WAREHOUSE MANAGEMENT SYSTEMS: RESOURCE COMMITMENT, CAPABILITIES, AND ORGANIZATIONAL PERFORMANCE

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Every day, logistics managers sift through mountains of information, looking to answer questions concerning their operations. For example, where should the most frequently ordered parts be located in the warehouse? How should inventory be deployed to optimize sales during a period of forecasted high demand? Or which motor carrier should be selected to provide transportation service to a new and potentially valuable customer? Information that could help managers to find solutions to these questions is often collected and available, but the sheer volume of data can be overwhelming. The ability to link information to immediate action is critical. Without reliable information support for logistics, firms could miss the chance to respond to market opportunities, become vulnerable to competitive threats, or struggle to simply provide good service.

The need for data management to support logistics processes has created demand for specialized information systems, custom-designed for logistics management needs (Copacino 1998; Gold et al. 1998; Knill 1998). Many firms are beginning to better understand the need for logistics information support, and as a result, have begun to invest in technologies that enhance decision-making capabilities for transportation management, warehouse management, and demand forecasting and planning among others (Bowersox, Closs, and Stank 1999; Closs and Savitskie 2003). The benefits of these technologies can be significant. The ability to use and leverage information in a timely fashion has been associated with increased internal efficiencies (Bowersox and Daugherty 1995; Closs, Goldsby, and Clinton 1997), as well as better customer responsiveness (Mentzer, Flint, and Hult 2001; Walton and Miller 1995), increased supplier-customer integration (Closs, Goldsby, and Clinton 1997; Closs and Savitskie 2003), enhanced perceptions of logistics service quality (Mentzer, Flint, and Hult 2001), and improved customer satisfaction and performance ratings (Bowersox and Daugherty 1995; Closs and Savitskie 2003; Gustin, Daugherty, and Stank 1995; Rabinovich and Evers 2003). As a result, the adoption and use of technology in support of logistics decision-making is more frequent and more important than ever before.

Significant research has examined the adoption and implementation of component technologies used for capturing and communicating logistics-related data, such as bar-coding, electronic data interchange, (EDI) and, more recently, radio frequency identification (RFID). However, despite the interest in information, little research to date has examined systems-level "smart" technologies, i.e., those that process data into a usable format for decision-making in logistics operations. The most commonly implemented systemic technologies include transportation management systems (TMS) and warehouse management systems (WMS). The current research represents an initial endeavor into the evaluation of these "smart" logistics information systems (LIS), by examining WMS applications within a set of sample companies. This study is designed to determine whether investment in operations-oriented WMS is likely to result in desirable outcomes for the warehouse firm or distribution center. The article concludes with a summary of the research findings and, based on these, suggests an agenda for future research related to WMS, as well as implications for the overall area of LIS and the integration of the technologies into firm and supply chain environments.

LOGISTICS INFORMATION SYSTEMS

Logistics information systems are defined as the "people, equipment, and procedures used to gather, sort, analyze, evaluate, and distribute needed, timely and accurate information to decision makers" (Murphy and Wood 2004, p. 66). A variety of LIS has been designed and implemented for different logistics activities and strategic purposes. Some of the more commonly implemented systems are used to support transportation management, warehouse management, yard management, and operations planning and scheduling. Regardless of their intended function, it is generally believed that these "smart" systems aid significantly in decision making related to the planning, assessment, and control of logistics activities (Bowersox and Daugherty 1995; Closs, Goldsby, and Clinton 1997).

Information and how it is managed have been frequent topics of interest to researchers over the past decade. Research has addressed a number of specific topics in the areas of information availability, integrated decision making, and technology adoption (Bardi, Raghunathan, and Bagchi 1994; Bookbinder and Dilts 1989; Closs, Goldsby, and Clinton 1997; Gustin, Daugherty, and Stank

1995; Rutner, Gibson, and Williams 2003; Walton and Miller 1995). However, despite these advances in theoretical development, little research has addressed LIS from a holistic systems perspective. Studies to date have tended to focus on information itself, and its outcomes, rather than the systems that are used to gather, manage, and control it. Furthermore, implementation and usage have rarely been connected to logistics organizations' strategic objectives. Research by Closs, Goldsby, and Clinton (1997), made an initial assessment of the outcomes of operating and planning systems on LIS capabilities and overall logistics competencies. More recently, Closs and Savitskie (2003) examined the relationships between logistics information technology integration and customer service performance, suggesting that customer integration mediates the technology – service relationship. There is still a need for research that establishes linkages between the implementation of logistics technologies, firm capabilities, and performance.

Numerous IT-related systems interact with and/or benefit the logistics function, though many of the systems are not exclusive to the domain of logistics. Systems such as those for enterprise resource planning (ERP) and materials requirements planning (MRP) have an interface with the logistics organization, but are typically housed within other functional areas of the firm. On the other hand, operational-level LIS such as transportation management systems (TMS) and warehouse management systems (WMS) are often considered to be the core information management systems of the logistics effort. TMS are those information technologies used to plan, optimize, and execute transportation operations. In general, the functions most central to a TMS are shipment planning and routing, carrier selection and evaluation, and transportation cost management and analysis. WMS systems, the focus of the current research, are used to plan, optimize, and execute warehouse operations. A WMS provides support for basic warehouse activities such as order picking, order packing, and inventory put-away. In addition, real-time inventory status is typically reported, as are measures of warehouse worker productivity (Caltagirone, Goldsby, and Griffis 2002).

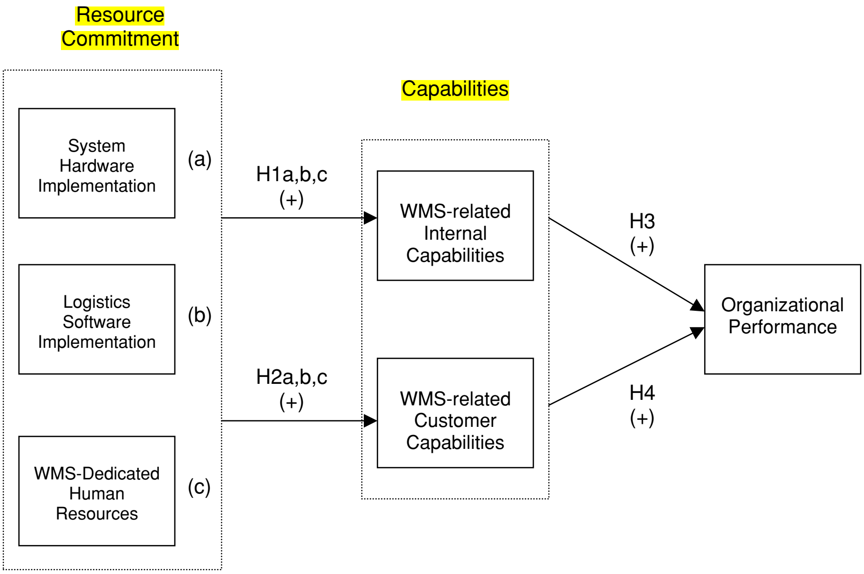
Although this article focuses primarily on WMS, the relationship between resources and capabilities is thought to be generalizable to other operations-level LIS, given that such systems require similar resource endowments for implementation and operation, and that the systems are each used to enhance general logistics capabilities.

THEORETICAL FOUNDATIONS

This study sought to examine potential outcomes of firms' resource commitment to WMS. Of particular interest was whether investment in WMS-related resources leads to tangible benefits for the firm. Thus a resource-based perspective was used to guide this study and is described below. The resource-based research framework is presented pictorially in Figure 1.

FIGURE 1

RESOURCE-BASED WMS FRAMEWORK



Resource-Based Theory of the Firm and LIS

Resource-based theory has long been used to explain differential performance between firms. The fundamental thesis of resource-based theory is that firms possess heterogeneous resource endowments, which in combination with unique firm environmental settings, lead to differentiable performance within a given marketplace. Penrose (1959) suggests that differential endowments are "what give each firm its unique character." The theory has advanced since Penrose's original writing, and has come to be used for explaining firms' strengths and weaknesses (Wernerfeldt 1984) and sources of competitive advantage (Barney 1991, 1986; Barney, Edwards, and Ringleb 1992; Dierickx and Cool 1989).

One derivative of resource-based theory that is particularly useful for the examination of WMS is offered by Barney (1991, 1986) and addresses firm resources as the "assets, capabilities, processes…and information…that enable the firm to implement strategies that improve its efficiency and effectiveness" (Barney 1991, p. 101). Though he notes that technological resources (i.e., software, hardware, etc.) alone are insufficient to allow firms to take advantage of resource inequalities over long periods of time, Barney suggests that interweaving specified technology systems into the workings of an existing business process provides a basis for developing capabilities that can be used to improve firm-level performance in the long-term (Barney 1991, p. 16).

A second theoretical branch of the resource-based perspective focuses on the use of knowledge and information as tactical resources and antecedents of business performance. Business capabilities are defined as the capacities for a set of resources to perform a specific task or activity (e.g., Grant 1991). Teece (1998) suggests that firms that best use information and knowledge resources will be faster and more effective at developing business capabilities, and specifically mentions the use of automation and information systems for logistics as an area where knowledge could be most valuable. Teece (1998) and Foss (1996) also suggest that firms that are able to fuse information systems to business processes will be most able to "capture value," i.e., leverage information management to gain positive financial outcomes.

In the case of the current study, the integration of the two theory streams suggests that resource investment in a WMS has the potential to result in specialized capabilities for the logistics functional unit. Specifically, if firm resources are committed to WMS with the processes and goals of the focal firm in mind, resource-based theory suggests that the firm will be able to develop WMS-related capabilities that can be leveraged to improve internal performance.

Based on conversations with managers and a review of the trade press, three types of resources are of particular interest for the current study of WMS. Information systems are known to require both hardware and software components to achieve full functionality (Gold, et al. 1998; Walton and Miller 1995), and there is often a system-specific investment in human resources needed to optimize the effectiveness of the systems (i.e., perform up-front installation and/or maintenance). The first three hypotheses address the relationships between resource commitment and WMS-related internal capabilities:

H1a: Resource commitment to system hardware implementation will be positively associated with WMS-related internal capabilities.

H1b: Resource commitment to logistics software implementation will be positively associated with WMS-related internal capabilities.

H1c: Resource commitment to WMS-dedicated human resources will be positively associated with WMS-related internal capabilities.

Furthermore, resource-based theory suggests that acquisition, development, and deployment of knowledge resources toward internal capabilities (i.e., efficiencies) are likely to influence firm capabilities in dealing with and serving customers (Conner 1991; Conner and Prahalad 1996; Teece 1998). Three hypotheses are presented to specifically address each of the three salient resource bases:

H2a: Resource commitment to system hardware implementation will be positively associated with WMS-related customer capabilities.

H2b: Resource commitment to logistics software implementation will be positively associated with WMS-related customer capabilities.

H2c: Resource commitment to WMS-dedicated human resources will be positively associated with WMS-related customer capabilities.

From the theoretical foundations, we can also deduce that firms are not only efficiency seekers, but effectiveness seekers, because effectiveness represents the fulfillment of customer needs. Therefore, as a result of internal and customer-related capabilities, resource-based theory proposes that overall firm performance advantages should result (Barney 1991; Barney, Edwards, and Ringleb 1992; Conner 1991). Thus, the following two capability-performance relationships are hypothesized:

H3: WMS-related internal capabilities will be positively associated with organizational performance.

H4: WMS-related customer capabilities will be positively associated with organizational performance.

Method

Based on literature background from the resource-based view of the firm, interviews with four logistics executives, and a sample of articles from the logistics trade press, a survey was developed to measure the resource commitment, capabilities, and performance associated with WMS. Measures were based on those established in previous studies, whenever possible. Measures for the resource commitment and capabilities constructs were adapted from Daugherty, Myers, and Autry's (1999) assessment of automatic replenishment systems. The performance measures used in the study were adapted from those used by Ellinger, Daugherty, and Keller (2000), who asked managers for perceptual performance measurements related to competitors. Due to an inability to obtain "hard" or objective performance measures, subjective performance measures based on respondents' perceptions of performance were used in this study. The use of subjective measures has been found to be a valid alternative when objective measures are not obtainable (Venkatraman and Ramanujan 1986). The survey instrument was then constructed following the guidelines outlined by Dillman (2000).

The instrument was pre-tested with 44 logistics and manufacturing managers and trainees who had knowledge of, or experience with, WMS. The pre-test respondents were from different facilities than the respondents participating in the final survey. Using input offered during the pretests, the survey was modified and scales were adjusted or expanded, where necessary, to improve validity. WMS resource commitment was measured using scales developed for this study, based on the academic and trade literature reviews. Internal and customer-related capabilities and performance measures were adapted from the works of Lee, Lee, and Pennings (2001) and Peteraf (1993). Demographic data describing the respondents were also collected.

Managers from 931 different warehouse facilities were randomly selected from the Warehouse Education and Research Council (WERC) member database as the sample frame. A survey packet containing the questionnaire, an endorsement letter from WERC, and instructions for replying was mailed to each of the managers in the sample. A total of 135 surveys were returned. However, four of the surveys were found to have excessive missing values, or were left entirely blank. Thus, 131 responses, representing a 14.1% response rate, were determined to be usable for the purposes of the research. Measurement items and descriptive statistics are presented in the Appendix.

To ensure valid and reliable measurement, a post hoc psychometric analysis was conducted. Scale items for each construct were subjected to confirmatory factor analysis using LISREL 8.3, as well as an assessment of reliability and internal consistency. All items loaded as expected on the hypothesized factors, and goodness-of-fit statistics, namely Comparative Fit Index (CFI) and Incremental Fit Index (IFI) statistics, indicate sound fit (each greater than 0.90) at 0.922 and 0.919, respectively. An alpha coefficient for each scale was also calculated to further establish the comparability of the scale items, except for the two-item organizational performance measure, which used a Pearson correlation to assess reliability. Finally, variance extracted (VE) was calculated for each scale and compared to shared variances with other constructs, as suggested by Fornell and Larcker (1981). All VE scores were in excess of the shared variances for each two-factor model, which serves as evidence of discriminant validity. Given assessment of sound convergent and discriminant validity, statistical testing of construct relationships may be conducted with greater confidence. The CFA results are listed in Table 1 along with measurement reliability and validity assessments. As indicated by the statistics presented in Table 1, the scales illustrate sound internal consistency and reliability.

TABLE 1

CONFIRMATORY FACTOR ANALYSIS RESULTS

Latent Variable/ Item Reference*		**Measurement Item**	**Parameter Value**	**t-value**	**Item Reliability**
System Hardware Implementation					
CR = 0.88	SH1	Handheld computers	1.37	6.47	0.54
VE = 0.69	SH2	WMS-devoted PC's/networks	1.28	7.45	0.56
	SH3	RF devices/ network	1.78	14.91	0.87
	SH4	Barcoding and/or scanners	1.64	12.90	0.78
Logistics Software Implementation					
CR = 0.80	LS1	Real-time tracking application	1.60	5.33	0.66
VE = 0.65	LS2	Receiving or sorting applications	2.00	11.56	0.77
	LS3	Picking application	1.62	11.00	0.73
	LS4	Materials handling application	1.18	8.41	0.60

TABLE 1 (CONT.)

CONFIRMATORY FACTOR ANALYSIS RESULTS

Latent Variable/ Item Reference*		Measurement Item	Parameter Value	t-value	Item Reliability
WMS-dedicated Human Resources					
CR = 0.79	HR1	WMS consultant	0.92	4.48	0.51
VE = 0.61	HR2	WMS project teams	1.60	8.00	0.61
	HR3	Systems integrator	1.97	9.92	0.69
	HR4	Project manager	2.26	11.79	0.73
WMS-related Internal Capabilities					
CR = 0.86	IC1	Reducing inventory	1.17	8.66	0.60
VE = 0.70	IC2	Better receiving counts	1.43	11.96	0.83
	IC3	Cost containment	1.38	11.52	0.75
	IC4	Improving space utilization	1.44	10.22	0.62
WMS-related Customer Capabilities					
CR = 0.89	CC1	Reducing stockouts	1.23	7.72	0.52
VE = 0.66	CC2	Reducing backorders	1.25	9.12	0.65
	CC3	Improving cycle time	1.56	13.07	0.78
	CC4	Reducing partial shipments	1.33	12.73	0.76
	CC5	Improving reliability of delivery	1.29	9.81	0.69
	CC6	Improving order accuracy	1.52	8.39	0.57
Organizational Performance					
CR = 0.92 VE = 0.91	OP1	Using WMS has made us more profitable.	1.50	14.05	0.91
	OP2	Using a WMS has helped customer relations.	1.57	14.15	0.91

FIT STATISTICS: CFI: 0.922; IFI: 0.919; RFI: 0.890; RMSEA: 0.010; NFI: 0.911

*"CR" refers to Composite Reliability and "VE" refers to Variance Extracted

Results

This study was intended to assess the relationships between resource commitment to WMS and desirable performance outcomes. Specifically, the relationships between three types of WMS resource commitment and WMS internal and customer-related capabilities were examined. Additional analysis centered on the relationships between the two types of WMS capabilities and organizational performance.

To accomplish these objectives, a path model was estimated using LISREL software. Ideally, a full structural equations model would have been used for this purpose; however, the sample size and number of parameters to be estimated made a full SEM unadvisable. Though there is no firm decision rule for minimum sample size for SEM, Anderson and Gerbing (1988), MacCallum, Browne, and Sugawara (1996) and Muthen and Muthen, (2002) each suggest that at lower sample sizes, typically below 150, structural models with latent variables become unreliable. Furthermore, Bentler and Chou (1987) and Hox and Maas (2002) similarly advise against the use of SEM in cases where the ratio of sample size to estimated parameters is less than 10. Given these factors, and considering the strength of the CFA results, a path model was deemed the appropriate technique. The results of the path model test are included in Table 2. Fit indices indicate good fit between the model and the data (CFI = 0.89; IFI = 0.89).

TABLE 2

SUMMARY ASSESSMENT OF RESEARCH HYPOTHESES

Dependent	Factor	Hypothesis	Expected Sign	Path Coefficient (t-value)*	Result
WMS-related Internal Capabilities	System Hardware Implementation	H1a	+	0.483 (4.61)	Supported
	Logistics Software Implementation	H1b	+	0.259 (3.01)	Supported
	WMS-dedicated Human Resources	H1c	+	0.067 (0.61)	Not Supported
WMS-related Customer Capabilities	System Hardware Implementation	H2a	+	0.414 (4.46)	Supported
	Logistics Software Implementation	H2b	+	0.409 (4.55)	Supported
	WMS-dedicated Human Resources	H2c	+	0.024 (0.33)	Not Supported
Organizational Performance	WMS-related Internal Capabilities	H3	+	0.460 (8.92)	Supported
	WMS-related Customer Capabilities	H4	+	0.532 (10.22)	Supported

FIT STATISTICS: CFI: 0.892; IFI: 0.890; RFI: 0.574; RMSEA: 0.035; NFI: 0.881

*Reported parameter values are taken from the standardized solution; t-values are from the unstandardized solution

Individual hypotheses were assessed by examining the significance and direction of each path. Hypotheses 1a, 1b, and 1c predicted that resource commitment to WMS is positively associated with WMS-related internal capabilities. Two of these three hypotheses are supported. System hardware implementation and logistics software implementation both had significant effects on internal capabilities, while investment in WMS-dedicated human resources did not. Similarly, Hypotheses 2a, 2b, and 2c predicted that resource commitment is positively associated with WMS-related customer capabilities. Two of these three sub-hypotheses are supported as well. Investments in hardware and software appear to lead to customer-related capabilities, but human resources were found to have a non-significant relationship. Thus, as was the case with the first set of hypotheses, the implementation of the technological resource bases seems to have an impact on the development of capabilities, while the "human element" fails to contribute to this development.

Finally, Hypotheses 3 and 4 completed the resource-based viewpoint, suggesting that both types of WMS-related capabilities are positively associated with organizational performance. These hypotheses were both supported. These results replicate previous studies of the capability – performance relationship.

DISCUSSION

The results of testing in the current research should be interesting to the logistics community for several reasons. This research makes it possible to begin to assess the influence that different categories of WMS-related resource investments have on development of logistics capabilities. One of the most interesting findings of the research was that the human resource elements – WMS-dedicated employees who assist with the installation, implementation, and/or management of the systems – seem to have little influence when firms seek to develop internal logistics and customer capabilities. This finding has some intuitive appeal – the technology, not the IT personnel, appears to drive logistics capability development. Additionally, investment in human resources for training, implementation, and similar tasks does not appear to contribute gains in efficiency in terms of inventory holdings, backorder reduction, or better customer service. These results may be encouraging to managers considering LIS solutions, as they could indicate that the systems are easily enough understood, used, and implemented, that employees require little additional advice or instruction, and no additional investment in human capital is required to operate and maintain them.

A second, more strategic finding from the study is of importance to researchers investigating the influence of knowledge and/or informational resource bases in organizational settings. Though knowledge-based resources have long been positioned in the literature as a futuristic and potentially fruitful avenue in pursuit of competitive advantage, the current research represents one of very few studies that empirically test these relationships. The findings indicate that the hardware/equipment and software that can be implemented to make firms more "informationally agile" not only influence internal warehouse operations (e.g., help employees to better use floor space, load trucks, etc.), but also are effective in providing other benefits such as heightened customer service via reduced stockouts and greater reliability of deliveries. There is the possibility as well that these benefits are achieved hierarchically – that internal capabilities lead to external capabilities – such that internal benefits might translate into benefits experienced by the customer. In fact, post hoc analysis in the current study finds initial support for this internal – external relationship, calling for further investigation.

Finally, the findings support an often-neglected function of the research process – the replication of former studies in strategic management that relate organizational capabilities to performance. Increasing focus has been placed recently on the neglect in social science disciplines to replicate research in multiple contexts to verify findings and increase nomological validity for important research concepts. The current study extends commonly held premises about the relationships between internal and external capabilities and organizational performance to the logistics and supply chain context. Additional support is found for these relationships in the current study, adding to the credibility of these results for future theoretical development.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS FOR LIS

The research reported in this article suggests that the warehousing and distribution community is beginning to embrace technological advancements that promise to make basic functions more effective and efficient in the near future. While the study provides new insight as to the potential outcomes of a firm's resource commitment to WMS, there are limitations associated with the study. Three limitations are related to the research method. First, it would have been more ideal to examine the research hypotheses using a structural equation model rather than a path model. However, the use of a full structural equation model would have required that the sample size for the study be significantly larger given the complexity of the research. Unfortunately, because LIS is a developing set of technologies, and because the number of companies having implemented LIS is still growing, there were not enough companies in the sample frame who had fully implemented the expert systems of interest (i.e., WMS) to facilitate the use of SEM. Second, while WMS was examined in the study, similar research on TMS or other similar, operations-level systems would serve to further generalize the results. Finally, while "hard" measures of performance data (e.g., profitability increases, ROI, etc.) were unobtainable in this study, the inclusion of such data in future research would reflect greater objectivity in terms of performance improvements, thus enhancing the findings of the research.

Research related to the adoption, acceptance, and/or usage of logistics information systems is in its formative stages. There is much work to be done by both academics and the practitioner community in WMS and other related areas that will help to shed more light on the usefulness and value of logistics technologies. Importantly, though the current study focuses primarily on WMS as a research context, future researchers should examine issues of broader scope, i.e., by addressing the entire array of LIS technologies, and their utility and limitations as decision making tools. To facilitate the development of the LIS research process, research topics are suggested that might be useful in advancing the theoretical and technological development of the systems described.

Research in four distinct but interrelated areas should be performed to better inform the logistics community about the benefits and perils of LIS implementation. First, research should examine the issues associated with integrating LIS into existing business models from both an internal and external perspective. Internally, the relationship between LIS and the strategic decisions of the firm merits some investigation. The LIS should support the overall objectives of the firm and enable the firm to achieve its corporate strategies. Research on the relationship between LIS and corporate strategies would provide information on the appropriateness of implementing various logistics information systems in different environments. For example, firms can choose to develop a LIS internally, outsource development, or purchase a packaged solution. Yet another alternative is to pursue a hybrid approach in which the firm purchases selected standard components and customizes others. Managers need to evaluate the advantages and disadvantages associated with each of these options. Research can help to identify firm characteristics that would be most conducive for successful adoption within each alternative.

From an external perspective, research should investigate the effects of communicating information about the capabilities of a firm's LIS to its customers. What are the real or perceived benefits customers receive from conducting business with a firm using an established logistics information system? Additionally, there are implications that can arise when attempting to integrate LIS through "linked systems" with supply chain partners. In such a situation, it is essential to understand the factors that can foster or hinder collaboration.

A second stream of research might focus on examining the reciprocal effects of LIS on potential system users within the firm. Often, management finds that employees are resistant to the implementation of new technology. While managers may use the implementation of logistics information systems as a catalyst for change within the organization, it is also important to recognize that a fit between the interface of the system and employee capabilities can better facilitate implementation. Research should identify the capabilities required of employees for various types of logistics information systems. To facilitate the implementation process, "superusers" (i.e., line employees who are highly effective early adopters of the new technology), might take ownership of the LIS and train others on the operational aspects of the system. Research could help to identify the personal characteristics of these "superusers," enabling managers to identify and leverage the abilities of such individuals within their firms.

Similarly, LIS capabilities need to align with the needs of the employees who use the systems on a daily basis. Managers should be concerned that their system is enabling employees to do their jobs more efficiently and effectively; otherwise, employees may not understand the value inherent in LIS. Research should examine the value of LIS from the employee point of view to identify potential areas of concern and the role employee understanding plays in system adoption. One way to ease the transition to a LIS is to implement the technology in stages, adding modules as employees become comfortable with the technology and as managers identify the value associated with each module. Research should investigate the best method for implementation – implement in stages or implement all of the needed modules at once. The optimal strategy may vary from firm to firm based on employee and firm characteristics.

Advanced planning and scheduling (APS) systems represent another class of LIS calling for further investigation. Like WMS technology, investment in APS systems is believed to support favorable outcomes in both logistics service and cost. Yet the specific outcomes and the means by which these outcomes are generated can vary between APS and its more operations-oriented brethren. While WMS and TMS support operational decision-making in warehousing and transportation, respectively, APS offers a more strategic perspective geared toward planning of materials, goods, and other resources. APS also tends to be employed centrally within the firm, providing planning and scheduling decision support across a network of facilities. Meanwhile, TMS and WMS, in particular, are likely to be deployed in a decentralized manner, providing facility-specific decision support. Therefore, the results of this research are not necessarily generalizable to APS. However, it is believed that the hypothesized outcomes could find support given focused examination. Further research should be directed toward APS technologies to ascertain the robustness of the hypothesized relationships across broader classification of LIS initiatives.

A final area of research addresses those aspects of LIS implementation related to daily usage and system operation. Managers are interested in issues related to the daily service and maintenance requirements that may be needed to ensure optimal performance. Should these activities be integrated into current business processes, and if so, who in the organization should be held responsible? Firms may also evaluate outsourcing these activities and therefore need to consider the costs versus benefits of each option. Another important decision for managers to consider is whether and/or when to invest in upgrades for LIS. What is the effect of buying perpetual upgrades versus postponing upgrades to minimize capital investment?

From an academic perspective, an examination of what managers initially desire in terms of systems configuration and their expectations as to the functionality of LIS can provide insights into the success of LIS as well as the satisfaction outcomes of using LIS. In addition, the impact of integrating LIS with logistics initiatives such as postponement or automatic replenishment programs should be studied. Research in these areas will help managers in the selection and implementation of logistics information systems that are most appropriate for their firms.

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APPENDIX

MEASUREMENT ITEMS

Latent Variable/ Item Reference	Measurement Item	Mean	Std. Deviation
System Hardware Implementation*			
SH1	Handheld computers	4.60	2.58
SH2	WMS-devoted PC's/networks	5.55	2.13
SH3	RF devices/ network	5.97	1.77
SH4	Barcoding and/or scanners	5.90	1.82
Logistics Software Implementation*			
LS1	Real-time tracking application	4.73	2.31
LS2	Receiving or sorting applications	4.95	2.35
LS3	Picking application	5.73	1.87
LS4	Materials handling application	4.35	2.49
WMS-dedicated Human Resources*			
HR1	WMS consultant	2.66	2.29
HR2	WMS project teams	4.45	2.50
HR3	Systems integrator	3.44	2.41
HR4	Project manager	4.60	2.52
WMS-related Internal Capabilities**			
IC1	Reducing inventory	4.16	1.75
IC2	Better receiving counts	5.40	1.72
IC3	Cost containment	4.94	1.88
IC4	Improving space utilization	5.05	1.68
WMS-related Customer Capabilities**			
CC1	Reducing stockouts	4.75	1.76
CC2	Reducing backorders	4.47	1.77
CC3	Improving cycle time	5.41	1.75
CC4	Reducing partial shipments	4.34	1.88
CC5	Improving reliability of delivery	4.94	1.90
CC6	Improving order accuracy	5.67	1.69
Organizational Performance***			
OP1	Using WMS has made us more profitable.	5.17	1.59
OP2	Using a WMS has helped customer relations.	5.20	1.68

*Survey respondents were presented with the following instructions for these questions: "The following items are related to WMS. Please rate the degree to which your firm has implemented each (1 = not implemented at all, and 7 = fully implemented)". (adapted from Daugherty, Myers, and Autry 1999).

**Survey respondents were presented with the following instructions for these questions: "How effective has your WMS been in the following areas? (1 = not effective, 7 = extremely effective)" (adapted from Daugherty, Myers, and Autry 1999).

***Survey respondents were presented with the following instructions for these questions: "To what extent do you agree or disagree with the following statements? (1 = strongly disagree, 7 = strongly agree)" (adapted from Ellinger, Daugherty, and Keller 2000).

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