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The impacts of the integrated logistics systems on electronic commerce and enterprise resource planning systems

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Abstract

The growth of the supply chain concept has required logistics organizations to improve the flow of information both internally and externally. The increased information requirements have facilitated an integration of logistics information systems (LIS) and supply chain information systems in many companies. The increasing use of electronic commerce and enterprise resource planning and other LIS tools and techniques will shape the business process for the foreseeable future. Companies should understand their options and their impacts when making decisions to support their supply chain systems.
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1. Introduction

There has been a steady growth of information systems in inventory management, production, and logistics. This paper reports the results of a recent longitudinal study into the use of logistics information systems (LIS). The survey results reported herein highlight an increasing use of LIS and its ability to link functional areas of business. Additionally, the paper examines the role of two information system tools—electronic commerce (EC) and enterprise resource planning (ERP)—that had not been investigated in previous editions of the study. Information regarding the respondents' EC and ERP adoption sequences, use of key subsystems, and relationships with integrated logistics systems are presented.

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To accomplish these tasks, the paper is divided into six sections. Following the introduction, a brief literature review provides insight into the issues of LIS adoption and integration. Other key sections provide insight into the study methodology, survey respondent profiles, and major findings. Limitations of the study and future opportunities for analysis are also provided. Finally, a conclusions section summarizes the key points of the research.

2. Previous research

LIS has been a major area of study in the logistics and operations areas for more than 25 years (House and Jackson, 1976; Lambert et al., 1978; Williams et al., 1998; Whipple et al., 1999). Issues relevant to the current research include: the usage rates of LIS tools, integration of logistics and LIS, emerging LIS technologies, and LIS adoptions patterns. Key works in each relevant area are discussed below.

A variety of researchers have examined the usage rates of various LIS tools. A number of these studies were conducted approximately every five years since 1975 (Gustin, 1984, 1993, 1995; Rutner et al., 2001). This stream of research provided the framework for the current study and includes a number of relevant findings. Each study is much like a company's financial statement. The study provides a "snapshot in time" of the current LIS tools in use as well as identifying future possible trends. For example, each study identifies the usage rates of approximately twenty-five LIS subsystems. This series of studies provides the plan for not only the theoretical portion of the study, but also the actual design of the longitudinal portion of the questionnaire used in this study. Finally, a number of additional studies help to frame the overall LIS research by identifying the various programs, data collection elements, and previous usage rates to ensure that all of the traditional elements of a LIS are included within this study (Waller, 1993; Langley et al., 1988; Kling and Grimm, 1988).

An additional related area of examination is an evaluation of the ability to integrate logistics and LIS throughout the organization. The Gustin et al., research focuses on the impact of logistics integration as compared to the adoption and success of LIS within an organization. They present numerous significant findings based on the adoption of various LIS application tools and the level of logistics integration (Gustin et al., 1995). They specifically asked the level of integration of logistics throughout the respondents' organizations. They identify that the companies that have a higher level of logistics integration throughout the firm are also likely to be using more LIS systems.

Since the first part of the research is based on the previous research, there are additional opportunities to examine newer trends and IS areas. Therefore, a current trends in LIS section is included to address emerging issues. Recent studies of IS tools help the researchers identify new systems and methods that deserve examination. The previous (Gustin et al., 1995) research could not incorporate all of the advances since their last study. Various more recent studies discuss 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). Two other topics also receive extensive attention in the current trends literature—ERP (Bradley et al., 1998; Shaw, 1998; Piturro, 1999; Bradley et al., 1999a) and EC (DeCovny, 1998; Bradley et al., 1999a,b; Witt, 1999;

Brooksher, 1999). Of all these current trends, the increasing use of ERP and EC provide an interesting area that should impact LIS.

The combination of previous research of LIS and the emerging trend in IS provided an excellent framework to build this research. However, the do not in them selves provide a theoretical framework for analysis. To ensure that this current research does not provide another "snapshot" set of findings, a key element of LIS adoption was the timing of the adoption of the technologies and that impact. While most of the previous studies identify some timing issues, the diffusion rate of these technologies is an important point. Rodgers (1995) provides an excellent framework to identify the early verse the late adopters and the impacts of different timing. He identifies that (1) early adopters will differ from late adopters, (2) the perceived attributes of an innovation will affect its rate of adoption, and (3) that critical factors must be in-place to create the "S-shaped" curve. These points present an excellent framework to test the impacts of implementation of the various LIS, ERP, EC and other IS factors on various logistics areas including integration.

All of the articles in the literature help to identify the gaps within the current body of knowledge. The previous works identify a number of snapshots of usage. Also, do not examine the impact of the most current technologies of EC and ERP. Finally, they highlight the need to evaluate the impacts of the timing and diffusion.

3. Methodology

The previous research identified a number of goals to accomplish with this research. The study should identify the impact of EC and ERP to LIS. Also, it should highlight how the diffusion will impact early or late adopters. Finally, it should provide a current snapshot of current data usage.

To achieve these goals and to gather accurate and generalizable data, a set of possible respondents was generated from two organizations: Council of Logistics Management (CLM) and the attendee list from the Distribution Computer Expo (DCE). Both the CLM membership and DCE lists were limited to the LIS/SCMIS managers and users. This screening process provided a set of very technical LIS professionals working in logistics organizations. The goal was to reach large numbers of LIS personnel working within logistics organizations within the United States and Canada. Based on the objectives, a traditional mail survey with follow-up mailings was determined to be the most appropriate data collection instrument (Dillman, 1978).

A survey instrument was developed based on previous studies and pre-tested. The final questionnaire was an eight-page booklet that had 160 items examining current LIS systems, data collection, use of EC and ERP, demographic, and other types of questions. Since this was a longitudinal study, seven of the eight pages did not change from previous studies. The "current topics" page was pre-tested by fifteen CLM professionals. After minor modifications, the final instrument was produced.

To further reduce the list, consultants, 3PLs, carriers, and academics were also removed from the overall lists. The final combine CLM and DCE list produced 1949 possible informants. Of the surveys sent, 265 completed and returned. This was a response rate was 13.59% after the

undeliverable surveys were removed from the sample. This appears to an acceptable rate for a lengthy questionnaire in an era of reduced response rates using the traditional mail survey. [1] Furthermore, two tests of non-response bias found no significant difference between respondents and non-respondents. The first was a test of public information of company demographics (Rutner and Langley, 2001) and the second was the more traditional comparison of early to late respondents (Lambert et al., 1978).

The research methodology allowed the researchers to test not only the effects of LIS integration, but also continued the longitudinal study of LIS. Furthermore, it gathered data on critical new areas impacting LIS and various areas across the business organization.

4. Research findings

4.1. Respondent demographics

The large number of respondents created a dataset in which most types of businesses, industries, and sizes of companies were represented in the results. The one concern was the large percentage of respondents from the manufacturing sector. Therefore, it was appropriate to test if this group biased the total data. A simple *T*-test to compare manufactures to other respondents did not identify any statistically significant differences in over twenty random chosen variables. Table 1 provides a breakdown of the respondents' key demographic information.

In summary, the typical survey respondent was a sizable manufacturing company that produced consumer goods (durables, food products, textiles, etc.), used a centralized approach to supply chain management and logistics, and was located at the company's central office.

4.2. Logistics integration

In the previous surveys, the questionnaire asked the respondents to report the level of logistics integration within their organization. After a description of integrated logistics systems, the survey asked, "In your firm, is it your opinion that the nature of the integrated logistics concept has?" The respondents could choose between (1) not been recognized, (2) been recognized but the decision was made not to implement it, (3) been recognized and adopted but not successfully implemented, or (4) been adopted and successfully implemented.

The respondents were fairly evenly distributed between the four choices. All four of the responses were between 19% and 32%. The most common was that the integrated logistics concept had been recognized within the organization, but not adopted. Fig. 1 presents the overall results from this question.

Surprisingly, this finding had not change from much from any of the previous Gustin surveys (1984, 1993, 1995) (Rutner et al., 2001). With the growth of logistics knowledge and LIS throughout industry, the assumption would be that more firms would have migrated through the

[1] Based on a comparison of response rates for mail surveys in Journal of Business Logistics, Vol. 11, No. 1 (1990) through Vol. 21, No. 2 (2000).

Table 1
Respondent demographics

Demographic category	Percentage of companies
Primary business	
Manufacturing	61.9%
Service (retailing, wholesaling, etc.)	29.4
Not indicated	12.7
Industry	
Consumer durable products	11.6%
Food production and processing	9.7
Textiles	8.5
Chemicals	6.9
Electrical machinery and equipment	6.2
Other (remaining nine categories)	20.7
Not indicated	35.1
Division annual sales[a]	
Under $100 million	75.7
Between $100 million and $1 billion	10.8
Over $1 billion	0.1
Not indicated	12.7
Logistics operations	
Centralized	48.1%
Decentralized	14.0
Combination	32.6
Other/not indicated	5.3

[a] Both division and total sales were gathered, however division sales was chosen as a more useful measure for various analysis.

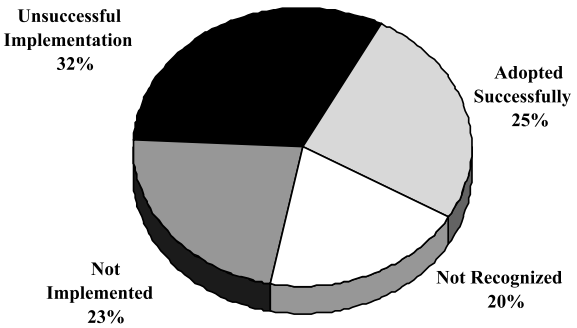

Fig. 1. Integrate logistics systems.

various phases toward the full integration. However, the findings indicated that firms remain in various states of logistics integration.

This question identified updated the previous finding on the levels of LIS integration and gather the current level. However, this only presents part of the overall findings. This information does not discuss the timing of integration throughout the firms.

4.3. Electronic commerce and logistics

In addition to the level of logistics integration, another part of the research is to identify the impacts of EC and ERP on integration. The first part of this section presents the usage of the various areas of EC. The remaining portion evaluates the relationships between LIS and EC.

Not surprisingly, the respondents reported a high usage of EC. However, the research subdivided EC into four specific categories: sales through EC, purchasing with EC, use of an intranet, and customer access to an extranet. When the specific areas of EC were examined, the findings were not as universal. Many companies reported high use of one area of EC and little or no plans to use another portion. Fig. 2 presents the level of EC usage by the various categories.

As can be seen from Fig. 2, intranet-based systems were the most widely adopted EC application, with more than 60% of the firms surveyed reporting successful implementations. By contrast, only 25% of the firms had successfully implemented Internet-based sales applications. Even fewer firms (12%) reported successful implementations of Internet-based purchasing systems, and only 11% had successfully implemented extranet-based supply chain coordination and planning systems.

A second finding of the usage of EC identifies that there appears to be a sequence or process that companies follow when adopting EC. First, a company will have an internal intranet. This is followed by a sales oriented approach with the adoption of a sales Internet page(s). The final two areas appear to be interchangeable by organization. The diffusion theory implies that the intranet portion has gathered enough factors to be in the S-shaped portion of the process while the lack of universal acceptance by the final two areas can be used to differentiate between the early and late adopters.

Using the different areas of EC adoption to frame the comparison, an examination of the relationship between the level of logistics integration and EC implementation produced some interesting findings. Table 2 presents the summary results of the Pearson Chi-square test.

Table 2 reveals significant differences in the implementation of (1) Internet-based purchasing activities, (2) intranet-based communication, and (3) extranet-based supply chain coordination with respect to the level of logistics integration. Closer examination of the data suggests that firms that have successfully implemented the integrated logistics concept are significantly more likely to have also implemented these EC applications. An interesting finding is that the implementation of Internet-based sales applications appears to be independent of the level of logistics integration.

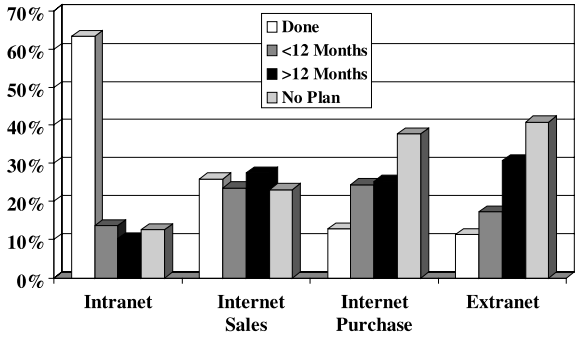

Fig. 2. EC implementation process.

Table 2
Logistics integration and EC implementation

EC activity	Value	*p*-value
Internet sales	9.981	0.352
Internet purchasing	23.840	0.005*
Intranet activity	24.984	0.003*
Extranet activity	35.847	0.000*

* Significant at the 0.05 level.

The lack of a significant relationship between logistics integration and Internet-based sales appears to be due to the large number of manufacturers within the respondent pool. At the time of the data collection, a large number of manufacturing firms were still working on implementation plans for business-to-business websites. This is reflected by the large percentage of firms that responded that the company was in the implementation process of Internet-based sales.

The second key point relates to the failure of many dot.com type organizations to fulfill their on-line promises due to inadequate logistics support. The companies that tie their logistics and EC together should be more successful in the business place. The relationship between logistics integration and information systems reinforces this concept.

The final point is that the diffusion of EC technology appears to have slowed beyond the intranet. Many companies are not beyond the basic implementation of EC. The relationship between logistics integration and the increased number of LIS tools employed may be valid here as well. A company that is successful in implementing logistics integration will be more advanced in LIS *and* EC. Also, an assumption can be made that companies that had advance LIS are more likely to advance through the EC phases more quickly since LIS pre-dates EC. However, the opposite may be true as well and presents an opportunity for future testing.

In summary, the relationship between EC and logistics integration presents both interesting findings and opportunities to organizations. First, the results present a baseline for companies to benchmark their operations. Furthermore, the more advanced companies have tied their logistics operations with other portions of the firm to include EC. However, this only addresses one goal of the research—EC and logistics integration.

4.4. Enterprise resource planning and logistics

After looking at the impacts of one of the major new areas of information systems (EC), the next logical step was to determine any possible effects caused by the relationship between logistics integration and ERP. The questionnaire asked the respondents to address a number of issues about ERP. Each company identified its current status: had implemented ERP, was in the process, or had no plan to implement. The level of ERP usage is presented in Fig. 3.

The vast majority of respondents used ERP in some form. Almost 73% of the companies were using some portion of an ERP system. Furthermore, 20% were in the process of implementing and only 7% had no plan or were unsure. Therefore, the data supports the concept that ERP is becoming a widely accepted computerized process for handling data in American corporations with over 92% of companies using or in the process of implementing.

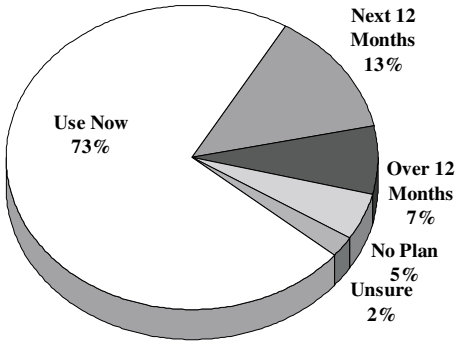

Fig. 3. Companies' use of ERP.

With ERP becoming so widespread, the more important question was the use of specific areas. The companies had to identify which business areas or functions used ERP (i.e., financial control, MRP, inventory management, etc.) Just as EC had a high overall usage with a wide variation in specific application areas, the various ERP areas had a wide range of results. Fig. 4 presents a summary of the four logistics based areas of ERP reported by the respondents.

The relationships between logistics integration and the implementation of key ERP components are summarized in Table 3. Table 3 presents the results of the Chi-square test comparing the

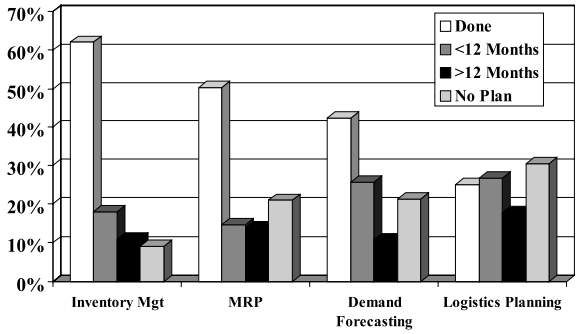

Fig. 4. ERP subsystem plans.

Table 3
Logistics integration and ERP implementation

ERP component	Value	*p*-value
Logistics planning	48.828	0.000*
Production scheduling/MRP	25.252	0.003*
Financial management	33.768	0.000*
Inventory management	16.021	0.066**
Demand forecasting	18.607	0.029*
Human resources management	21.971	0.009*

* Significant at the 0.05 level.
** Significant at the 0.10 level.

use and planned use of all of the ERP components with the level of integration within the firm. The test compared the companies reported stage of logistics integration with the current level of adoption of ERP subsystems. Significant differences were found for five of six major ERP components. More advanced logistics firms, those that have successfully implemented the integrated logistics concept, are more likely to have implemented the logistics planning, production scheduling, financial management, demand forecasting, and human resources components of an ERP. Interestingly, the findings suggest that implementation of an inventory management component is not related to the level of logistics integration. A likely explanation for this finding is that virtually all companies (97%) responding to this survey indicated that they were already using inventory management systems.

As with EC, there appears to be a number of relationships between the level of logistics integration and ERP adoption. First, there is a very strong relationship between logistics integration and implementation of the various ERP components. Companies that have moved farther through the logistics integration process were statistically more likely to have implemented various ERP products. Even inventory management, which 98% of the respondent companies reported currently measuring and managing in some form, had a relationship with ERP (0.1 level). Therefore, the relationship implies that the adoption of ERP helps companies to integrate across logistics areas with other business functions (i.e., accounting, and HRM (see Table 3)). Another possible solution is that businesses that integrate logistics throughout the organization are more likely to implement an ERP product that also integrates various areas' data.

The practical implication is that companies considering integrating either ERP or logistics will be more successful in the adoption if they have implemented the other portion. As with the EC relationship, the assumption is that since LIS pre-date ERP, logistics integration improves ERP implementation. Therefore, a company that has an integrated logistics philosophy will be more successful at adopting an ERP package. However, it is possible that the reverse relationship is true as well.

The second key point is the results provide practitioners another opportunity to benchmarking their companies. The high levels of ERP adoption present a business necessity for most organizations. The ERP packages are becoming requirements in the logistics and business environments. Companies should consider not only adopting ERP, but evaluate which modules will present the most benefits for their specific organization and supply chain partners.

In summary, the research supports previous studies that both EC and ERP are becoming widely accepted business tools throughout the supply chain. Also, it appears that companies are at different levels of implementation and are not choosing to adopt all subsystems. This is likely due to the various types of companies within the sample (i.e., manufacturers, distributors, retailers, etc.) Therefore, the vast majority of companies will be using a combination of EC and ERP to manage logistics operations in the near-term. Finally, both EC and ERP are directly related to the level of logistics integration throughout the organization. The companies that integrate logistics appear to be more successful at implementing the more current systems of ERP and EC.

5. Research opportunities

Based on the initial research findings, there are a number of key areas for future exploration. The first is the interaction of logistics integration with other portions of LIS. This study focused

on the "new" areas of EC and ERP. However, it would be logical to assume that there are effects on other portions of LIS that may be as dramatic. The second important question is the level of impact of the first set of findings. While there are significant differences between the groups based on the level of logistics integration, a future study should examine what are the effects on a company's financial and operational performance. The final opportunity for additional research would expand the concept of integration beyond the company and compare the impact with Supply Chain Management. This would identify if there are similar results for organizations that integrate their business processes across companies possibly using LIS, EC, and/or ERP as linking tools.

6. Conclusions

While there are limitations as with any study, several important points are identified by the research. First, there continues to be growth in the adoption of EC systems that support logistics integration. Companies that have successfully implemented the integrated logistics concept are significantly more likely to have also implemented some form of EC than those who have not, although the type of EC application varies considerably. More advanced companies are beginning to extend their logistics operations to the EC environment through the implementation of Internet-based purchasing and extranet-based supply chain management applications. For companies that have moved as far through the integration process, the implementation of systems that support intranet-based activities and communication appears to be an important first step toward achieving logistics integration via other, advanced EC tools.

Second, logistics integration and ERP implementation go hand-in-hand, with success in one area fostering success in the other. This is to be expected, as ERP systems provide a mechanism for collecting, managing and sharing (i.e., integrating) organizational data across business functions, including the data needed to support the integration of logistics operations. Like EC, there continues to be growth in the adoption of ERP systems. However, unlike EC, ERP implementation is already very widespread. So widespread, in fact, that they have essentially become a necessity within the logistics and business environments. Thus, companies should focus not on whether to implement an ERP, but on determining which components of an ERP will product the greatest benefit to the firm.

Finally, implementation of EC and ERP systems provides higher levels of support for the integration of logistical operations by improving both the access to and linkages among diverse types of information that are important to the logistics function. If current trends in logistics and information systems integration persist (and there is no reason to believe they will not), not only will reliance on such systems continue to increase, but so too will the level of system complexity, as more and more inter-enterprise functionality is added. As such, it will be increasingly important for managers in both the information system and logistics fields to strengthen and tighten the working relationships between the two functions—i.e., information systems will need to support logistics, and vice versa. Successful implementation of the integrated logistics concept and the information systems that enable it will depend on a spirit of mutual support and cooperation.

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