Evaluating Logistics Capabilities on Firm Performance of the Photonics Industry in Taiwan

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***Abstract*— This study empirically examined the impact of logistics capabilities on firm performance in the photonics industry. Structural equating modelling (SEM) was employed to test the research hypotheses with the use of data collected from a survey of 221 photonics manufacturing firms in Taiwan. Three dimensions were identified based on a factor analysis, including warehousing capability, information technology capability, and transportation capability. The research findings indicated that logistics capabilities positively influence firm performance. Information technology capability was found to be the most important logistics capability in the photonics industry, followed by warehousing capability, and transportation capability. There is also a discussion of the theoretical and managerial implications for the photonics industry.**

***Keywords*—** Logistic capability; Photonics industry; Structural equating modelling; Firm performance.

1. Introduction

Photonics is considered to be a key emerging technology in the 21st century, and it has drawn much managerial and operational attention [1]. Photonics refers to an area of science and technology that combines the power and possibilities of light with those of electronics [2]. The field of photonics is characterized by a wide variety of high technology applications and products. A variety of applications of photonics extends from optical sensing, lighting, and the generation and detection of energy to communication technologies and information display, storage, transmission, and processing. Well-known photonics applications include CD and DVD players, digital cameras, computers, and TV screens. Other photonics-related technologies include LED (Light Emitting Diode) lighting, and OLED (Organic Light Emitting Diode) displays [1]. With their extraordinarily broad spectrum of processes related to generating, transmitting, and utilizing light technology, photonics products are significantly associated with current lifestyles.

As reported, worldwide sales of photonics-related products reached US$55 billion in 1998, and the predicted annual growth rates range between 10% and 20% [1]. In 2005, the world photonics market had grown to US$120 billion and significantly increased to US$429 billion in 2011 [3]. Taiwan is an export-oriented country, and either as a result of brand ownership or being original equipment manufacturers (OEMs), Taiwanese manufacturers hold a critical position in the supply chain of the global photonics industry. Specifically, concerning photonics-related products, Taiwan ranks first in thin-film transistor–liquid crystal display (TFT-LCD) production with 42% of the world market. Additionally, in the total production value of light-emitting diodes (LED) it ranks second, while concerning solar cell production, Taiwan ranks as the fourth largest manufacturer in the world, with a total value of US$3.13 billion dollars in 2011. The total production value of the Taiwan photonics industry from US$63.3 billion in 2007 significantly increased to US$90 billion in 2011 [3], [4].

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Since the characteristics of photonics products are different as compared with other high-tech products (e.g. semiconductor wafers, PCs, and notebooks), the photonics manufacturers need to specifically consider the weight and shape of their products when undertaking logistics operations. For example, take the case of flat panel displays. Manufacturers need to collect raw materials such as glass, color filters, and optical films from different overseas suppliers and ship the finished products, such as LCD/LED TVs, to their customers in different countries. This type of cargo is, for a single packing unit, usually over one metric ton in weight and over one meter in height. Another example is solar panels, which require large heavy glass panels for the production of the final products. With the development of international business, multinational firms have been pursuing greater efficiency in regard to logistics and transportation systems. In particular, the demands of transportation necessitate efficient integrated moves, premium package services, and the best use of available modal transport and logistics operations [5]. Thus, logistics capabilities have become increasingly important in organizations [6], [7].

There is a growing body of previous studies that have addressed the idea that firm resources and capabilities are key factors leading to the formation of competitive advantage in a competitive environment based on the Resource-Based View (RBV) theory [7], [8], [9]. The RBV suggests that a competitive advantage of a firm lies primarily in the application of a bundle of the valuable, interchangeable, and intangible/tangible resources owned by the firms involved [8]. Under the concept of the RBV, logistics capabilities have been utilized for developing competitive advantages by photonics manufacturers because of the complexity of logistics activity requirements. Companies with efficient logistics capabilities can enhance operational capability, thereby allowing for a quick response to requirements from their customers and hence improving firm competence. Previous studies have shown that logistics capabilities are critical factors to the success of an industry [10], [11], [12]. Similarly, photonics manufacturers can strengthen their logistics capabilities for the purpose of increasing their firms' financial performance, as well as firm competitiveness [7], [13], [14], [15].

While logistics capabilities and logistics performance have been widely discussed in prior literature over the past decade [11], [16], there seem to be relatively few studies that have included empirical analyses between logistics capabilities and firm performance in the photonics industry. Thus, the purpose of this study is to identify crucial logistics capabilities, and furthermore to examine the effects of the logistics capability dimensions on firm performance in the context of the photonics industry.

Based on the RBV, for the purposes of this study, a theoretical model was constructed, and a set of hypotheses was developed for the purpose of examining the relationship between logistics capabilities and firm performance. There are five sections in this study. Following the introduction, in Section 2, the literature regarding a resource-based view, logistics capabilities, and firm performance is discussed. Section 3 describes the research methodology, including the sampling technique, questionnaire survey, and analysis methods. Section 4 presents the analytical results and findings from the factor analysis, confirmatory factor analysis, and structural equation modelling. In the final section, some conclusions are drawn from the research findings and there is a discussion of their implications for photonics companies.

2. Literature review and research hypotheses

2.1. Resource-based View (RBV)

The resource-based view (RBV) was proposed by Ref. [8] and argued that the internal resources and capabilities of firms are the key resources for forming sustained competitive advantage. RBV can be defined as a competitive advantage by which firms apply a bundle of valuable, interchangeable, and intangible/tangible resources to influence firm performance [8]. Ref. [9] asserted that resources are tradable and non-specific to firms, and include such things as assets, capabilities, competencies, information, knowledge [17], and so forth; whereas capabilities are firm-specific and are used to engage the resources within firms, such as implicit processes to transfer knowledge within a firm [9], [18]. Capabilities are the results of resource deployment and organizational processes and are characterized by a dynamic "doing" nature [9].

Thus, capabilities should be treated independently from resources.

The RBV has been examined in many empirical studies in regard to some specific industries [19], [20], [21]. Ref. [22] applied the RBV to firms in order to investigate the relationship between service capabilities and logistics service provider performance. The results of this study indicated that differences in service performance exist between different logistics service provider types. Ref. [15] investigated the relationships between logistics capabilities and financial performance. Their results revealed that information-based capability is the most critical capability for manufacturing firms in Taiwan. Ref. [7] also studied key resources and capabilities for liner shipping services. The results showed that operation capability is perceived as the most important dimension for liner shipping services. Therefore, the RBV provided a sound theoretical foundation for this study by which to examine the relationship between logistics capabilities and firm performance.

2.2. Logistics capabilities

Firm logistics capability has been perceived as one way to enhance financial performance [23]. There are many publications that have addressed and discussed logistics-related capabilities [24] and [25]. Ref. [26] described overall logistics activities as including inventory management and traffic management, as well as covering material handling, warehouse and distribution centre management, salvage scrap disposal, interplant movement, plant and warehouse site selection, and moving people. Ref. [27] indicated that logistical competency could be achieved by coordinating network design, information, transportation, inventory, and warehousing, material handling and packaging. Ref. [28] also proposed elements of logistics systems, including protective packaging and material handling, transportation, distribution centres, warehouse and plant locations, and inventory management and warehousing [29]. In studying maritime firms in Taiwan, Ref. [30] employed 33 service attributes and identified eight strategic logistics service factors. The results of this studies suggested that of these factors, value-added service strategy and equipment and facilities strategy can be regarded as significantly different between the two different types of maritime firms under consideration in that study, which were divided into implemented logistics and non-implemented logistics firms.

In addition, logistics attributes, such as EDI linkage, cargo tracking, customer response, service reliability, and value-added services, have been demonstrated to be the driver for superior performance [22], [31], [32]. Ref. [22] assessed the dimensionality of 24 logistics-related attributes on the basis of a resource-based conceptual model to examine the effects of service performance by studying different types of logistics service providers. Ref. [14] suggested that logistics attributes in international distribution centres consist of cargo storage, labelled and bonded storage cargo packaging, import unpacking, cargo kitting, export stuffing, inland transportation arrangement, cargo inspection, bar code operation, cargo pick-up, cargo processing, multiple country distribution, assembly and stripping. In an appraisal of previous studies, many practical logistics activities have been identified, including transportation, warehousing and storage, industrial packaging, material handling, inventory control, order fulfilment, demand forecasting, production planning/scheduling, procurement, customer service, facility location, return goods handling, parts and service support, and salvage and scrap disposal.

A review of papers, journals, and books reveals that most logistics activities have focused on the research of logistics service providers [33], shipping carriers [14], third parties [31], [34], and international distribution centres [14], all of which have examined critical logistics service dimensions specific to their industries. Thus, there is a lack of research on examining logistics capabilities and its relationships on firm performance in the context of photonics manufacturers. After summarizing the body of the previous literature, 18 logistics capabilities attributes were selected for use in the survey used in the current study.

2.3. Firm performance

Firm performance has been defined in a variety of ways [35]. Performance is an evaluation of the level at which a firm achieves its objects or goals [36], which can be measured using “hard” (objective) measures [37] and “soft” (perceptual or responsiveness) measures [38]. Firm performance can be classified as financial and non-financial (operational) performance [39]. Financial performance is mainly evaluated through indicators such as sales growth, profit margin, return on investment, return on sales and earnings per share [37]; whereas the non-financial performance approach focuses on market share, new product introduction, product quality, marketing effectiveness, and technological efficiency.

Privately held companies rarely make their performance data available to the public because of confidentiality concerns, hence, empirical studies that deal with firm performance encounter a severe challenge in obtaining accurate and reliable performance data. Recent research has shown that certain perceptual measures (e.g., managerial perceptions of market share, profit margin) correlate closely with objective financial and marketing information (e.g., market share, return-on-assets, and return-on-equity) [40]. Thus, for the purposes of this research, perceptual performance measures were used that relate to financial performance. In addition to the three standard performance measures, customer satisfaction was added because previous studies [41] have indicated that customer satisfaction is directly related to firm performance and suggest that logistics managers are aware of their firm's overall level of customer satisfaction [42]. In this study, firm performance was measured by asking the respondents to self-evaluate their company's performance in comparison with their perception of the performance in the industry. Measurement scales were based on those used by Ref. [43].

2.4. Research hypotheses

The objective of this research is to examine the effect of logistics capabilities on firm performance of the photonics industry in Taiwan. Logistical capabilities in a firm can be achieved by coordinating network design, information, transportation, inventory and warehousing, material handling and packaging activities [27]. Thus, logistics capabilities, including transportation, warehousing, inventory, material management, and information systems, need to be considered in order to establish customer satisfaction [44], [45]. Ref. [33] suggested that logistics managers need to realize the benefits that developing logistics capabilities brings to firm profits because firms can enhance their profitability through establishing logistics capabilities. Ref. [13] stated that the integration of logistics capabilities (e.g. inventory deployment, information, cost/value, technology, and transportation management) could be of great influence on the success of decreasing supply chain operation costs. Ref. [46] also indicated that a positive relation is supported between logistics capabilities and enterprise operational success. Previous studies have supported the finding of a positive effect that logistics capabilities have on firm profitability [22] [43], [45], [47], [48]. Ref. [30] and [49] identified logistics service dimensions (including warehousing, customs declaration, and transportation operation) when studying maritime firms in Taiwan. Furthermore, [14] identified logistics capabilities in international distribution centres that may have a positive influence on firm performance.

Specifically, prior research has examined the effects of value-added logistics activities on firm performance [22], [50], [51]. Logistics attributes have been demonstrated to be drivers for superior performance, such as EDI linkage, cargo tracking, and value-added services [22], [31], [52], [53]. Ref. [47] also contended that value-added logistics capabilities have a positive influence on firm performance. Ref. [48] suggested that information-focused capabilities have a positive effect on firm performance. Ref. [54] also indicated that firm IT capability has a direct and positive impact on firm performance [55], [56]. Ref. [7] also suggested that firms with information system capability could enhance their competitive advantages in the context of liner shipping services. Based on the literature about the RBV, three logistics capability dimensions are assessed in this research, including warehousing, transportation, and information technology. Thus, this research hypothesizes the following.

H1: Warehousing capability will be positively related to firm performance in the photonics industry.

H2: Transportation capability will be positively related to firm performance in the photonics industry.

H3: Information technology capability will be positively related to firm performance in the photonics industry.

3. Methodology

3.1. Sample

The sample for this study was selected based on photonics-related manufacturing firms listed in the Directory of Members of the Taiwan Science Park Guild. A five-page questionnaire survey was sent to the photonics manufacturing enterprises (e.g. raw materials, spare parts, equipment producers, and key component manufacturers) in Taiwan. Of the 305 questionnaires mailed, 10 were returned because of address discrepancies, whereas the initial mailing returned 155 usable responses. A follow-up mailing was sent two weeks later after the initial mailing, leading to an additional 71 usable responses being obtained. From the resulting sample size of 295, 226 responses were received, resulting in a response rate of 76.61%. A total of 5 samples were eliminated because of incomplete responses and some managers leaving their companies. The total usable responses were 221 out of 295, so the overall response rate for this study was 74.91%.

3.2. Measures

In order to ensure instrument accuracy and the content validity of the questionnaire, a comprehensive review of the literature and interviews with practitioners were used in this study. The questions were based on previous studies and discussions with a number of executives and experts at the photonics manufacturing companies. Content validity assessment typically involves an organized review of a survey's content to ensure convergence and that the content does not include any unnecessary data that can influence the results. This provides the foundation on which valid survey instruments are methodologically and rigorously built. The content validity of the questionnaire used in this study was tested through a literature review and interviews with practitioners. That is, selection of the questions used in the questionnaire was based on previous studies and discussions with a number of logistics executives and experts. Information obtained during the discussions resulted in subsequent minor modifications to the questionnaire. All items within the questionnaire were ultimately accepted as relevant and as possessing content validity. Refined measurement items were included in the main survey questionnaire.

Ref. [57] suggested that a condensed version of a questionnaire containing key variables be sent to a sample of non-respondents for the purpose of detecting bias, which is a common and convenient approach to compare the first and second waves; however, non-response bias is assumed to be nonexistent if no significant differences exist in the survey variables. Thus, much of the mail survey work in logistics research [15], [48], [58] has used the procedures recommended by Ref. [59] to examine the potential non-response bias problem.

A comparison of early (those responding to the first mailing) and late (those responding to the second mailing) respondents was carried out to test for non-response bias [59]. The 221 survey respondents were divided into two groups, early (n=150, 67.87 percent) respondents and late (n= 71, the remaining 32.12 percent) respondents based on their response wave (first and second). Following this, a t-test was performed on the two group responses. At the 5 percent significance level, there were no significant differences between the two groups' perceptions of their satisfaction with the various logistics operational attributes. Although the results did not rule out the possibility of non-response bias, they suggested that non-response bias was not a problem since late respondents' responses were similar to those of early respondents.

3.3. Research steps

Based on Ref. [60], research steps included the instrument development, exploratory study, confirmatory study, and a test of the structural model. Ref. [61] also suggested a step-by-step stage of questionnaire design, which was used for the present study. The first step was the selection of logistics capabilities attributes by reviewing the literature on logistics systems and operation research, followed by the design of the questionnaire, personal interviews with photonics industry practitioners, and a content validity test. Several research techniques employed to develop and evaluate measurement scales included item-total correlations, exploratory factor analysis (EFA), and an estimation of reliability using the Cronbach's alpha value.

These techniques are useful in the early stages of empirical analysis where theoretical models do not exist and the basic purpose is exploration. However, these traditional techniques do not assess unidimensionality [42], [62], nor can undimensionality be demonstrated by either mathematical or practical examinations [10]. Consequently, several researchers have suggested the use of confirmatory factor analysis (CFA) with a multiple-indicator measurement model to assess unidimensionality [42], [63]. Exploratory techniques can help develop hypothesized measurement models that can subsequently be tested using confirmatory factor analysis. This study employed a survey to collect data for testing the proposed model of the effects of logistics capabilities dimensions on firm's financial and non-financial performance in Taiwanese photonics manufacturers. Analysis was conducted using SPSS 18.0 statistics software for Windows and the AMOS 18.0 statistical package.

4. Results of analysis

4.1. Characteristics of respondents

The respondent profiles are shown in Table 1. It can be seen that the results indicate that more than half of the questionnaire respondents were in positions of director/vice director at the time of the study. Others held the title of manager/assistant manager (26.2%), supervisor (12.2%), sales representative/clerk (5.0%), and vice president or above (3.6%). In general, middle-level managers accounted for most of the respondents (more than 65%), which is important, since managers at this level are involved with the handling of logistics functions. Table 1 also presents the type of products of the responding firms. The vast majority of respondents produce key components (67%), followed by equipment production (19.5%), raw materials (10%), and spare parts (3.6%). These results reveal that most firms in the Taiwanese photonics firms are assembly manufacturers. Most firms have operated their businesses between 11–15 years (53.4%), whereas 22.2 % of firms had been in operation for more than 16 years at the time of the study.

In Table 1, the results indicate that more than 33% of firms have between 21–50 employees, followed by firms with between 101–500 employees (30.7%). Only seven firms, accounting for 3.2 % of all respondents, have more than 1000 personnel. According to the respondents' reports, 35.2% of the firms had annual revenue between NT$10 million and NT$100 million; 33.5% had revenue between NT$101 million and NT$1 billion. Only 3.2 % of firms reported their annual revenue as more than NT$1 billion. From the information, it shows that most photonics manufacturing firms in Taiwan are either small or middle-size firms.

With regards to the ownership pattern, Table 1 shows that local firms accounted for a majority of all respondents (60.2%), while 26.7% and 13.1% of firms operate as foreign-local and foreign-owned business entities, respectively. Table 1 also presents the ratio of the photonics firms that ship their products via maritime transport, and as either finished products or raw materials. The results reveal that more than 60% of these firms employ maritime shipping, at a rate of over 50% for product delivery, since most photonics products are heavy and oversized in regard to packaging.

An evaluation of the aggregated perceptions of respondents for each attribute revealed that all 18 attributes were satisfactory, i.e., rated at the upper end of the five-point interval scale (mean score > 3.5), where 1 signified a maximum negative evaluation and 5 represented a maximum positive evaluation. Table 2 shows the satisfaction with logistics attributes, as perceived by respondents, in descending order. Notably, three attributes stood out as being rated as very good by the respondents (their mean scores were over 4.3): labeling, cargo tracking, and inland transportation arrangement. In contrast, the least satisfactory logistics attributes to respondents were: logistics solution design, radio frequency identification (RFID), and negotiation with carriers (their mean scores were below 4.0).

4.2. Exploratory factor analysis

Exploratory factor analysis with VARIMAX rotation was employed to identify crucial resources and logistics operational functions in Taiwanese photonics firms. To perform a factor analysis, the data matrix must initially be ensured to be sufficiently correlated. Two measures are frequently used to examine the appropriateness of factor analysis. Bartlett's Test of Sphericity is a measure intended to test correlations among variables, whereas the Kaiser-Meyer-Olkin index is another approach used to quantify the degree of inter-correlations among variables and the appropriateness of factor analysis, which ranges from zero to one; a value of one is attained when each variable is perfectly predicted without error by the other variables. A criterion of index above 0.8 is considered meritorious [64]. Therefore, data in this study were deemed appropriate for analysis based on Bartlett's Test of Sphericity (Chi-square value = 2496.067, $p<0.001$), which suggested that correlations existed among some of the response categories, while the Kaiser-Meyer-Olkin sampling adequacy had a value of 0.886. Furthermore, eigenvalues with a criterion greater than one were employed to determine the number of factors [61], as shown in Table 3. The results indicate that three factors emerging from the factor analysis accounted for approximately 65.92% of the total variance and were thus considered to represent all the logistics functions of photonics firms in Taiwan.

Table 1. Profile of respondents

	Number of respondents	Percentage of respondents
Job title		
Vice president or above	8	3.6
Manager/assistant manager	58	26.2
Direct/vice director	117	52.9
Supervisor	27	12.2
Sales representative/Clerk	11	5.0
Type of products		
Raw material	22	10.0
Spare parts	8	3.6
Production equipment	43	19.5
Key component	148	67.0
Age of firms (years)		
Less than 5	10	4.5
6-10	44	19.9
11-15	118	53.4
16-20	38	17.2
Above 21	11	5.0
Number of employees		
Less than 20	53	24.0
21-50	73	33.0
51-100	20	9.1
101-500	68	30.7
Above 500	7	3.2
Annual Revenue (million, NT$)		
Less than 10	62	28.1
10-100	78	35.2
101-1,000	74	33.5
Above 1,000	7	3.2
Ownership		
Local firm	133	60.2
Foreign-owned firm	29	13.1
Foreign-local firm	59	26.7
Maritime transport (%)		
Less than 10	33	14.9
11-20	13	5.9
21-50	32	14.5
Above 50	143	64.7

To aid interpretation, variables were then extracted with factor loadings greater than 0.5. These loadings were considered to be a conservative criterion, as suggested in Ref. [64]. Thus, three factors were subsequently found to underlie the functions sets based on responses, which were labelled and described as follows.

Factor 1: Warehousing capability. The first factor was warehousing-related activities, consisting of seven items, namely, cargo auditing, return cargo handling, cross docking, bar coding, consolidation, inspection, and labelling. Most items were related to warehousing operation activities, thus this factor was identified as warehousing capability, which accounted for 35.47% of the total variance.

Factor 2: Information technology capacity. The second factor consisted of seven items, namely, EDI service, collaboration, cargo insurance, cargo tracking, JIT delivery, RFID, and logistics solution design. These items are related to utilization of technology and information services for the purpose of facilitating cargo delivery efficiency and safety. The EDI service was the most highly correlated service attribute in this factor, and accounted for 19.28% of the total variance.

Factor 3: Transportation capability. The third factor was composed of four items, namely, inland transportation, international transportation arrangement, negotiation with carriers, and customs declaration. Inland transportation was the highest factor loading for this factor, which accounted for 11.17% of the total variance.

The results indicated that the information technology capability (mean = 4.145) was found to be the most important logistics capability to photonics manufacturers, followed by warehousing capability (mean=4.135), and transportation capability (mean = 4.017).

4.3. Reliability test

A reliability test, based on Cronbach's alpha statistics and corrected item-total correlation coefficients, was utilized to test the consistency and reliability of the factors. As shown in Table 3, the Cronbach's alpha values of each dimension were well above 0.8, which is considered a satisfactory level of reliability in research [61], [65].

Table 2. The satisfaction level of logistics attributes in the photonics industry.

Logistics attributes	Mean	S.D.	Rank
Labeling	**4.39**	.676	1
Cargo tracking	**4.35**	.634	2
Inland transportation arrangement	**4.30**	.583	3
Return cargo handling	4.24	.774	4
International transportation arrangement	4.23	.583	5
Customs declaration	4.23	.575	6
Bar coding	4.22	.798	7
EDI service	4.18	.514	8
Cargo auditing	4.16	.798	9
Cargo insurance	4.14	.610	10
Cross docking	4.09	.807	11
Just in time (JIT) delivery	4.07	.564	12
Cross-units collaboration	4.04	.512	13
Consolidation	4.00	.769	14
Inspection	4.00	.944	15
Logistics solution design	**3.94**	.887	16
Radio frequency identification (RFID)	**3.90**	.539	17
Negotiation with carriers	**3.51**	.861	18

Note: Mean: 1= very poor, 5= very good.
S.D. = standard deviation.

Table 3. Factor analysis of logistics capability

Logistics attributes	Factor1	Factor2	Factor3
Cargo auditing	**.926**	.096	.159
Return cargo handling	**.880**	.079	.019
Cross docking	**.839**	.074	.164
Bar coding	**.836**	.093	.179
Consolidation	**.823**	.097	.123
Inspection	**.822**	.137	.104
Labeling	**.763**	.046	.075
EDI service	.077	**.848**	.106
Cross-units collaboration	.086	**.791**	.152
Cargo insurance	.224	**.760**	.041
Cargo tracking	.059	**.749**	.039
Just in time (JIT) delivery	.070	**.719**	.049
Radio frequency identification (RFID)	.081	**.694**	.067
Logistics solution design	.020	**.651**	.051
Inland transportation arrangement	.204	.031	**.878**
International transportation arrangement	.103	.051	**.868**
Negotiation with carriers	.162	.059	**.743**
Customs clearance	.234	.252	**.606**
Eigenvalues	6.384	3.470	2.011
Percentage variance	35.466	19.276	54.742

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EDI service	.077	**.848**	.106
Cross-units collaboration	.086	**.791**	.152
Cargo insurance	.224	**.760**	.041
Cargo tracking	.059	**.749**	.039
Just in time (JIT) delivery	.070	**.719**	.049
Radio frequency identification (RFID)	.081	**.694**	.067
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International transportation arrangement	.103	.051	**.868**
Negotiation with carriers	.162	.059	**.743**
Customs clearance	.234	.252	**.606**
Eigenvalues	6.384	3.470	2.011
Cumulative percentage variance	35.466	54.742	65.915
Mean	4.135	4.145	4.017
Cronbach's α	0.940	0.872	0.813

4.4. Confirmatory factor analysis

The hypothesized model implies a measurement model where there are three latent variables composed of the corresponding multiple indicators (measures or items). The three constructs in the measurement model, namely warehousing capability, information technology capability, and transportation capability, are inter-related, as indicated by the two-headed arrows [66]. In addition, 18 observed variables are enclosed in squares. The statistical criteria for model modification decisions include squared multiple correlations, standardized residual covariance and model fit indices [67]. Once the proposed model has been purified, tests for validity, reliability, and unidimensionality can then be performed. According to Ref. [64], standardized residuals, with a value larger than 2.58 or less than 2.58, are considered statistically significant at the 0.05 significance level. The standardized residual values of the item "logistic solution design" exceeded 2.58 in absolute terms. One item in the information system capability dimension was not included in the revised model. A number of goodness-of-fit indices recommended by previous researchers were employed to assess the fit and unidimensionality of the measurement model [58]. As shown in Table 4, the goodness-of-fit index (GFI) and comparative fit index (CFI) presented values of 0.916 and 0.971, respectively. The GFI value and the CFI value both exceeded the recommended level of 0.9. The adjusted goodness-of-fit (AGFI) was 0.889, which also exceeded the recommended level of 0.8. In addition, the root mean square residual (RMSR) and the root-mean-square error of approximation (RMSEA) were 0.024 and 0.052, respectively; both were below the threshold level of 0.06. The normed Chi-Square (χ^2/df) also had a value of 1.589, which falls well within the recommended range for model parsimony. To sum up, the various overall goodness-of-fit measures for the model lent sufficient support for the results to be deemed as an acceptable representation of the proposed constructs.

Convergent validity can be evaluated by t-values for all statistically significant factor loadings. The t-value represents the parameter estimate divided by its standard error. Results showed that all t-values of the variables were significant at the 0.05 level, which in effect confirms that all indicators measured the same construct and provided satisfactory evidence of the convergent validity and unidimensionality of each construct [63]. Discriminate validity was also assessed by constraining the correlation parameter between constructs to 1.0. The difference in the chi-square value between the constrained and unconstrained models was shown to be significant, thereby suggesting the achievement of discriminate validity. Results showed that all chi-square differences were significant at the $p<0.01$ level, hence providing evidence of discriminate validity for this construct.

Table 4. Goodness of fit indicator

SEM indicator	Criteria	Results
$\chi 2$ (chi-square)	-	184.36
$\chi 2$/df	< 2	1.59
P value	> 0.05	0.00
GFI	> 0.9	0.92
AGFI	> 0.9	0.89
TLI	> 0.9	0.97
NFI	> 0.9	0.92
RMR	Close to 0	0.02
RMSEA	< 0.08	0.05

Note: GFI: goodness of fit index; AGFI: adjusted goodness-of-fit index; TLI: Tucker-Lewis index; NFI: normed fit index; RMR: root mean square residual; RMSEA: root mean square error of approximation.

4.5. Results of hypotheses testing

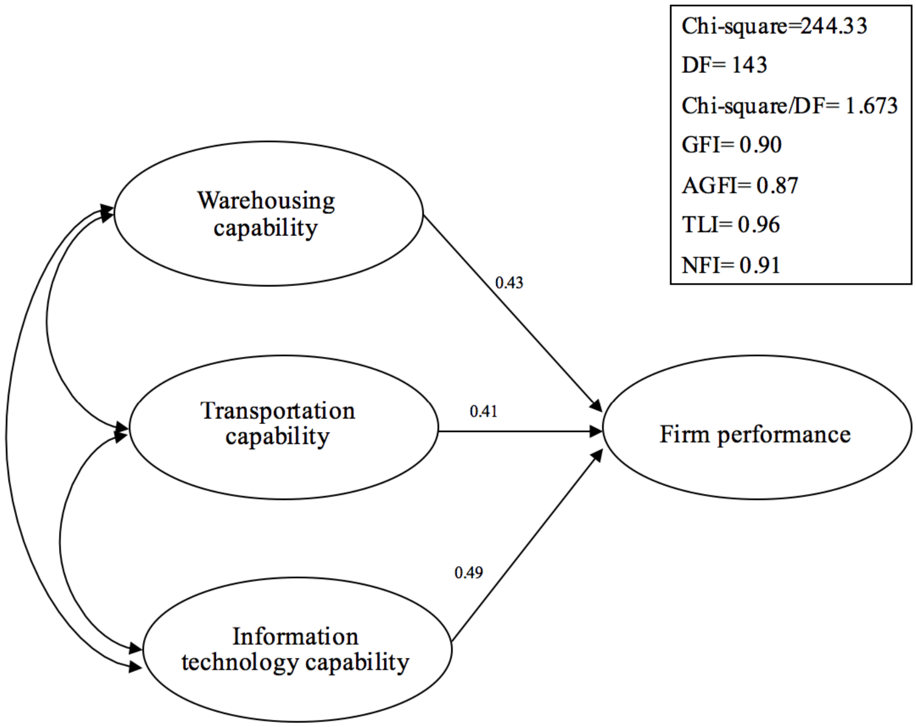
After confirming and establishing a model fit for the measurement model, the proposed structural model was assessed and the hypothesized relationships were examined. The results indicate that the data adequately supported the estimated model (see Figure 1). Although the Chi-Square statistic ($\chi 2$ =244.33, df =146) at 0.00 was greater than the 0.05 level of significance, the goodness of fit index was calculated to be 0.902, and the adjusted goodness-of-fit index yielded 0.872 after adjustment was made for degrees of freedom relative to the number of variables. This indicated that 87.2% of the variance and covariance in the data observed were predicted by the estimated model. Furthermore, the results of fitting the structural model to the data revealed that the model had a good fit, as indicated by the normed fit index (NFI= 0.910), comparative fit index (CFI=0.961), root mean square residual (RMR= 0.023), and root-mean-square error of approximation (RMSEA =0.055).

Table 5 summarizes the hypotheses testing results and indicated that all hypothesized relationships were significant at the significance level of 0.05. As shown in Figure 1, warehousing capability (estimate = 0.43, C.R. = 5.37) and information technology capability (estimate = 0.49, C.R. = 6.02) were found to have a significant relationship with firm performance. As regards transportation capability (estimate = 0.41, C.R. = 5.05), the results also revealed a positive significant relationship with firm performance. Thus, all hypotheses (H1, H2, and H3) were supported in this study. The results suggested that all logistics capabilities had an influence on the photonics industry firms' performance.

4.6. One-way analysis of variance (ANOVA) results

To evaluate the relationships between logistics capabilities and photonics manufacturer characteristics (i.e., type of product and firm's annual revenue), a one-way analysis of variance was performed. As can be seen in Table 6, the results of an ANOVA analysis indicated that three capability dimensions were found to significantly differ between the types of products in terms of raw material and spare parts, production equipment, and key component manufactures. Respondents from the key component manufacturers in these three dimensions, i.e., warehousing (mean = 4.255), information technology (mean = 4.081), and transportation (mean = 4.231), tended to have higher mean scores than those of raw materials and spare parts, and production equipment. Table 6 also shows the results of the Scheffé's test. Scheffé's test is a comparison test used to examine all group factor scores in order to determine which of the pairs shows significance [64]. Differences across the three types of manufacturers can thereby be identified. Concerning the dimensions of warehousing and information technology capability, the results indicated the manufacturers from key components significantly differed from those of raw material and spare parts, and production equipment. In addition, the Scheffé's test also revealed that raw material and spare parts manufacturers significantly differed from those of key components in the dimension of transportation.

As shown in Table 7, ANOVA analysis results indicated that the satisfaction accorded to logistics capabilities by the annual revenue of firms significantly differed at a 5% significance level, namely, warehousing and information technology dimensions. A comparison of the mean scores showed that an annual revenue less than NT$10 million in the photonics industry tended to result in the highest score in the dimensions of warehousing capability (mean = 4.419), whereas firms with annual revenues greater than NT$100 million had higher mean scores in regard to information technology capability (mean = 4.128), as compared with other types of manufacturers. From the Scheffé's test results, warehousing capability and information technology capability were found to significantly differ between firms with annual revenues of less than NT$10 million versus firms with over NT$100 million.



Note: GFI: goodness of fit index; AGFI: adjusted goodness-of-fit index; TLI: Tucker-Lewis index; NFI: normed fit index; RMR: root mean square residual; RMSEA: root mean square error of approximation.

Figure 1. Structural modelling result.

Table 5. Structural equation modeling results

	Paths	Estimates		
		Standardized β	S.E.[a]	C.R.[b]
H1	(Warehousing capability) → （Firm performance ）	0.43	0.44	5.37[**c]
H2	(Transportation capability) → （Firm performance ）	0.41	0.58	5.05[**]
H3	(Information technology capability) → (Firm performance)	0.49	0.72	6.02[**]

Note: a. S.E. is an estimate of the standard error of the covariance.
b. C.R. is a critical ratio that obtained by dividing the covariance estimate by its standard error.
c. ** P value is significant at the 0.05 level.

Table 6. The level of the respondents’ satisfaction with logistics capabilities in photonics companies according to the types of products

	Type of photonics companies’ products	F value	Scheffé

Logistics capabilities	Raw material and spare parts (N=30) (1)	Production equipment (N=43) (2)	Key component (N= 148) (3)		
Warehousing	3.617[a] (0.813)[b]	4.047 (0.584)	4.255 (0.562)	12.148***	(1,2) (1,3)
Information technology	3.671 (0.467)	4.040 (0.505)	4.081 (0.404)	11.187***	(1,2) (1,3)
Transportation	3.933 (0.334)	3.994 (0.468)	4.231 (0.488)	7.875***	(1,3)

Note: a. represents a mean; b. represents a standard deviation.
*** represents significance level $p < 0.01$.
** represents significance level $p < 0.05$.

Table 7. The level of respondents' satisfaction with logistics capabilities in photonics companies according to the revenue of firm

	Annual Revenue				Unit: NT$
Logistics capability	<10 million (N=62) (1)	11-100 million (N=78) (2)	> 100 million (N=81) (3)	F value	Scheffé
Warehousing	4.419[a] (0.494)[b]	3.901 (0.735)	4.123 (0.537)	12.722***	(1,2) (1,3) (2,3)
Information technology	4.031 (0.395)	3.916 (0.484)	4.128 (0.449)	4.047**	(1,2)
Transportation	4.233 (0.537)	4.151 (0.510)	4.071 (0.392)	2.043	-

Note: a. represents a mean; b. represents a standard deviation.
*** represents significance level $p < 0.01$.
** represents significance level $p < 0.05$.

5. Conclusions

Whereas core competencies are valuable capabilities or resources of a firm, this study has provided a framework for examining the impact of logistics capabilities on firm performance in the photonics industry. This study's main findings, derived from a survey conducted in Taiwan, are summarized below.

First, respondents indicated that logistics capabilities with respect to warehousing, transportation, and information technology dimensions are all important in the photonics industry. The mean scores of these three logistics capability dimensions were all greater than 4.0. Specifically, information technology capability was found to be the most important logistics capability, followed by warehousing capability, and transportation capability. These research findings are consistent with previous studies on logistics capabilities [10], [13], [22], [43], [47], [48]. The present research suggests that photonics firms need to be especially concerned with these dimensions when they wish to increase their firm performance.

Second, in an appraisal of previous studies, this study provides a fundamental concept by which photonics executives can identify and assess their key logistics capabilities. Despite the existence of the concept of capability for many decades, it is now gaining more acceptance as a method for sustaining competitive advantage in a particular market. However, the implications of capability have been lacking in the photonics industry context. This research not only identified crucial logistics capabilities but also examined its relationships with firm performance.

Third, of particular importance, in previously described studies, logistics capabilities not only involved one capability (warehousing capability) but also covered other key capabilities, such as transportation and information technology capabilities. This implies that photonics executives need to consider an overall integrated strategy before they implement any strategic decisions. Thus, it is hoped that an understanding of competitor behaviour and strategies, based on the concept of capability and resources, should enable photonics firms to compete effectively in a competitive market.

From a theoretical perspective, although several previous studies have examined the importance of logistics capabilities in a specific industry [7], [14], [22], [31], researchers have mainly concentrated on evaluating critical logistics service attributes for the purpose of meeting customer requirements. Few researchers have investigated the key resources and capabilities necessary for assessing logistics capabilities from a resource-based view. This implies that the RBV theory about a firm can be applied in the photonics industry.

6. Discussion

However, there are some limitations to this research, and there exists a wide scope for future research. A) this research was limited to examining the relationship between key capabilities and firm performance. Further studies could be conducted to ascertain antecedent and consequent relationships between capability and competitive advantage. Another worthwhile direction for future research could be the use of the concept of strategic groups to identify strategic differentiation and competitive advantages in a competitive environment, based on key capability dimensions. Strategic group mapping is beneficial for understanding a situation in a particular industry. Such an approach could investigate strategic and operational differences among various firms within an industry. Additionally, strategic group analysis is a helpful tool for informing companies about significant differences among the competitors' approaches to the marketplace.

B) methodologically, a structural equation modeling (SEM) was adequate to identify the key dimensions of logistics capabilities and the impact of these dimensions on firm performance. Possibly, the analytic hierarchy process (AHP) approach could usefully provide some quantitative aspects to what is otherwise, by and large a subjective assessment. This approach could help to eliminate personal prejudices, conflicting evidences, or errors in judgment, which are commonplace in subjective assessment procedures.

C) the analysis used in this study was static, i.e., the evaluation of the respondents' perceptions was conducted at one point in time. Longitudinal research could be employed to examine how perceptions of key logistics capabilities change over time.

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