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Impact of RFID Technology Utilization on Operational Performance

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Abstract

*Purpose – The impact of RFID technology utilization on operational performance is investigated.* A structural model that incorporates RFID technology utilization as antecedent to operational performance is theorized and assessed.

*Design/methodology/approach - Data from a sample of 122 manufacturing sector organizations were collected and the model was assessed following a structural equation methodology.*

*Findings - RFID technology utilization directly and positively impacts operational performance.*

*Research limitations/implications - Interpretation of the results should be tempered in light of this early stage of adoption of RFID technology in the manufacturing sector.*

*Practical implications – Manufacturing managers can expect improved operational performance to result from the implementation of RFID technology.*

*Originality/value – The study offers empirical support for the adoption of RFID technology for the purpose of improving operational performance within the manufacturing sector.*
1. **Introduction**

Manufacturing organizations have begun implementing RFID technology in the hope of both operational and supply chain performance improvement. The technology holds promise for both improving the efficiency of operations and logistics processes and improving the effectiveness of the organization in terms of satisfaction of both the immediate customers of the organization and the ultimate customers of the supply chain.

As manufacturing managers consider the costs and benefits of adopting the technology, they should consider its impact on operational, business, and supply chain performance. The first and primary focus of operations managers is likely to be the benefits on operational performance. Will RFID technology utilization lead to improvements in operational performance metrics such as throughput, lead time, product cycle time, and due date performance?

If RFID technology utilization does not lead to improved operational performance, it is unlikely that business and supply chain performance improvements will be realized. We focus on this most basic of relationships – the impact of RFID technology utilization on operational performance. We theorize an RFID-performance model and test the model with data collected from a sample of manufacturing organizations using a structural equation methodology.

A review of the literature and discussion of the study hypothesis follows in the next section. A discussion of the methodology employed in the study is then presented followed by a description of the scale assessment and the structural equation modeling results. Finally, a conclusions section incorporating discussions of the contributions of the study, limitations of the study, recommendations for future research, and managerial implications follows.
2. Literature review and hypothesis

According to Drake and Schlachter (2007) development of technologies over the last 25 years has changed the operational environment of organizations. Dos Santos and Smith (2008, p. 127) state, “it is widely believed that the use of radio frequency identification (RFID) technology will enable substantive supply chain transformations.” These authors also state that through the use of RFID deployment firms can gain competitive advantage.

Large organizations, such as Walmart (Lee and Park, 2008) and Volvo (Holmqvist and Stefansson, 2006), are forcing the use of the technology onto their upstream supply chain members. This results in some of the organizations that are supply chain members focusing on RFID technology simply as a cost of doing business (Zelbst et al., 2008). Vijayaraman and Osyk (2006) state that many organizations in the supply chain of Walmart have no choice but to adopt RFID technology. This focus could result in an organization not using information available to them to increase operational performance. For the transformation identified by Dos Santos and Smith 2008) to take place at the supply chain level, the performance outcomes at the operational level need to be assessed.

According to Peng et al. (2008), an organization’s operational performance and strengths need to be assessed using varied measures of operational performance such as lead time, cycle time, operating expense, throughput, and inventory expense (Mabin and Balderstone, 2003). This research will evaluate the impact of the utilization of RFID technology on the operational performance of manufacturing organizations. We develop and assess an RFID performance model that incorporates RFID technology utilization as antecedent to operational performance with the link between the constructs being positive and significant. The model is depicted in Figure 1.
Management is involved in a constant balancing between strategic changes and operational performance (Naranjo-Gil et al., 2008). According to Yeung et al. (2008) technology that provides information can help to improve not only efficiency but also effectiveness in operational performance. Extrapolating from these authors’ work and Mabin and Balderstone’s (2003) work, throughput is related to effectiveness and inventory and operating expense are related to efficiency. Operational performance is also dependent upon an organization’s capabilities and technologies (Hatch, 2008). Organizations focusing on underlying technologies find an improvement in throughput, inventory expense, and operating expense resulting in a positive impact on operational performance (Huckman and Zinner, 2008). Therefore:

**H1: RFID technology utilization positively impacts operational performance.**

3. **Methodology**

3.1 **Data collection process**

Data were collected via an on-line data service during the summer of 2008. Of the 300 individuals who accessed the survey, 122 completed the RFID technology utilization and operational performance scales. All respondents represent the manufacturing sector. Of the sample population 67% are in managerial or supervisory positions and 33% are in operational positions. Respondents have been in their current positions for 6.93 years and represent organizations from 18 different manufacturing categories.

3.2 **Measurement scales**

The theorized model (Figure 1) incorporates RFID technology utilization and operational performance constructs. The RFID technology utilization scale was originally developed and assessed for reliability and validity by Green et al. (2008). The items are designed to assess the
degree to which manufacturing organizations have implemented and utilize RFID technology. The eight-item operational performance scale was developed and assessed for reliability and validity by Inman et al. (2008). Inman et al. (2008) note that the items in the scale are based on operational performance metrics originally identified by Mabin and Balderstone (2003). Respondents were asked to rate their organization's performance in each of eight operational performance metrics as compared to the industry average. The study scales are presented in Table 1.

Insert Table 1 about here

Non-response bias was assessed by comparing the responses of early and late respondents using a common approach described by Lambert and Harrington (1990). Seventy-seven of the study respondents were categorized as early respondents and 45 were categorized as late respondents based on whether they responded to the initial or follow-up request to participate. A comparison of the means of the demographic variables (years in current position and total number of employees in organization) and for the individual item means was conducted using one-way ANOVA. The comparisons resulted in non-significant differences indicating that the concern related to non-response bias is minimized.

Common method bias may lead to inflated estimates of the relationships among variables when data are collected from single respondents (Podsakoff and Organ, 1986). Taking direction from Mossholder et al. (1998), common method bias was assessed through single factor confirmatory factor analysis. This analysis with all items loading on one factor does not fit the data well with a relative chi-square value of 13.25, an NNFI of .881, and a CFI of .887. This lack of fit indicates that the concern related to common method bias is minimized.
4. Results

4.1 Measurement scale assessment

Garver and Mentzer (1999) recommend computing Cronbach's coefficient alpha to assess scale reliability, with alpha values greater than or equal to 0.70 indicating sufficient reliability. Alpha scores for both the RFID technology utilization (alpha = .986) and operational performance (alpha = .970) scales exceed the .70 level. Both scales exhibit sufficient reliability with coefficient alpha values greater than the .80 criterion recommended by Nunnally and Bernstein (1994) for basic research.

Garver and Mentzer (1999) recommend reviewing the magnitude of the parameter estimates for the individual measurement items to assess convergent validity, with a strong condition of validity indicated when the estimates are statistically significant and greater than or equal to .70. All nine estimates for the RFID technology utilization scale are statistically significant and exceed the recommended .70 level. All eight estimates for the operational performance scale are statistically significant and exceed the recommended .70 level. Figure 2 incorporates the parameter estimates and accompanying t-values.

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Insert Figure 2 about here
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Discriminant validity was assessed using a chi-square difference test as recommended by Garver and Mentzer (1999). A statistically significant difference in chi-squares indicates sufficient discriminant validity (Garver and Mentzer, 1999; Ahire, Golhar, and Waller, 1996; Gerbing and Anderson, 1988). The computed chi-square difference is 1,361.12 and is significant at the .01 level.
Koufteros (1999) recommends that the individual scales be incorporated together in a measurement model and that this model be subjected to an additional confirmatory factor analysis and that relative chi-square, non-normed fit index (NNFI), and comparative fit index (CFI) values be used to assess fit when the sample size is relatively small. Relative chi-square values of less than 2.00 and NNFI and CFI values greater than .90 indicate reasonable fit (Koufteros, 1999). Results of the analysis indicate that the measurement model fits the data relatively well with a relative chi-square value of 1.830, an NNFI of .986, and a CFI of .988. The measurement model is illustrated in Figure 2.

The individual measurement scales are sufficiently valid and reliable to support further analysis. Additionally, the measurement model fits the data sufficiently well to support further analysis.

4.2 Descriptive statistics and correlations

Scale item values were averaged to obtain summary variables for RFID technology utilization and operational performance. Descriptive statistics and correlations for the summary variables are presented in Table 2. Summary variable means for RFID technology utilization and operational performance are 3.04 and 4.07, respectively. The relatively low mean for RFID technology utilization reflects the relatively early stage of adoption of the technology in the manufacturing sector. RFID technology utilization is positively related to operational performance with a correlation coefficient of .48 significant at the .01 level.

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Insert Table 2 about here
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4.3 Structural equation modeling results

The structural model is displayed in Figure 3. The model fits the data relatively well with a relative chi-square of 1.83, RMSEA of 0.08, NNFI of 0.99, and CFI of .99. The path from RFID technology utilization to operational performance (hypotheses 1) is significant at the .01 level with a standardized coefficient of .56 and an associated t-value of 6.09. Hypothesis one is supported. RFID technology utilization directly impacts operational performance.

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Insert Figure 3 about here
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The results support the general proposition that implementation of RFID technology in the manufacturing sector will yield improved operational performance. Even at this early stage of adoption, manufacturers can expect improvements in terms of efficiency metrics such as inventory levels, operating expense, and inventory expense and effectiveness metrics such as throughput and due date performance.

5. Conclusions

We theorize a model in which an organization’s degree of RFID technology utilization directly enhances operational performance. Findings indicate that RFID technology utilization does directly impact operational performance as hypothesized. The adoption of RFID technology leads to improvements in an organization’s operational performance.

5.1 Limitations of the study

Data for the study were collected during the summer of 2008. At this time, RFID technology utilization is in the relatively early stages of the technology utilization life cycle. Interpretation of the results should be tempered in light of this early of adoption. The scope of this study is limited only to the operational level benefits of RFID technology utilization. We do not assess
the impact of the technology on business and supply chain level performance. Our limited focus is designed to investigate the impact of the technology at the most basic level.

5.2 Future research

Because RFID technology utilization is in the early stages of adoption, continued investigation into the impact of the technology on firm and supply chain performance is necessary as the RFID story unfolds. As RFID technology utilization becomes more pervasive, it will be important to investigate its impact on both large and small businesses and throughout multiple sectors. The primary focus of the technology has been on improving efficiencies related to the production and tracking of goods. It is important also to assess the impact of the technology within the services and governmental sectors. RFID technology has the potential not only to improve the “bottom line” for adopters based on its ability to reduce costs but to enhance firm and supply chain performance from a marketing perspective. Additional research focused on the ability of RFID technology to generate sales is also necessary.

5.3 Managerial implications

Within the manufacturing sector, the implementation of RFID technology can lead to improved operational performance. The technology is linked to improved throughput, lead times, product cycle times, due date performance, and cash flow. It is also linked to reductions in operating and inventory expenses and reduced inventory levels. While this is not the only potential for improved performance, it is the most basic. This research indicates that RFID utilization should not be seen by the practitioner simply as a cost of doing business but rather as a way to improve efficiency and effectiveness which ultimately will lead to increased profits.
References


Table 1
Measurement scales

**RFID utilization (alpha = .986)**

*Please indicate the extent to which agree or disagree with each statement (1 = strongly disagree, 7 = strongly agree).*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>We currently use RFID technology to manage inventory flows through our manufacturing</td>
</tr>
<tr>
<td></td>
<td>processes.</td>
</tr>
<tr>
<td>2</td>
<td>Our suppliers are required to provide products to us that facilitate RFID tracking.</td>
</tr>
<tr>
<td>3</td>
<td>Our customers require us to provide products to them that facilitate RFID tracking.</td>
</tr>
<tr>
<td>4</td>
<td>We use RFID technology to manage raw material inventory levels.</td>
</tr>
<tr>
<td>5</td>
<td>We use RFID technology to manage WIP inventory levels.</td>
</tr>
<tr>
<td>6</td>
<td>We use RFID technology to manage FG inventory levels.</td>
</tr>
<tr>
<td>7</td>
<td>Our current RFID technology facilitates tracking at the item level.</td>
</tr>
<tr>
<td>8</td>
<td>Our current RFID technology facilitates tracking at the bulk (i.e. pallet) level.</td>
</tr>
<tr>
<td>9</td>
<td>We plan to expand the use of RFID technology over the next several years to manage</td>
</tr>
<tr>
<td></td>
<td>inventory flows through our manufacturing processes.</td>
</tr>
</tbody>
</table>

**Operational Performance (alpha = .970)**

*Please rate your organization's performance in each of the following areas as compared to the industry average. (1 = well below industry average; 7 = well above industry average)*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Throughput</td>
</tr>
<tr>
<td>2</td>
<td>Inventory expense</td>
</tr>
<tr>
<td>3</td>
<td>Operating expense</td>
</tr>
<tr>
<td>4</td>
<td>Lead time</td>
</tr>
<tr>
<td>5</td>
<td>Product cycle time (throughput time)</td>
</tr>
<tr>
<td>6</td>
<td>Due date performance</td>
</tr>
<tr>
<td>7</td>
<td>Inventory levels</td>
</tr>
<tr>
<td>8</td>
<td>Cash flow</td>
</tr>
</tbody>
</table>
Table 2 Descriptive Statistics and Correlation Matrix

Panel A – Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFID Utilization</td>
<td>3.04</td>
<td>1.83</td>
</tr>
<tr>
<td>Operational Performance</td>
<td>4.07</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Panel B - Correlation Matrix

<table>
<thead>
<tr>
<th>Variable</th>
<th>UTIL</th>
<th>OPPERF</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFID Utilization (RFID)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Operational Performance (OPPERF)</td>
<td>.484**</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: All coefficients significant at the 0.01 level (2-tailed).
Figure 1
RFID Technology Performance Model with Hypothesis
Figure 2
Measurement Model
with standardized coefficients and (t-values)

Relative Chi-Square = 1.83; NNFI = 0.99; CFI = .99
Figure 3
RFID Technology Performance Model
with standardized coefficient and (t-value)
Relative Chi-Square = 1.83; NNFI = 0.99; CFI = .99