A Framework for Evaluating Relationship among Dynamic Capability, Technological Innovation Capabilities and Performance Outcomes

Li-Ren Yang and Shyh-Horng Sheu

***Abstract*—Developing dynamic capability in turbulent environments is important. The primary purpose of this study was to evaluate the relationship among dynamic capability, technological innovation capacities, and performance outcomes. To address the aims, a survey was conducted in the Taiwanese industry. Additionally, the structural equation modeling (SEM) approach was used to validate the research model. These analyses suggest that developing dynamic capability has a positive effect on technological innovation capacities, which subsequently leads to improved performance outcomes.**

***Index Terms*—Dynamic capability, technological innovation capabilities, performance outcomes.**

I. Introduction

Decision making in turbulent environments is important. Many companies attempt to use dynamic capability to improve new product development (NPD) performance. In turbulent environments, dynamic capabilities—"the ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments"—have been viewed as viable means for managing in turbulent environments [1]. Although some of the companies have knowledge of dynamic capability, most of the knowledge exists in fragmented form. The poor understanding of dynamic capabilities makes it difficult to use dynamic capability to improve NPD performance. Thus, to help project managers make decisions in turbulent environments, the primary purpose of this study was to evaluate the effect of dynamic capability on NPD performance. The analyses of dynamic capability and relationships with technological innovation capacities and NPD performance are based on an industry-wide survey performed between December 2011 and June 2012. A data collection tool was developed to assess dynamic capability and performance outcomes on NPD projects in the Taiwanese high-tech industry, yielding 284 project responses. The data analyzed in this study are project-specific, meaning the data are representative of the levels of dynamic capability developed in projects.

II. Conceptual Framework and Research Hypotheses

Yam *et al*. [2] highlighted the importance of the role of dynamic capability in managing innovation. The study suggested that the interaction of departments of an organization is important for innovation. The literature supports dynamic capability as a means to enhance technological innovation. Based on the relevant literature, this study develops the following research hypothesis:

H1: Dynamic capability positively influences project's technological innovation capabilities.

Previous studies identified technological innovation as an important factor in new product development [3]. A review of the literature suggests that technological innovation provides significant benefits to new product development. Technological innovation is recognized as an important resource for new product development. The result of previous research also confirmed that technological innovation contributes to new product development performance [4]. Based on the relevant literature, the following hypothesis is postulated and tested:

H2: Technological innovation capabilities have a positive effect on new product development performance.

The prior research indicated that dynamic capability contributes to new product development performance [5]. As such, dynamic capability leads to improved new product development performance. Thus, the following hypothesis is proposed:

H3: Dynamic capability has a positive effect on new product development performance.

Previous studies indicated that technological innovation capabilities play an important role in new product development performance. As such, NPD performance may derive from technological innovation capabilities. Several researchers have also stated that task characteristics play a moderating role in the relationship between practice use and project performance [6], [7]. O'Connor and Won [8], [9] developed six categories of task characteristics (task procedures, time/space/cost, data complexity, task management, nature of task product, and human resource) to classify tasks by their attributes.

III. Methodology

A. Research Instrument

The survey instrument was developed to measure dynamic capability and its associations with technological innovation capabilities and NPD performance in the Taiwanese high-tech industry. Study participants were first asked to identify a recent NPD project that they were familiar with for

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assessment. The survey was composed of five sections: 1) dynamic capability, 2) technological innovation capabilities, 3) task characteristics, 4) NPD performance, and 5) company, project, and personal information.

TABLE I: CHARACTERISTICS OF SAMPLED PROJECTS

Characteristic	Class	Number	Percent
Industry sector	Optoelectronics	21	7.4
Industry sector	Consumer electronics	51	18.0
Industry sector	Communication equipment	32	11.3
Industry sector	Computer hardware and peripheral	108	38.0
Industry sector	Integrated circuit (IC)	43	15.1
Industry sector	Precision machine	18	6.3
Industry sector	Other	11	3.9
Product newness	New-to-the-world innovations	75	26.4
Product newness	New product lines to the firm	48	16.9
Product newness	Line extensions	97	34.2
Product newness	Improvement/revision to existing products	44	15.5
Product newness	Cost reductions	20	7.0
Percent of company revenue on R&D	<1%	21	7.4
Percent of company revenue on R&D	2-3%	27	9.5
Percent of company revenue on R&D	4-5%	73	25.7
Percent of company revenue on R&D	6-10%	72	25.4
Percent of company revenue on R&D	11-15%	31	10.9
Percent of company revenue on R&D	16-20%	41	14.4
Percent of company revenue on R&D	>20%	19	6.7
Number of team members	<5	33	11.6
Number of team members	5-10	59	20.8
Number of team members	11-15	14	4.9
Number of team members	16-20	57	20.1
Number of team members	21-25	44	15.5
Number of team members	26-30	12	4.2
Number of team members	>30	65	22.9
Number of employees in the company	<10	11	3.9
Number of employees in the company	10-29	24	8.5
Number of employees in the company	30-59	20	7.0
Number of employees in the company	60-99	11	3.9
Number of employees in the company	100-199	15	5.3
Number of employees in the company	200-499	61	21.5
Number of employees in the company	>499	142	50.0

B. Sampling Method and Sample Description

Individuals interested in participating in the study were identified by a search from various industry associations. A survey of NPD projects was conducted in the Taiwanese high-tech industry between December 2011 and June 2012. The targeted respondents were identified as the senior individuals who were familiar with dynamic capability, technological innovation capabilities, and NPD performance. In order to obtain a truly representative sample, the geographic mix of projects was intentionally diverse. Additionally, a specified mix of project type was targeted in order to obtain a representative sample of the industry.

All of the companies were contacted via phone or email to identify the person involved in projects by name and title. The investigators then contacted the respondents to confirm their participation in this study. This study attempted to use phone or email to identify the persons with adequate background and experience. This approach helped the investigators select the right respondents who possess adequate knowledge to properly evaluate the subjective project and are capable of answering all of the survey questions. Project responses were collected via paper and online surveys. The projects were examined to ensure that no duplicate project information was collected. Ultimately, 284 survey responses were used in the analysis. Table I presents characteristics of sampled projects. In addition, profile of respondents is shown in Table II.

TABLE II: PROFILE OF RESPONDENTS

Variable	Category	Number	Percent
Position	Managers/deputy manager	109	38.3
Position	Assistant manager	5	1.8
Position	Director	39	13.7
Position	Engineer /Specialist	131	46.1
Age	<26	37	13.0
Age	26-30	81	28.5
Age	31-35	27	9.5
Age	36-40	41	14.4
Age	41-45	42	14.8
Age	>45	56	19.7

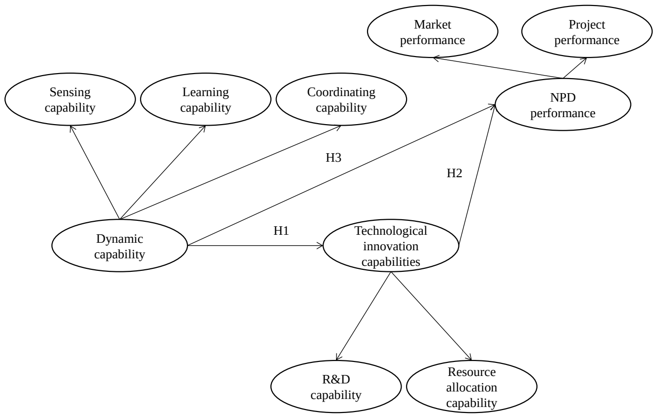

Fig. 1. Theoretical model.

C. Survey Design and Construct Measurement

Multi-item scales were developed for each of the variables included in the theoretical model (see Fig. 1). The items used to measure dynamic capability were based on Pavlou and El Sawy [10]. On the other hand, the scales developed by Yam *et al*. [2] were adapted to evaluate technological innovation capabilities. In addition, items used to rate task characteristics were based on the studies developed by O'Connor and Won [8], [9]. They proposed six categories of task characteristics to classify tasks by their attributes. However, because this study addresses the issue of new product development, only four categories associated with NPD were considered: member diversity, process complexity, data and information complexity, and communication complexity. Finally, questions from Atuahene-Gima [11], Cooper and Kleinschmidt [12], and Griffin and Page [13] were adapted to measure new product development performance. The survey used these items because the literature and recommendations of five NPD practitioners have shown that these items are closely linked to new product development projects. These professionals averaged 16 years of experience. Each item was rated on a 7-point scale, where 1 represented strongly disagree and 7 represented strongly agree.

D. Content Validity

Content validity refers to the extent to which a measure represents all facets of a given concept. The content validity of the survey used in this study was tested through a literature review and interviews with the five NPD practitioners. The refined assessment items were included in the final survey. Finally, copies of a draft survey were also sent to three professors in the NPD discipline to pre-test for the clarity of questions. Their insights were also incorporated into the final version of the survey.

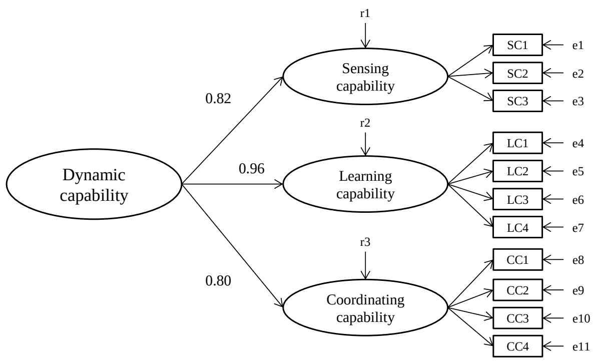

Fig. 2. CFA measurement model for dynamic capability.

IV. RESULTS AND ANALYSIS

A. Measurement Model Test Results

Prior to estimating the structural model, a confirmatory factor analysis (CFA) was conducted to verify the measurement model. Multiple fit criteria were used to assess the overall fit of the model. In the proposed model, dynamic capability, technological innovation capabilities, and NPD performance are a second order construct. The data were analyzed using the AMOS/SPSS statistical package. The model refinement was performed to improve the fit to its recommended levels as shown in Fig. 2 to Fig. 4.

Based on several trials resulting in elimination of some of the items, all of the scales met the recommended levels. Furthermore, the composite reliability for all constructs was above the 0.7 level suggested by Hair *et al*. [14], indicating adequate reliability for each construct. Thus, the results provide evidence that the scales are reliable (see Table III).

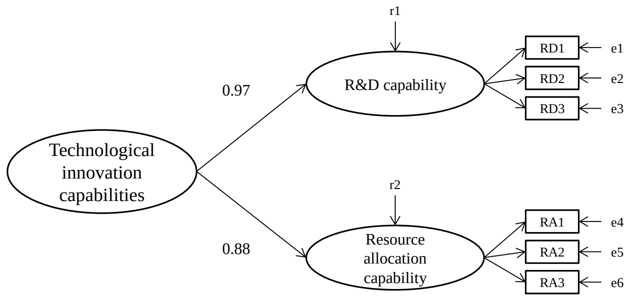

Fig. 3. CFA measurement model for technological innovation capabilities.

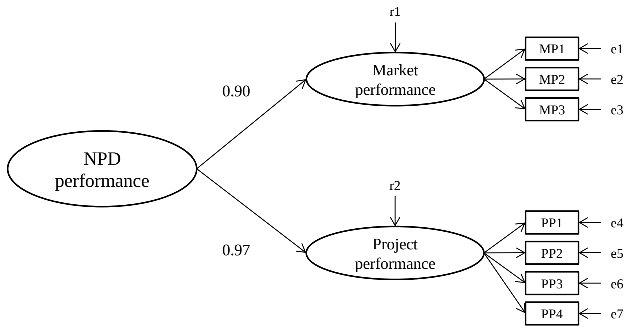

Fig. 4. CFA measurement model for NPD performance.

All of the factor loadings are statistically significant at the five percent level and exceed the 0.5 standard [15], as shown in Table 3. In addition, all constructs have an average variance extracted (AVE) greater than 0.5. Thus, these constructs demonstrate adequate convergent validity. Discriminant validity evaluates whether the constructs are measuring different concepts [14]. The procedure requires comparing the set of models where each pair of latent constructs has a constrained correlation of one with the correspondent models where such pairs of constructs are freely estimated [16]. The results show that the chi-square values are significantly lower for the unconstrained models at the five percent level, which suggests that the constructs exhibit discriminant validity.

B. Structural Model Test Results

Fig. 5 presents results of the overall model fit in the structural model. A feasible model was selected based on the recommended Goodness-Of-Fit (GOF) measures and the model that satisfies both theoretical expectations and GOF was finally selected for structural equation modeling (SEM) analysis [17]. Thus, the model refinement was performed to improve the fit to its recommended levels. This model yielded a model fit of NFI = 0.958, CFI = 0.963, GFI = 0.939, AGFI = 0.812, and RMSEA = 0.074. The overall fit statistics indicated a very good fit for the model.

The test of H1, H2, and H3 was based on the direct effects (structural coefficients) among the constructs as shown in Fig. 3. H1 proposed a positive relationship between dynamic capability and technological innovation capabilities. This hypothesis was supported since the standardized coefficient was 0.87 and statistically significant ($p < 0.001$). H2 proposed a positive relationship between technological innovation capabilities and NPD performance. This hypothesis was supported by a statistically significant structural coefficient of 0.86 ($p < 0.001$). However, the direct impact from dynamic capability to NPD performance is not significant (coefficient = -0.10; $p > 0.05$), and therefore H3 is not supported.

TABLE III: RESULTS OF CFA

Construct and item	Standardized factor loading	Composite reliability/ AVE
Dynamic capability – Sensing capability (SC)	--	0.832/0.626
SC1: We periodically reviewed the likely effect of changes in our project environment on customers.	0.925	--
SC2: We often reviewed our product development efforts to ensure they are in line with what the customers want.	0.702	--
SC3: We devoted a lot of time implementing ideas for new products and improving our existing products.	0.727	--
Dynamic capability – Learning capability (LC)	--	0.855/0.598
LC1: We had effective routines to identify and import new information and knowledge.	0.780	--
LC2: We had adequate routines to assimilate new information and knowledge.	0.683	--
LC3: We were effective in utilizing knowledge into new products.	0.767	--
LC4: We were effective in developing new knowledge that has the potential to influence product development.	0.854	--
Dynamic capability – Coordinating capability (CC)	--	0.921/0.744
CC1: We ensured that the output of our work is synchronized with the work of others.	0.895	--
CC2: We ensured an appropriate allocation of resources within our project.	0.886	--
CC3: Project team members were assigned to tasks commensurate with their task-relevant knowledge and skills.	0.833	--
CC4: Our project team was well coordinated.	0.834	--
Technological innovation capabilities – R&D capability (RD)	--	0.755/0.509
RD1: Our project had high quality and quick feedbacks from manufacturing to design and engineering.	0.597	--
RD2: Our project had good mechanisms for transferring technology from research to product development.	0.787	--
RD3: Our project had great extent of market and customer feedback into technological innovation process.	0.743	--
Technological innovation capabilities – Resource allocation capability (RA)	--	0.756/0.509
RA1: Our project attached importance to human resource.	0.685	--
RA2: Our project selected key personnel in each functional department into the innovation process.	0.690	--

TABLE III: RESULTS OF CFA (CONTINUED)

Construct and item	Standardized factor loading	Composite reliability/ AVE
RA3: Our project provided steady capital supplement in innovation activity.	0.763	--
New product development performance – Market performance (MP)	--	0.899/0.748
MP1: The consumers appreciated this product's quality.	0.848	--
MP2: The product contributed to strengthen the relationships with customers.	0.853	--
MP3: The product met customer needs.	0.892	--
New product development performance – Project performance (PP)	--	0.802/0.504
PP1: The product provided our firm with proprietary advantage such as patents or trade secrets.	0.640	--
PP2: The product achieved important cost efficiencies for the firm.	0.714	--
PP3: The product met the cost objectives.	0.734	--
PP4: Time-to-market of the product was essentially the same as planned.	0.748	--

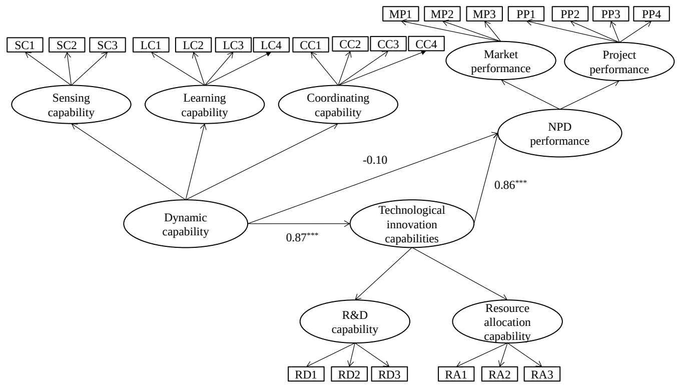

Fig. 5. Research model estimation results.

V. CONCLUSIONS

This research provides empirical evidence that supports the expectation of gaining significant benefits from developing dynamic capability. It reveals the importance of increasing dynamic capability to improve NPD performance. The research results offer guides to enhance new product development performance. The research findings indicate that dynamic capability is associated with technological innovation capacities, which supports H1. Additionally, the research findings imply that technological innovation capacities improve NPD performance in terms of project and market performance, which supports H2. However, the research results show that the direct impact from dynamic capability to NPD performance is not significant, and therefore H3 is not supported.

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