quality of the outcome (performance and satisfaction) of a 3PL relationship	▸ What key elements support or deter the effective implementation (user and/or provider) of 3PL relationship? ▸ What key elements support or deter the effective performance and satisfaction (user and/or provider) of 3PL relationship?
Performance, Satisfaction	Measurement of performance and satisfaction outcomes related to a 3PL relationship	▸ What measures of performance/satisfaction should a 3PL user use to assess 3PL relationships? ▸ What measures of performance/satisfaction should a 3PL provider use to assess 3PL relationships? ▸ What is the performance/satisfaction measurement process for a 3PL relationship?

including reasons to outsource (why and why not), services to outsource, 3PL provider evaluation, implementation success factors (including contracts), 3PL relationship success factors, and performance and satisfaction assessment.

For each topic, findings from the literature are presented comprehensively in a table with the most frequently cited items highlighted in bold to help readers focus attention within the extensive lists. While the volume of information precludes a complete discussion of each table, selected key items from each table are assessed and, subsequently, emerging trends are presented. Each section (and each table) is designed to stand alone if necessary to support each reader's individual interests. As an additional tool, Appendix A presents a summary of all the assessed research, facilitating further reader exploration into any of the conclusions presented.

The material presented can be used in several ways. For one, 3PL users can customize the lists and subsequent discussions as reference for their own outsourcing situations and opportunities. Likewise, 3PL providers can utilize the insights to both provide assistance to potential customers and support evaluation of relationships with their existing partners. Finally, industry and academic researchers can employ this paper as a centralized foundation to launch and direct future 3PL research.

RESEARCH IN THIRD PARTY LOGISTICS

The term "third-party logistics" evolved in the late 1980's (Sheffi, 1990) as an extension of contractual relationships between companies and external logistics providers. The delineation between a contractual and third-party relationship is somewhat unclear, but Murphy and Poist (2000, p. 121) offer a definition of 3PL as,

> A relationship between a shipper and third party which, compared with basic services, has more customized offerings, encompasses a broader number of service functions, and is characterized by a longer-term, more mutually beneficial relationship."

Research indicates that 3PL relationships reach beyond an arms-length, transactional basis to include key elements such as trust (Bowersox, 1990; Leahy, Murphy, and Poist, 1995) and interdependence (Zineldin and Bredenlow, 2003) that tend to be identified in partnership-like relationships.

Appendix A demonstrates that academic literature on third-party logistics has expanded to a significant volume. It is worthwhile to first highlight two initiatives that stand out due to scope and approach. The first, conducted by Bob Lieb of Northeastern University in association with Accenture, assesses 3PL industry views with both user and provider surveys on an annual basis. The user survey (Lieb and Bentz, 2004a) evaluates logistics executive perspectives of provider evaluation, services used, value, and satisfaction, while the provider survey (Lieb and Bentz, 2004b) analyzes 3PL provider outlooks of financials, selling, operational issues, and industry developments. The second primary 3PL research project is led annually by John Langley of Georgia Institute of Technology in conjunction with Capgemini and FedEx Supply Chain Services (Capgemini et al., 2004). Focusing on primary global logistics markets, this research evaluates market trends, services, challenges, value, and future directions. In their 10th and 9th consecutive years respectively, both the Lieb and Langley studies provide strong macro perspectives of 3PL industry trends and maturation. The following sections of this paper will incorporate these and other 3PL research papers to evaluate the individual key topics of logistics outsourcing.

Reasons to Outsource

As depicted in Table 2, many detailed, interrelated drivers influence the outsourcing decision (with the reasons most frequently identified in the literature distinguished in bold). This decision, however, is most often primarily driven by a combination of performance, cost, and

TABLE 2
REASONS TO OUTSOURCE

Corporate Effectiveness, Productivity	Expansion, Globalization
Capability range	Capacity increase
Control of processes, assets	**Complexity of global network**
Expertise and experience	Expansion acceleration
JIT enablement	Geographic location
Operating performance, productivity improvements	
Processes improvement, updating	**Flexibility**
Productivity, resource sharing	Demand fluctuations, peaks accommodation
Time-to-market speed	**Flexibility, response to change**
Supply chain re-design	Risk reduction, sharing
Supply chain visibility	
	Labor
Cost and Return	Corporate restructuring
Capital reduction, asset transfer, fixed to variable cost transfer	Inadequate resources
Cost reduction	Labor problems reduction
Inventory reduction	**Headcount reduction**
	Personnel deployment (to provider)
	Personnel productivity
Customer Service	**Qualitative Improvements**
Customer contact control	Commitment, energy increases in non-core area
Delivery cycle times reduction	Credibility and image improvement
Delivery reliability	Innovation generation
Service quality improvements	Organization transformation
Corporate Focus	**Technology**
Complexity reduction	**Data security**
Centralized capability	**Information quality improvement**
Focus on core business, competencies	**Technology, integration improvements**

Bold indicates items most frequently cited by literature base.

service. Can an external provider do it better at higher service levels and/or at lower costs? From an operations perspective, users pursue improved logistics performance and productivity with the 3PL provider's focus and expertise (Greaver, 1999) as well as advanced functionality such as just-in-time (JIT) (Lynch, 2004). 3PL users also seek improved service levels for their customers (Sink, Langley, and Gibson, 1996; Sink and Langley 1997; Lambert, Emmelhainz, and Gardner, 1999) from factors such as delivery reliability (Maltz, 1994b) or cycle time reduction (Bot and Neumann, 2003). From a cost perspective, users look to lower the operational costs of the function as well as transfer assets to the provider, allowing them to reduce fixed costs (Greaver, 1999; Zineldin and Bredenlow, 2003; Lynch, 2004). Often, a major focus of the cost reduction is on employee headcount (Daugherty, Stank, and Rogers, 1996; Sink, Langley, and Gibson 1996).

While performance, service, and cost remain primary outsourcing drivers, additional factors are emerging as important considerations. Global expansion is identified in the literature base as one key motivator of outsourcing (Razzaque and Sheng, 1998; House and Stank, 2001) in that 3PL providers can offer swift penetration to new markets, especially in high economic growth areas such as China and India (Lieb and Bentz, 2004a). Users also cite enhanced flexibility with 3PL providers, enabling adaptation to rapidly changing demand and capacity events (Fernie, 1999; Skjoett-Larsen, 2000). Finally, technology presents another driver for outsourcing as users rely on providers' best practice technology to enhance information flow, quality, and security given rapidly and unpredictably changing technology options (Lieb and Randall, 1996; Gutierrez and Duran 1997; House and Stank 2001).

Even if many of the above, as well as additional conditions for outsourcing are identified, the decision is still not necessarily clear. Table 3 presents reasons to maintain logistics services in-house. Primarily, companies may be concerned with the loss of control over a function, especially one that is customer facing (Sohail and Sohal, 2003; Capgemini et al., 2004) or considered core (Greaver, 1999). Readers should note that increased control is also paradoxically listed in Table 2 as a reason to outsource. Also, outsourced processes are difficult to bring back in-house (Greaver, 1999), and users face anxiety regarding uncertainty of 3PL capabilities, effectiveness, and cost (Sohail and Sohal, 2003; Capgemini et al., 2004). Furthermore, since outsourcing generally leads to headcount reassignment and reduction, users should be aware of employee morale and job preservation issues (Greaver, 1999), which in some cases can lead to reduced commitment and increased likelihood of sabotage. Finally, users who do not currently have control of logistics costs and processes (Greaver, 1999) should realize that outsourcing may not provide an effortless panacea for their problems.

Ultimately, the decision to outsource or not is generally made at the highest corporate levels (Mottley, 2005). Bearing in mind the numerous intentions to pursue and not pursue logistics outsourcing, achieving awareness, consensus, and communication of the reasons remains paramount both during initial decision-making and the provider evaluation processes. Users must systematically identify and address all outsourcing drivers, both positive and negative, then develop a documented position to guide internal resources. Some reasons can be addressed with a business case or ROI model, though qualitative considerations must also be weighed. Failure to consider and address all outsourcing reasons may lead to a lack of commitment and create a negative outsourcing implementation environment that will doom the project before it begins.

Services to Outsource

The decision to outsource or not corresponds directly with an assessment of which services to potentially outsource. Table 4 presents a list of logistics functions that a company may consider for outsourcing. Early outsourcing efforts focused on transportation and warehousing. Outsourced warehouse solutions have evolved from basic use of contract storage facilities to include not only

TABLE 3
REASONS TO NOT OUTSOURCE

Uncertainty, Anxiety	Labor
Confidentiality compromise	Employee commitment/morale loss, culture change
Difficulty to reverse	Job preservation
Uncertainty of provider capabilities, service	
Uncertainty of change	**Relationships**
Uncertainty of estimating true provider costs	Customer impacts
Lack of understanding of existing costs, processes	Desire to maintain vendor relationships
	Relationship building difficulty
Control	
Logistics a core function	
Loss of control	

Bold indicates items most frequently cited by literature base.

TABLE 4
LOGISTICS FUNCTIONS/SERVICES TO OUTSOURCE

Transportation	**Order Mgmt., Distribution**	**International**
All functions (outbound and/or inbound)	Cross-docking	Bonded warehousing
Carrier contracting	Distribution communication	Export licensing assistance
Carrier performance measurement	Expedited delivery	Export operations, freight forwarding
Fleet operations, maintenance	Merge-in-transit	Import operations, customs brokerage, clearance
Freight audit, payment	Order fulfillment	Intl. distribution
Freight rate negotiations, carrier selection	**Order entry, processing**	Intl. shipping
Freight, shipment consolidation	Order picking, packing, fulfillment	Intl. sourcing
Shipment planning, tendering, routing, scheduling	**Packaging, labeling**	Intl. communications
Tracking, tracing	Pickup and delivery	Letter of credit compliance
Inv. Mgmt, Warehousing	**Customer Service**	**Technology**
Inventory control, replenishment	After-sales service	eCommerce initiatives
Inventory ownership	Billing	EDI
Kitting	Customer installation	Systems, technology operations
Slotting, layout	Customer service	Software selection
Warehousing, warehouse management	**Returns, reverse logistics**	Wireless communications
	Spare parts, repairs	
Manufacturing, Assembly	**Network, Facilities**	**Other**
Assembly, configuration	Distribution network strategy, design	Financial services
Contract manufacturing	Facility financing, construction	Forecasting
Customization	Facility location	Materials procurement
		MRO purchasing
	Supply Chain Management	Packaging design
	4PL, lead logistics services	Product life-cycle mgmt.
	All supply chain functions	Product testing
	Consulting	Relocation
	Performance reporting	Value-added services
	Supply chain integration	Vendor-managed inventory

Bold indicates items most frequently cited by literature base.

inventory planning and control but also distribution functions such as order management, picking, packaging, and delivery (Murphy and Poist, 2000; Sohal, Millen, and Moss, 2002). Related to transportation, some users opt to outsource specific steps in the process such as rate negotiations, shipment consolidation, planning and tendering, and freight audit and payment (Gunasekaran and Ngai, 2003; Capgemini et al., 2004; Lieb and Bentz, 2004a). Users may also opt for a fully outsourced (outbound and/or inbound) transportation solution (Capgemini et al., 2004; Lieb and Bentz, 2004a), including procurement, planning, and execution. Fleet management is another transportation function frequently mentioned in the 3PL literature (Sheffi, 1990; Rabinovich, Windle, Dresner, and Corsi, 1999). The 2004 Lieb/Accenture (2004a) study indicates that warehouse management, rate negotiations, and shipment consolidation are the highest impact outsourced logistics services relative to cost, with warehouse management and order fulfillment delivering the best service improvements.

Looking beyond warehousing and transportation, several niche areas of logistics have gained prominence for outsourcing recently. Freight-forwarding and customs brokerage activities (Sink, Langley, and Gibson, 1996; Murphy and Poist, 2000) are targets due to the growing regulatory complexity of international trade. Reverse logistics activities, including returns, repairs, and disposal (Sink and Langley, 1997; van Hoek, 2000) offer opportunities to minimize costs associated with these often overlooked cost-centers. Furthermore, companies have sought to jumpstart technology through outsourcing (Sheffi, 1990; Piplani, Pokharel, and Tan, 2004), especially relative to eCommerce channels (Sink, Langley, and Gibson, 1996; Gunasekaran and Ngai, 2003) and radio frequency identification (RFID) (Lieb and Bentz, 2004b). Finally, 4th party logistics (4PL), also referred to as lead logistics provider (LLP), involves outsourcing the entire management of all or most logistics suppliers and providers (Marino, 2002; Lieb and Kendrick, 2003). The concept has not seemed to gain significant traction in industry, however.

As Table 4 reveals, the literature base has essentially identified any and all logistics functions as candidates for 3PL. The big concern is to develop a clear understanding of how outsourcing some functions will impact the control and effectiveness of other functions. Even if users are only considering outsourcing a few functions, they should review a complete list to assess potential synergies and drawbacks with other in-house functions. To capture the value of supply chain integration, there is currently a movement towards larger scale solutions that incorporate numerous functions (Lieb and Bentz, 2004a), especially related to door-to-door delivery of international shipments. Likewise, the Langley study (Capgemini et al., 2004) indicates that users expect a wide, comprehensive set of functionality and advises that the providers are not keeping up with user demands for services. In a cautionary tone, Murphy and Poist (2000) found that providers and users were not aligned in services offered versus used.

3PL Provider Evaluation

Given a decision to outsource, companies must carefully assess potential 3PL partners. Table 5 catalogs provider evaluation factors and, similar to the reasons to outsource, cost (Boyson et al. 1999; Laarhoven, Berglund and Peters 2000) and service (Menon, McGinnis, and Ackerman, 1998; Hong, Chin, and Liu 2004) generally dominate selection criteria. The most recent Lieb/Accenture (2004a) study indicates that cost most often governs initial selection of 3PL providers, but service most influences contract renewals. Maltz (1994b) found that outsourcing of warehousing tends to be driven more by service than cost. Beyond cost and service, users must consider 3PL provider capability from multiple perspectives such as range and customizability of services offered (Bhatnagar, Sohal, and Millen 1999; Sohail and Sohal 2003), size (Boyson et al., 1999), facilities and equipment (Lynch 2004), technology (Sink and Langley 1997; Razzaque and Sheng 1998), and quality improvement processes (Razzaque and Sheng, 1998). Since management expertise and depth are important, the experience, strength, and structure of provider management will also influence evaluation (Menon, McGinnis, and Ackerman, 1998; Laarhoven, Berglund, and Peters, 2000). Finally, users should evaluate the potential future success of the relationship by looking at key factors such as strategic direction, financial stability, culture, and compatibility (Boyson et al., 1999; Lynch, 2004).

Given the multitude of evaluation factors that span the scale from quantitative to qualitative, identifying the best 3PL partner can be a complex process, requiring a thorough understanding of the 3PL marketplace and a meticulous selection approach (Razzaque and Sheng 1998). Uncertainty of 3PL capabilities will constantly overshadow the selection process. Thus, 3PL providers must not only educate potential customers on expected benefits

TABLE 5
3PL PROVIDER EVALUATION FACTORS

Price	Performance incentives; **Price of services**; ROI
Provider Capability	Certification; Customer service capability; Customized services; Facilities, equipment; International capability; Operating model (remote, on-site); **Operational Capability**; Project management; **Quality improvement process**; Security; Range of services; Best practice, knowledge sharing; Size; Support services
Service	Service compatibility; **Service quality**; Service reliability; Service speed
Logistics Network	Asset vs. non-asset model; Capacity; International scope; Location; Network/coverage
Staff	Ethics; **Experience, staff quality**; HR policy; **Management structure, strength, depth**; Professionalism
References, Reputation	**Current customer base, references, and lost customers**; **Industry reputation**; Personal knowledge of provider; Prior relationships with provider; **Reputation**
Technology	Data detail, quality; Systems flexibility, capacity, compatibility; **Technology, information systems**
Flexibility	Operating flexibility; Pricing flexibility; Problem-solving creativity; Responsiveness to contingencies
Direction	**Corporate fit, culture compatibility**; **Financial stability**; Growth potential; Long-term relationship opportunity; Risk; Strategic direction, vision

Bold indicates items most frequently cited by literature base.

(Razzaque and Sheng 1998) but also demonstrate verifiable capabilities. Internal documentation and client references are extremely important. Providers should also realize that the user options often include keeping the process in-house as the user is essentially comparing internal capabilities with that of the 3PL market. When the decision path is not clear, the user firm will frequently default to keeping the services in-house. As a final note, users should maintain a thorough and documented evaluation methodology, including selection criteria, weighting of this criteria, and subsequent assessments of providers. For aspects that may be difficult to measure, such as fit or service levels, it may be helpful for multiple resources at the user company to qualitatively evaluate potential providers relative to a minimally acceptable level. Like assessing the decision to outsource, building a time-phased return on investment model (ROI) can also help identify leading provider candidates, but users should be wary of over-focusing on cost.

Contracts and Implementation Success Factors

Implementation success factors and contracts go hand-in-hand, so these topics are discussed together. First, critical success factors for implementing 3PL relationships are presented in Table 6. To start, a joint, rigorous definition of requirements and service levels is paramount for setting the performance baselines and expectations (Sohal, Millen, and Moss, 2002; Capgemini et al., 2004). This is complemented by definition of roles and responsibilities (Bowersox, 1990; Lieb, Millen, and Van Wassenhove, 1993) and operations processes and standards (Razzaque and Sheng 1998; Lynch 2004). Communication of accurate promises of capabilities is also critical (Ackerman, 1996). Furthermore, focus and timing are complex issues as the literature points to both a limited initial roll-out (House and Stank, 2001) that focuses on core competencies (Leahy, Murphy, and Poist, 1995; Murphy and Poist, 2000) and a long-term focus (Stank and Daugherty, 1997; Gunasekaran and Ngai 2003) with a migration plan towards advanced services (Capgemini et al., 2004).

The contract defines the basis for the relationship between the 3PL provider and user. While most providers will have a standard contract template, some customers push for their own version. Regardless of who establishes the contract, many key elements must be present to protect all parties (Table 7). For one, responsibilities for both sides, not just the 3PL, must be clear (Boyson et al., 1999; Lynch, 2004), as should the scope of services and performance metrics with target levels (Greaver, 1999). Standard financial factors, including prices and payment, are a necessity (Boyson et al., 1999), but an unbiased methodology should also be included to account for price modifications given uncontrollable market supply/demand conditions (Lynch 2004). Since conflicts and issues may emerge, the contract should also include dispute mechanisms, a thorough termination clause, and allocation of liabilities (Boyson et al., 1999).

Given the complexity of the contract and success factors, the implementation of outsourced logistics functions must be a mutual and coordinated process (Greco, 1997), especially given that it sets the tone for the future operating relationship. Since the provider

TABLE 6
CRITICAL IMPLEMENTATION SUCCESS FACTORS

Requirements Alignment	Focus and Timing
Accurate capability promises, communication	Focus on core competency
Clear operating standards, procedures, rules, policies	Limited initial roll-out
User systems understanding	Limited, defined scope of operations
User understanding of provider operations	**Long-term focus**
Definition of requirements, expectations, service levels	Migration toward advanced services
Definition of roles, responsibilities and boundaries	Reasonable timing (relative to business, market conditions)
	Sufficient implementation time
Pricing	**Training**
Cost baseline definition	Process training
Gain sharing definition	Technology training
Price negotiations (but not over-focus)	
	Contract
	Accurate, complete contract
	Separation, change options and strategy
	See Table 7

Bold indicates items most frequently cited by literature base.

TABLE 7
KEY 3PL CONTRACT CONSIDERATIONS

Responsibilities	Term
Provider responsibilities, obligations	**Contract length, term**
User responsibilities	
Decision rights	**Financial**
Description of processes	**Cost, price of services**
Description of scope of services	Cost, price changes
Factors of production (people, facilities, equipment, technology, other assets)	Gain-sharing
Reporting	**Payment method, terms**
Technology, intellectual property	Under, Overcharges
Volume commitments	
	Dispute, Termination
Performance	Arbitration
Non-compliance penalties	Dispute mechanisms
Performance metrics, service levels	**Termination clause (with rights, ownership)**
	Risk, Liability
	Loss, damage
	Insurance, allocation of liabilities

Bold indicates items most frequently cited by literature base.

generally retains more implementation expertise than the user, the onus falls on the provider to guide the process. Key phases will often include discovery (during which the provider collects detailed requirements), solution development, testing, training, and rollout. To guide these phases, the 3PL should maintain repeatable and standardized yet customizable documentation that defines implementation processes, timing, deliverables and roles and responsibilities. The provider must also prepare documentation to guide both provider and the user through the discovery phase to explore current operating procedures, gather historical data, and determine service baselines. Although the 3PL may drive the implementation process, the user must maintain significant participation with a committed, open attitude.

Success Factors - 3PL Relationships

Once implementation is complete, there is a multitude of critical success factors for maintaining effective 3PL relationships (Table 8). Many of the most frequently cited 3PL relationship success factors deal with alignment between the 3PL and user. Examples include benefit and risk sharing, commitment honoring, cultural fit, and goal congruence (Bowersox, 1990; Knemeyer, Corsi and Murphy, 2003; Zineldin and Bredenlow, 2003). The provider must not only maintain a complete understanding of requirements and be responsive to the user, but also adapt as these needs change (Leahy, Murphy, and Poist, 1995; Murphy and Poist, 2000). On the user side, employee sabotage instigated by layoffs and reassignments will prove detrimental to the 3PL relationship, so management must preserve worker morale, cooperation, and commitment (Bardi and Tracey, 1991; Ackerman, 1996). Top management support (Razzaque and Sheng, 1998) and subsequent involvement at all levels (Bowersox, 1990) will provide valuable support here.

While technology should be both best practice and customizable (Sohal, Millen, and Moss, 2002; Capgemini et al., 2004), two-way as well as internal communication (including feedback) information sharing, and dispute resolution are also

TABLE 8
SUCCESS FACTORS FOR MAINTAINING 3PL RELATIONSHIPS

Provider Capability	Working Relationship	Alignment
Clear advantage	Compatibility	**Benefits, risks sharing**
Economies of scale	**Commitment**	**Commitment honoring**
Expertise	Conflict resolution, friction points identified	**Cultural understanding and fit**
Financial strength	Convenience	Expectations communication (internal, external)
Flexibility, innovation	Dependability, reliability	**Goal, objective alignment, strategic fit**
Localization	Empathy, attachment	Investment (non-retrieval resource commitment)
Network coverage	Fairness, reciprocity	Symmetry, equity
Number of services	Interdependence	
Responsiveness to user	Knowledge transfer	**Tools**
Understanding user operations, needs	Lack of opportunism	Timely information, data
	Loyalty	**Two-way, consistent, rich communication and feedback**
User Capability	Mutual integrity	**User control**
Clear outsourcing strategy	Mutual respect	Employee empowerment
Cooperation, commitment (no sabotage)	Openness, honesty	Internal communication
Deployment of buyer personnel	**Trust**	Joint operating controls
Involvement at all levels	Willingness to make relationship work	Joint planning
Management strategy, process for provider		Joint process improvement
Personnel motivation, reward	**Performance, Effectiveness**	**Performance measurement, criteria**
Processes in order	Provider profitability	
Top management support	**Cost savings realization**	
	Ease of doing business	
Technology, Data	Effective financial arrangement	
Data quality, usability	Focus on user	
Proprietary info. sharing	Service consistency	
Best practice technology	Service quality	
Technology integration, customization, fit		

Bold indicates items most frequently cited by literature base.

critical to the relationship (Leahy, Murphy, and Poist 1995; Zineldin and Bredenlow, 2003). Likewise, cooperative processes should be in place to manage operational controls, planning, process improvement (Lambert, Emmelhainz, and Gardner 1999; Capgemini et al., 2004), and performance measurement (Lieb and Randall, 1996; Sohal, Millen, and Moss, 2002). Although specific performance measures will be discussed in the next section, the literature addresses several important general performance outcomes led by cost realization as well as service quality and consistency (Leahy, Murphy, and Poist, 1995; Razzaque and Sheng, 1998). Many qualitative relationship factors are also cited in the literature with trust (Tate, 1996; Knemeyer, Corsi, and Murphy, 2003) being the most prominent. Reliability (Murphy and Poist, 2000), fairness (Tate, 1996), loyalty (Lynch, 2004), integrity (Zineldin and Bredenlow, 2003), respect (Bot and Neumann, 2003), and openness (Razzaque and Sheng, 1998) are also among the cited qualitative aspects.

With many diverse critical success factors, 3PL relationships can be difficult to manage. Active participation is required at multiple levels on both the provider and user sides. Since the provider's business thrives on pleasing the customer, their motivation is clear. Participation on the user side can be a concern, however. While the effectiveness of the user's business relies on the success of the provider's operations, users still may not provide required levels of participation due to the aforementioned problems of support and commitment. Another significant challenge in a 3PL relationship is for both parties to understand the relative importance of the success factors. Alignment of expectations, operations, performance, and the relationship are crucial to an effective 3PL environment, yet this congruence is often difficult to measure. While Murphy and Poist (2000) find a high degree of similarity of goal congruence between providers and users, partners should not overlook the need to assess mutuality of success factors, however, since all 3PL relationships are unique.

Performance and Satisfaction Assessment

The last critical topic of 3PL is the assessment of performance and satisfaction. As discussed in the previous section, performance measurement is cited frequently in the literature as a 3PL critical success factor. Table 9 organizes performance measures cited by the literature based on the ability to quantify these measures. The literature tends to focus on logistics effectiveness and return. Key items, including customer service levels (Boyson et al., 1999; Lambert, Emmelhainz, and Gardner, 1999), geographic coverage (Hong, Chin, and Liu, 2004; Knemeyer and Murphy, 2004), labor (Hong, Chin, and Liu, 2004; Knemeyer and Murphy, 2004), capital investment (Sohal, Millen, and Moss, 2002; Capgemini et al., 2004), and supply chain performance (Sohail and Sohal, 2003; Lynch, 2004) may be relatively straightforward to quantify and can become part of corporate-wide measures. Other items, such as logistics flexibility and expertise (Lieb and Randall, 1996; Sink and Langley, 1997), are more difficult to quantify as are focus (Sink and Langley, 1997) and technology (Capgemini et al., 2004; Knemeyer and Murphy, 2004). The literature also suggests numerous indicators of 3PL provider service quality to the user, some of which revolve around proactive handling of service exceptions and mistakes (Daugherty, Stank, and Rogers, 1996; Knemeyer, Corsi, and Murphy, 2003; Hong, Chin, and Liu, 2004).

Performance is a major but not comprehensive component of overall relationship satisfaction, so user satisfaction should also be measured. Macro indications of 3PL industry satisfaction tend to be mostly positive as several studies indicate that users appear to be relatively satisfied with their 3PL use (Murphy and Poist, 2000; Capgemini et al., 2004; Lieb and Bentz, 2004a). However, the Langley study (Capgemini et al., 2003) warns of a gap between actualized versus expected success and indicates that generally users desire more enhanced offerings than what is currently available for global solutions and supply chain integration. The 2004 Lieb/Accenture (2004a) study reports declining levels with some 3PL user performance measures including cost, service, satisfaction, morale, and supply chain integration. While no definite trends of problems have been identified, 3PL outsourcing participants should remain alert to the potential escalation of problems as their relationships become more sophisticated. As a final note, measurement of 3PL provider satisfaction should not be ignored since it may impact commitment to the user. The Lieb/Accenture (2004b) study indicates 3PL providers are becoming more selective of customers due to eroding profitability driven in part by significant pricing pressures.

Several key inferences may be drawn from the above discussion of performance and satisfaction measurement. For one, performance measures should at least initially be closely tied to the original reasons for outsourcing. Focus should be placed both on quantitative and qualitative measures as appropriate to recognizing the outsourcing goals. The quantitative measures should be automated as much as possible, and the qualitative factors can be assessed periodically with surveys or focus groups. Like

TABLE 9
3PL PERFORMANCE MEASURES

Area	Highly Quantifiable	Moderately Quantifiable	Difficult to Quantify
Logistics Effectiveness	Cash cycles **Customer service levels** **Geographic coverage** Inventory levels Logistics system responsiveness Loss and damage Operational efficiency Order cycle time Product, service availability **Supply chain performance**	Cost control Customer satisfaction **Flexibility, change** Movement from push to pull Post-sales customer support Risk Specialized services	Competitive advantage **Logistics expertise, market knowledge**
Service (to User)	Error rates Notification of service issues Performance reporting Service exception handling	Mistake recovery Responsiveness Transition satisfaction Value analysis assistance	Personnel quality
Return, Cost	**Capital, asset investment** **Labor base, cost** Price stability Total cost	Return on investment (cost, service) Technology cost	
Focus		Ability to focus on core business Employee morale Reduced time spent on logistics	
Technology		Access to data eBusiness capability, support **Logistics systems, technology capability**	

Bold indicates items most frequently cited by literature base.

the relationship success criteria in the previous section, it is critical for the provider and user to be aligned relative to the importance of the performance measures and actively engage in joint performance reporting and review, regardless of who owns responsibility for the measurement process. Furthermore, performance results should be communicated relative to expectations on both sides and should also drive formalized, joint continuous process improvement efforts.

CONCLUSIONS

The 3PL industry continues to grow (Capgemini et al., 2004; Lieb and Bentz, 2004a), and academia has offered valuable research to support this expansion. Given its spread, however, this literature is not necessarily easily usable for practitioners. This article has sought to address this opportunity by reviewing and organizing the 3PL literature base, focusing on key topics including outsourcing reasons, services to outsource, 3PL provider evaluation, implementation success factors, contracts, relationship success factors, and performance measurement. It fundamentally provides a centralized reference for readers to better navigate the findings from the wealth of academic research. Although this paper has comprehensively summarized the literature base, readers should be aware that the tables and discussions presented here still do not exhaust all possible considerations.

Selecting and implementing 3PL is a long and complex process that can potentially lead to significantly rewarding or disastrous results. Details can make or break the success of a 3PL relationship, so users must be extremely thorough throughout the process to enable the best chance of success. While there is some degree of replicability among 3PL relationships across different companies, each will be unique to some extent. To maximize the potential success of their 3PL endeavors, users should gather as much intelligence as possible to customize their own requirements. Readers should consider this paper as one source of such intelligence and use it as a gateway to more than 75 other academic 3PL works.

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APPENDIX A
SUMMARY OF 3PL RESEARCH

Paper	Year	Methodology	Reasons to Outsource	Services to Outsource	Provider Evaluation	Contracts	Success Factors	Performance, Satisfaction
Ackerman	1996	Conceptual					Y	
Aertsen	1993	Conceptual		Y				
Aghazadeh	2003	Case					Y	
Bardi and Tracey	1991	Survey (Buyer)	Y	Y			Y	
Bask	2001	Conceptual					Y	
Bhatnagar et al.	1999	Survey (Buyer)	Y	Y	Y		Y	Y
Bolumole	2001	Conceptual	Y					
Bolumole	2003	Conceptual	Y					
Bowersox	1990	Case(s)	Y				Y	
Boyson et al.	1999	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Capgemini et al.	2003	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Capgemini et al.	2004	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Choy and Lee	2002	Case(s)			Y			
Dapiran et al.	1996	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Daugherty et al.	1996	Survey (Buyer)					Y	Y
Daughtery and Droge	1991	Survey (Buyer)	Y	Y				
Fernie	1999	Survey (Buyer)	Y	Y	Y	Y		Y
Foggin et al.	2004	Conceptual			Y			
Gunasekaran and Ngai	2003	Case(s)		Y			Y	
Gutierrez and Duran	1997	Survey (Buyer)	Y	Y				Y
Halldorsson and Skjott-Larsen	2004	Conceptual	Y		Y		Y	
van Hoek	2000	Survey (3PL)		Y		Y	Y	Y
van Hoek	2001	Survey (3PL)	Y	Y				Y
Hong et al.	2004	Survey (Buyer)		Y	Y	Y	Y	Y
House and Stank	2001	Case(s)	Y	Y			Y	
Knemeyer et al.	2003	Survey (Buyer)		Y			Y	Y
Knemeyer and Murphy	2004	Survey (Buyer)		Y			Y	Y
Knemeyer and Murphy	2005	Survey (Buyer)		Y			Y	Y
Laarhoven et al.	2000	Survey (Buyer)	Y	Y		Y	Y	Y
Lambert et al.	1999	Case(s)	Y				Y	Y
Leahy et al.	1995	Survey (3PL)		Y			Y	Y
Lieb	1992	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Lieb et al.	1993	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Lieb and Randall	1996	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Lieb and Randall	1999	Survey (3PL)		Y		Y	Y	
Lieb and Kendrick	2003	Survey (3PL)	Y	Y			Y	
Lieb and Bentz	2004	Survey (Buyer)		Y			Y	Y
Lieb and Bentz	2005	Survey (Buyer)		Y		Y		Y
Logan	2000	Conceptual				Y	Y	
Maltz et al.	1993	Survey (Buyer)		Y				
Maltz (a)	1994	Survey (Buyer)	Y					
Maltz (b)	1994	Survey (Buyer)	Y					Y
Maltz and Ellram	1997	Conceptual	Y					
Maltz and Ellram	2000	Survey (Buyer)	Y	Y				
Meade and Sarkis	2002	Conceptual			Y			
Menon et al.	1998	Survey (Buyer)			Y			Y
Millen et al.	1997	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Moberg and Speh	2004	Survey (Buyer)			Y			
Moore	1998	Survey (Buyer)					Y	
Murphy and Poist	1998	Survey (Buyer)		Y				
Murphy and Poist	2000	Survey (Buyer, 3PL)		Y			Y	Y

Paper	Year	Methodology	Reasons to Outsource	Services to Outsource	Provider Evaluation	Contracts	Success Factors	Performance, Satisfaction
Piplani et al.	2004	Survey (3PL)		Y	Y		Y	
Rabinovich et al.	1999	Survey (Buyer)	Y	Y				
Rao et al.	1993	Case(s)	Y	Y				
Rao and Young	1994	Case(s)	Y					
Razzaque and Sheng	1998	Conceptual	Y		Y		Y	
Sankaran et al.	2002	Case(s)				Y		
Sauvage	2003	Survey (3PL)					Y	
Sheehan	1989	Case(s)	Y		Y			
Sheffi	1990	Conceptual	Y					
Sink et al.	1996	Case(s)	Y		Y			
Sink and Langley	1997	Survey (Buyer)	Y	Y	Y		Y	Y
Sinkovics and Roath	2004	Survey (Buyer)					Y	Y
Skjoett-Larsen	2000	Case(s)	Y				Y	
Sohail and Sohal	2003	Survey (Buyer)	Y	Y	Y	Y	Y	Y
Sohal et al.	2002	Survey (Buyer)		Y			Y	Y
Stank and Daugherty	1997	Survey (Buyer)					Y	
Stank et al.	2003	Survey (Buyer, 3PL)					Y	Y
Sum and Teo	1999	Survey (3PL)			Y		Y	Y
Tate	1996	Case(s)					Y	
Vaidyanathan	2005	Conceptual	Y					
van Damme and Van Amstel	1999	Conceptual	Y		Y		Y	
Vickery et al.	2004	Survey (Buyer, 3PL)					Y	Y
Virum	1993	Case(s)	Y				Y	
Wilding and Juriado	2004	Survey (Buyer)	Y	Y			Y	Y
Zineldin and Bredenlow	2003	Case(s)					Y	

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Michael Maloni is an assistant professor at Kennesaw State University. Prior to returning to academics in 2004, Dr. Maloni managed $80 million of supply chain services for a third-party logistics (3PL) company. He conducts research in third-party logistics and international transportation, and his work has been published in the *Journal of Business Logistics*, the *Journal of Operations Management*, the *Transportation Journal*, and the *European Journal of Operational Research*. Dr. Maloni holds a Ph.D. in operations and supply chain management from Ohio State University.

PLANT SUPPLY LOGISTICS: BALANCING DELIVERY AND STOCKOUT COSTS

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ABSTRACT

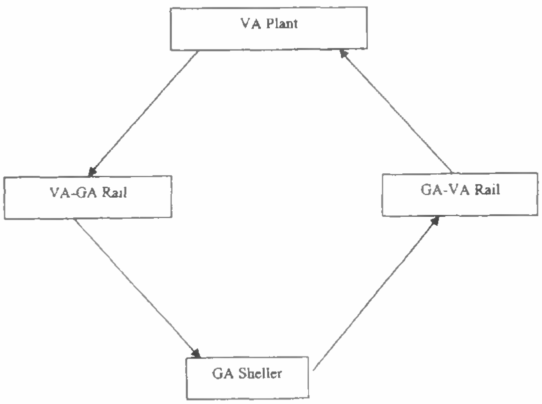
A manufacturer leases rail cars to transport raw material from the supplier to the factory. The manufacturer must balance the costs of leasing rail cars versus stockouts (leading to plant closings) and inventory carrying costs. Using a model of circular queues and a simulation, the cost implications of leasing different numbers of rail cars are analyzed. It is concluded that stockout costs exceed the cost of excess inventory and capacity in the logistics system.

INTRODUCTION

Transporting raw materials to a production facility would seem to be almost trivial when the final product requires only one primary raw material. While the process is not as involved as a multi-level bill of materials system, there are still a number of variables with which one must deal, particularly in the logistics system. In this case, the raw material, peanuts, are transported from a sheller near Columbus, Georgia, to Portsmouth, Virginia, to be converted into peanut butter. The transportation is via railroad—a distance of about 700 miles. The manufacturer is currently required to lease rail cars, which are then moved from Georgia to Virginia full of raw, shelled peanuts, and returned to Georgia empty. The question the plant manager faces on a regular basis is how many rail cars to lease?

Analytically, the system faced by the plant manager is a circular queueing system. As explained in Appendix A, this is a special case of a Jackson network (see Figure 1). In the usual queueing process, customers enter the system, are served and leave the system. In our case, the rail cars leased by the company moved in a continuous loop. The rail cars are "served"' in Georgia when they were loaded with peanuts, in Virginia when they are unloaded at the plant and en route in both directions. Appendix A describes briefly the analytical construction of the problem.

FIGURE 1
THE CIRCULAR QUEUE



There are numerous examples in the literature of analytic solutions to rail car scheduling (Cordeau, Soumis, and Derosiers, 2000; Lüübbecke and Zimmermann, 2003; and Sherali and Maguire, 2000). Although the objective here was to solve for the optimal number of rail cars, an analytical solution was not a practical option for several reasons. The first is the limitation of Jackson networks for predictive purposes (see Appendix A); the second is the nature of the data. The probability distributions of service times were empirical distributions. Using theoretical distributions would have made the problem computationally more attractive, but less realistic. Third, the company did not want to release cost figures. Therefore, results could only be stated as trade-offs in terms of numbers of rail cars and number of days the plant would be shut down. Given the results, however, the company could easily calculate the corresponding total costs. Finally, the company wanted the flexibility to test easily a variety of scenarios. For these reasons, it was decided to use simulation as the method of dealing with the problem. It was also easier to explain the process and results to the plant manager. Further, the plant manager could watch the outcomes develop as the simulation was running and could run the simulation with various scenarios.

THE PROBLEM

The peanut butter manufacturer in Virginia (VA) required an average of 180,000 pounds of peanuts per day to keep the line running. Rail cars carrying 190,000 pounds of peanuts each supplied the plant. The rail cars queued up at the plant waiting to be unloaded. Any time the queue was empty, the plant had to be shut down at a corresponding substantial cost. If there were too many rail cars in the queue, it could cause a problem, especially in the summer. Peanuts are a live organic product and could spoil if left sitting in the sun too long. Although the company could provide no specific data for this problem, management asked that the solution tell them the length of the queue at the plant and the mean number of days in the queue.

The peanuts are purchased from a sheller in Georgia (GA). The sheller buys raw peanuts from the farmers, shells them, and loads them in the hopper cars. Since the sheller maintains an inventory of peanuts, there is virtually no queue at the sheller except on weekends. A rail car arriving at the sheller is loaded and sent on its way. The plant in VA operates seven days per week; the sheller in GA operates five days per week. In other words, during the five days per week the sheller is operating, it is assumed that the queue time is zero. On the weekends, the queue time is one or two days, depending upon whether the rail car arrives on Sunday or Saturday. Except for the weekends, the company had no record of the sheller ever being a cause of delay.

The travel time between the sheller and the plant (and the return trip) varied widely. The rail cars were sent from the sheller to a rail yard, where they waited until a northbound train was formed. When they reached Virginia, they were once again taken to a rail yard, where the train was broken down. The peanut cars then had to wait for a switching locomotive to take them to the plant. It was assumed that the rail cars arrived at the destination server in the same order in which they left the source server. In other words, no passing was allowed. The travel times both ways varied according to the following empirical probability distribution, with the average (mean) time in both directions equal to 7.9 days (see Table 1). Since a simulation was used instead of an analytical solution, there was no need to attempt to fit the data to a theoretical probability distribution.

The rate of consumption of the peanuts at the plant depended upon the availability of machines, workers, other raw materials as well as the master schedule provided by company headquarters. The output of the plant was measured in cases of peanut butter. Each case required eighteen pounds of peanuts. The consumption of peanuts and production of peanut butter varied randomly according to an empirical probability distribution with mean consumption equal to 181,260 pounds (see Table 2).

Since the plant manager thought in terms of cases produced, this is how production is entered into the simulation program. It is a simple matter to convert from cases produced to total pounds—the unit of measure for shipping the peanuts. The third column represents the method of eliciting probability estimates from the plant manager. The manager was asked to state the number of days that the plant would most likely have the associated production level in any given two week period. This information was verified from plant production records. The second and fourth columns are those actually used by the simulation.

TABLE 1
RAIL TRAVEL
PROBABILITY DISTRIBUTION

Days	Probability
5	0.01
6	0.18
7	0.27
8	0.25
9	0.13
10	0.09
11	0.03
12	0.04

TABLE 2
PEANUT CONSUMPTION
PROBABILITY DISTRIBUTION

Average Cases	Production Pounds	Days per 14 Days	Probability
0	0	0.0	0.0
1,000	18,000	0.0	0.0
2,000	36,000	0.14	0.01
3,000	54,000	0.28	0.02
4,000	72,000	0.28	0.02
5,000	90,000	0.42	0.03
6,000	108,000	0.56	0.04
7,000	126,000	0.84	0.06
8,000	144,000	0.98	0.07
9,000	162,000	1.40	0.10
10,000	180,000	1.96	0.14
11,000	198,000	2.24	0.16
12,000	216,000	2.10	0.15
13,000	234,000	1.82	0.13
14,000	252,000	0.84	0.06
15,000	270,000	0.14	0.01

THE SIMULATION

At the time this research was conducted, the company was using twenty-five rail cars. Although the plant manager was satisfied with 25 cars from the point of view of keeping the factory operating, it was of interest to know if it would be economical to reduce the number of cars. In consultation with the plant manager, it was decided to run simulations for ten through twenty-six rail cars. This would yield seventeen data points for plotting the graphs. The company could then calculate the trade-offs. For each number of rail cars, a sample of size 30 was generated. Each of the 30 items in each sample was generated by a simulation of 2000 days—slightly over five years.

Both Banks and Carson (1984) and Thesen and Travis (1992) emphasize the importance of minimizing initial bias. Banks and Carson (1984) state that there is no analytical method for doing so, but suggest setting the initial conditions as close to reality as possible. To this end, the rail cars were evenly distributed at the plant and the sheller. The plant had sufficient inventory of peanuts to avoid running out before new shipments arrived, and new shipments could be made from Georgia without the initial wait for empty cars. The initial conditions slightly increased the queue sizes at the two locations, but over 2000 days, the effect would be minimal. Since the system stabilizes so quickly, there was no need to distribute cars en route.

The simulation was written in third generation software of a specific simulation software. This choice was made to provide flexibility for the plant manager, and to provide easy portability of the software to workstations at the plant. Each run generated a number of statistics including the following data: (See Figure 2).

- Average length of each queue
- Mean number of days in each queue
- Number of days the plant was shut down for lack of raw materials

FIGURE 2
DISPLAY OF ONE SIMULATION RUN

```
                    PEANUT TRANSPORTATION SIMULATION RESULTS

Day = 2000   Number of cars in the system =          25
                 Length of Portsmouth queue =          15
             Scheduled for production today =      162000
                       Amount left in lead car =     62000
   Length of Portsmount-Georgia Rail queue =          5
                      Length of Georgia queue =          0
   Length of Georgia-Portsmouth Rail queue =          4
             Cumulative days out of material =          0
-----------------------------------------------------------------------
                      AVERAGE STATISTICS FOR 2000 DAYS

        Number of rail cars in system          =      25
        Average queue length at Portsmouth     =      8.2 rail cars
        Mean Days in Portsmouth queue          =      8.7 days
        Average rail queue length, P-G         =      5.6 rail cars
        Mean Days in P-G rail queue            =      8.4 days
        Average queue length at Georgia        =      0.3 cars
        Average rail queue length, G-P         =      5.8 rail cars
        Mean Days in G-P rail queue            =      8.9 days
        Total Days out of material             =      0 days (0.0%)
```

THE RESULTS

As already stated, the actual system was being operated with twenty-five rail cars at the beginning of the study. This was the "way they had always done it," but the new plant manager wanted to challenge that assumption. The results from the simulation with 25 cars were used to validate the system (Fishman, 1973). The days out, queue length in Virginia, and average time in the queue in Virginia were consistent with actual observations at the plant and with data provided by the plant manager for the twenty-five car case.

Figure 3 shows the average number of days out of 2000 the plant would be shut down for each number of rail cars in the system. It varies from 772 (38.6 percent of the days) for ten rail cars to 0.4 (rounded to zero on the graph) for twenty-six. The 95 percent confidence interval ranges from ±28.59 for the average 772 days with ten rail cars to ±2.21 for the average 0.4 with 26 rail cars. Decreasing the number of days the plant must close has a cost, however. Although the actual cost of leasing rail cars was not known, the queue at VA serves as a surrogate. This is because as long as the cars are moving, they are being productive. When they are in the queue at the plant, they and their contents are in inventory and are thus simply adding to carrying costs.

As shown in Figure 4, the average number of cars in the VA queue (at the plant) ranges from 1.31 when ten cars are in the system to 9.11 when 26 cars are in the system. In percentage terms, the queue ranges from 13.1 percent of the ten rail cars in the system to 35 percent of the 26 cars in the system. While the number of cars in the system went up by 260 percent, the average number of cars in the queue went up by 595 percent. In other words, the increase in the cost of holding inventory at the plant has been more than twice as much as the cost of leasing rail cars. These two costs together must be traded off against the cost of closing the plant for lack of materials.

FIGURE 3
CARS VS. DAYS OUT

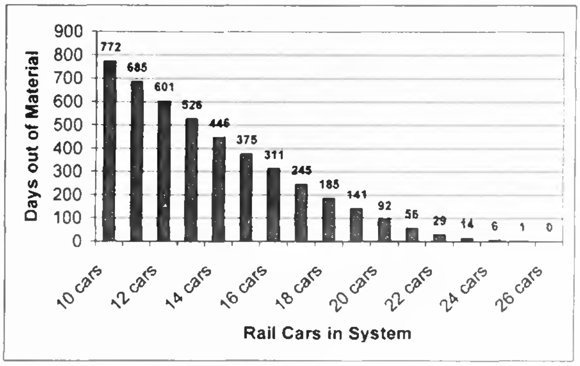
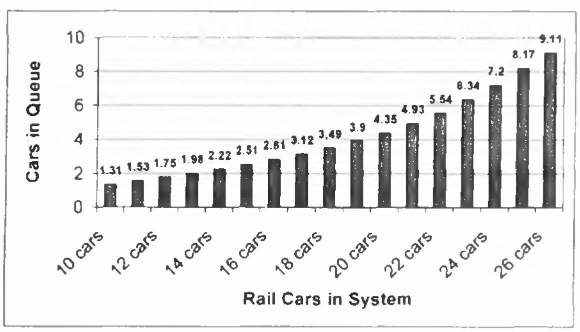


FIGURE 4
LENGTH OF VA QUEUE



The average time spent in the VA queue shows similar results. As shown in Figure 5, the average number of days per rail car spent in the VA queue ranges from 2.65 days for 10 cars to 9.63 days for 26 cars. Since the GA queue and the transit times are relatively constant no matter how many cars are in the system, the average rail car spends approximately thirteen percent of its time in the VA queue when ten cars are in the system and approximately thirty-four percent when 26 cars are in the system. The average time spent en route is the same in both directions since they are driven by identical probability distributions.

As shown in Figure 6, the average time on the GA-VA rail route (or queue), for example, increases slightly as the number of cars in the system increases. This is caused by the rule that cars may not pass each other. Otherwise, the average time would remain the same for all cases. In similar fashion, under the fill rule at Georgia (fill a car as soon as it arrives), the average queue length there increases slightly from 0.2 to 0.4 cars as the number of cars in the system increases from 10 to 26. This is because the supplier works only five days per week; so, with more cars in the system, the weekend queue becomes longer.

FIGURE 5
DAYS IN VA QUEUE

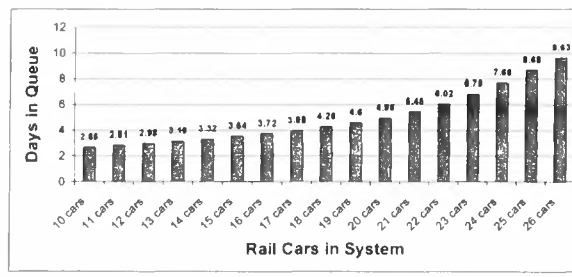
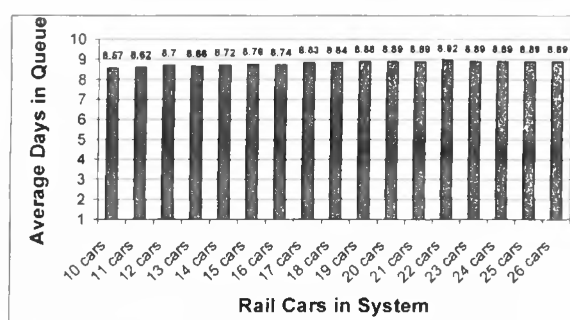


FIGURE 6
DAYS IN GA-VA QUEUE



RECOMMENDATIONS

Without actual cost figures, it appears that twenty-five or twenty-six is, in fact, the best number of cars to lease. More than twenty-six would be unnecessary since the plant would almost never shut down with twenty-six in use. To make a decision, the company should inject actual costs into the calculations and make the trade-offs. Management must be careful to include all the relevant costs. The cost of the rail cars must include not only the cost of leasing that number of cars, but must also include the cost of holding the additional peanut inventory in the queue at the plant.

To gain insight into what the decisions should be, the authors independently contacted a rail car leasing company. Hopper cars of the type used by the peanut butter manufacturer would cost $325 per month on a five-year lease or $340 per month on a three-year lease. This includes maintenance, a liner to keep the peanuts clean, and a hatch to allow unloading from the top of the hopper car. Each car would cost, assuming a five-year lease, $3900 per year to lease. Twenty-five cars would cost $97,500 per year. Since twenty-five cars is a relatively small number for the leasing company, there are no price breaks for a problem of this magnitude. In the simulation results, the annual cost of the rail cars would range from $39,000 for ten cars to $101,400 for twenty-six cars. These data are representative of what the manufacturer may have paid, and are not their actual costs. But, since the cost of shutting down and restarting a continuous process factory is high no matter what the product, and marginal cost of the extra rail car is so small ($3900), and given the constraints of transporting the peanuts via rail, there is no reasonable scenario under which the plant manager should reduce the number of rail cars.

Another area where the plant manager could cut costs is in the peanut inventory carried in the queue at the Portsmouth plant. The number of rail cars in the queue and their average stay are both around 8.5. Since each rail car holds 190,000 pounds, and the spot price of raw peanuts is about $390.00 per ton, each car holds about $37,050 worth of peanuts. Using the generally accepted U.S. average inventory carrying cost of 35 percent of the cost of the peanuts per year, it would cost approximately $302 to carry the inventory in each rail car for the 8.5 days. Since the firm uses about 300 rail cars full of peanuts per year, the inventory holding cost amounts to about $90,595 per year. Relative to the annual turnover for the plant, this is a very small amount. Even if the holding cost were tripled to 100 percent, it would be a relatively small amount. In addition, given the variability in transit times via rail, reducing the queue at the Portsmouth plant would also increase the probability of a plant shut down for lack of material. The marginal cost of carrying the extra inventory is not large enough to justify taking this additional risk.

RESEARCH EXTENSIONS

The simulation opened additional doors for research. The company could, for example, switch from rail cars to trucks. This, in fact, was proposed to the company by a trucking firm. Although trucks carry a much smaller load (44,000 pounds), they make the trip much faster and with less variation since they travel directly from the sheller to the plant without going through the switching yards. The trucking company claimed they could supply the plant with ten trucks. The plant manager did not want to consider this option since the unloading facility was designed specifically for rail cars, and switching to trucks would have required a considerable capital investment. The simulation model was used to test the claim of the trucking company and it was found that ten trucks did, indeed, yield about the same results as twenty-five rail cars.

Also proposed was using a rail-truck combination to use trucks as a back-up to avoid running out of material. Several factors caused this option to be rejected. One is that the rail transit times are entirely under control of the railroad, and the variation is caused by delays in the switching yard. Getting information about arrival times would be difficult to impossible within a time frame in which one could mobilize truck transportation unless one kept one or two trucks on stand-by. Keeping trucks on stand-by would be more expensive than simply adding additional rail cars to the system.

Another option would have been to allow different decision rules for loading cars at the Georgia facility. A queue could be allowed to form in Georgia and a rail car filled and released only when a rail car is emptied in Virginia (a type of kanban approach); or a maximum could be set on the number of rail cars filled and released per day in Georgia. This would keep the queue at the plant from getting too long. Although the queue at the sheller would grow in length (when the rail cars were empty), these rules would decrease the length of the VA queue and thus decrease the costs of holding peanut inventory and spoilage. As was shown previously, however, the potential gains from decreasing the Portsmouth queue length are minimal or even possibly negative. In addition, the process would be under the control of the sheller, which means there would be no guarantee that the rail cars would be loaded when the factory needed them. There also would be a cost to coordinating and communicating with the sheller and a cost of allowing empty rail cars to stay at their facility.

For a given number of rail cars, the probability distribution of travel times could be varied to see if there would be an advantage to negotiate more stable travel times with the railroad. Unfortunately, that did not seem to be even a remote possibility.

A random production rate was assumed for all simulations. This was reasonable given the plant operation at the time, but it may be possible to vary the production rate according to a plan and thus to adapt to the length of the queue at the plant. This was considered unlikely by the plant manager since that degree of control over the production rate would have required a major process improvement effort at the plant.

CONCLUSION

As stated at the beginning of the article, the typical queueing system consists of a stream of customers entering the system at either a constant or random rate. They are directed to one or more servers where the service rate is, again, either constant or random. The customers then leave the system. The literature for both theory and applications in these typical systems is quite rich. Circular queues, however, present a different scenario. Customers stay in the system and proceed from server to server infinitely. The literature on circular queues is fairly sparse, although applications in the "real world" are common in logistics systems including scheduled ocean transportation. It was shown that a relatively intractable problem theoretically can be solved using simulation. Although the solution is not optimal, as simulation results never are, it provides clear guidance to the decision maker. The results of this research demonstrate that simulation is a viable tool for dealing with circular queueing logistics problems.

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APPENDIX A

Queueing systems typically have one or more servers serving a stream of customers who enter an open system from the outside, are served, and then leave the system. The primary problem is to determine, given the appropriate cost and/or value functions, the number of servers one must have to process the customers in an optimal manner. Circular queueing systems, on the other hand, are closed network systems. They are a special case of Jackson systems (Ozekici, 1990). The system has a fixed number of customers who are served consecutively by two or more servers in an endless loop. The primary problem in this case is to determine the number of customers required to minimize the cost of server idle time plus the cost of the customers. Circular queues are relatively difficult to deal with analytically. In an early work, Cox and Smith (1961), for example, devote only three pages to the topic, and then only under constraining assumptions. Gelenbe, Pujolle, and Nelson (1987), give a more detailed analysis in their chapter on Jackson networks. The limitation of Jackson networks in this case is that they are robust in describing a system, but limited in predicting a system (Lipsky, 1992).

In the present case, the circular queue consists of four servers. Server one is a peanut butter manufacturer in Virginia. Server three is the vendor—the peanut sheller in Georgia. Servers two and four are railroads transporting the loaded rail cars from Georgia to Virginia and the empty cars back again. The peanuts are processed (shelled) in Georgia and then shipped to Virginia via rail car to be manufactured into peanut butter. Since they are moving through the system and being served, the customers are the rail cars. They were served (loaded) in Georgia, travel to Virginia full, served (unloaded) in Virginia, and returned to Georgia empty. The manufacturer in Virginia lease the rail cars. The problem is to determine the optimal number of rail cars to lease.

If the vector $k = (k_1, k_2, k_3, k_4)$ represents the number of customers (rail cars) at each of the N (N = 4) servers, then

$K = \sum_{i=1}^{4} k_i$ = total rail cars in the system

The matrix of transition probabilities is as follows:

$P[p_{ij}] = \begin{bmatrix} 0100 \\ 0010 \\ 0001 \\ 1000 \end{bmatrix}$, where p_{ij} is the probability of a customer moving from serving station i to serving station j.

The matrix P reflects the circular nature of the Jackson network. Given that a customer (rail car) is at a particular serving station, the next station to which it moves is deterministic; i.e., it moves there with probability 1. Since customers are not allowed to enter or leave the system, the system is closed.

The system may be diagrammed as in Figure A1:

k_i = number of customers in queue i including the customer being served.

p_{ij} = probability of a customer going from station i to station j.

μ_i = mean service time at server station i.

FIGURE A1

$$\begin{array}{ccc}
k_1 -- \mu_1 \rightarrow p_{12} \rightarrow & & k_2 \\
\uparrow & & | \\
p_{41} & & \mu_2 \\
\uparrow & & \downarrow \\
\mu_4 & & p_{23} \\
| & & \downarrow \\
k_4 \leftarrow p_{34} \leftarrow & & \mu_3 -- k_3
\end{array}$$

This is intended to be an overview of the theory and not a comprehensive view of the literature.

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WORKING TOWARD A SEAMLESS SUPPLY CHAIN: AN EXPLORATORY ANALYSIS OF THE IMPACT OF SUPPLY CHAIN ON COMPANY PERFORMANCE

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ABSTRACT

This paper explores the role that several supply chain dimensions play in achieving overall firm performance. Measures suggested in prior studies were factor analyzed for convergent and discriminant validity and then used in a regression model. This study uses data from the Council of Supply Chain Management Professionals (CSCMP) member firms, with top level supply chain managers as informants. The results suggest that of the three dimensions tested, two are significant contributors to firm profitability, including customer service and business process usage. Relationship confidence was not found to significantly impact overall firm performance.

INTRODUCTION

Supply chain management has become an important topic to both practitioners and researchers alike. Practitioner definitions of supply chain management are numerous and emphasize different aspects of firm relationships. For example, the definition may emphasize meeting the "real needs of the end customer" (Wisner, Leong and Tan, 2004) or it may emphasize logistics-type processes as suggested by the Supply Chain Council definition:

> Managing supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order

management, distribution across all channels, and delivery to the customer (Wisner, Leong and Tan, 2004).

Yet another definition (Council of Supply Chain Management Professionals, 2006) emphasizes the strategic nature of supply chain across firms but does not mention the end customer:

> Supply Chain Management is the systemic, strategic coordination of traditional business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.

None of these definitions mentions firm performance yet supply chain management has firm performance as an implicit goal.

In the academic literature, supply chain management emphasizes both cost reduction and increased customer value (Brewer and Speh, 2000) leading to sustainable competitive advantage (Mentzer et al., 2001). More recently, a survey of supply chain professionals was undertaken in an attempt to better define supply chain management (Gibson, Mentzer, and Cook, 2005). Yet even this most recent work suggests that "only time will tell if it [CSCMP definition] becomes the consensus definition of SCM."

Perhaps because of lack of a consensus definition and a lack of consistent management understanding, there remains a question of the connection between a high-performing supply chain and individual company performance. The lack of adequate understanding is likely due to the multifaceted and complex nature of supply chain relationships and the lack of firm-spanning metrics with which to measure these relationships. Cooper, Lambert, and Pagh (1997) suggest a conceptual supply chain framework consisting of business processes, management components, and supply chain structure and further suggest how to operationalize the framework using case studies (Lambert, Cooper, and Pagh, 1998). While managing the supply chain from point of origin to point of consumption is indeed a difficult task, the introduction of technology that improves information flow may help with firm integration across the supply chain (Walton and Miller, 1995). Further, many executives believe that profitability could increase if key business processes are linked and managed across multiple companies (Lambert, Cooper, and Pagh, 1998).

The present research explores the importance of business processes, including customer service, business process documentation and measurement and management components such as accurate information exchange to firm performance using data collected from an online survey of high-level supply chain managers. The remainder of this work is organized as follows. First, the supply chain literature is briefly reviewed before describing the methodology. Next, the results are presented followed by a discussion of the managerial implications and recommendations for future research.

LITERATURE REVIEW

Business process documentation and measurement is found to vary with the importance of the process to the focal companies (Lambert, Cooper, and Pagh, 1998). A process may be defined as "a structured and measured set of activities designed to produce a specific output for a particular customer or market" (Davenport, 1993). While not all supply chain processes can be managed and documented in their entirety, for the more important processes this documentation will certainly decrease transaction costs and add to firm profitability.

Information exchange has been found to impact logistics performance (Gustin, Daugherty and Stank, 1995). Ellinger, Daugherty and Keller (2000) found that information integration was linked with logistics service and thus firm performance. Firms using high levels of integration in warehousing operations were found to have higher levels of performance in that area (Rogers, Daugherty, and Ellinger, 1996).

While there have been a number of books and papers outlining the definition and scope of supply chain management (Mentzer, et. al, 2001; Simchi-Levi, Kaminsky, Simchi-Levi, 2003; Wisner, Leong, and Tan, 2004, for example), research studies to examine supply chain partnerships (Lambert, Knemeyer and Gardner, 2004), and sources of competitive advantage attributable to supply chain management (Mentzer, 2004), to date there has been little investigation of the impact of supply chain processes and management on firm performance.

RESEARCH QUESTION AND METHODOLOGY

Model Development

This exploratory research begins with an examination of the relationship between firm performance and business process documentation, accurate information exchange and customer service. The dimensions are defined as follows:

Firm performance: The overall performance of the firm, compared to major competitors

Business process documentation: The extent of documentation of business processes within and across firms. This includes documentation of process changes as well as information technology support of supply chain processes.

Accurate information exchange: Perception that key customers, suppliers, and service providers providers exchange accurate information across the supply chain.

Customer service: includes product availability (the proportion of units, order lines, or orders completely filled) and delivery quality (depends on the incidence (or lack thereof) of in-transit damage, shipment of incorrect items, and incorrect shipment quantity), as well as the ability to reduce lead time without overtime charges.

Research Question

The research question investigated is: Which of the above supply chain dimensions (business process documentation, relationship confidence, and customer service) explain more of the variance in firm performance? The research was conducted using multiple regres-sion analysis to explore the following model:

Firm Financial Performance = $\beta_0 + \Sigma\beta_i X_i + \varepsilon_i$

Where:

β_0 = Y intercept

β_i = relative importance of each independent variable

X_i = each independent variable representing a supply chain dimension

ε_i = perceptual or idiosyncratic error introduced into the model

Or more specifically:

Overall Firm Performance = β_0 + β_1Customer Service + β_2 Business Process Usage + β_3 Relationship Confidence + ε_i .

The model suggests that each of the supply chain dimensions is positively related to overall firm performance. Each measure was constructed from the average answer to a specific set of questions. Only those questions that exhibit convergent and discriminant validity and reliability remain in each set. The factor scores and reliability estimates for the remaining measures are shown in Table 1. The data were also analyzed for non-response bias. There were no statistically different responses between early and late informants indicating a low likelihood of non-response bias (Armstrong and Overton, 1977).

Data

The data used in this research comes from a web-based survey that was sent to senior supply chain professional members of the Council of Supply Chain Management Professionals. The informants span a variety of industries. The respondent firms are well dispersed in terms of sales and number of employees. Table 2 gives demographic information about the firms included in the research.

TABLE 1
PARTIAL ROTATED COMPONENT MATRIX AND RELIABILITY SCORES

	Customer Service	Business Process Usage	Relationship Confidence
Accommodate Delivery Times	.825		
Provide Customer Quantity	.810		
Response to Need without Additional Charges	.799		
Ability to Reduce Lead Time to Close to Zero	.712		
Quoted Order Lead Times	.670		
On-time Performance vs Customer Commit Date	.654		
Top Management Supports SC Processes		.778	
SC Vision Communicated through Organization		.765	
Business Process Changes are Measured		.756	
Documented Business Processes		.720	
IT Supports SC Processes		.691	
Jobs in SC can be Described		.659	
Key Service Providers Give Accurate Information			.791
Key Suppliers Give Accurate Information			.786
Key Customers Give Accurate Information			.721
Key Service Providers Get Accurate Information			.721
Key Suppliers Get Accurate Information			.698
Key Suppliers Are Concerned that Our Business Succeeds			.668
Key Customers Get Accurate Information			.597
Cronbach's Alpha	**.882**	**.884**	**.892**

TABLE 2
A DESCRIPTION OF THE RESPONDENT FIRMS

Business Description		Number of Employees	
Business Type	**Percentage**	**Category**	**Percentage**
Raw Materials/Components	14.0	Fewer than 500	26.0
Final Product Manufacturer	34.3	500-999	12.0
Wholesaler/Retailer	5.3	1,000-9,999	44.0
Other Services	29.3	10,000 or greater	18.0
Other	17.1		
Annual Revenue	**Percentage**	**Number of Firms Responding-159**	
$25 million or less USD	8.7		
>$25 million-$100 million USD	13.3		
>$100 million-$1 billion USD	36.0		
>$1 billion-$5 billion USD	26.7		
>$5 billion-$10 billion USD	7.3		
>$10 billion USD	8.0		

The survey grew out of an earlier qualitative study completed by the lead author, which involved in-depth interviews of 31 senior supply chain executives of Global 1000 companies. Three industry managers reviewed the survey for likely understanding by the informants and determined that it was easily understood. An invitation letter was emailed to prospective informants directing them to the URL where the survey was located.

All members of the Council of Supply Chain Management Professionals that indicated a position of Director or Vice President of Supply Chain were invited to participate. From 1826 emailed invitations to participate, 224 addresses were undeliverable, 175 addresses returned a message indicating the informant was away and not reading email during the time the survey was administered, and 159 complete responses were received for a response rate of 11%. This response rate was considered reasonable and similar to other research studies in the field (e.g., Wisner, 2003).

The results of the regression analysis are shown in Table 3.

DISCUSSION OF RESULTS AND MANAGERIAL IMPLICATIONS

While the overall model was found to be significant, only two of the dimensions of supply chain management were found to be significant contributors to overall firm performance. The results for each dimension are discussed below.

Customer Service

An increase in customer service was found to be positively related to overall firm performance. This dimension was the most important contributor in explaining the variance in overall firm performance. The customer service measures used in this research focus on delivering the product on time and complete as well as company flexibility in filling orders with near zero lead-time. This suggests that the company is filling every order, thus increasing firm performance by maximizing sales.

Business Process Usage

An increase in business process documentation and definition was found to be positively related

TABLE 3
THE EFFECTS OF CERTAIN SUPPLY CHAIN DIMENSIONS ON FIRM PERFORMANCE

Dependent Variable: Overall firm performance
Form: OLS Regression
No. of Observations: 159
Model's R-square: .299
Model's F Statistic: 20.796
Significance of F: .000

Variable	Expected Sign	Coefficient (Std. Error)	T-statistic (Significance)*
Constant		1.132 (.385)	2.940 (.004)
Customer Service	0	.564 (.109)	5.191 (.000)*
Business Process	0	.276 (.084)	3.302 (.001)*
Relationship	0	-.154 (.134)	-1.151 (.252)

to overall firm performance. This dimension was the second contributor in explaining the variance in overall firm performance. Documenting and using supply chain processes along with top management support of these processes may add to firm performance. When processes are valued and measured, performance on those measures likely follows. This research suggests that use and monitoring of the correct processes does indeed add value to firm performance.

Exchange of Accurate Information

The exchange of information between key service providers, suppliers and customers and the focal firm did not have an impact on overall firm performance. This was a surprising result since, with additional accurate information, the supply chain, including the focal firm, should be able to reduce inventory, thus reducing cost. One explanation may be that the current level of information exchange between these key players in the network was already quite high. Any additional information exchange may have little impact on performance and indeed may be unnecessary.

CONCLUSION

This article explores the role that several supply chain dimensions play in contributing to overall firm performance. Measures suggested in prior studies were factor analyzed for convergent and discriminant validity and then used in a regression model. This study uses data from CSCMP member firms, with top level supply chain managers as informants. The results suggest that of the three dimensions tested, two are significant contributors to firm profitability, including customer service and business process usage. Relationship confidence was not found to significantly impact overall firm performance.

Future research areas include further modifying the model to gain additional insight into additional supply chain drivers of overall firm performance.

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Journal of Transportation Management

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MANUSCRIPT SAMPLE

A FRAMEWORK FOR EVALUATING SUPPLY CHAIN PERFORMANCE

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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.

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

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