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Outbound Logistics Performance and Profitability: Taxonomy of Manufacturing and Service Organizations

Matthew J. Liberatore[1]* and Tan Miller[2]

[1]Center for Business Analytics, Villanova School of Business, Villanova University, Villanova, USA
[2]Global Supply Chain Management Program, College of Business Administration, Rider University, Lawrence, USA

Abstract

This paper develops a taxonomy of manufacturing and service firms formed by their emphasis on different key performance metrics to monitor and manage the outbound logistics portion of the supply chain. Furthermore, this study determines whether the use of specific key metrics by firms in these different classifications varies by industry, and what effect, if any, the varying emphases on different key performance metrics within classifications have on firm financial performance. The original data for this study were obtained from SAPs Benchmarking Program for Supply Chain Planning and utilizes performance metrics data from 247 manufacturing and service firms. Cluster analysis was used to develop a taxonomy based on the outbound logistics metrics. Four clusters were found to be distinct and well-formed and emphasize different sets of outbound logistics performance metrics. The clusters were named Inventory Investment Minimizers; Low Cost, Low Service Providers; Planners and Efficient Distribution Spenders; and Heavy Distribution Spenders. This study evaluated whether the emphasis on specific sets of outbound logistics performance metrics tends to be associated with firms in specific industries, and whether differences in firm financial performance, as measured by net operating margin, were found across clusters. This is the first effort to investigate whether a taxonomy of firms can be developed based on the firms' use of different performance metrics to monitor and manage outbound logistics.

Keywords: Outbound logistics; Supply chain performance metrics; Financial performance; Cluster analysis

Introduction

Outbound logistics within the supply chain plays a critical role in a supplier's overall customer relationship management (CRM) process. Outbound logistics can be defined as: "The process related to the movement and storage of products from the end of the production line to the end user" [1]. Most retailers including firms such as Walmart and Target hold their suppliers to very stringent product delivery standards. Failure by a supplier to provide reliable delivery service to its retail customers can result in significant financial penalties and even the delisting (i.e., the elimination) of a supplier's products from a retailer's active product portfolio. Thus, outbound logistics performance represents a major factor in a retailer's decision whether or not to stock a supplier's products (e.g., [2]).

Outbound logistics includes the "last mile" (i.e., the final step of the delivery process) which is often referred to as one of the key make or break steps in the CRM process. Given its critical role, a firm's planning and approach towards outbound logistics can benefit greatly from quantitative "firm performance data" based research, as well as from insights generated by more qualitative perception based data. A few research studies have focused specifically on the link between logistics performance and firm financial profitability. For example, Stapelton et al. [3] discuss how the Strategic Profit Model can be used to determine the effect of adjusting logistical policies on firm financial performance. Additionally, using survey data, Ojha, Gianiodis and Manuja [4] investigate the effect of logistical business continuity planning on firms' operational capabilities and financial performance.

However, despite the importance of the role of outbound logistics in supply chain management, minimal rigorous performance data based research has been done on the direct, stand-alone impact of outbound logistics on such questions as its influence on a firm's profitability and how firms' approaches to outbound logistics differ. Rather, the literature to date tends to group outbound logistics activities into broader studies of supply chain operations where outbound logistics represents just one sub-component. In this research, outbound logistics represents our sole focus. Further, research on supply chain management including outbound logistics also tends to be survey-based (i.e., based on surveys of practitioners' perceptions) rather than performance data based. In this study, we attempt to address this gap by utilizing actual firm performance data.

Since there is no rigorous quantitative published research which evaluates the impact of outbound logistics performance on firm profitability, we review related research on overall supply chain performance. A survey of senior executives found that supply chain is a critical driver of shareholder value and corporate differentiation [5]. Hendricks and Singhal [6] found that supply chain glitches led to strong negative financial impacts on operating income, return on assets and return on sales. Ellinger et al. [7] studied the relationship between supply chain management competency and firm success. They measured supply chain management competency using Delphi-style opinion data from AMR Research's Supply Chain Top 25 rankings, and used Altman's Z-score statistic [8] to measure firm's financial success. They found that firms recognized by industry experts for supply chain management competency have significantly higher Z-scores than their close competitors and industry averages.

Later research focused on the impact of supply chain practices and processes (as opposed to performance) on firm financial performance. Shi and Yu [9] conducted a review of the literature on supply chain

***Corresponding author:** Matthew J. Liberatore, Director, Center for Business Analytics, Villanova School of Business, Villanova University, Villanova, USA, Tel: 6105194390; E-mail: matthew.liberatore@villanova.edu

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management and firm financial performance. The studies they reviewed utilized either perceptual surveys of supply chain executives or secondary data sources. Their review focused on supply chain practices as contrasted with supply chain performance metrics. They found that sourcing strategy, information technology, supply chain integration and external relationships play important roles in improving financial performance. The authors conclude that, in particular, optimal levels of outsourceabilty, supply chain alignment and integration with IT infrastructure and supply chain relationship management are essential to realize full effective advantage of supply chain management. Using a meta analytic approach of completed studies Leuschner et al. [10] also found a positive and significant link between supply chain integration and firm performance.

Several authors have studied and categorized supply chain performance metrics but have not linked them to firm performance. Supply chain metrics are thought to affect strategic, tactical and operational planning and control, by playing a role in setting objectives, evaluating performance, and determining future courses of actions [11]. Gunasekaran and Kobu [12] provided a literature review of performance metrics in logistics and supply chain management. Gunasekaran et al. [13] developed a framework for supply chain performance metrics and identified a key set of performance metrics and measures for a supply chain. In a later study, Gunasekaran et al. [11] presented a set of supply chain metrics in the context of supply chain activities/processes: plan, source, make/assemble and deliver/customer. They conducted a survey of large UK companies to detemine the importance of these metrics. Their findings led to a supply chain performance framework that includes performance metrics for each supply chain activity/process at the strategic, tactical and operational levels.

Shepherd and Gunter [14] developed a taxonomy of supply chain metrics according to the processes identified in the SCOR model [15]: plan, source, make, deliver and return; whether they measure time, cost, quality, flexibility or innovativeness; and whether they are quantitative or qualitative. Chan and Qi [16] identify six core processes (supplier, inbound logistics, manufacturing, outbound logistics, marketing and sales, end customers) and present an approach for performance measurement that includes input, output and composite measures (such as productivity, efficiency, and utilization).

However, research has not established the link between supply chain performance metrics and financial performance. As stated by Shi and Yu ([9], p.1284) in their review of the literature, “Comparing to the extensive research on SCM’s operational performance measurements, our understanding of its financial impact is far from enough.” Our research focuses on the financial impact of outbound logistics using outbound logistics performance metrics. It is unclear whether the impact of outbound logistics on firm performance varies by industry or whether there are groups of firms across various industries that perform in a similar fashion. How firms perform across a range of outbound logistics metrics can provide insight into their supply chain operational planning, management and control processes [11]. Whether these differing operational approaches are linked to differences in firm profitability is also unknown. We investigate whether there are distinct groupings of firms formed by their emphasis on key outbound logistics performance metrics and whether these groupings vary by industry, and what effect, if any, these different emphases have on firm financial performance. Cluster analysis is ideally suited to enable us to identify these groupings. We investigate our hypotheses using performance metric and firm profitability data obtained from SAP that comprise a sample of manufacturing and service firms.

Materials and Methods

Research hypotheses

In our research, we sought to determine if firms with similar performance levels and similar emphasis on selected aspects of outbound logistics achieved similar financial operating results. Further, we also wished to explore whether superior performance or relatively heavy emphasis in certain aspects of the outbound logistics process resulted in relatively higher profitability for firms than did superior performance or emphasis in other areas. In other words, our research set out to understand which outbound logistics metrics (and activities) a firm should place more emphasis upon in order to achieve higher profitability.

Interactions with supply chain professionals across a wide range of industries leads us to hypothesize that improvement in outbound logistics should have a positive impact on a firm’s financial profitability and that there are differences in outbound logistics performance across industries. However, there remains a dearth of rigorous quantitative analysis that provides specific guidance in this area, motivating this research.

In the manufacturing strategy literature, there have been several studies that have investigated the relationship between competitive priorities and manufacturing strategies (e.g., [17]). Kathuria [18] has studied the relationship between industry, competitive priorities, and performance criteria for small manufacturers. In a related way, we study the relationships between industry, outbound logistics priorities and firm performance. Following the general approach of Kathuria [18], we investigate the relationship between industry, outbound logistics priorities, and performance. Our conceptualization is stated in the form of three hypotheses that are related to the three hypotheses tested in Kathuria [18]:

Hypothesis 1: Firms can be classified into different groups based on their emphasis outbound logistics metrics.

Hypothesis 2: Depending upon the outbound logistics orientation of the groups identified the groups will perform at different levels of profitability.

Hypothesis 3: His group orientation – i.e., the outbound delivery metrics emphasized by a group – is associated with industry membership.

Data

Previous related supply chain studies have used survey-based research that relies on the perceptions or rankings of supply chain executives and practitioners using Likert scale questions (e.g., 1 to 5, poor to excellent). While valuable, these studies are not “objective” or “fact-based” quantitative studies. For this reason, to best achieve our research objectives, we decided to obtain actual performance data on a set of performance levels and costs for outbound logistics.

Variable selection: We sought to develop data on a concise set of variables that covered all components of outbound logistics. For our purposes, we defined outbound logistics as consisting of:

- The management of the inventory produced (to be delivered to the customer)
- The distribution process (i.e., warehousing and transportation)
- The service to the customer (i.e., the actual delivery)

- Capabilities and commitment to demand forecasting and supply chain planning.

Based upon the process and capabilities just defined, we identified the following variables that we wished to include in our study:

1. Inventory carrying costs
2. Obsolete inventory costs
3. Days of inventory on hand
4. Warehousing costs
5. Transportation costs
6. On-time delivery performance
7. Forecast accuracy
8. Supply chain planning costs

In a review of several well-known supply chain management texts, all of these outbound logistics metrics were repeatedly referenced as key performance indicators (e.g., [19-21]. Further, the selection of these metrics ties to the research of Gunasekaran et al. [13]. In their discussion of metrics for the "performance evaluation of the delivery link" category, on-time delivery, total distribution costs, and transportation cost are discussed, among others. Under the "supply chain financial and logistics costs" category total inventory cost and accuracy of forecasting are discussed, among others. Inventory carrying costs, days of inventory on hand, and obsolete inventory costs provide a perspective on a firm's costs of inventory, its commitment to having inventory available for customers and how well a firm plans its inventory. In particular, the level of obsolete inventory a firm may experience offers insight into how well a firm can accurately forecast long-term demand for its products and then execute its plan.

Warehousing and transportation are two primary components of the distribution process. Thus, from a cost perspective, we thought it important to capture both of these cost variables. As we will discuss later, the costs of key activities such as warehousing and transportation can provide different insights, including a perspective on how significant a commitment a firm chooses to make to the distribution process (i.e., the importance of the distribution process to a firm), or alternatively, the efficiency of a firm's distribution process.

Surveys of supply chain practitioners such as those done by the Aberdeen Group (as reported in [22]) invariably show that practitioners rate on-time delivery as the most important measure of a supplier's service to a customer. Therefore, we selected on-time performance as the key service indicator to include in our analysis.

Forecast accuracy is a good barometer of a firm's capability to perform short run planning in a key area – matching demand and supply. Additionally, a firm's forecast accuracy affects other key plans and decisions such as production and delivery plans. Typically, forecast accuracy measures in private industry calibrate the accuracy of relatively short-run forecasts. Some firms measure forecast accuracy two months into the future, while others may use somewhat shorter or longer time definitions. The forecast horizon is often (and ideally) linked to a firm's lead time. However, forecast accuracy is a relatively short-run based planning measure.

To assess a firm's commitment to long term planning, we selected supply chain planning cost, those expenditures related to developing long-term supply chain plans that include those for outbound logistics. Our rationale for including this variable is that one can consider a firm's expenditure level on supply chain planning as a surrogate for the firm's commitment to meeting customers' delivery needs.

We also required a ninth variable, namely, the operating margin of each firm. A firm's operating margin reflects a firm's profitability after the delivery (and sale) of its inventory to its customers. Since outbound logistics covers the delivery and sale of inventory, operating margin is the appropriate measure of profitability for our study.

The data for this study were obtained from SAPs Benchmarking Program for Supply Chain Planning. These data were collected via electronic surveys conducted between 2007 and 2012 from supply chain managers in various manufacturing and service organizations. The respondents were supply chain managers who were asked to provide actual values for the metrics, each of which was explicitly defined in the survey. SAP professionals within their Customer Value organization were responsible for managing the survey, and they checked and validated each data element before including it within the database. Once we received the data set we checked for outliers and incorrect values. We required that each case have a value for operating margin since it is the outcome variable of interest. A total of 247 useable cases comprise the data set. Some of the cases have missing data for one or more outbound logistics metrics.

Missing data analysis: Tsikriktsis [23] states that the treatment of missing data has been overlooked in the OM literature and should be explicitly considered in a discussion of research methods. The deletion of entire cases that have any missing data (called listwise deletion) can have a substantial effect on the size of the data set and a loss of statistical power. As mentioned above, 247 cases in the data set have a value for Operating Margin, while some cases may have one or more of the eight outbound logistics performance metrics missing. A missing data analysis is needed to determine the amount of data that are missing and whether the pattern of missing observations is random or not.

The data set consists of 2,223 data items (9 variables*247 cases), where 330 or 14.84% are missing. For each variable, such as Days of Inventory, separate variance t-tests were run to compare the group of cases with data on another variable (say Obsolete Inventory) with those cases without data on that variable. Of the 9*8=72 tests, only two are significant: Inventory Carrying Cost with Warehouse Management Cost, and Obsolete Inventory with Inventory Carrying Cost, so we conclude that there is no systematic non-random pattern. The definitions of the eight outbound logistics metrics used in this study are given in Table 1.

The amount and pattern of missing data should affect the technique used for replacing missing data values [23]. The possible patterns are non-missing at random (NMAR), missing at random (MAR), and missing completely at random (MCAR). The latter is the best case, and means that the presence of missing data on some variable is unrelated to the values of other variables in the data set. Little's test [24] is the standard for determining whether the data set is MCAR or not. Applying Little's test [24] we find that our data set is MCAR (chi square test statistic=356.491, d. f. 324, p=0.103). Since the data set is MCAR and there are more than 10% missing, Tsikriktsis [23] recommends using pairwise deletion first and either regression or hot-deck methods as a second choice. Pairwise deletion is appropriate for statistical methods such as correlation that require only pairs of data but are inappropriate when full cases are needed as in cluster analysis. Hot deck requires replacing a missing value with an actual value from a similar case in the data set. Linear regression requires developing an equation that is used to estimate the missing value as a function of the other variables in the data set. We chose linear regression since it is more straightforward and less subjective. Linear regression was successfully able to estimate all missing data elements (Table 1).

Operating margin was measured as earnings before interest and taxes (EBIT). Our sample is drawn from a mix of industries as represented by two-digit NAICS codes, and each observation is comprised of data from a single year over the 2007- 2012 time frame. Operating margins can vary across industries and are influenced by prevailing economic conditions. To make the operating margins comparable across the sample, we subtracted the median operating margin for the appropriate industry and year (obtained from Compustat) from the firm's actual operating margin to obtain an adjusted operating margin. The adjusted operating margin indicates how much more (less) profitable a firm in the sample is with respect to their industry during a given year.

Demographics: Table 2 provides the distribution of responding organizations by industry, while Table 3 shows the distribution of annual revenue across the respondents. Manufacturing firms comprise 83.1% of the sample with representation from a variety of industries. The firms in the sample range in annual revenue from under \$100 million (7%) to over \$5 billion (8%), with the vast majority between \$100 million and \$5 billion (85%).

Correlation: The correlation matrix for the full data set is given as Table 4. Note that the correlation results without the imputed values are very similar to those shown. Some of the outbound delivery metrics are significantly correlated and a few have relatively high correlation values (Tables 2-4).

Results

Clusters emphasizing multiple metrics

Various researchers have recommended that principal component analysis (PCA) with orthogonal rotation be performed on the data set prior to performing cluster analysis to adjust for high correlation among variables [25,26]. PCA was performed on the data set using varimax rotation with Kaiser normalization, and resulted in four factors. The four factor scores for each observation were used in the subsequent cluster analysis.

Metric	Definition
InvCC	Inventory Carrying Cost (% of revenue)
WhMgt	Warehouse Management Cost (% of revenue)
ObsInv	Obsolete Inventory (% of inventory value)
TransSpd	Transportation Spend (% of revenue)
SCPCost	Supply Chain Planning Cost (% of revenue)
On-Time	On-Time Delivery Performance (in %)
ForcAcc	Forecast Accuracy (in %)
DaysInv	Days In Inventory (number of days)

Table 1: Definition of the outbound logistics metrics.

Industry	Frequency (per cent)
Apparel, Leather and Textiles	11 (4.5)
Computers, Electronics, and Electrical Equipment	36 (14.6)
Food, Beverage, and Tobacco	37 (15.0)
Furniture, Wood, Paper and Printing	9 (3.6)
Metals and Machinery	45 (18.2)
Miscellaneous Manufacturing and Mining	21 (8.5)
Miscellaneous Services	9 (3.6)
Petro Chemicals, Plastics, Rubber and Minerals	26 (10.5)
Retail Trade	23 (9.3)
Transportation Equipment	20 (8.1)
Wholesale Trade	10 (4.0)
Total	247

Table 2: Industries of responding organizations.

Range (in millions)	Frequency (Percent)
<50	5 (2.0)
50-100	13 (5.3)
100-250	34 (13.8)
250-500	44 (17.8)
500-1000	50 (20.2)
1000-1500	33 (13.4)
1500-2500	31 (12.6)
2500-5000	17 (6.9)
5000-10000	17 (6.9)
>10000	3 (1.2)
Total	247

Table 3: Distribution of annual revenue of responding organizations.

Cluster analysis was applied to develop the taxonomy based on the outbound logistics metrics defined in Table 1. Hierarchical clustering was used to determine the number of clusters and non-hierarchical clustering was applied to determine the membership of the clusters [25,26]. This approach has been applied in other operations management studies (e.g., [18,27]).

Lehmann [28] suggests that the number of clusters should be between n/30 and n/60, where n is the sample size. This leads to a consideration of the number of clusters in this study to between four and eight. The data were analyzed using Ward's method for hierarchical clustering with squared Euclidian distances. Following Hair et al. [26] the agglomeration coefficient was used to determine the number of clusters over the four-to-eight range. The stopping rule is based on the size of the percentage change in the agglomeration coefficient from a larger to a smaller number of clusters. When large increases occur in moving from one set of clusters to the next, the prior cluster solution is selected because the new combination is joining quite different clusters. This approach has been used by several operations management researchers [29,30].

The results show that four clusters is best, with five and six clusters relatively close in agglomeration coefficient values. We then ran k-means clustering for k=4, k=5 and k=6 to determine the cluster membership. Since the results for k-means clustering can depend on the order of the observations, we made a series of additional runs for k=4, k=5 and k=6 where the order of the cases were randomized. The results show that the initial k=4 solution is the most stable. Based on the results, we selected the four-cluster solution.

ANOVA was used to test for differences in the eight outbound logistics metrics between the four clusters. Following the approach used by Kathuria [18] and Zhao et al. [29] to present the results of cluster analysis as used in OM research, Table 5 presents the cluster means, the standard errors, the cluster number(s) from which this cluster was significantly different at the 0.05 level of significance, and the relative rankings of the eight metrics within the clusters. The F-statistics provides strong evidence that one or more of the cluster means differed from the others on all eight metrics at the $p<0.0001$ level, an indication that the clusters are well-formed. However, since the Levene test indicated that the variances are not homogeneous across the clusters for all metrics except for ForcAcc, the Welch test was run since it does not require homogeneity of variances to test for differences in the eight

	InvCC	WhMgt	ObsInv	TransSpd	SCPCost	On-Time	ForcAcc	DaysInv
InvCC		0.309** (0.000)	0.356** (0.000)	-0.096 (0.134)	0.120 (0.060)	-0.146* (0.022)	-0.193* (0.002)	0.469** (0.000)
WhMgt			0.120 (0.060)	0.252** (0.000)	0.023 (0.718)	-0.002 (0.970)	-0.090 (0.160)	0.119 (0.062)
ObsInv				-0.034 (0.598)	0.027 (0.670)	0.028 (0.656)	-0.021 (0.748)	-0.136* (0.033)
TransSpd					-0.002 (0.975)	-0.033 (0.610)	-0.020 (0.750)	-0.112 (0.078)
SCPCost						0.118 (0.064)	-0.049 (0.443)	0.228** (0.000)
On-Time							0.244** (0.000)	-0.205** (0.001)
ForcAcc								-0.110 (0.084)

[a]p-values are in parentheses below estimated coefficients** indicates significance at the 0.01 level* indicates significance at the 0.05 level

Table 4: Correlation matrix for outbound logistics metrics[a].

Metric	Cluster #1	Cluster #2	Cluster #3	Cluster #4	F-stat[a]
	(n=56)	(*n*=22)	(*n*=48)	(*n*=121)	
InvCC					
Cluster Mean	2.679 (4)[b]	3.498 (3,4)	2.492 (2,4)	1.201 (1.2,3)	33.997***
S. E.	0.22321	0.46409	0.18608	0.06405	
Rank[c]	2	1	3	4	
WhMgt					
Cluster Mean	1.381 (2)	3.815 (1,3,4)	1.440 (2)	1.291(2)	21.881***
S. E.	0.14814	0.63597	0.14822	0.10218	
Rank	3	1	2	4	
ObsInv					
Cluster Mean	5.211 (2)	18.484 (1,3,4)	6.121 (2)	4.228 (2)	57.173***
S. E.	0.51854	2.33187	0.60026	0.29808	
Rank	3	1	2	4	
TransSpd					
Cluster Mean	2.682 (-)	4.060 (3)	2.402 (2)	3.385 (-)	4.086***
S. E.	0.23388	0.5569	0.26436	0.23248	
Rank	3	1	4	2	
SCPCost					
Cluster Mean	0.504 (3)	0.565 (3)	1.315(1,2,4)	0.477 (3)	39.111***
S. E.	0.03455	0.07639	0.12964	0.02621	
Rank	3	2	1	4	
On-Time					
Cluster Mean	74.280 (2,3,4)	90.486 (1)	92.305 (1)	92.107 (1)	64.337***
S. E.	1.77988	1.63391	0.79109	0.57075	
Rank	4	3	1	2	
ForcAcc					
Cluster Mean	66.186 (2,3,4)	77.278 (1)	78.702 (1)	83.087(1)	27.653***
S. E.	1.53348	2.1325	1.67821	1.06474	
Rank	4	3	2	1	
DaysInv					
Cluster Mean	80.216 (2,3,4)	48.155 (1,3)	95.898 (1,2,4)	46.446 (1,3)	51.292***
S. E.	4.07576	6.1397	4.29623	1.99438	
Rank	2	3	1	4	

***p<0.0001

[a]note: In addition to the F-statistic the Welch test was run since the hypothesis that the variances are homogeneous for all metrics across the clusters is not supported (except for ForcAcc); the Welch test is significant at the p <0.01 for all metrics, indicating that for each metric the hypothesis that the cluster means are all equal is not supported

[b]numbers in parentheses indicate(s) the cluster(s) from which this cluster is significantly different at the 0.05 level

cranks are based on highest to lowest values

Table 5: Outbound logistics metrics emphasized by clusters.

outbound logistics metrics between the four clusters. The Welch test was significant at the p<0.01 level for all metrics, verifying the ANOVA results. The Scheffe pairwise comparison of the mean differences at the 0.05 level indicates those cluster means for a given metric that are significantly different from other cluster means. All cluster means for every metric except for two were statistically significantly different from at least one other cluster mean.

Cluster descriptions

Cluster 1: Low Cost, Low Service Providers. The spending on distribution as a percent of revenue of the 56 manufacturing firms that compose Cluster 1 is moderately below the average of all firms (4.1% vs. 4.7% for all firms). In both components of distribution (i.e., warehousing and transportation), the spending of Cluster 1 firms lags the overall firm-wide average by 12% and 13% respectively (Table 5).

Additionally, Cluster 1 firms have below average on-time performance when compared to the average for all 247 firms (74.2% vs. the 88.0% average of all firms). On-time performance is a critical component of delivery service, and therefore, given the very poor performance in this area, this cluster is named low cost, low service providers. Cluster 1 firms also exhibit significantly lower forecasting functionality with an average forecast accuracy of 66.2% vs. the 77.9% sample average.

Interestingly, while Cluster 1 firms have a somewhat higher average inventory carrying cost as a percent of revenue than the average for all firms (2.7% vs. 2.0%), these firms have a somewhat lower average level of obsolete inventory (5.2% vs. 6.1%). On the other hand, Cluster 1 firms' days of inventory (80 days) are significantly higher than the average for all firms (64 days). Thus, overall this cluster exhibits a rather mixed inventory management performance level.

Cluster 2: Heavy Distribution Spenders. The 22 firms that comprise this cluster spend a significantly higher percent of their revenue on the combination of warehousing and transportation than do any of the other clusters. The firms in Cluster 2 spend about 7.9% of their total revenue on these two functions, while no other cluster spends more than 4.7% of their total revenue on distribution. We therefore title this cluster heavy distribution spenders given that they spend over double the percentage of revenue on this function compared to the cluster that spends the least on distribution (Cluster 3), and about 70% more than the average spent on distribution by all 247 firms in the survey. The emphasis of Cluster 2 firms on distribution activities (i.e., on maintaining, controlling and delivering finished goods to customers) results in relatively good on time performance (90.5%) by these companies. However, Cluster 2 firms have only average forecast accuracy (77.2%).

A somewhat surprising area of performance for this cluster is inventory management. Cluster 2 firms' days of inventory on hand (48) are about 16 days below the 247 firm-wide average. At the same time however, the firms in this cluster have average inventory carrying costs as a percent of revenue that are 75% above the overall firm average and obsolete inventory costs that are the highest of all clusters and triple the average of all firms. In summary, Cluster 2 firms exhibit a very mixed overall performance level.

Cluster 3: Planners and Efficient Distribution Spenders. This cluster of 48 firms exhibits the lowest level of spending on distribution (as a percent of revenue) of any of the four clusters. Cluster 3 firms on average expend 18% less on the sum of transportation and warehousing (distribution) than do the 247 firms in all four clusters overall. Cluster 3 firms average 3.8% of total revenue spent on distribution compared to an overall average of 4.7% for all firms. These firms spend the lowest percent of their revenues of any cluster on transportation (2.4%), and a below average percent of their revenues on warehouse operations (1.4% vs. 1.6% overall average).

At the same time, the firms in Cluster 3 spend two times more on supply chain planning (as a percent of revenue) than the overall sample average. Given this combination of relatively low distribution spending, coupled with a strong emphasis on planning, we call these firms planners and efficient distribution spenders. With respect to planning, the cluster with the next highest percent of revenue spent on supply chain planning (Cluster 2) allocates far less than 50% of the relative revenue spent on planning by Cluster 3. There is some evidence that this emphasis on planning contributes to the supply chain execution of Cluster 3 firms. Specifically, Cluster 3 firms exhibit the best on-time delivery performance (92.3%) of the four clusters. At the same time, this group of firms has just minimally above average forecast accuracy compared to the entire set of firms surveyed (78.7% vs. 77.9%).

It is interesting to observe that in terms of inventory costs, Cluster 3 firms are on the relatively high side. Specifically, this group of firms has above average inventory carry costs as a percent of revenue (2.5% vs. 2.0%), while their obsolete inventory costs mirror the average for all 247 firms (both 6.1% as a percent of total revenue). However, Cluster 3 firms average 96 days of inventory on hand, very significantly higher than the overall average of 64 days for all 247 firms in total.

Cluster 4: Inventory Investment Minimizers. The 121 firms in Cluster 4, the largest of the four clusters, have the lowest levels of obsolete inventory (4.2%) expressed as a percentage of revenue. This is over 30% lower than the average of all 247 firms (6.1%), and over 4 times lower than the cluster with the highest percent (Cluster 2). Cluster 4 firms also have the lowest inventory carrying costs (expressed as a percentage of revenue) of any cluster (1.2% vs. 2.0% average for all firms). Further, Cluster 4 firms' average of only 46 days of inventory on hand is lowest among all clusters and is significantly less than the overall average of 64 days among all firms. Overall, all three inventory management metrics indicate that the firms in Cluster 4 focus more on minimizing inventory investment than do firms in the other three clusters, hence the name given to this cluster is inventory investment minimizers.

Interestingly, Cluster 4 firms have the second best (and nearly identical to the best) on-time performance (92.1%) of any cluster and their average exceeds the overall firm average (88.0%) by 4%. Cluster 4 firms also display the highest level of forecast accuracy (83.1%), which exceeds the overall average for all 247 firms of 77.9% by over 5%. Finally, these firms' expenditures on distribution (4.68% of their revenues) is almost identical to the average distribution spending of all firms (4.66%).

The above results support Hypothesis 1 – i.e., that firms can be classified into different groups based upon their emphasis on outbound logistics metrics. And importantly, the results suggest that in general firms emphasize various sets of outbound logistic metrics that reflect their operational planning and control processes in order to meet the needs of the particular markets they serve.

Operating margins and cluster membership

As shown in Table 6, the mean adjusted operating margins of the four clusters range from a high of 5.6% for cluster 3 to a low of 3.4% for cluster 4, a difference of 65%. The operating margin across the entire sample is 4.2%, and so the differences of cluster 3 and 4's means appear substantial. However, as shown in Table 6, the ANOVA test results indicate that the differences across cluster means are not statistically significant. The relatively high standard deviation of operating margins within each cluster relative to their means (high coefficient of variation) appears to be a major contributor to this result. The above results do not support Hypothesis 2 and suggest that there are different emphases on outbound logistics performance metrics that lead to similar levels of firm profitability (Table 6).

Metric	Cluster #1	Cluster #2	Cluster #3	Cluster #4	F-stat[a]
	(n=56)	(*n*=22)	(*n*=48)	(*n*=121)	0.946
OpMarg					
Cluster Mean	0.044	0.048	0.056	0.034	
Std. Deviation	0.06862	0.07101	0.07281	0.08688	
Std. Error	0.00917	0.01514	0.01051	0.0079	
Mean Rank	3	2	1	4	
[a]p=0.419					

Table 6: Operating margin differences across clusters.

Industry	Cluster Number of Cases				Frequency/Percent[c]
	1	2	3	4	
Apparel, Leather and Textiles	1 (2.5)[b]	1 (1.0)	4 (2.1)	5 (5.4)	11/4.5
Computers, Electronics, and Electrical Equipment	12 (8.2)	0 (3.2)	16 (7.0)	8 (17.6)	36/14.6
Food, Beverage, and Tobacco	5 (8.4)	4 (3.3)	3 (7.2)	25 (18.1)	37/15.0
Furniture, Wood, Paper and Printing	0 (2.0)	4 (0.8)	0 (1.7)	5 (4.4)	9/3.6
Metals and Machinery	14 (10.2)	4 (4.0)	7 (8.7)	20 (22.0)	45/18.2
Miscellaneous Manufacturing and Mining	3 (4.8)	2 (1.9)	3 (4.1)	13 (10.3)	21/8.5
Miscellaneous Services	2 (2.0)	0 (0.8)	1 (1.7)	6 (4.4)	9/3.6
Petro Chemicals, Plastics, Rubber and Minerals	10 (5.9)	1 (2.3)	3 (5.1)	12 (12.7)	26/10.5
Retail Trade	4 (5.2)	2 (2.0)	7 (4.5)	10(11.3)	23/9.3
Transportation Equipment	3 (4.5)	4 (1.8)	2 (3.9)	11 (9.8)	20/8.1
Wholesale Trade	2 (2.3)	0 (0.9)	2 (1.9)	6 (4.9)	10/4.0
Total	56	22	48	121	247

[a]Chi Square = 64.779, df = 30, p < 0.0001

[b]The numbers in parentheses are the expected cell counts

[c]The percentages are based on the total sample of 247

Table 7: Distribution of Respondents by Industry and Cluster[a].

Industry – cluster relationship

A chi-square test was used to determine whether there is a relationship between cluster membership and the industry grouping in which the firm belongs. Table 7 illustrates the distribution of industries by the four clusters and the test results. The test results indicate that there are significant differences in industry membership across clusters. A comparison of actual vs. expected cell counts indicates that the following clusters have relatively more firms from specific industries as follows:

Cluster 1: Computers, electronics and electrical equipment; machinery and metals; and petrochemicals, plastics, rubber and minerals.

Cluster 2: Furniture, wood, paper and printing; and transportation equipment.

Cluster 3: Computers, electronics and electrical equipment; retail trade.

Cluster 4: Food, beverage and tobacco; and miscellaneous manufacturing and mining.

Apparel, leather and textiles; miscellaneous services; and wholesale trade are the only industries not having relatively more firms in a specific cluster. These are three of the four industries with the smallest numbers of respondents. The above results support Hypothesis 3 and suggest that emphasis on specific sets of outbound logistic performance metrics tend to be associated with firms in specific industries.

Conclusions

This study analyzed the competitive outbound logistics priorities of 247 firms across a wide variety of industries. Our analysis indicates that different groups of these firms emphasize different operational and planning priorities. Specifically, our research suggests that firms across multiple industries can be classified into several statistically distinct groups (or clusters) based on their different performance priorities with respect to outbound logistics. Importantly, our research also found that there were not statistically significant differences in the levels of profitability achieved by our four groupings or clusters of firms, where each group had different outbound logistics priorities. This finding suggests that individual firms cannot rely on one standard approach to outbound logistics. Rather, it indicates that individual firms must develop an approach tailored to their particular supply chain and customers.

The Inventory Investment Minimizers, the largest group representing about 49% of the sample, focus on tightly controlling their inventory investment, carrying and obsolescence costs. The second largest group, the Low Cost, Low Service Providers who comprise 23% of the sample, focus on maintaining low distribution costs and sacrifice on-time service levels in doing so. The Planners and Efficient Distribution Spenders, 19% of the sample, invest more resources on supply chain planning activities and this allows them to provide superior on-time delivery service at relatively low costs. The smallest group in our sample (9%), the Heavy Distribution Spenders, as their name suggests do spend heavily on warehousing and transportation, and this results in good on-time delivery service (Table 7).

An important attribute of a good supply chain manager, and more broadly, a firm with strong supply chain management, is the ability to discern and develop a supply chain operating model that uniquely meets the needs of the individual firm. It is often stated that there is no one supply chain strategy that works for all firms [19,22]. Rather, firms and their managers must assess the requirements and expectations of their customers and suppliers, their internal firm capabilities, as well as their external competitive environment, and all other market forces to develop the optimal supply chain plan for their company. At the same time, there are clearly not an infinite set of viable supply chain operating models that firms may adopt. Supply chain plans ultimately translate into tactics and operational activities in specific areas such as outbound logistics. One implication or interpretation of our Hypothesis 1 is that there are a set of different operational planning and control activities related to outbound logistics that firms may choose between. Our results identified four different clusters (i.e., planning and operational priorities) that the sample firms gravitated towards. Thus, the statistical significance of Hypothesis 1 suggests that firms do choose among a set of distinct priorities in crafting the best outbound logistics operations approach for their particular company.

As noted, the Hypothesis (#2) that different clusters (with different outbound logistics orientations) would have different levels of profitability was rejected. That is, the mean profitability of each of the four clusters are not statistically different. The rejection of this hypothesis offers some interesting implications. First, it suggests that there is no one outbound logistics operational approach that yields levels of profitability superior to all others. Rather, different firms may achieve optimal profits through different outbound logistics approaches. One question this raises is: can we interpret any alignment or compatibility between the acceptance of Hypothesis 1 and the rejection of Hypothesis 2? A possible interpretation that facilitates "compatibility" between these two results is as follows. If one outbound logistics approach was clearly more profitable than all others, one would expect the vast majority of firms to adopt this "more profitable" approach. Further, if the vast majority of firms followed similar outbound logistics approaches, then one would not expect to observe four distinct (and statistically different) clusters. However, our results demonstrated that within our sample, four statistically different groups of firms do exist. In this sense, the acceptance of Hypothesis 1 and the rejection of Hypothesis 2 are compatible and explainable. Specifically, there are a number of different outbound logistics approaches that can potentially be successful. Not every approach however will work successfully for every firm. Therefore, successful firms need to select the approach most appropriate for their particular company.

Turning to Hypothesis 3, it is not surprising that this hypothesis proved to be statistically significant (i.e., true). Again, Hypothesis 3 is that the group orientation – outbound delivery metrics emphasized – is associated with industry membership. Different industries often have different customer delivery requirements and expectations. For example, in the consumer products industry, customers' (e.g., retailers') requirements for on-time deliveries of "commodity" products such as toothpaste, shampoo, etc. are extremely exacting. There are numerous suppliers of these products, and retailers will not accept poor performance from vendors. Prolonged poor on-time delivery performance can result in retailers literally delisting (eliminating) a suppliers' products from their store inventory. In contrast, in industries where a supplier is providing specialty finished products, or perhaps even intermediate goods, mediocre on-time performance will not result in the delisting of a supplier's products.

Days of inventory on hand is another example of a metric where intrinsic differences between industries would lead one to expect differences in outbound logistics. For example, in in the fresh food category of the food industry days of inventory on hand must be constrained due to shelf life limitations. However, shelf life is not a factor affecting outbound logistics performance in many other industries. Thus, product type or product attributes, as well as differences in competitive requirements, lead firms in different industries to their own particular orientation to, and priorities on, outbound logistics operations. The statistical significance of Hypothesis 3 lends credence to this expectation or interpretation.

Unlike previous research this study did not establish a strong connection between differences in supply chain performance and firm financial performance. One possible explanation is that previous research did not investigate the link between supply chain performance metrics and firm performance. For example, in contrast to our use of outbound logistics metrics, D'Avanzo et al. [5] used a variety of data sources in their analysis, including interviews and survey data, as well as three high-level measures: cost of goods sold as a percentage of revenue, inventory turns, and return on assets. Ellinger et al. [7] and the studies reviewed by Shi and Yu [9] utilized either perceptual surveys or secondary data sources, and focused on the connection between firm performance and supply chain practices or competency as contrasted with performance metrics. The meta analytic approach pursued by Leuschner et al. [10] found a postive and significant link between supply chain integration and firm performance. Again, detailed supply chain metrics were not addressed in the studies they considered.

The selection of the eight metrics used in this study ties to the work of Gunasekaran et al. [13]. Each of these outbound logistics metrics were significantly different between at least two of our four clusters, providing some additional support for the discriminating value of the metrics selected. This finding suggests that future studies seeking to examine the link between supply chain performance and firm financial performance should utilize metrics drawn from Gunasekaran et al. [13].

Limitations

While this study offers important insights on priorities and approaches to outbound logistics operations, it also has limitations that lead to potential future areas of study. While our sample covers a broad range of manufacturing and service industries, it is heavily focused on manufacturing firms. The presence of a relatively limited number of service firms (42, or 17% of the sample), might have potentially impacted the formation of the clusters. Future research should address cluster formation based on a more balanced sample of manufacturing and service firms, enabling a comparison of the resulting cluster profiles and those found in this research.

Our sample covers firms who produce and/or sell both finished goods and in some cases intermediate products. In the future, it would be interesting to conduct separate studies of finished goods and intermediate goods producers and suppliers. Differences both within each group and between each group could be evaluated. Another potential area of future study is the more detailed or lower levels of outbound logistics operations and performance metrics appropriate at that level such as those in Gunasekaran et al. [11] or Shepherd and Gunter [14]. For purposes of this study, we focused on the high level or overarching metrics used to monitor and measure overall outbound logistics operations (e.g., total warehouse management costs and total transportation spend). In the future, it would be insightful to explore these activities in greater depth. For example, warehouse management activities and costs can be broken down into major sub-components such as receiving, put-away, storage, picking and shipping. It would be valuable to explore whether different groups of firms place operational emphasis in different lower level areas, and if so, are there discernible differences in outbound logistics performance related to these differing priorities.

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