Does Investment in Technology Resources affect Motor Carrier Firm Performance?

JOHN R. MACDONALD
Robert H. Smith School of Business
The University of Maryland
College Park, MD 20742
Tel: 301-434-2992
Email: jmacdona@umd.edu

November 2005

I am grateful to Joe Bailey for many helpful comments on earlier drafts of this paper.

Does Investment in Technology Resources affect Motor Carrier Firm Performance?

ABSTRACT

Prevalent in the IT literature is the concept of the productivity paradox. This states that the effects of IT investment seem to show up everywhere except those that measure productivity (firm performance). Owing to the extremely competitive nature of the motor carrier industry, money must be well spent and provide the carrier with performance gains to survive. In this study, two measures of IT spending, physical capital and human capital, are used to examine whether IT investment does indeed affect carrier performance. Performance is measured as a level of firm efficiency (sales/employee). Results are significant and have important implications. The level of physical assets (computers) that a firm uses has a direct and positive impact on firm efficiency. However, the more human capital (programmers) a firm hires to develop software, the *worse* the efficiency of the firm. This suggests that perhaps motor carriers should invest in off-the-shelf IT packages as opposed to creating their own. Finally, the interaction of the two variables and sales was looked at to determine their effect as firms grow. The interaction of physical IT capital and firm size showed that as the firm grows, the effect of physical IT capital grows, suggesting that it may be an antidote to firm bureaucracy.

Key words: motor carrier, firm performance, information technology investment

Does Investment in Technology Resources affect Motor Carrier Firm Performance?

INTRODUCTION

The number of motor carriers registered in the U.S. has nearly tripled in the past 15 years, yielding a highly competitive business climate. In 1990, the U.S. Department of Transportation had 216,000 Interstate Motor Carriers on file. By 1995, the number had risen to 346,000 and by 2002, there were 585,677 motor carriers on file (Feitler et al., 1997; American Trucking Association, 2003). Those firms failing to adapt to this environment of competition will probably be left behind by that same competitive market dynamic (Singh *et al.*, 1986).

There are various ways that a motor carrier can employ to try to increase firm performance and survive in such a competitive environment. Information Technology (IT) investment is one of those ways that has only become an option in the past couple of decades, and many carriers are investing heavily in IT. This can be seen by the carriers writing dispatching programs, purchasing logistics software such as CAPS or i2, developing websites that are more than online brochures and have e-commerce ability, GPS enabled tracking of trucks, onboard computers, bar-coding systems, RFID (radio frequency) tracking, warehouse management systems, and others (Patterson et al., 2004).

The important question is whether investment in IT actually contributes to firm performance in a measurable way. If the answer is yes, firms should invest further in IT to maintain and grow competitive advantage. If the answer is no, then the firm must decide whether intangible benefits provided by IT investment (such as communication efficiency and allowing customers to track their shipments online) outweigh the monetary cost of the technology in the minds of the management.

Given that the motor carrier industry accounts for nearly 1.5 million employed persons in the United States alone (Bureau of Transportation Statistics, 2005), it is surprising that the effect of IT on these firms has not been looked at before now. There are many practitioner publications as well as academic journals that have looked at the adoption of various technologies, but few if any that talk about any resulting performance implications. Is the [implicit] assumption that IT does provide competitive advantage or rather that it is a competitive necessity?

The purpose of this paper is to determine if IT investment significantly impacts firm performance as measured by firm efficiency by looking at two ways of measuring IT investment. This paper contributes to the Transportation and Logistics body of literature in three ways.

Firstly, this research will begin filling a literature gap in the Logistics and Transportation body of knowledge relating to Information Technology affecting firm performance. This type of literature is prevalent in the IT literature, but lacking in Logistics and Transportation journals. Before this study was commenced, six leading Transportation and Logistics related journals[1] (Gibson and Hanna, 2000; Carter, 2002) were looked at over a period of six years ranging from 2000 to 2005. It was found that very few articles were directly related to the impact or even use of IT in the motor carrier industry.

Secondly, this issue is practical to guiding firm management in their IT investment decision making process. Managers are always trying to confirm whether their fiscal and investment policies are helping the firm to perform well and grow. The findings of this paper will begin to aid managers in their decision making process for making IT investments. It also shows them the importance and competitive advantage IT has to offer transportation related firms.

Finally, the notion that IT resources act as an antidote to bureaucracy will be looked at. Bailey et al. (2005) had found that IT investment may be an antidote to the problems associated with larger firms and bureaucracy as they assessed firms in the pharmaceutical industry. In recent years, the large motor carriers have gotten even larger. The question is whether these firms will be more efficient or less efficient the larger they are. Can IT aid that efficiency?

LITERATURE REVIEW

Theoretical Framework

The theoretical framework for this paper will be the resource-based view of the firm. A basic premise of the understanding of the resource-based view is that firms compete based on "unique" firm resources that are inimitable or require substantial investment to imitate, valuable, or hard to find (Barney, 1991; Conner, 1991; Schulze, 1992; Bharadwaj, 2000). These resources have been generally defined by researchers as including assets, capabilities, knowledge, and organizational processes (Bharadwaj, 2000). Hopper (1990) made a specific IT-link to the resource-based view by finding that the SABRE airline reservation system constituted a resource because it was valuable and rare upon its introduction and gave American Airlines a competitive advantage. Several recent studies in the IT literature such as the Bharadwaj (2000) paper as well as Mata et al. (1995), Jarvenpaa and Leidner (1998), and Zhu and Kraemer (2002) have framed their models using the resource-based view, which gives credibility for its continued use as a framework in this research.

Three categories of resources, namely personnel-based, tangible, and intangible, can be defined that will form the base for the variables chosen for the model used (Grant, 1991). Personnel-based resources are simply those resources that the employees hold, such as knowledge, training, company culture, etc. Tangible resources can be anything from the capital (cash) of the firm to the physical assets of the firm such as trucks, warehouses, inventory of finished goods or raw materials. Finally, intangible resources range from brand name and image to reputation to quality of the finished service or product. In making a link to IT, Bharadwaj (2000) argues that IT-specific resources can also be sources of competitive advantage. He concludes from past research that managers and programmers can serve as a personnel-based resource and that physical IT infrastructure can serve as a tangible asset.

Information Technology and Transportation Literature

In the IT literature, it has been noted that there is a substantial impact of information technology on firm performance (Dedrick et al., 2003). Early on, that impact was in doubt as the concept of the "productivity paradox" was developed. As Brynjolfsson and Hitt (1996) state,

> "the productivity paradox of IT is most accurately linked to a subset of studies based on the theory of production which either found no positive correlation overall (Barua et al., 1991; Loveman, 1994), or found that benefits fell short of costs (Morrison and Berndt, 1990)."

In other words, the productivity paradox simply states that IT shows up everywhere in a company except in the productivity statistics. This paradox was later refuted by Brynjolfsson and Hitt (1996) who acknowledge that it existed, but declare the paradox to have disappeared in 1991 according to their data set. To confirm this result and show that IT does affect firm performance, subsequent studies, such as Bharadwaj (2000), have found that firms designated as IT leaders generally have higher profits and lower costs. Similarly, IT-intense firms were found by Zhu and Kraemer (2002) to experience lower cost of goods sold and also a positive effect on inventory turnover. Finally, IT has a greater effect on performance in some industries versus others (Kohli and Devaraj, 2003).

In the logistics literature, much of the IT-related emphasis has been on three streams of research – the usage of EDI, E-commerce development, and investment in mobile communications. EDI made great inroads in the 1980's and 1990's in the motor carrier industry, and Crum et al. (1998) found in their longitudinal study that EDI offered operating efficiency to firms. Machuca and Barajas (2004) used simulation to discover that EDI has a great impact on mean inventory costs, reduced amplification of the bullwhip effect, and lower net excess stock in the supply chain.

In 2000, NetMarketing ranked the transportation and shipping industry as fifth overall for the industry with Best B-to-B (Business-to-Business) websites, confirming that transportation companies have spent investment dollars in e-commerce (NetMarketing, 2000). Similarly, Ellinger et al. (2003) did a study of motor carrier websites and found that many of them had extensive e-commerce features, but they did not attempt any links between e-commerce capabilities and resources on firm performance. However, the positive impact of the internet on firms is well established in the literature (Cronin, 1994; Hoffman and Novak, 1997; Avlonitis and Karayanni, 2000).

Finally, for communications, it was estimated in 1994 that thirty-four percent of the US installed base of wireless communication was the transportation industry, making it the largest user among industries (Dollar, 1995). Manrodt et al. (2003) found that firms benefited operationally (such as lower out-of-route miles and less accidents) from investment in mobile communications. These benefits lead to lower costs and indirectly, greater firm performance.

In summary, while there is some research on IT usage and the effect on certain carrier operations, there is a relative dearth of research targeted to the overall performance of logistics and transportation firms.

HYPOTHESES

As previously mentioned, physical capital can refer to any physical assets the firm owns – land, warehouses, equipment, etc. Investment in IT-specific capital will usually help the firm to have higher profits and lower costs (Bharadwaj, 2000). Zhu and Kraemer (2002) found that overall, e-commerce capability increased firm performance.

Motor carriers have been investing heavily in acquiring information technology. Physical assets such as computers are being purchased for every truck. Moreover, many firms are developing their own warehouse or fleet management systems, which require many developers to program. Additionally, many carriers today have websites that have required a great deal of programming since they can allow such complex functions such as load booking and track-and-trace of current shipments. Having these computers on hand as well as the hired programmers allows the following two postulations:

H1: IT physical capital stock increases firm efficiency.

H2: IT human capital stock increases firm efficiency.

In their recent paper, Bailey et al. (2005) have an interesting finding that bears additional attention. In a study of the pharmaceutical industry, they found that as firms got larger, IT investment had a greater impact on the discovery of innovations, suggesting to them that IT investment can have a mitigating effect on bureaucracy. It is known that information technology can help large organizations streamline the vast amounts of data and information that they have. Several authors have looked at the effect of IT on bureaucracy. IT has increased operational agility (Sambamurthy et al., 2003), made workers more effective on the job (Winter and Taylor, 1996; Orlikowski, 2002), and changed the organizational structure of the firm (Boynton et al., 1994; Gash and Orlikowski, 1991; Pinnseneault and Kraemer, 1997).

The question now becomes, what might lead to this? Perhaps it is that large firms are able to invest and adapt new technologies to their firm than smaller firms who have less resources (Armstrong and Sambamurthy, 1999). Large firms may also be able to benefit from economies of scale in their investments. Finally, a lot of software has many features that are unnecessary and cannot be used by small firms, leaving the large firms to benefit in a greater way from the same investment dollars spent (Iacovou et al., 1995).

Due to these reasons, it is postulated that:

> *H3: The larger the size of the firm, the greater the impact IT investment will have on increasing firm efficiency.*

METHODOLOGY

Data Source

The data for this study comes from a database compiled by Harte-Hanks, Inc. Using this data enabled the testing of the hypotheses on 685 observations. Many previous studies have also used Harte-Hanks databases such as Bailey et al. (2005), Zhu and Kraemer (2002), Hitt (1999), and Brynjolfsson and Hitt (1996).

The data contains a variety of firm-level variables on USDOT registered motor carriers spread over two observation years, 2002 and 2003. As a resource, IT does not take long to have a performance effect. Having a cell phone or on-board computer has the immediate effect of minimizing dispatch time, limiting out-of-route miles, etc. In another example, in January 2005, Wal-Mart began using RFID tags to track inventory for many of its products. After only 10 months of use, a recent University of Arkansas study concluded that the RFID technology is reducing out-of-stock product by 16% and cut manual orders by 10% (Sullivan 2005). Since the measurement of IT investment is a physical measure of that is already in use, two observation years is enough to produce reliable results.

Dependent Variable Measure

The dependent variable for this research is an efficiency measure of firm performance. Melville et al. (2004) assert that performance can be divided into two categories, business process performance and organizational performance. Several examples of business process performance and the accompanying metrics, also listed by Melville et al. (2004), are McAfee (2002), who used on-time shipping, Devaraj and Kohli (2000) with their metric of customer satisfaction, and Barua et al. (1995) with their usage of inventory turnover. It can be seen that business process performance is a "range of measures associated with operational efficiency" (Melville et al., 2004). To measure this efficiency, firm performance is calculated as "firm sales in 2003 / employees". This gives us a measure of sales per employee. It should also be noted that measuring the variable in this method helps control for the skewness of the data set. Understandably the data is skewed as more than eighty percent of all motor carriers operate with fewer than six trucks (American Trucking Association, 2003), but a few companies operate with thousands of trucks.

Independent Variable Measures

All independent variables include a one year time lag and are measured in 2002. They are then expected to have an impact in 2003. Several studies have used lag effects (Devaraj and Kohli, 2000, Bresnahan et al., 2002) with Kohli and Devaraj (2003) even calling for greater use of it in longitudinal data sets.

Size. Since two measures of firm size (sales and employees) are already used in the dependent variable calculation, it is better to use a different measure as an independent variable to minimize correlation. A common measure of firm size in the motor carrier industry is the number of truck drivers that a firm has. This number is commonly tracked because of high turnover rates in the industry. Therefore, the number of drivers in the firm will be used to control for firm size. Additionally, several authors have used a quadratic variable to determine whether a U-shaped relationship existed between the independent variable and dependent variable (Scherer, 1965; Soete, 1979; Audretsch and Acs, 1991). Therefore, a separate variable, which is simply the square term of the drivers variable, is included in this model to ascertain any varying relationship between firm size and firm performance as measured by efficiency.

PC's. The number of personal computers (PC's) that the firm has invested in and has on hand is a measure of a tangible resource. However, when measured as a raw number of PC's in a previous model run for this research, the coefficient was shown to be not significant. Having had a similar issue, Bresnahan et al. (2002) changed their variable to measure intensity versus an actual stock count. Following their lead for this study, the total number of PC's was divided by the number of employees to give a measure of PC-intensity within the firm.

Programmers. The number of programmers a firm has is a measure of its human-IT investment and a personnel-based resource. Citing the same problem as above, the number of programmers was divided by the number of total employees to give an intensity factor.

Interaction terms. Two interaction terms are included. Both PC's and Programmers are interacted with the firm size variable of sales. High correlation between most variables was initially a problem, and there were two things done to combat this. First, the observant reader would have noted that firm sales is being used in this variable as compared to the other measure of firm size which is drivers. While the correlation variables between the interaction terms and the size terms are still high, they are lower than if drivers had been used. The second method was to mean-center the main effects of PC, programmers, and sales. Other authors have had similar issues. As Ang et al. (2002) explain, "without centering, our data exhibit very high levels of multicollinearity". This substantially reduced the correlation with the two intensity variables.

The model that is used in the paper is as follows:

$$FIRMPERF = \beta_0 + \beta_1 PCIT + \beta_2 HIT + \beta_3 PCXSALE + \beta_4 PRGXSALE + \beta_5 DRIVERS + \beta_6 DRIVERS^2$$

RESULTS

Before the regression was run, a correlation matrix of all included variables was assessed (Table 1). The purpose of this matrix is to show whether the variables used are similar to one another and in essence measuring the same effect in the model.

Table 1: Correlations Between Variables

	FIRMPERF	DRIVERS	$DRIVERS^2$	PCIT	HIT	PCXSALE	PRGXSALE
FIRMPERF (DV)	1						
DRIVERS	.019	1					
$DRIVERS^2$	-.002	.882**	1				
PCIT (pc intensity)	.095**	-.051	-.044	1			
HIT (programmer intensity)	.071**	.163**	.095**	.195**	1		
PCXSALE (pc and sales interaction term)	.019	.855**	.959**	-.029	.007	1	
PRGXSALE (Programmer and sales interaction term)	.007	.077**	.077**	-.014	.010	.430**	1

**Significant at the 0.05 percent level

The table shows that there are only four correlations which are with a correlation greater than 20% (0.2). The high correlation between drivers and the square of drivers is logical and expected, since they have the same root data. Likewise, since both interaction terms include sales as part of their calculation, the moderate .430 correlation factor is again expected and acceptable. There is, however, a significant correlation between the PC interaction term and both of the firm size variables. The programmer interaction term is not at all so high and it is not known what is really causing this issue. One explanation is that since most motor carriers now have an onboard computer in each truck, the number count of PC's includes this onboard computer count, the number of drivers (users of the trucks) would naturally be highly correlated in that situation.

The finalized model was run using ordinary least squares regression (OLS) and the results shown in Table 2.

Table 2: Results of OLS Model

Variable	Beta Coefficient	*t*-statistic	p-value
PCIT (pc intensity)	.213	5.345	.000
HIT (programmer intensity)	-.106	-2.499	.013
PCXSALE (pc and sales interaction term)	.232	2.697	.007
PRGXSALE (programmer and sales interaction term)	-.200	-2.300	.022
DRIVERS	-.171	-2.443	.015
$DRIVERS^2$	.131	1.893	.059
CONSTANT	.112	36.955	.000

# of Observations:	685
R-square value:	.053
Model F-value:	6.323
Model p-value:	.000

The model as a whole is significant at the p=0.01 level and the table of results shows that all variables were significant at the p=0.05 level except for the quadratic term of firm size, which was significant at the p=0.10 level.

DISCUSSION

Some of these results are quite surprising and some were expected. PCIT is positive and significant, which supports Hypothesis 1. As the intensity measure of PC's in a firm increases, firm efficiency also increases. The negative coefficient on the programmer intensity variable, HIT, is counter to expectations. The result is implying that as the intensity of programmers in a firm increases, firm efficiency is actually reduced. Hypothesis 2 is thus not supported.

One explanation for the human capital result could lie in understanding the resources involved in programming an in-house product or purchasing an off-the-shelf software program. The purpose of hiring a programmer is to actually code or create a program. In the context of motor carriers, this could be a transportation management system, means of communicating to drivers, EDI interfaces, and e-commerce related applications such as a webpage, etc. In his work entitled "The Mythical Man Month", author Frederick Brooks describes how the more programmers there are that are thrown at a project, the more behind schedule (and consequently over budget) the project becomes. This phenomenon arises in great part due to communication difficulties between all participants (Brooks 1995). It is the author's personal experience that many programmers hired by motor carriers do not speak the "transportation" language and are essentially unaware often times of the purpose or need for the program they are creating for the firm. This lack of effective communication can frustrate all involved parties, and usually delays the project. The firm may then hire additional programmers to try to speed up the project, and thus realizing the effect Brooks described. An off-the-shelf program, while perhaps less flexible around the motor carriers' exact needs, may be a simpler less costly solution and even more quickly provide the desired efficiency or customer service gains.

Hypothesis 3 proposed that the larger the firm was, the greater the effect of IT investment would be. The interaction variables, PCXSALE and PRGXSALE were both significant, however, similar to the results of the direct effects, the physical capital variable was positive, while the human capital variable was negative. This tells us that as the firm grows, the impact of physical capital on firm efficiency is greater. On the other hand, as the firm grows, the impact of human capital is to make the firm operate less efficiently. These results lend support to the theory that investment in information technology can be an "antidote for bureaucracy" (Bailey et al., 2005).

Finally, the two size variables, DRIVERS and $DRIVERS^2$, are both significant. Again, the interesting result is the negative coefficient on the DRIVERS variable. This implies that as the firm grows and more drivers are hired, the performance of the firm in terms of efficiency actually worsens. Bureaucracy is likely one of the culprits, and provides more importance to the findings of the interaction terms discussed above.

It is important to briefly discuss the low R-square value that resulted from the model. With a value of 0.053, we are effectively told that 5.3% of the y-value variability is explained by the model. Given, however, that the variables are highly significant, and the history of other motor carrier related regressions producing similarly low R-square values (Feitler et al, 1997), the result is not of great concern for this model.

Limitations

The primary limitation of this paper is that the results are not very robust to different operationalizations of the dependent variable. Recall that the dependent variable is an efficiency measure of the firm obtained by dividing firm sales by the number of employees. There were three choices of the denominator firm size variables in the data set: employees (total), employees (drivers only), and number of trucks. Substituting one measurement for another can yield insignificant results for the independent variables. This problem is similar to that which Kohli and Devaraj (2003) faced in their research and discussed. Methods for overcoming this problem include obtaining a more longitudinal data set and greater sample size (Kohli and Devaraj, 2003).

A reminder to managers is now voiced that this research is just the beginning of a more detailed understanding of how IT investment affects firm performance. The results make managers more aware of what they can be watching for and possible alternatives when the issue at hand revolves around investment in programming or the purchase of an off-the-shelf software. However, each firm may have a different set of variables, and managers need to understand their situation primarily. More empirical work needs to be done to make the direction for managers more clear and visible.

FUTURE RESEARCH

Since this is a new area for the transportation and logistics body of literature, there are quite a few opportunities that exist for future research.

If the data set had allowed, there are four additional variables that would have added depth and preciseness to the current study: total IT staff (both outsourced and full-hires), a measure of programmer and IT man-hours, actual cost measures of IT investment, and the differentiation between types of motor carriers.

Eighty percent of motor carriers have six or fewer trucks. Many of these firms would never hire a full time programmer, or even invest in the type of software set it would require. Knowing instead a count of full-time IT staff would be more meaningful. Even this however, may fail to capture all the actual IT human capital investment as the CEO/dispatcher/accountant of a 6-truck firm may also perform any needed IT-related duties but never consider themselves as IT staff. The ideal variable, though extremely difficult to measure, would be man-hours per week spent managing information technology, whether in-sourced or out-sourced. This variable would also better capture any outsourced work the firm might have.

Another measure of IT investment, such as the categorized costs paid for IT physical or human capital would lend insight to whether a programmed in-house application led to better performance, or a purchased software suite was better. Finally, being able to differentiate between LTL (Less-than-Truckload) or TL (Truckload) companies may provide results that very between the sectors and help managers target their decisions more accurately.

Other questions are: Does the successful implementation of one technology indicate future successful implantations and therefore a further increase in performance (due to organizational learning)? Does the type of information technology impact firm performance in varying degrees? Which technology increases efficiency the most? Recent work in the IT field by Zhu (2004) cites the need for complementarities among between variables will also help to explain and remove the "productivity paradox" discussed earlier. These and other questions and topics leave an exciting realm of opportunities for the researcher.

CONCLUSION

In summary, this research has shown that IT significantly affects firm performance as measured by efficiency, with physical assets bringing a positive effect, and human capital investment bringing a negative effect. Additionally, it was shown that indeed, investment in physical IT capital may have a positive effect on reducing bureaucracy in a firm.

ENDNOTES

1. The six journals surveyed were: Journal of Business Logistics, Transportation Journal, Transportation Research: Part E, Journal of Supply Chain Management, International Journal of Logistics Management, and the International Journal of Physical Distribution and Logistics Management

REFERENCES

American Trucking Associations, Inc. 2003. *American Trucking Trends*, Alexandria, VA.

Ang, S., Slaughter, S., Ng, K. Y. "Human Capital and Institutional Determinants of Information Technology Compensation: Modeling Multilevel and Cross-Level Interactions" *Management Science* 48, no. 11 (2002): 1427

Armstrong, C. P. and Sambamurthy, V. "Information technology assimilation in firms: The Influence of Senior Leadership and IT Infrastructures" *Information Systems Research* 10, no. 4 (1999): 304-327

Audretsch D. and Z. Acs. "Innovation and Size at the Firm Level" *Southern Economic Journal* 57 , January (1991): 739-744

Avlonitis, G. J. and Karayanni, D. A. "The Impact of Internet Use on Business-to-Business Marketing: Examples from American and European Companies" *Industrial Marketing Management* 29, no. 5 (2000): 1-22

Bailey, J. P., Cantor, D. E., Grimm, C. G. "The Impact of IT Investment on Product Innovation: Theory and Evidence from the Pharmaceutical Industry" *University of Maryland College Park Working Paper*, College Park, Maryland (2005)

Barney, J. B. "Firm Resources and Sustained Competitive Advantage" *Journal of Management* 17, no. 1(1991): 99-120

Barua, A., Kriebel, C., Mukhopadhyay, T. "Information Technology and Business Value: An Analytic and Empirical Investigation" *University of Texas at Austin Working Paper*, Austin, TX. (1991)

Barua, A., Kriebel, C., Mukhopadhyay, T. "Information Technologies and Business Value - An Analytic and Empirical Investigation". *Information Systems Research* 6, no. 1 (1995): 3-23

Bharadwaj, A. "A Resource-based Perspective of Information Technologies and Business Value: An Empirical Investigation" *MIS Quarterly* 24, no. 1 (2000): 169-198

Boynton, Z., Zmud, R.W, and Jacobs, G.C. "The Influence of IT Management Practice on IT Use in Large Organizations" *MIS Quarterly* 18, no. 3 (1994): 299-318

Bresnahan, Timothy, Brynjolfsson, Erik and Lorin M. Hitt. "Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-level Evidence" *Quarterly Journal of Economic* 117, no. 1 (2002): 339-376.

Brooks, Frederick P. 1995. *The Mythical Man-Month*. Reading, MA: Addison-Wesley

Brynjolfsson, E. and Hitt, L. "Paradox Lost? Firm-Level Evidence On The Returns To Information Systems Spending" *Management Science* 42, no. 4 (1996): 541-559.

Bureau of Transportation Statistics. "National Transportation Statistics 2005" http://www.bts.gov/publications/national_transportation_statistics/2005/index.html

Carter, C. R. "Assessing Logistics and Transportation Journals: Alternative Perspectives" *Transportation Journal* 42, no. 2 (2002): 39

Conner, K. "A Historical Comparison of Resource-Based Theory and Five Schools of Thought within IO Economics: Do We Have a New Theory of the Firm?" *Journal of Management* 17, no. 1 (1991): 121-154

Cronin, M. J. 1994. "Doing Business on the Internet, How the Electronic Highway is Transforming American Companies", New York: Van Nostrand Reinhold

Crum, M. R., Johnson, D. A., Allen, B. J. "A Longitudinal Assessment of EDI Use in the U.S. Motor Carrier Industry" *Transportation Journal* 38, no. 1 (1998): 15-28

Dedrick, J., Gurbaxani, V., Kraemer, K. "Information Technology and Economic Performance: A Critical Review of the Empirical Evidence" *ACM Computing Surveys* 35, no. 1 (2003): 1-28

Devaraj, S. and Kohli, R. "Information Technology Payoff in the Health-Care Industry: A Longitudinal Study" *Journal of Management Information Systems* 16, no. 4 (2000): 41-67

Dollar, T. "A World Without Wires" *Distribution* 94, no. 10 (1995): 59-62

Ellinger, A. E., Lynch, D. F., Andzulis, J. K. "B-To-B E-Commerce: A Content Analytical Assessment of Motor Carrier Websites" *Journal of Business Logistics* 24, no.1 (2003)199–220

Feitler, J. N., Corsi, T. M. and Grimm, C. M. "Measuring Firm Strategic Change in the Regulated and Deregulated Motor Carrier Industry: An 18-Year Evaluation" *Transportation Research, Part E* 33, no. 3 (1997): 159-169

Gash, D.C. and Orlikowski,W.J. "Changing Frames: Towards an Understanding of Information Technology and Organizational Change" *Academy of Management Best Papers Proceedings*, (1991): 189-193

Gibson, B. J. and Hanna, J. B. "An Analysis of the Value of Logistics Periodicals for Research, Teaching, and Outreach Purposes" *Proceedings of the Twenty-Ninth Annual Transportation and Logistics Educators' Conference*, (2000): 125-160

Grant, R. M. "The Resource-based Theory of Competitive Advantage" *California Management Review* 33, no. 3 (1991): 114-135

Hitt, L. M. "Information Technology and Firm Boundaries: Evidence from Panel Data" *Information Systems Research* 10, no. 2 (1999): 134-150

Hoffman, D. and Novak, T. "A New Marketing Paradigm for Electronic Commerce" *The Information Society, Special Issue on Electronic Commerce* 13 (1997): 43-54

Hopper, M. D. "Rattling SABRE - New Ways to Compete on Information" *Harvard Business Review* 68, no. 3 (1990): 118-125

Iacovou, C. L., Benbasat, I., and Dexter, A. S. “Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology” *MIS Quarterly* 19, no. 4 (1995): 465-485

Jarvenpaa, S. L, and Leidner, D. E. “An Information Company in Mexico: Extending the Resource-Based View of the Firm to a Developing Country Context” *Information Systems Research* 9, no. 4 (1998): 342-361

Kohli, R. and Devaraj, S. “Measuring Information Technology Payoff: A Meta-Analysis of Structural Variables in Firm-Level Empirical Research” *Information Systems Research* 14, no. 2 (2003): 127-145

Loveman, G. W. 1994. "An Assessment of the Productivity Impact on Information Technologies," in *Information Technology and the Corporation of the 1990's: Research Studies,* edited by T. J. Allen and M. S. Scott Morton, MIT Press, Cambridge, MA

Machuca, J. and Barajas, R. P. “The Impact of Electronic Data Interchange on Reducing Bullwhip Effect and Supply Chain Inventory Costs” *Transportation Research: Part E* 40 (2003): 209-228

Manrodt K.B., Kent J.L. and Parker R.S. “Operational Implications of Mobile Communications in the Motor Carrier Industry” *Transportation Journal* 42, no. 3 (2003): 50-58

Mata, F. J., Fuerst, W. L., Barney, J. B. “Information Technology and Sustained Competitive Advantage: A Resource-Based Analysis” *MIS Quarterly* 19, no. 4 (1995): 487-505

McAfee, A. “The Impact of Enterprise Information Technology Adoption on Operational Performance: An Empirical Investigation” *Production and Operations Management* 11, no. 1 (2002): 33-53

Melville, N., Kraemer, K., Gurbaxani, V. “Review: Information Technology and Organizational Performance: An Integrative Model of IT Business Value” *MIS Quarterly* 28, no. 2 (2004): 283

Morrison, C. J. and Berndt, E. R. 1990. “Assessing the Productivity of Information Technology Equipment in the U.S. Manufacturing Industries” *National Bureau of Economic Research Working Paper 3582*

Orlikowski, W.J. “Knowing in Practice: Enacting a Collective Capability in Distributed Organizing” *Organization Science* 13, no. 3 (2002): 249-273

Patterson, K. A., Grimm, C. M., Corsi, T. M. “Diffusion of Supply Chain Technologies”. *Transportation Journal* 43, no. 3 (2004): 5

Pinsonneault, A. and Kraemer, K.L “Middle Management Downsizing: An Empirical Investigation of the Impact of Information Technology” *Management Science* 43, no. 5 (1997): 659-680

Sambamurthy, V., Bharadwaj, A., and Grover, V. “Shaping Agility Through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms” *MIS Quarterly* 27, no. 2 (2003): 237-264

Scherer. “Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions” *American Economic Review* (1965): 1097-1125

Schulze, W. S. “The Two Resource-Based Models of the Firm: definitions and Implications for Research” *Academy of Management Best Paper Proceedings* 1992

Singh, J. V., Tucker, D. J., House, R. J. “Organizational Legitimacy and the Liability of Newness” *Administrative Science Quarterly* 31, no. 2(1986): 171-193

Soete, L. L. G. “Firm Size and Inventive Activity: The Evidence Reconsidered” *European Economic Review* (1979): 319-340

Sullivan, Laurie. “Wal-Mart Brings the RFID Proof” *Information Week* Oct. 17, 2005: 22

Winter, S.J. and Taylor, S.L. “The Role of IT in the Transformation of Work: A Comparison of Post-Industrial, Industrial, and Proto-industrial Organization” *Information Systems Research* 7, no. 1 (1996): 5-22

Zhu, Kevin. “Technology Infrastructure and E-Commerce Capability: A Resource-Based Assessment of Their Business Value” *Journal of Management Information Systems* 21, no. 1 (2004): 167-202

Zhu K. and Kraemer, K. “e-Commerce Metrics for Net-Enhanced Organizations: Assessing the Value of E-commerce to Firm Performance in the Manufacturing Sector” *Information Systems Research* 13, no. 3 (2002): 275-296