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ABSTRACT

There is a great deal of research regarding Supply Chain Management (SCM) and Logistics Information Systems (LIS). However, there has not been a recent examination of the current state of Transportation Management Systems (TMS). This article provides an overview of the previous research and examines the current state of TMS and the relationships between these systems and other information systems in general. The results of over twenty years of LIS and TMS data are presented to highlight potential information gaps and significant relationships between TMS and other functions.

INTRODUCTION

The rapidly changing area of information systems (IS) has created a number of challenges for transportation professionals. Practitioners must evaluate current systems, make budget allocation decisions to purchase new systems and software, and employ TMS to measure and improve the operational performance of their organizations. However, there is a lack of benchmark data regarding the relationships between TMS and other supply chain management information systems (SCMIS).

Therefore, a goal of the research is to identify gaps in the current LIS literature and research. These gaps provide a foundation for the examination of the impacts of TMS within the transportation organization and across the company. Also, the findings highlight the data areas that are being collected and used to support transportation operations and assist transportation and information managers' decision process.

After this introduction, there is a brief overview of the relevant literature. The methodology section discusses the data collection process. The results cover both the basic data and present interesting relationships between TMS and other areas of the organization. Finally, the managerial implications and conclusions are discussed.

LITERATURE REVIEW

A large number of articles have been written on the various aspects of LIS and TMS. A complete review of all of the previous literature is beyond the scope of the current research. However, a number of original studies have helped to establish the field of LIS (House and Jackson, 1976; Lambert et al., 1978). These previous studies have framed much of the LIS research that has followed. Also, there have been two recent articles that presented extensive literature reviews (Williams et al., 1998; Whipple et al., 1999). All of these articles helped to frame the overall format and goals of the present study.

One key point made repeatedly in previous literature is the constant evolution of the field. TMS, LIS and SCMIS systems are constantly changing. Therefore, a current study was needed to update previous findings and to evaluate new and emerging trends. Various studies had collected different types of information including usage of various programs, usage rates over time, data collection elements and a number of other factors (Waller, 1983; Kling & Grimm, 1988; Langley et al., 1988). Also, there were a number of transportation management system specific trends examined in a series of articles beginning in 1975 (Gustin, 1984; Gustin, 1993; Gustin, 1995).

Changes and updates in a number of new IS programs and concepts have been developed since the final Gustin survey (Gustin et al. 1995). Other recent studies have discussed new types of supply chain management tools (Harrington, 1997), inventory related software (Maclead, 1994; Forger, 1999), functional execution systems for logistics and operations (Smith, et al., 1998), and transportation and distribution software suites (Anonymous, 1998). In addition to these new SCMIS and TMS improvements, two of the most important changes that have also received extensive attention in the current literature are Enterprise Resource Planning (ERP) (Bradley et al., 1998; Shaw, 1998; Bradley et al. 1999a; Piturro, 1999) and Electronic Commerce (EC) (DeCovny, 1998; Bradley et al. 1999b; Brooksher, 1999; Witt, 1999).

The literature review also identified a gap in the previous research. While there was some reported research on the impacts of TMS, no broad overview of TMS or its relationships to other areas of the LIS was presented.

DATA COLLECTION

A primary goal of the research was to gather LIS/TMS information from appropriate users. Therefore, a mailing list was derived from two sources: the Council of Logistics Management and the Distribution Computer Expo attendee list. To reach large numbers of logistics and transportation professionals that were users and knowledgeable of LIS/TMS, each list was pre-screened to eliminate unlikely candidates. The CLM list was screened to identify information systems managers working for logistics and transportation operations. The Distribution Computer Expo list was reduced to include only attendees that worked for logistics and transportation companies. Finally, consultants and academics were eliminated from the potential mailing lists. From these two reduced lists, the overall mailing list was created.

A secondary goal was to continue to gather data across time. While it was not possible to replicate the exact sample of companies used in the previous Gustin surveys, most were incorporated to create a longitudinal study (Gustin, 1984, 1993, and 1995). Furthermore, the previous survey formed the basis for the current questionnaire. Based on these factors, the Dillman (1978) research method was used with a pretest, an initial survey, follow-up mailings and reminders.

The questionnaire included not only the previous instruments' questions, but also items of current interest regarding topics such as EC and ERP. The instrument was an eight page booklet with a total of 160 responses covering a full range of historical, current and projected topics of SCMIS.

A total of 1,950 surveys were mailed of which 265 were completed and returned. After removing undeliverable questionnaires, the final response rate was 13.6%. The response rate was compared to articles in the *Journal of Business Logistics* from 1990 through 2000 and it was determined that similar articles and survey instruments had very comparable response rates. Therefore, this response rate appears to be acceptable given the difficulty and length of the survey. Also, to test for non-response bias, early respondents were compared to late respondents on a number of variables (Lambert et al. 1978). No significant differences between the groups were found. Therefore, it was assumed that the respondents were a representative sample.

FINDINGS

With over 250 respondents, a wide range of companies were represented in the data sample. Numerous types of companies and industries were represented. However, the largest single group in the sample consisted of manufacturing firms. To ensure that the large number of manufacturing respondents did not influence the data, a test for bias was conducted on a number of variables between manufacturers and service respondents. There was no bias for any of the test variables. Table 1 summarizes the overall demographic data of the respondent group.

TABLE 1
SUMMARY DEMOGRAPHIC DATA

Demographic Category	Percent of Companies
Primary Business	
Manufacturing	61.9%
Services (retailing, wholesaling, etc.)	25.4
Not indicated	12.7
Industry	
Consumer Durable Products	11.6%
Food Production & Processing	9.7
Textiles	8.5
Chemicals	6.9
Electrical Machinery & Equipment	6.2
Third Party Logistics	5.4
Drug	4.2
Paper, Packaging, & Related	4.2
Other (6 remaining categories)	6.9
Not indicated	35.1
Division Annual Sales*	
Under $100 million	75.7%
Between $100 million and $1 billion	10.8
Above $1 billion	0.1
Not indicated	12.7

* Both Division and Total Sales were gathered; however, Division Sales was chosen as a more appropriate measure for various analyses.

Descriptive Data

The first important area of examination was the use of various TMS components. To examine use, the questionnaire collected a number of data items. First, respondents identified which transportation data elements their company collected. These items were compared to the previous surveys to identify trends. Over time, there was a steady increase in the collection of all the various transportation data elements (Table 2). While there were some small declines on individual variables, there was an increase of data usage for every variable when viewed across the entire time period.

It appears that companies are doing a relatively good job of using TMS to gather basic operational data. The respondents had a very high level of information on shipping locations for customers and open order files. However, regarding the areas that were not as tactical, there appears to be a lower level of computerization. Companies were less likely to use their TMS to gather rates, pay freight bills or schedule shipments. The least collected data element was transit time. Apparently, many of the respondents did not feel a need to record transit times within their current TMS.

The other descriptive portion of the research included the use of data elements by the

TABLE 2
TRANSPORTATION DATA ELEMENTS

Data Element	1975	1982	1987	1992	2000
Shipping Locations	92%	97%	97%	98%	98%
Open Order Files	84	85	89	92	94
Manifest/Bill of Lading	49	55	70	71	83
Carrier File	57	53	64	66	75
Freight Rates	45	36	61	63	71
Freight Bill Payment	51	56	62	63	71
Shipment Schedules	34	51	57	59	70
Transit Times	35	30	35	37	52

respondents. As with the large differences between the levels of data gathered by organizations, there was a sizeable disparity between the importance for different transportation activities and the information needed (Table 3).

The outbound information was the most important to the respondents. Their companies were not as concerned with inbound or especially intra-company transportation information. However, the level of dissatisfaction with the information provided by the TMS was similar for both inbound and outbound transportation. The only mildly surprising point was that intra-company movements had a lower rating on meeting information needs than outbound shipments. This may be due to the low level of importance which has not forced internal carriers to provide higher levels of internal in-transit visibility. One key point is, regardless of the transportation activity, the ability of the TMS to meet the needs of the organization was significantly lower than the demand (pair samples t-test).

Another important descriptive statistic is the TMS used by the respondent companies. There was a very wide range of products employed by transportation organizations. There were 58 different TMS products in use by the 196 companies using a TMS. None of the responses accounted for over 10% of the total. The most common choice was an internal TMS (17 respondents). The second most used system was part of a Manugistics package, including the Global Transportation and Trade Management software (12). The vast majority of respondents used either an internally developed or "off-the-shelf" package. No single TMS vendor or program dominates the market at this time.

The final descriptive item involved the use of TMS to improve the company's performance. Respondents were asked about the level of satisfaction with their TMS systems. Of the respondents using a TMS, 77% were either satisfied or very satisfied with their system's impact on the organization's performance (Figure 1).

Significant Findings

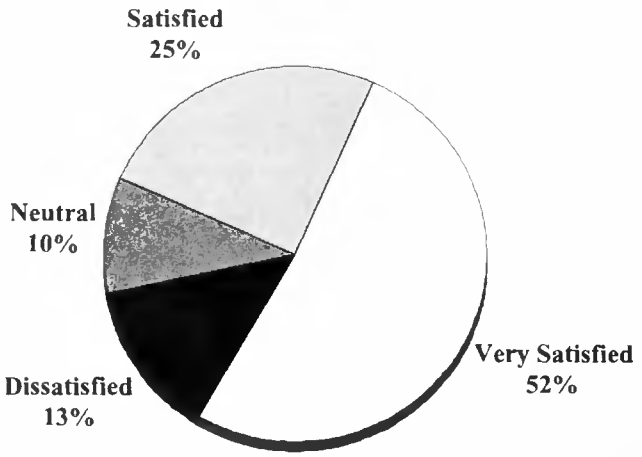
The descriptive items provided an interesting set of findings. However, the more in-depth examination of the data identified additional

TABLE 3
TRANSPORTATION DATA AREA INFORMATION GAPS

Transportation Activity	Information Need (mean rating)	TMS Meets Info Needs (mean rating)	Gap Between Mean Ratings	t	Sig.
Outbound Transportation	6.05	4.80	1.25	12.178	.000
Inbound Transportation	5.28	3.92	1.36	10.378	.000
Intra-company Transportation	4.67	4.31	0.36	2.731	.007

"Information Needs" rating scale: 1 = Low to 7 = High
"TMS Meets Information Needs" rating scale: 1 = Not at all to 7 = Completely

FIGURE 1
TRANSPORTATION MANAGEMENT SYSTEMS SATISFACTION



items. First, there were a number of "obvious" findings in the data. For example, companies that employed a TMS were significantly more likely to track freight rates than those that did not, based on an analysis using a Pearson Chi-square test (Value = 13.602, $p < .001$). There were a number of similar items in this category. These findings, while not surprising, confirm the benefits of TMS by providing a much higher level of transportation related information (Table 4).

While it is logical that the TMS creates a significant increase in the volume of transportation related data, an interesting finding concerned the relationship with non-transportation specific variables. A number of variables that were not likely to be linked to the use of a TMS were significant. Companies that used a TMS had a much higher level of computerization with a number of inventory, production and sales data elements. They were more likely to track inventory costs and storage levels. Also, they demonstrated a higher level of forecasting. Table 5 presents the unique data elements where TMS use has significant relationships.

There are a number of important points that are related to the findings in Tables 4 and 5. First, companies that implement a TMS collect a much higher level of information than those organizations that do not. At least two reasonable explanations for this can be found. Either the TMS is an indicator of firms that are more technologically advanced or the implementation of a TMS facilitates the sharing of information throughout an organization.

The second key point based on the findings is that there is a clear relationship between the use of a TMS and the collection of non-transportation data elements within the firm. A transportation organization that operates a TMS is much more likely to gather information from other areas of the business: distribution, sales, and production. For example, only 8.3% of non-TMS companies track stockout costs, but 16.0% of the TMS organizations measure them. While both are low, the TMS users are significantly ahead of their competitors ($p<.087$). Also, it is likely that the transportation function shares more information with other business areas.

Another set of important findings deals with the value of information as identified in Table 3. The overall respondent group identified the importance of inbound, outbound and intra-company information and the gaps in current technology. An interesting finding is that the use of a TMS does not appear to dramatically change

TABLE 4
TMS RELATIONSHIP WITH TRANSPORTATION DATA ELEMENTS

Data Element	Value	p-value
Shipping Locations	5.881	.053**
Open Order Files	6.288	.098**
Manifest/Bill of Lading	16.331	.001*
Carrier File	7.921	.048*
Freight Rates	13.602	.001*
Freight Bill Payment	6.789	.034*
Shipment Schedules	23.254	.000*
Transit Times	2.074	.355
Freight Claims	10.213	.005*

*Significant at the .05 level
**Significant at the .10 level

TABLE 5
TMS RELATIONSHIP WITH NON-TRANSPORTATION DATA ELEMENTS

Data Element	Value	p-value
Warehousing Costs	14.394	.002*
Storage Costs	4.983	.083**
Handling Costs	6.694	.035*
Production Costs	9.909	.007*
Inventory Levels	14.488	.001*
Packaging Costs	11.058	.011*
Stockout Costs	6.556	.087**
Back Orders	15.281	.002*
Customer's Financial Limits	13.973	.001*
Master Order File	6.195	.045*
Forecasted Sales	26.274	.000*

*Significant at the .05 level
**Significant at the .10 level

these results. The only significant finding was that companies using a TMS believe that outbound transportation information is much more important than non-users. This might account for the implementation of the TMS in the first place. However, there was not a significant difference in the ability of the TMS to meet the information needs. It is likely that the implementation of the TMS increases the expectation levels of the users which raises both the level of information need and also affects the perception of how well the TMS meets that need. Therefore, while the TMS does improves the quality of information, the perceived gap remains. Table 6 supports this finding.

The final area of examination concerned the impact of the TMS on current information trends: EC and ERP. Unlike some of the other relationships, there were no significant differences based on the implementation of a TMS. The widespread adoption of ERP (74.9%) by logistics organization may make any minor differences by TMS users insignificant. Also, the wide variation of the EC results identified the lack of strategies by most companies.

The data presented a number of logical and unique findings. The indicated relationships between the TMS and information areas outside of transportation were the most unexpected. Furthermore, the lack of significant findings in a number of areas highlights that the TMS is not a solution for all areas of need. Finally, the descriptive data present useful information for managers.

MANAGERIAL IMPLICATIONS

The first item that practitioners could use is the identification of data that are being collected by companies' TMS. Table 2's usage rates provide an excellent set of benchmark data with which transportation organizations can compare. Each company can determine if it is collecting appropriate transportation elements based on industry wide practices. Also, the data allow companies to benchmark their transportation information gaps. Finally, organizations can evaluate the success of their TMS compared to other companies' satisfaction levels. Furthermore, if a transportation division is attempting to justify the purchase of a TMS, the results provide strong support.

TABLE 6
TRANSPORTATION DATA AREAS INFORMATION GAPS AND TMS RELATIONSHIPS

	Information Need		TMS Meets Information Needs	
Transportation Activity	**Value**	**p-value**	**Value**	**p-value**
Outbound Transportation	11.134	.049*	2.144	.906
Inbound Transportation	8.580	.199	5.757	.451
Intra-company Transportation	4.669	.587	4.289	.638

*Significant at the .05 level **Significant at the .10 level

In addition to viewing the satisfaction of other users of TMS, there are other positive indicators for the implementation of a TMS. The relationships between non-transportation elements and the TMS highlight the positive effects and synergy that occur with the sharing of data. The inclusion of a TMS in the overall LIS strategy increased information throughout the system. Also, this allows practitioners to gather information from other business areas that may impact transportation operations.

Another piece of information that executives can use concerns the findings on ERP and EC. In both cases, there was no perceived benefit to implementing a TMS when compared to ERP or EC. Neither EC nor ERP had significantly different results when compared to TMS implementation. Therefore, transportation professionals should be careful in committing limited resources from their budget for EC or ERP. The use of EC and ERP appear to be a senior executive level decision and cross functional boundaries. The findings illustrate that, rather than providing specific improvements to transportation functions, most benefits from EC and ERP are general and support the entire company.

Finally, managers can use the findings to evaluate the role of transportation within the overall SCMIS strategy. While most of this article's findings are operational and tactical, the next step of IS integration will be strategic and occur across the entire supply chain. The findings presented here can help to identify standardized, key data elements that should be shared with business partners outside the company. Executives will have to determine which, if any, of these items are sensitive or proprietary to their operations. Furthermore, the value of these interactions is still not clearly defined. While it appears that there are benefits and satisfaction from sharing information, this study did not perform a benefit-to-cost analysis, which would need to be considered in any implementation of SCMIS.

CONCLUSIONS AND FUTURE OPPORTUNITIES

In general, the use of the TMS appears to create value within transportation and logistics organizations. The TMS improves transportation operations by incorporating specific transportation data elements. Also, the interactions with other data sources within the firm, and possibly across the supply chain, improve information sharing. The overall impact of TMS appears to be very positive.

A future opportunity for research might involve measuring the financial impact of the TMS. A continuation of this longitudinal study should include the financial considerations of implementing TMS improvements. Furthermore, it could evaluate the economic effects of other SCMIS as well.

A second research opportunity stems from the apparent lack of impact on TMS from the implementation of EC or ERP. A further examination could help to identify the reasons for this finding. The next study would also provide ERP suppliers more time to produce advanced transportation packages to incorporate into ERP systems. Furthermore, a few years would allow the eLogistics portion of EC to mature, consolidate and stabilize. This would allow a more accurate analysis of impacts on transportation.

The final future area of study is directly related to the findings of the present study. Will the growing interaction between TMS and other IS areas of a company continue? Will this relationship form a more standardized SCMIS in the future? These are relevant questions to pursue in future research efforts.

This research highlighted the growth and successes of TMS within industry. While Thomas Jefferson once said, "Information is the currency of democracy," it appears that now 'Information is the currency of transportation."

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