The Effects of Logistics Measurement Capability on Performance

Kuo-Chung Shang∗

Abstract

A survey of 1,200 manufacturing firms in Taiwan was undertaken in order to examine the relationships among logistics measurement capabilities (including general measurement and benchmarking), logistics performance, and financial performance. Results showed that general measurement capability (which refers to functional measurement, total cost analysis, and customer-oriented measures) is the most critical capability that can impact upon benchmarking capability and logistics performance. Moreover, general measurement capability can also indirectly impact on financial performance through logistics performance or benchmarking capability. Furthermore, a positively associated relationship between benchmarking capability and financial performance is confirmed.

Keywords: Logistics measurement capability; Logistics performance; Structural equation modeling

1. Introduction

One of the most significant changes in the paradigm of business management is the fact that individual businesses no longer compete as solely autonomous entities, but rather as supply chains [20]. Logistics and supply chain management (SCM) has become an important source of sustainable competitive advantage [23,40,49]. In addition, the capability approach to logistics/SCM has become prominent in research studies [59,44,28,10,56,46]. Furthermore, measurement capability is the basis for calibrating the effectiveness of other capabilities [46]. As the proverb says, if you cannot measure it, you cannot manage it, thus, high-performance logistics “…requires mastering the discipline of measurement” [38:2], particularly in the supply chain vs. supply chain environment [27]. The objective of this study is to explore the relationship between logistics measurement capability and performance in the manufacturing industry of Taiwan in order to understand if superior logistics measurement capability leads to superior logistics and financial performance.

In the following sections (Section 2), the existing literature is reviewed

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to build a theoretical base for proposing comprehensive hypotheses and establishing the research structure (Section 3). Section 4 describes the research design and methodology. The collected data are examined to ascertain whether they have been appropriately analyzed by the use of structural equation modeling (hereafter referred to as SEM). The results of the statistical analysis are detailed in Section 5. Section 6 concludes the findings and contributions of this study. The implications of the study and suggestions for future research are also presented.

2. Literature Review

2.1 Logistics Measurement Capabilities

Measurement refers to a firm’s performance measurement system [48] which can be defined as ‘…the process of quantifying the efficiency and effectiveness of action [leading]…to performance’ [47:80]. Keebler et al. (1999) indicated that an excellent measurement system should produce three primary benefits: reduced costs, improved service, and the generation of healthy growth [38]. Moreover, measurement is not solely a logistics and supply chain concern, but is particularly critical in the logistics and SCM field because of cross-functional and inter-organizational requirement [10, 32, 35]. Recent research has identified performance measurement as one of the top three areas of logistics research needs [9]. Logistics measurement in this research is composed of two logistics capabilities, general measurement and benchmarking and details as below.

General measurement refers to functional assessment, total cost analysis, and customer-oriented measures. Functional assessment focuses on five areas, namely, asset management, cost, customer service, productivity, and quality [46, 11, 10, 27]. Total cost analysis means that management minimizes total logistics costs rather than minimizes the cost of individual activities at a given level of customer service [42]. Customer-oriented measures are fundamental to measurement [46]. As Fawcett and Cooper (1998) pointed out customer-oriented measures help the firm understands customers’ real needs so that the firm can tailor product/service packages to meet those needs [27].

Benchmarking capability is a critical step in process reengineering which can lead to improved performance [9, 52]. It can be classified into three levels, namely, internal benchmarking, competitive benchmarking, and cooperative benchmarking. In internal benchmarking, firms ‘compare the performance of internal business units involved in similar operations, or [which] operate in different regions’ [10:96]. Competitive benchmarking is
defined as ‘comparing performance to industry standards or that of competitors’ [21:41]. It involves identifying the organization’s direct competitors in the marketplace [5]. Cooperative benchmarking compares one’s own organization with other companies in different industries representing the best-in-class companies for particular aspects of the selected business operations [5,24].

Benchmarking success depends on several key factors, including level of education, understanding one’s own internal processes, improved customer service, enhanced goal setting, and quality improvements [5,53]. The structure of logistics measurement capability in this research is summarized in Figure 1.

![Figure 1 The Structure of Logistic Measurement Capability](image)

2.2 Performance

Performance has been viewed in a great variety of ways by researchers [10,16,18,19,50,58]. The definition and measurement of performance is often a challenge for researchers because organizations have multiple and frequently conflicting goals [18,52]. Thus, the definition of the performance is ‘…ultimately up to the evaluator’ [34:263]. The performance of a distribution channel can be studied from two different viewpoints, namely, the total channel system (i.e. supply chain) and an individual channel member [34]. This study, however, focuses only on the individual or strategic business unit (SBU) level of performance (or micro view) rather than on the aggregate (or macro perspective) supply chain performance because supply chain performance is difficult to identity.

Performance measures can be classified into outcome-based performance, the final outcomes of a set of behaviours, and behaviour-based per-
formance, the set of behaviours that precede the final outcome [34]. In the channel of distribution context, outcome-based performance measures focus on a channel member’s results, that is, financial measures of performance or channel member satisfaction. In contrast, behaviour-based performance focuses on the specific activities of a channel member such as stocking, warehousing, delivering, and promoting goods [52,45]. Outcome-based measures are more frequently used in empirical studies but it has been argued that they measure only past success or failure, and do not explain why the one or the other occurred or what can be done in the future [34,55]. However, behaviour-based measures can provide supplemental information [52,56]. Therefore, in channel member performance measurement, Haytko recommends a multiple indicators approach that includes outcome-based and behaviour-based performance [34].

Performance in this study is separated into financial performance (outcome-based performance) and logistics performance (behavior-based performance). Financial performance includes profit, ROA (Return on Asset), and ROI (Return on Investment). Logistics performance includes delivery dependability, order fill capacity, responsiveness to key customer, advanced notification, customer service flexibility, and product introduction.

3. The Conceptual Model

General measurement capability includes functional assessment, total cost analysis, and customer-oriented measures as shown in Figure 1. Functional assessment capability focuses on basic measurement such as that of asset, cost customer service, productivity, and quality. In contrast, both total cost analysis and customer-oriented measures focus on the total supply chain process rather than functional measurement. Both capabilities have been shown to be positively connected with performance [11,10,46,56]. Accordingly, the following hypotheses are introduced:

H1: There is a positive association between general measurement capability and logistics performance, in Taiwan’s manufacturing firms.

H2: There is a positive association between general measurement capability and financial performance, in Taiwan’s manufacturing firms.

On the other hand, benchmarking capability helps managers search for best practice and facilitates organizational learning in order to achieve superior performance. Empirical research has found benchmarking to be positively associated with logistics performance and financial performance [22,56,33,27,15]. Thus, the following hypotheses are proposed:
H3: There is a positive association between benchmarking capability and logistics performance, in Taiwan’s manufacturing firms.

H4: There is a positive association between benchmarking capability and financial performance, in Taiwan’s manufacturing firms.

General measurement is fundamental to benchmarking. Firms first undertake general measurement before proceeding to benchmarking, otherwise it will be difficult to compare different performance indexes within an organization. Thus, the hypothesis below is proposed.

H5: There is a positive association between general measurement capability and benchmarking capability, in Taiwan’s manufacturing firms.

Further, Venkatraman and Ramanujam’s assertion that operational performance (such as logistics performance) reflects key operational success factors that lead to financial performance, has been demonstrated by Ellinger et al. [57,25]. Thus, logistics performance is seen to affect financial performance and the present research therefore hypothesizes:

H6: There is a positive association between logistics performance and financial performance, in Taiwan’s manufacturing firms.

The conceptual model and researcher hypotheses are shown in Figure 2.

![Figure 2 Conceptual Model](image-url)
4. Methodology

4.1 Sample Technique

In order to increase the generalizability of the study, a questionnaire survey was administered to a multi-industry sample of manufacturing firms in Taiwan. The hypotheses were tested on 1,200 of the largest manufacturing firms in Taiwan drawn from the annual report entitled “The Top 5000: The Largest Corporations in Taiwan” [17]. This report listed the 5,000 largest corporations from various industries, according to specific criteria, such as sales, profit, ROI and productivity. However, the sampling frame for the present research purpose only comprised the largest 1,200 firms belonging to the manufacturing industry. Questionnaires were sent to the offices of the presidents or chief executive officers of the 1,200 firms targeted.

4.2 Questionnaire Design

The items to determine general measurement and benchmarking capabilities were based upon past logistics studies [31,26,38] and logistics and financial performance were measured on a most frequently utilized by researchers [44,25] as shown in Table 1. A pretest was carried out by interviewing four academic experts, one consultant in IT and SCM, and four managers in charge of production, strategic planning, accounting, and distribution, respectively, in order to obtain their valuable suggestions for questionnaire improvement. Some minor revision was necessary after the pretest. Table 1 contains the entire list of finalized items, means, and standard deviation (SD) used for each measure. As shown in Table 1, a summed scale viewpoint indicates that the majority of respondents concurred that general measurement and benchmarking capabilities were good in their strategic business units (SBUs) or firms because their means were all larger than 4.

The revised seven-page survey instrument (a Chinese version) was mailed to respondents together with a cover letter explaining the purpose of the study and a postage paid return envelope was attached with the questionnaire. After two weeks, follow-up mailings were sent to those respondents who had not returned questionnaires in the first wave survey.

Eleven questionnaires were returned as non-deliverable. Ten of the 208 returned questionnaires were discarded because respondents had put the same answers on all Likert-scale items. The total response rate was therefore 16.5 per cent (198/1200), an acceptable low response rate among logistics empirical studies of the manufacturing industry (e.g. 11.5% and 17.1% in the studies of Bowersox et al., [10], and Michigan State University Global Log-
Table 1 Items and Latent Variables

<table>
<thead>
<tr>
<th>Items and Latent Variables</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>*General Measurement Capability (alpha=0.94)</td>
<td>5.02</td>
<td>0.93</td>
</tr>
<tr>
<td>R1 The quality of data available for performance measurement in my firm is better today than three years ago.</td>
<td>5.24</td>
<td>1.15</td>
</tr>
<tr>
<td>R2 Managers in my firm make decisions using total cost measurement.</td>
<td>5.10</td>
<td>1.14</td>
</tr>
<tr>
<td>R3 My firm utilizes a formal programme to measure customer satisfaction in addition to internal customer service statistics.</td>
<td>4.92</td>
<td>1.21</td>
</tr>
<tr>
<td>R4 My firm has improved overall functional performance measurement capabilities over the past five year.</td>
<td>5.36</td>
<td>1.07</td>
</tr>
<tr>
<td>R5 The logistics measures my firm uses accurately capture the events/activities being measured.</td>
<td>4.79</td>
<td>1.10</td>
</tr>
<tr>
<td>R6 The logistics measures my firm uses internally have significant benefits that outweigh the costs of data collection, analysis, and reporting.</td>
<td>4.77</td>
<td>1.04</td>
</tr>
<tr>
<td>R7 The logistics measures my firm uses are readily understandable by decision-makers.</td>
<td>5.02</td>
<td>1.09</td>
</tr>
<tr>
<td>R8 The logistics measures my firm uses promote coordination across functions and divisions.</td>
<td>4.93</td>
<td>1.15</td>
</tr>
<tr>
<td>*Benchmarking Capability (alpha=0.86)</td>
<td>5.06</td>
<td>1.08</td>
</tr>
<tr>
<td>R9 My firm benchmarks outside our primary industry.</td>
<td>5.06</td>
<td>1.35</td>
</tr>
<tr>
<td>R10 Managers in my firm understand how our logistics performance compares to major competitors.</td>
<td>5.23</td>
<td>1.17</td>
</tr>
<tr>
<td>R11 My firm benchmarks performance metrics.</td>
<td>5.21</td>
<td>1.20</td>
</tr>
<tr>
<td>R12 My firm benchmarks best practices and processes.</td>
<td>4.74</td>
<td>1.37</td>
</tr>
<tr>
<td>**Financial Performance (alpha=0.95)</td>
<td>4.57</td>
<td>1.26</td>
</tr>
<tr>
<td>P1 Profit (before tax)</td>
<td>4.60</td>
<td>1.39</td>
</tr>
<tr>
<td>P2 Return on assets (ROA)</td>
<td>4.57</td>
<td>1.29</td>
</tr>
<tr>
<td>P3 Return on investment (ROI)</td>
<td>4.54</td>
<td>1.29</td>
</tr>
<tr>
<td>**Logistics Performance (alpha=0.87)</td>
<td>5.08</td>
<td>0.95</td>
</tr>
<tr>
<td>P4 To meet quoted or anticipated delivery dates and quantities on a consistent basis.</td>
<td>5.01</td>
<td>1.09</td>
</tr>
<tr>
<td>P5 To provide desired quantities on a consistent basis.</td>
<td>5.22</td>
<td>1.09</td>
</tr>
<tr>
<td>P6 To notify customers in advance of delivery delays or product shortages.</td>
<td>5.01</td>
<td>1.03</td>
</tr>
</tbody>
</table>

*Seven point scale, strongly disagree (1) to strongly agree (7)
**Seven point scale. Relative to major competitors, Much worse (1) to Much Better (7)

* It is a summated scale
istics Research Team [46]).

To detect any potential non-response bias, the last quartile or second wave of respondents’ responses is assumed to be most similar to those of non-respondents [4,41]. To check for difference between respondents and non-respondents, the returned second wave questionnaire responses were compared with those of the first wave, by t-test analysis. Results showed there were no significant differences (at p>0.05) as regards all capabilities and performance variables analyzed and therefore non-response bias was not a problem.

4.3 Structural Equation Modeling (SEM)

SEM will be the main data analysis method in this research. It is a rigorous and powerful statistical research technique, which can easily assess validity and reliability and rigorously test the hypotheses [30,39]. Accordingly, Garver and Mentzer stated, ‘Given the importance of testing for validity when conducting rigorous theoretical research, logistics research needs to more fully utilize this [structural equation modeling] methodological tool’ [29:33].

This study adopted the two-step SEM approach to assess the reliability and validity of the constructs. The researcher firstly assessed the validity of the measurement model by confirmatory factor analysis (CFA) and then, when the measurement model had been validated, the researcher proceeded to the second step, estimating the structural model between latent variables [2,29]. The AMOS (i.e. Analysis of Moment Structures) program [3] was used to deal with the CFA analysis and full structural equation models.

Evaluation of model fit is an important step on SEM. Unfortunately, SEM has no single index to satisfy statistical tests. Thus, researchers are encouraged to adopt combined goodness-of-fit indexes to evaluate model fit [29] and four goodness-of-fit indexes, including the chi-square statistic, the root mean square error of approximation (RMSEA), Tucker-Lewis index (TLI), and comparative fit index (CFI), were adopted in this research.

5. Analysis and Results

5.1 Characteristics of Respondents

The top six industries sampled were the electronics industry: 35 (17.7%) firms; the semi-conductor industry: 20 (10.1%) firms; the information and communications industry: 19 (9.6%) firms; the chemical product industry: 18 (9.1%) firms; the automotive and accessories industry: 18 (9.1%); and the
metal refinery industry: 18 (9.1%). Nineteen per cent of sampled firms had over 1,000 employees, whereas 25% of sampled firms had less than 200 employees. Most sampled firms employed between 200-400 (30%) full-time workers. The majority of respondents (73%) had worked in their present firms for over 4 years and consequently had sufficient knowledge to answer.

Table 2 Characteristics of Respondents

<table>
<thead>
<tr>
<th>Employees</th>
<th>Sales (Hundred Million New Taiwanese Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>4% &lt;10</td>
</tr>
<tr>
<td>101-200</td>
<td>21.2% 11-2-</td>
</tr>
<tr>
<td>201-400</td>
<td>28.8% 21-30</td>
</tr>
<tr>
<td>401-600</td>
<td>12.1% 31-40</td>
</tr>
<tr>
<td>601-1000</td>
<td>14.1% 41-100</td>
</tr>
<tr>
<td>&gt;1001</td>
<td>18.6% &gt;101</td>
</tr>
<tr>
<td>N.A. a</td>
<td>1% N.A a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry Description- Leading Categories</th>
<th>Respondents’ Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic</td>
<td>Vice-president or above 17.1%</td>
</tr>
<tr>
<td>Semi-Conductor</td>
<td>Department/Area manager 21.7%</td>
</tr>
<tr>
<td>Information &amp; Communication</td>
<td>Senior manager 11.6%</td>
</tr>
<tr>
<td>Chemical Product</td>
<td>President assistant 10.1%</td>
</tr>
<tr>
<td>Automotive &amp; Accessories</td>
<td>Junior manager 12.1%</td>
</tr>
<tr>
<td>Metal Refinery</td>
<td>Other 18.7%</td>
</tr>
<tr>
<td>Other b</td>
<td>N.A. a 8.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length of Service in the Company</th>
</tr>
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<tbody>
<tr>
<td>&lt;3</td>
</tr>
<tr>
<td>4-6</td>
</tr>
<tr>
<td>7-9</td>
</tr>
<tr>
<td>10-12</td>
</tr>
<tr>
<td>13-15</td>
</tr>
<tr>
<td>&gt;15</td>
</tr>
<tr>
<td>N.A. a</td>
</tr>
</tbody>
</table>

Note:

a N.A. represents no response.
b Other industries include metal work, textiles, chemicals, paper, rubber, plastic, machineries, pharmaceutical, and so forth. No industry represented more than 6% of the total sample.
the questionnaire accurately and reliably. In addition, 80% of questionnaires were filled in by vice-presidents or presidents (17%), department and senior managers (33%), presidents’ assistants (10%), and junior managers (12%), which further reinforced the reliability of the survey’s findings. A summary of respondents’ characteristics is presented in Table 2.

5.2 Analysis of the Measurement Models

The minimum requirements for model identification in the measurement model were satisfied. Unidimensionality and convergent validity were satisfactory [29,39] because (1) the three goodness-of-fit indexes (the comparative fit index, CFI= 0.981>0.95; the Tucker-Lewis index, TLI=0.978>0.95; the root mean square error of approximation, RMSEA=0.046<0.08) satisfied the cutoff criteria [36,6], (2) no pair of standardized residual values was greater than ±2.58, (3) no specifically larger modification indices (MI) values were expected to be modified, (4) all expected parameter change (EPC) values were smaller than ±0.3, (5) all t-values of variables were significant (t-values > ±1.96), and (6) all factor loadings (λ) on each variable were greater than 0.7

Reliability was assessed by $R^2$ (item reliability) and Cronbach’s alpha. All variables of $R^2$ (the squared multiple correlations) were greater than or equal to 0.5, demonstrating that item reliability was satisfied [29,39]. Scale reliability, calculated by Cronbach’s alpha, was verified because all values of Cronbach’s alpha were larger than 0.8 as shown in Table 1 [29].

Discriminant validity, which was assessed using the $\chi^2$ difference test to compare the base model (unconstrained) and other pairs of constructs (constrained) [2,1], was satisfactory because all pairs of latent variables were statistically significant (p<0.05).

5.2 Analysis of the Structural Model

The minimum requirements for full model (Figure 2) identification were satisfied. The chi-square ($\chi^2$) statistic provides a null hypothesis ($H_0$) test where ‘the sample covariance matrix is equivalent to the model-implied covariance matrix, within sampling error’[51:268]. Thus, the researcher hopes not to reject the $H_0$. In this case, the chi-square statistic test was significant (p=0.001), but chi-square measurement is too sensitive to sample size [8,7, 54], therefore researchers must ‘take a more pragmatic approach to the evaluation process’ [14:81]. On the other hand, the other fit indexes (e.g. CFI, TLI, RMSEA) were adopted and accepted (CFI=0.981; TLI=0.978; RMSEA=0.046), implying that this estimated model was a good-fit model.
Standardized residuals and modification index (MI) were examined after evaluation of fit. No variables in this model had to be modified because none had sizeable standardized residuals (value > ±2.58) nor especially larger MI and EPC values. A parsimonious model remained after separately deleting those paths (i.e. benchmarking → logistics performance and measurement → financial performance) which were not significant (t values < ±1.645; one-tailed test; \( \alpha = 0.05 \)) and the model was re-estimated. The final model is displayed in Figure 3 (chi-square = 184.834; d.f. = 131; \( p = 0.001 \); CFI = 0.981; TLI = 0.978; RMSEA = 0.046). It is more parsimonious and stable than the original model because its CAIC (Consistent Akaike Information Criterion), and ECVI (expected cross validation index) values are smaller than those in the original hypothesized model [13,14,37,54].

5.3 Research Findings

Hypotheses 1, 4, 5, and 6 were supported, indicating that significant positive relationships existed between general measurement capability and logistics performance (\( \lambda = 0.546; t = 7.278 \)), and benchmarking capability (\( \lambda = 0.856; t = 10.063 \)). Moreover, two significant positive relationships were also supported between logistics performance and financial performance (\( \lambda = 0.630; t = 8.80 \)), benchmarking performance and financial performance (\( \lambda = 0.129; t = 1.765 \)). Hypotheses 2 and 3 were not sufficiently
significant to support meaningful positive relationships between general measurement capability and financial performance, and benchmarking capability and logistics performance. Of note, general measurement capability was not found to directly impact on financial performance but to indirectly impact on financial performance through benchmarking capability (indirect effect 1) and logistics performance (indirect effect 2). In other words, general measurement capability had an indirect effect on financial performance (indirect effect 1 = 0.0302; indirect effect 2 = 0.110).

6. Discussion and Conclusions

The research findings reveal that general measurement capability plays a very critical role in not only facilitating firms’ benchmarking capability but also enhancing firms’ superior performance. General measurement capability comprises functional measurement (e.g. quality and cost) and process measurement (e.g. total cost analysis and customer-oriented measures). The results suggest that logistics or top managers encourage firms to build varied functional measurements under the philosophy of total cost analysis and customer-oriented measures and thus improve benchmarking capability in order to acquire and maintain long-term superior logistics performance which will, in turn, lead to better financial performance.

On the other hand, benchmarking capability was found also very important because it can directly influence financial performance, such as profit, ROI, ROA. The results suggest that logistics or top management could construct a benchmarking system to compare different performance indexes within an organization with the firm’s major competitors or partners, and with other best-in-class companies in respect of particular aspects of the selected business operations.

However, several important issues for further research can be drawn out and are detailed below. First, this study's sample was drawn from the top, largest 1,200 manufacturing firms in Taiwan. The conclusions inferred can only be generalized to include the top largest manufacturing firms in Taiwan. The further research can include the small or weak and non-manufacturing firms.

Secondly, it will be reliably if the further research can be conducted a longitudinal study. Different firms have distinct strategic goals in the short term, such as customer satisfaction, market share, growth, etc. Moreover, firms may enhance market share by sacrificing short-term profit in order to acquire long-term profit. The performance items in this study could not
reflect these varying situations, especially in dynamic business environments.

Both activity-based costing (ABC) and the balanced scorecard are new approaches in logistics and SCM practice. Researchers have used the ABC system or the balanced scorecard to construct a supply chain measured system [43,12]. However, do they lead to superior logistics or financial performance when firms employ them?

Logistics and financial performance, in this study, referred to the firm or SBUs not the supply chain. Supply chain management has become an important research issue. Thus, how to effectively measure supply chain performance is a key problem and worthy of further research.

References


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