NORTH-HOLLAND

Available online at www.sciencedirect.com
SCIENCE DIRECT®

Industrial Marketing Management 33 (2004) 593–605

INDUSTRIAL MARKETING MANAGEMENT

The R&D and marketing cooperation across new product development stages: An empirical study of Taiwan's IT industry

Louis Y.Y. Lu[1], Chyan Yang*

Institute of Business and Management, National Chiao Tung University, 4F, No. 114, Chung-Hsiao West Road, Sec. 1, Taipei 100, Taiwan, ROC

Received 4 December 2002; received in revised form 30 September 2003; accepted 2 November2003
Available online 29 December 2003

Abstract

This study extends the new product development (NPD) process research to a new environmental context (Taiwan's IT industry) and a new business type (original design manufacturing, ODM). Taiwan's IT industry has achieved a very outstanding performance during the last two decades. The island's experience is quite valuable for those emerging countries that are struggling to transform themselves from producing low-value goods to making high-technology products. After analyzing the data collected from 153 research and development (R&D) and marketing managers in Taiwanese IT firms, this study finds that the higher the perceived importance of R&D–marketing cooperation is, the higher the attained level of R&D–marketing cooperation will be. Consequently, a better NPD performance can be achieved. This study additionally reports that a firm that has adopted a Defender innovation strategy attains a lower level of R&D–marketing cooperation, and has a poorer NPD performance than those firms that adopted either Prospector or Analyzer innovation strategies. Finally, environmental uncertainty has no significant impacts on the perceived importance and the attained level of R&D–marketing cooperation.
© 2003 Elsevier Inc. All rights reserved.

Keywords: New product development (NPD); NPD stages; R&D and marketing cooperation; Taiwan; IT industry

1. Introduction

Many empirical studies have demonstrated that the effective cooperation between research and development (R&D) and marketing increases the success rate of a new product development (NPD; Atuahene-Gima & Evangelista, 2000; Cooper & Kleinschmidt, 1987; Hise, O'Neal, Parasuraman, & McNeal, 1990; Song & Parry, 1992). The active participation of R&D and marketing personnel in the NPD process enhances the company's ability in developing new products to satisfy customer needs. Although some research studies extend the relationship beyond R&D and marketing to include other functional units (Olson, Orville, Walker, Ruekert, & Bonner, 2001), R&D–marketing cooperation still plays a major role in the success of an NPD. In practice, an NPD process consists of several stages. Do varied levels of R&D–marketing cooperation occur at different NPD stages? Do R&D and marketing personnel show different perspectives on the NPD process? Do the innovation strategy and environmental uncertainty possess any effect on NPD performance? What is the difference between more successful and less successful projects? This study develops a model to investigate these issues in Taiwan's highly successful IT industry.

To shed some new light on research over the NPD process, the present study extends the previous research in the following ways: First, Taiwan's IT industry has achieved outstanding results over the last two decades (Chang & Yu, 2001, chap. 12). However, a study dedicated to Taiwan's IT industry has not yet been proffered. The majority of previous research studies were carried out in developed countries with little attention on the newly industrializing economies (NIEs). This study is the first one dedicated to the NPD process on Taiwan's IT industry. Cultural difference might actually raise new issues in some respects. Hofstede (1980) reported that

* Corresponding author. Tel.: +886-2-2349-4936; fax: +886-2-2349-4926.
E-mail addresses: louisyylu@yahoo.com.tw (L.Y.Y. Lu), chyan_yang@yahoo.com (C. Yang).
[1] 6F, No. 1, Alley 6, Lane 107, He-Ping East Road, Sec. 2, Taipei, 106, Taiwan. Tel.: +886-2-27031609.

0019-8501/$ – see front matter © 2003 Elsevier Inc. All rights reserved.
doi:10.1016/j.indmarman.2003.11.002

culture values do affect the behavior pattern. Yeh (1988) also found that cultural characteristics affect the leadership style and value.

Several scholars have conducted research on the NPD of high-technology firms in some developing countries (Li & Atuahene-Gima, 2001; Song, Montaya-Weiss, & Schmidt, 1997). These research studies cover many types of industry such as chemical, pharmaceuticals, bioengineering, automobile, etc. They also include a wider range of high-technology firms. However, focusing on a relatively homogeneous industry can isolate the potential contaminating effects caused by the industry-specific characteristics. Moreover, industry-specific characteristics will drive companies in different industries to adopt assorted strategies to win the market in their domains.

In the IT industry, product life cycle is extremely short. Companies need to deliver new products before they have any market value. The rapid changes in technology and the market force the R&D and marketing departments to cooperate closely, to react to any sudden changes. These two unique features of the IT industry indeed impact the nature of R&D and marketing cooperation. To cope with the rapid change in technology and the extremely short product life cycles, the cross-functional cooperation of the NPD process in the IT industry may be different from those industries with a longer product life cycle. Therefore, it is worthwhile to separately investigate these issues.

The second extension of this study is that firms in developed countries focus mainly on the own brand manufacturing (OBM)[2] business. This study examines R&D–marketing cooperation in an original design manufacturing (ODM) and original equipment manufacturing (OEM) business. In Taiwan's IT industry, the main type of business is OEM/ODM. An OEM/ODM business is different from an OBM business in many aspects. For an OBM, companies can entirely control their marketing activities. However, for OEM/ODM, firms are not involved in their OEM/ODM customers' sales/marketing activities. Being isolated from the customer base, how do Taiwanese IT firms implement their NPD process?

Taiwan-made IT products dominate the worldwide market in many categories (see Table 1). Many of them share over 50% of the worldwide market. This evidence demonstrates that Taiwan's IT industry has had a highly successful growth experience, from which it can be documented and lessons can be learned. Many developing countries are eager to transfer themselves from producing low-value goods to making high-technology products. The authors believe that the results of this study can provide valuable implications for them.

Table 1
2001 IT production in Taiwan

Product	Revenue (US$M)	Quantity (K-units)	Worldwide share (%)
Notebook PC	12,239	14,161	55.3
Desktop PC	6866	25,405	24.0
Motherboard	5647	80,565	70.4
CRT monitor	5240	46,171	51.2
LCD monitor	3131	9007	58.6
CD/DVD/RW drives	2106	51,998	31.9
Digital camera	1132	8821	39.7

Source: MIC/ITIS (2002).

This study finally reports a popular NPD process adopted by Taiwan's IT industry. The NPD processes of Taiwanese IT firms are design and development (D&D)-oriented. It is a kind of OEM/ODM sales-driven process. The stages of this process are different from that of an R&D-oriented NPD process. This successful NPD process can provide helpful recommendations to those other countries or industries that also focus on any D&D-oriented business.

2. Literature review

2.1. NPD stages

Prior researchers suggest several different systems of an NPD process (Cooper, 2001; McGrath, 1996, chap. 3; Ulrich & Eppinger, 1995, chap. 2). Cooper (2001) proposed a stage–gate system. The key stages are discovery, scoping, build the business case, development, testing and validation, and launch. Each stage is involved with multiple functional departments, and there is a gate between each two contiguous stages. The gates serve as quality-control checking points. Three quality issues are checked: quality of execution, business rationale, and quality of action plan. McGrath (1996, chap. 3) suggested five phases for the implementation of concurrent engineering. They are concept evaluation, planning and specification, development, test and evaluation, and product release. Ulrich and Eppinger (1995, chap. 2) presented a generic development process with five phases including concept development, system-level design, detail design, testing and refinement, and production ramp-up.

Taiwan's IT industry provides very little research functions, as the major role of NPD in Taiwanese IT firms is not R&D, but rather, design and development. New product design and process development are their major NPD activities. Because Taiwanese IT firms are not usually involved with new technology discovery or crea-

[2] Through this paper, OEM stands for original equipment manufacturing, and is defined as a business of "manufacturing parts and components to specification provided by buyers" (Yusuf, 2003, chap. 7). ODM stands for original design manufacturing, and is defined as conducting functions from "postconceptual design services to the manufacturing." OBM stands for original brand manufacturing, and is defined as "selling the products under its own brand name." Another type of taxonomy combines OEM and ODM into a contract manufacturer, and OBM is referred to as an original equipment manufacturer. This paper adopts the terms of OEM/ODM/OBM (Gereffi, 1999; Mathews, 1997; Yusuf, 2003, chap. 7).

tion, their NPD stages are hence different from those firms that conduct R&D. When the authors of this study discuss the NPD process with industrial practitioners, a basic skeleton of the NPD process in Taiwan's IT industry is described, and the vast majority of NPD processes used by Taiwanese IT firms are modified from a pioneering company.

The NPD process is also a stage–gate system. It is divided into six stages: feasibility study, product planning, product development, prototyping, pilot run, and mass production. This study adopts this popular NPD system for its detailed investigation. Due to a small home market, Taiwanese IT firms have no position as a standard creator, but the best they can do is be the quickest standard follower. Marketing people carefully watch out for trends and frequently discuss them with OEM/ODM customers. Once a global standard is about to be formed, NPD projects are initiated immediately, with NPD teams working hard to timely deliver the most competitive products and services to customers. Taiwanese IT firms as such have been very successful standard followers over the past two decades.

2.2. Innovation strategy

When investigating the NPD process, several research studies found that a firm's innovation strategy has a significant relationship with cross-functional cooperation and NPD performance (Cooper & Kleinschmidt, 1987; Olson et al., 2001). Many NPD studies in the literature adopt the taxonomy developed by Miles and Snow (1978, chap. 1) for innovation strategies. Prospector, Analyzer, and Defender innovation strategies are used in high-technology NPD studies. The Reactor strategy is excluded because it is not able to assure the long-term survival of a firm (Gupta, Raj, & Wilemon, 1986; Song, Neeley, & Zhao, 1996; Song & Parry, 1992).

Miles and Snow (1978, chap. 1) defined these four strategies as follows: "Prospectors are organizations that almost continually search for market opportunities, and they regularly experiment with potential responses to emerging environmental trends. Thus, these organizations often are the creators of change and uncertainty to which their competitors must respond." "Analyzers are organizations that operate in two types of product-market domains, one relatively stable, the other changing. . . ., and then they rapidly adopt those that appear to be the most promising." "Defenders are organizations which have narrow product-market domains. . . .These organizations seldom need to make major adjustments in their technology, structure, or methods of operation. Instead they devote primary attention to improving the efficiency of their existing operations." "Reactors are organizations in which top managers frequently perceive change and uncertainty occurring in their organizational environments but are unable to respond effectively. . . ., it seldom makes adjustment of any sort until forced to do so by environmental pressures."

A Prospector values the first movement and risk-taking in a new market and product development. It conducts its business in a broad market and product domain. A Defender maintains a niche market by providing relatively stable services. It offers excellent quality, superior service, and low prices to secure its business domain. An Analyzer is a mixture of a Prospector and a Defender. It maintains limited product lines to quickly respond to market change. A Reactor is unable to effectively respond to changes in the environment and it cannot survive in the extremely competitive IT industry.

2.3. Environmental uncertainty

Organizational theory suggests that environmental uncertainty significantly impacts organizational structure and performance. Technical and market uncertainties are used to measure environmental uncertainty. Technical uncertainty relates to the lack of knowledge about the exact means to accomplish an NPD project (Tatikonda & Montoya-Weiss, 2001). Some sources can cause technical uncertainty such as technological evolution, technological discontinuities, rates of technology change, disruptive technologies, etc. Technological evolution means that a new technology substitutes for the prior technology and results in new industry standards (Tushman & Rosenkopf, 1992). Technological discontinuities can be characterized as competence-destroying or competence-enhancing. A disruptive technology is a new product or service that disrupts an industry and eventually wins most of the market share. In the IT industry, the rate of technology change is very fast, and the technical uncertainty is relatively high.

Market uncertainty can be objectively measured in terms of its complexity, dynamics, and variability (Jaworski & Kohli, 1993; Song, Thieme, & Xie, 1998). Prior research studies report that environmental uncertainty could impact the perceived importance of cross-functional cooperation (Griffin & Hauser, 1996; Gupta et al., 1986) and have a moderating effect on the relationship between R&D–marketing cooperation and NPD performance (Gupta et al., 1986). Li (1999) argued that when competition is high, R&D and marketing personnel must strengthen their cooperation so as to win an advantage over the competitors. However, Souder, Sherman, and Davies-Cooper (1998) found that the moderating effects are only supported at 3 out of 28 interaction tests. The results of the moderating effects are mixed.

3. Conceptual framework and research hypotheses

3.1. Conceptual framework

In this study, the authors propose a conceptual framework as shown in Fig. 1. The following sources are used

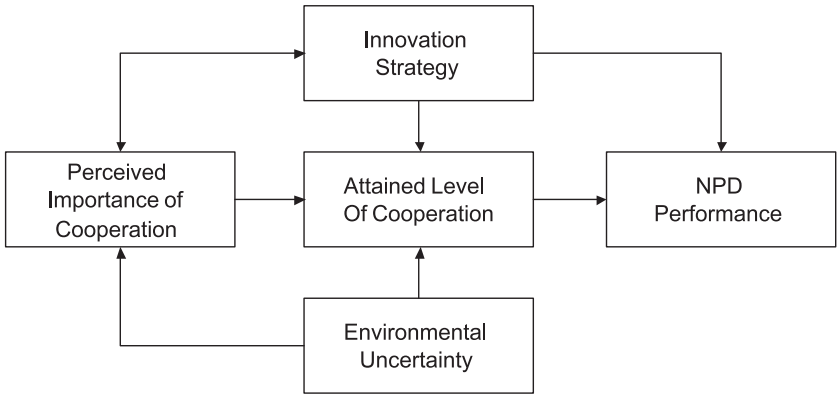


Fig. 1. Conceptual framework.

to construct the model: (1) prior research results; (2) authors' practical experience; and (3) NPD managers' recommendations during in-depth interviews. This model investigates the relationships among the perceived importance of R&D–marketing cooperation, the attained level of R&D–marketing cooperation, and NPD performance. Furthermore, the effects of innovation strategy and environmental uncertainty are also examined.

3.2. Perceived importance and attained level of R&D–marketing cooperation

NPD is a function of teamwork. Previous studies show that a higher cooperating NPD team could result in a better NPD performance. Social behavior theory suggests that the perception of another's behavior increases the likelihood of engaging in that behavior (Bargh, Chen, & Burrows, 1996). If NPD team members from different functional departments perceive a higher level of importance on cross-functional cooperation, then, they are more willing to conduct the cooperation. Consequently, the attained level of cross-functional cooperation is higher. Hence, it is hypothesized:

Hypothesis 1: The higher the perceived importance of R&D–marketing cooperation is in an NPD stage, the higher the attained level for cooperation will be in that stage.

3.3. The relationship between R&D–marketing cooperation and NPD performance

Many empirical studies demonstrate that the level of cross-functional cooperation is a critical determinant of NPD success (Calantone & Di Benedetto, 1988; Pinto, Pinto, & Prescott, 1993; Ruekert & Walker, 1987; Yap & Souder, 1994). NPD typically involves R&D and marketing personnel in identifying marketing opportunities, setting new product goals, and resolving product-cost performance tradeoffs (Souder, 1988). If R&D and marketing personnel do not communicate and cooperate effectively, then, the information of market needs and the knowledge of product creation will be disjointed. Griffin and Hauser (1996) suggested that the ability in integrating R&D and marketing personnel to reduce environmental uncertainty could improve NPD performance. Therefore, effective R&D and marketing cooperation is important to the creation of profitable new products in a timely way (Griffin & Hauser, 1996; Gupta et al., 1986; Olson, Walker, & Ruekert, 1995; Souder, 1988). Thus, it is proposed:

Hypothesis 2: The higher the attained level of R&D–marketing cooperation is, the better the NPD performance will be.

3.4. The effects of innovation strategy

An earlier study suggests that the aggressiveness of an innovation strategy increases the perceived importance of R&D–marketing cooperation (Gupta et al., 1986). On the other hand, a firm that perceives the importance of R&D–marketing cooperation may adopt more aggressive innovation strategy to gain better profit. However, in a recent study, Rochford and Rudelius (1997) found that a product innovation strategy does not influence the perceived importance of cross-functional cooperation. Learning theory suggests that learning from past experiences can enhance people's perception and improve their behavior in the future. In the beginning, only a few people perceive the importance of R&D–marketing cooperation for the success of NPD. Once the importance of cooperation is repeatedly demonstrated in several successful NPD projects, NPD members will learn and recognize its importance toward a successful NPD. Through continuous education and training, the importance of cross-functional cooperation has become a consensus now, and it is particularly distinct in the IT industry. The crucial challenges and competition in the IT industry force NPD team members to understand the importance of cross-functional cooperation. Therefore, a hypothesis is proposed as:

Hypothesis 3a: The levels of perceived importance of R&D–marketing cooperation are high in the IT industry, no matter which innovation strategy a firm adopts.

Knowing what one should do is easy, but doing what should be done is a challenge. Knowing what should be done does not guarantee that people will do it accordingly. Only through learning by doing do people fully understand the crucial role of cross-functional cooperation in the NPD success. For Prospectors and Analyzers, timing is very critical to a successful NPD. If NPD teams can deliver new products ahead of their competitors, they can enjoy the benefits of higher profit. Moreover, the enjoyment of success can further advance the willingness of future cooperation. For Defenders, the ultimate goal is to deliver new products with excellent quality and lower price. There, the timing requirement is not so relatively critical. The cooperation between operations and R&D, or between operations and marketing is more important. Hence, it is postulated:

Hypothesis 3b: An innovation strategy can influence the attained level of R&D–marketing cooperation. Defenders have a lower level of R&D and marketing cooperation than Prospectors and Analyzers.

NPD managers who appropriately fit their strategy into a market situation will see higher new-product success rates. Cooper and Kleinschmidt (1995) found that an innovation strategy leads the management to fund adequate resources for specific product development, consequently resulting in a more successful NPD. Prospectors take significant risk in NPD, but also possess higher rewards when an NPD product succeeds. Analyzers do not enjoy the same higher profit margins as Prospectors, but their risk is lower. Defenders must provide excellent quality and lower prices to secure their business. They will not deliver products until the market and technology are mature. In the IT industry, the product life cycle is very short, leaving little room for Defenders to endeavor their best efforts to deliver the most competitive products. Hence, it is proposed:

Hypothesis 3c: An innovation strategy can impact NPD performance. In the IT industry, Defenders have lower NPD performance than Prospectors and Analyzers.

Olson et al. (1995) suggested that higher levels of cross-functional cooperation might not always be beneficial to NPD performance. In the later study, Olson et al. (2001) found that the moderating effect of an innovation strategy on the relationship between operation–marketing cooperation and NPD performance is significantly supported. However, this moderating effect is not significant between R&D–marketing cooperation and NPD performance. This study investigates R&D and marketing cooperation and, therefore, it is hypothesized:

Hypothesis 3d: An innovation strategy does not moderate the relationship between R&D–marketing cooperation and NPD performance.

3.5. The effects of environmental uncertainty

Based on information processing theory, when the market and technology are predictable, decisions and actions can be preprogrammed, and a high level of R&D–marketing cooperation may not be necessary. When environmental uncertainty is high, an NPD team will perceive higher needs for R&D–marketing cooperation (Souder et al., 1998). Gupta et al. (1986) suggested that the perceived uncertainty of the environment increases the perceived importance of R&D–marketing cooperation. Hence, it is proposed:

Hypothesis 4a: Environmental uncertainty can strengthen the perceived importance of R&D–marketing cooperation.

Li (1999) reported that market uncertainty increases the need for cross-functional information sharing. When environmental uncertainty is high, R&D and marketing personnel must intensify their cooperation so as to keep all NPD team members informed about market trends and competitor's moves, and then take quick and appropriate actions. Therefore, environmental uncertainty can force NPD teams to perform a faster, more effective, and more efficient NPD process (Song et al., 1998). The hypothesis is:

Hypothesis 4b: Environmental uncertainty can enhance the attained level of R&D–marketing cooperation.

Menon, Jaworski, and Kohli (1997) found that cross-functional cooperation is more important for product quality under a turbulent market than in a stable market. However, Souder et al. (1998) reported that this moderating effect is only minimally supported (3 out of 28 cases). They showed that only market uncertainty moderates the relationship between R&D–marketing cooperation and prototype development proficiency. The moderating effect is not supported in

Table 2
Demographic characteristics of the respondents

	Number	Percentage (%)
Type of industry		
PC systems	19	12.4
Peripherals	40	26.1
Communications	20	13.1
Opto-electronics	15	9.8
Semiconductors	26	17.0
Consumer electronics	10	6.5
Components	14	9.2
Software	9	5.9
	153	100
Job classification		
Top R&D manager	66	43.1
Lower–middle R&D manager	16	10.5
Top marketing manager	49	32.0
Lower–middle marketing manager	22	14.4
	153	100

Table 3
Statistics of key measures

Measure	Mean	S.D.	Correlation coefficients				
			1	2	3	4	5
1. Innovation strategy	1.94	0.62	(n.a.)				
2. Environmental uncertainty	4.72	1.12	−.02	(.80)			
3. Perceived importance of cooperation	6.49	0.46	.03	.08	(.86)		
4. Attained level of cooperation	5.60	0.80	−.11	.11	.52**	(.90)	
5. NPD performance	4.96	1.16	−.23*	−.04	.12	.43**	(.82)

n.a.: not applicable, ( ): coefficient alpha.
* $P<.001$.
** $P<.01$.

other conditions, neither between market uncertainty and other performances nor between technical uncertainty and all NPD performances. This study follows the result of Souder et al. and hypothesizes that:

Hypothesis 4c: Environmental uncertainty does not moderate the relationship between R&D–marketing cooperation and NPD performance.

4. Empirical study

4.1. Research instrument development

This study consists of in-depth interviews and a questionnaire survey. The authors identified measurement scales from the NPD literature and then conducted intensive discussions with academic experts and NPD managers to develop a questionnaire draft. The draft was translated into Chinese using the translation/retranslation method. This method was conducted by two translators independently translating the English questionnaire into Chinese versions, and then, the other two translating the Chinese versions back into English. The latter English versions were compared with the original one to make sure that the meanings were consistent with the original concepts.

Two pretests were conducted. Participants were asked to identify any confusion. Five EMBA students with business experiences performed the first pretest. After the pretest, the questionnaire was revised. The second pretest was conducted on 18 R&D and marketing managers from three Taiwanese IT firms. Minor modifications were incorporated into the final questionnaire. The pretests indicate that the questionnaire is deemed appropriate to examine R&D and marketing cooperation in Taiwanese IT firms.

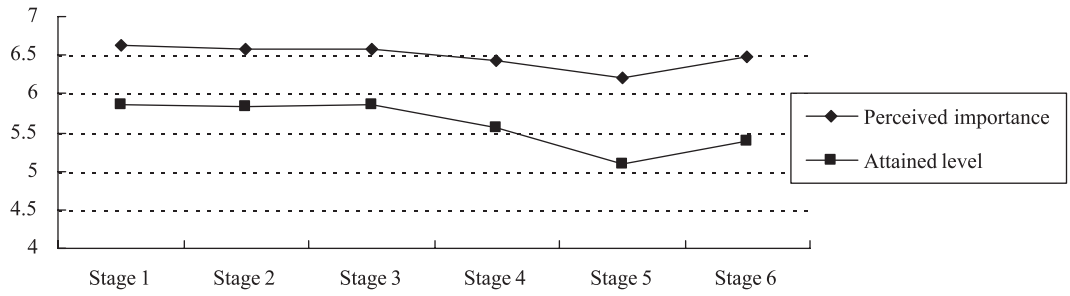
4.2. Sample and data collection

All the IT firms listed in the then Taiwan Stock Exchanges (TSE) are screened according to the following criteria:

- The firm is in the IT industry.
- The firm has R&D and marketing departments.
- The firm has commercialized its NPD products.

The authors screened the candidates by accessing the database of TSE and the companies' websites. Finally, 151 firms were included in the sample population.

To be convenient for the respondents, the questionnaire was delivered to the presidents of the 151 firms in two forms: e-mail or regular mail. Along with the questionnaire, a personalized letter was sent to the president. The letter asked that he/she select the proper strategic business units (SBU) in his/her company and forward the questionnaires to the selected NPD managers. To encourage participation, all the informants were assured that their responses would be kept confidential and will only be shown in an aggregated form. The authors also promised to give a copy of the results to all respondents. After several follow-up e-mails and phone calls, 153 usable responses were received from 82 R&D managers and 71 marketing managers employed by 43 companies. The



Note: Stage 1 - feasibility study
Stage 2 - product planning
Stage 3 - product development
Stage 4 - prototyping
Stage 5 - pilot run
Stage 6 - mass production

Fig. 2. Perceived importance versus attained level.

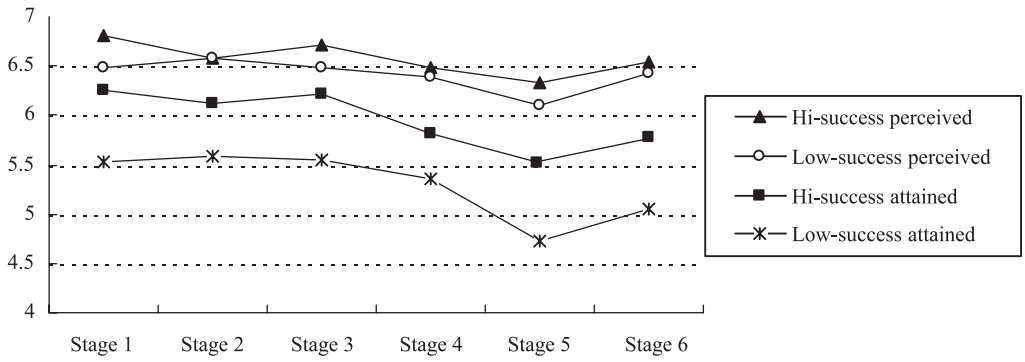


Fig. 3. Perceived importance and attained level: more successful versus less successful.

total process of data collection started from Q4 2001 and ended in Q1 2002. The response rate for firms is 28.48%. Table 2 presents a summary of the demographic characteristics of the respondents.

To examine nonresponse bias, the mean of the companies' performance data of the respondents and nonrespondents were compared on three dimensions: annual sales, EPS, and total number of employees. The performance data were retrieved from the database of TSE and no significant differences were found. The means of the primary interested variables of the early and the late respondents were also compared. The results indicate no statistically significant differences. It is concluded that the data indeed represent Taiwan's IT industry.

4.3. Measurement

The study uses multiple-item scales to measure the corresponding construct. All of those measures are scored on seven-point Likert scales. Some measurement items were derived and adapted from validated scales, while some items were developed specifically to reflect the real situation in Taiwan's IT industry. The items used to measure the underlying construct are summarized in Appendix A.

Fourteen items are used to measure R&D and marketing cooperation at six NPD stages. Five items are used to measure the environmental uncertainty. Numerous indicators can be used to measure NPD performance, such as market share, customer satisfaction, profit margins, technical performance, time to market, success rate, etc. Griffin and Hauser (1996) suggested that a successful NPD is able to commercialize a profitable product in a timely fashion. Olson et al. (1995) claimed that due to tight resources and a rapidly changing environment, completing a product in a timely manner becomes increasingly important. Considering the unique characteristics of the IT industry, the authors follow Griffin and Hauser's suggestion and take timeliness, profitability, and overall success as the measures of NPD performance.

4.4. Reliability and validity

The Cronbach alpha coefficient is used to assess the internal consistency of all multi-item scales. These coefficients, together with the mean and standard deviation, are shown in Table 3. All of the alpha coefficients exceed .8. This demonstrates an adequate internal consistency. The statistics of key measures are shown in Table 3. Factor analysis is used to verify if multiple items are loaded on the corresponding conceptual construct. All the factor loadings are .4 or greater for the underlying construct, and are less than .4 for the others. The results demonstrate the construct validity.

5. Analysis and results

Linear regression analyses are used to test the postulated relationships. Variance inflation factors (VIF) are

Table 4
ANOVA analysis of perceived importance by innovation strategy

	Mean scores			ANOVA (P value)	Posterior analysis (P value)	
	Prospector ($n=34$)	Analyzer ($n=94$)	Defender ($n=25$)		Prospector vs. Analyzer	Defender vs. others
Perceived importance						
Feasibility study	6.65	6.68	6.44	.26		
Product planning	6.53	6.60	6.57	.82		
Product development	6.62	6.61	6.48	.58		
Prototyping	6.18	6.53	6.44	.08		
Pilot run	5.99	6.37	5.92	.003 *	.008 *	.109
Mass production	6.39	6.51	6.52	.60		

* $P<.01$.

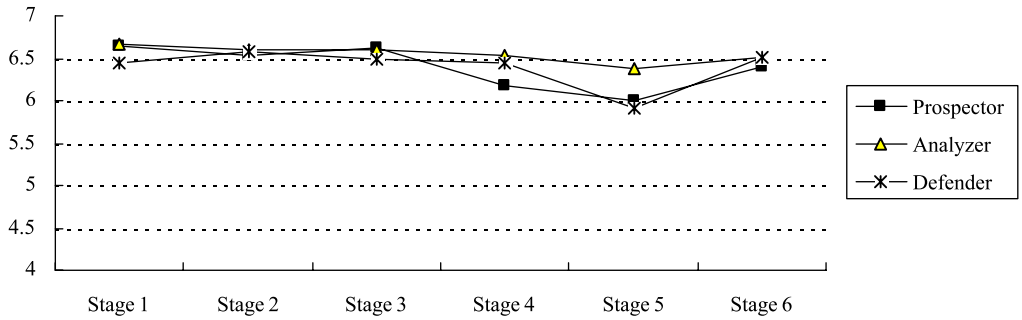


Fig. 4. Perceived importance of R&D–marketing cooperation by innovation strategy.

calculated to examine the presence of multicollinearity. These factors are below the acceptable cutoff of 10 (Neter, Kutner, Nachtsheim, & Wasserman, 1996). When testing the moderating effect, the data are centered to reduce multicollinearity and to render more meaningful interpretations of the regression coefficients. To provide a clearer expression to practitioners, line charts are used as far as possible in the following discussions. ANOVA tests are used to check if any effect from innovation strategies exists on the perceived importance of cooperation, the attained level of cooperation, and the NPD performance.

5.1. Perceived importance and attained level of cooperation

H1 hypothesizes that, at each stage, the higher the perceived importance of R&D–marketing cooperation is, the higher the attained level of the cooperation will be. Linear regression analyses demonstrate that the relationships are strongly supported for all six stages ($P<.001$). Fig. 2 explicitly exhibits this relationship. The data reveal very important information on Taiwanese IT firms: NPD managers perceive a very high level of R&D–marketing cooperation, more than six out of a seven-point scale, and the attained levels are all over five. These high numbers might be one of the reasons why Taiwan's IT industry has had such an outstanding performance in the last decade. From Fig. 2, the levels of cooperation at the early stages are higher than those at the latter stages. This is consistent with the findings of a previous research (Olsen et al., 2001).

5.2. NPD performance

H2 proposes that the higher the attained level of R&D–marketing cooperation is, the better the NPD performance will be. The results of the linear regression analyses show that the relationships are strongly supported at all six stages ($P<.0001$). These results are consistent with prior research studies (Gupta et al., 1986; Olsen et al., 1995; Song & Parry, 1992). The authors used the median of NPD performance to split NPD projects into two groups: more successful and less successful. The levels of perceived importance of cooperation between these two groups are only significantly different at the feasibility study and product development stages. However, less successful NPD projects significantly attain lower levels of cooperation at all NPD stages. Fig. 3 shows the levels of cooperation of these two groups, exhibiting that all NPD managers highly understand the importance of R&D–marketing cooperation, but only parts of them actually implement it and gain better NPD performance. Combining the results of H1 and H2, it can be concluded that the higher the perceived importance of R&D–marketing cooperation is, the higher the attained level of the cooperation will be. Consequently, a better NPD performance can be achieved. When all the firms have high perceived importance of R&D–marketing cooperation, the variation is too small to make a difference. Only through learning by doing can people indeed fully understand the crucial role of cross-functional cooperation for NPD success and realize how to thoroughly implement it.

5.3. Innovation strategy

H3a postulates that the perceived importance of R&D–marketing cooperation shows no difference among three innovation strategies. ANOVA is used to test this and Table 4 shows the results. The levels of perceived importance of cooperation are only significantly different at the pilot run stage. The Analyzer has a significantly higher perception at this stage than others. H3a is,

Table 5
Attained level of cooperation and NPD performance by innovation strategy

	Mean scores			Defender vs. others (P value)
	Prospector ($n=34$)	Analyzer ($n=94$)	Defender ($n=25$)	
Attained level				
Feasibility study	5.85	5.95	5.52	.10
Product planning	5.76	5.94	5.49	.08
Product development	5.93	5.91	5.50	.045*
Prototyping	5.56	5.59	5.50	.76
Pilot run	5.29	5.16	4.54	.008**
Mass production	5.40	5.42	5.19	.33
NPD performance	5.18	5.07	4.25	<.001***

* $P<.05$.
** $P<.01$.
*** $P<.001$.

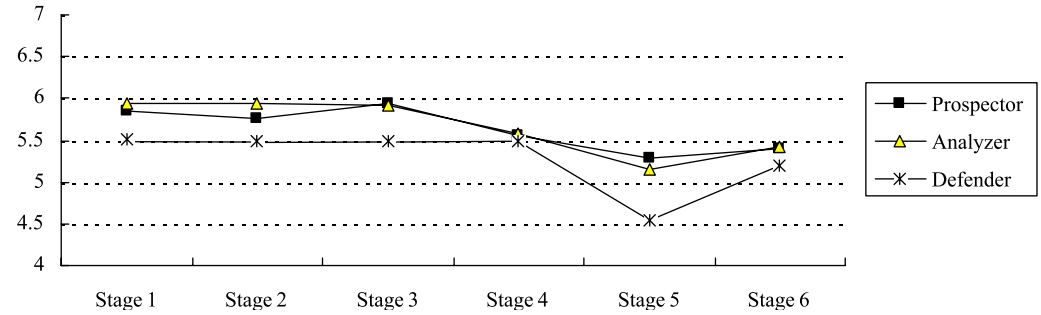


Fig. 5. Attained level of R&D–marketing cooperation by innovation strategy.

hence, generally supported, reconfirming Rochford and Rudelius' (1997) finding. A chi-square test is used to investigate the relationship between the perceived importance of R&D–marketing cooperation and innovation strategy. The result indicates that they are independent. It represents that not only does the innovation strategy not affect the perceived importance of cooperation, but also that the perceived importance of cooperation does not affect the innovation strategy. Fig. 4 exhibits the levels of perceived importance of cooperation for three different innovation strategies.

H3b proposes that Defenders have lower attained levels of cooperation. As shown in Table 5 and Fig. 5, defenders have attained lower levels of cooperation than the other two at all six NPD stages. However, it is only significantly different at product development ($P<.05$) and pilot run stages ($P<.01$). Therefore, H3b is only partially supported.

H3c proposes that Defenders have a lower NPD performance than Prospectors and Analyzers. In Table 5, the data show that Defenders have the worst NPD performance, and their performance is significantly different from that of Prospectors and Analyzers ($P<.001$). The results support H3c. Cooper and Kleinschmidt (1995) found that a firm with a clear product strategy that is able to leverage its existing markets and technologies has a better NPD performance. The study reports a consistent result with their findings.

5.4. Environmental uncertainty

H4a proposes that environmental uncertainty can strengthen the perceived importance of R&D–marketing cooperation. To test the effects of environmental uncertainty, the median is used to split the data into two groups: high and low environmental uncertainty. The levels of perceived importance at all six stages are tested. The differences between the high- and low-environmental-uncertainty groups are only significant at the product planning stage ($P=.03$) and, thus, H4a is not supported, as shown in Fig. 6. The result is contradictory with prior research findings. In the IT industry, product life cycles are very short, and technology and the market are ever changing. NPD team members are used to facing an uncertain environment, and they take it as being normal. This might be the reason why the result is different from that of prior research.

H4b postulates that environmental uncertainty can enhance the attained level of cooperation. Fig. 6 clearly exhibits that the high-environmental-uncertainty group has a higher attained level of cooperation than the low-environmental-uncertainty group. However, the differences between the two groups are only significant at the prototyping ($P=.04$) and pilot run ($P=.035$) stages. Therefore, H4b is partially supported. Although the impact of the environmental uncertainty to NPD performance is not included in the study, the data show that the high-environmental-uncertainty group has a lower performance than that of the low-envi-

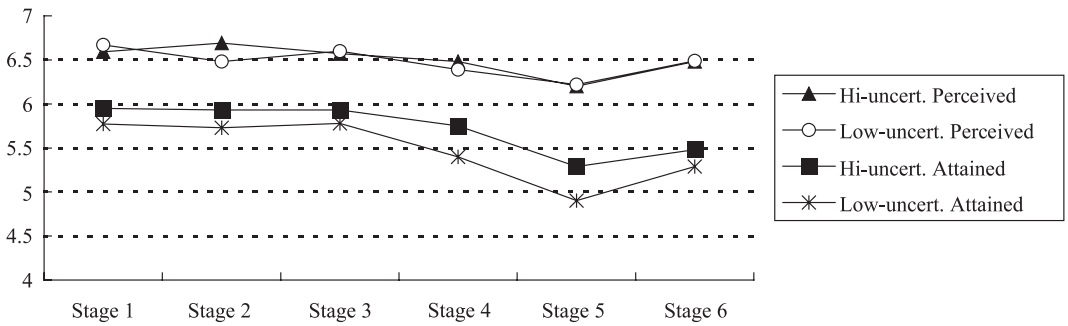


Fig. 6. Perceived importance and attained level: high uncertainty versus low uncertainty.

Table 6
Standardized regression results on NPD performance

	Model 1	Model 2
Cooperation	0.41***	0.72*
STGY0	− 0.05	0.26
STGY1	− 0.24 **	0.31
Uncertainty	− 0.10	0.29
Cooperation × STGY0		− 0.31
Cooperation × STGY1		− 0.54
Cooperation × Uncertainty		− 0.47
Model *F*-statistic	11.43***	6.67***
Adjusted R^2	.22	.21

* $P<.01$.
** $P<.05$.
*** $P<.001$.

ronmental-uncertainty group (mean = 4.83 vs. 5.09, respectively). This implies that environmental uncertainty is bad for NPD performance in the IT industry.

5.5. The moderating effects

A linear regression analysis is used to test the moderating effects of innovation strategy and environmental uncertainty on the relationship between the attained level of R&D–marketing cooperation and NPD performance. Two dummy variables, STGY0 and STGY1, are used to represent three innovation strategies. For the Prospector, STGY0 = 0 and STGY1 = 0. For the Analyzer, STGY0 = 1 and STGY1 = 0. For the Defender, STGY0 = 0 and STGY1 = 1. Table 6 shows the regression results. Model 2 reveals that the moderating effects of innovation strategy and environmental uncertainty are not significantly supported. The results reconfirm the findings of Olson et al. (2001) and Souder et al. (1998).

5.6. R&D and marketing managers' perspectives

Prior research studies found that R&D and marketing personnel do not inherently, easily cooperate together due to differences on personality, language, way of thinking, and responsibilities (Griffin & Huaser, 1996; Gupta et al., 1986; Moenaert, Souder, De Meyer, & Deschoolmeester, 1994; Olson et al., 2001). However, this study reports that R&D and marketing managers only exhibit different perceived importance of cooperation at the prototyping stage ($P=.01$) and different attained levels of cooperation at the product planning stage ($P=.05$). There are no significant differences at the other stages. This means that the perspectives of R&D and marketing managers on cooperation are generally not different in Taiwan's IT industry. With the same perception, R&D and marketing personnel can closely cooperate together. This might be one of the reasons why Taiwan's IT industry has performed so successfully over the past decades. Fig. 7 presents the data of R&D and marketing managers' perspectives on the perceived importance and the attained level of cooperation.

6. Conclusion

This study extends NPD research to Taiwan's IT industry, which mainly focuses on OEM/ODM business. The island's IT industry has achieved tremendous growth rates over the last two decades, yet, few studies have systematically investigated the successful NPD practices of this emerging country. This research enhances the understanding of the NPD process in Taiwan's IT industry, providing insights to academic researchers and industrial experts who are interested in Taiwan's IT industry. The authors believe that the findings can also be a valuable reference for other developing countries that are facing a similar situation as Taiwan did. From the survey, the authors find that although an ODM business does not involve marketing activities to end-users, ODM firms still need to invest sufficient resources for marketing activities. If a firm is able to plan and develop new products that meet customers' requirements and propose products before the ODM customers request them; then, ODM customers will be satisfied and more willing to do business with the firm.

Some key success factors to Taiwan's IT industry are pointed out in *Made by Taiwan* (Chang & Yu, 2001, chap. 12), including sufficient amount of hardworking engineers, returning overseas-educated professionals, clustered firms in industrial parks, etc. Currently, these phenomena are also occurring in mainland China, as a huge and growing pool of young Chinese engineering talent are studying in U.S.

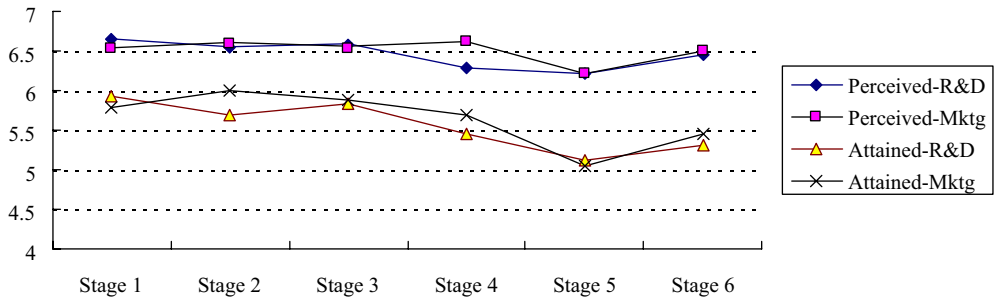


Fig. 7. R&D and marketing comparison.

universities now. Mainland China has gradually liberalized its economic strategy and achieved distinguished growth in the past years. Many overseas educated talents are willing to return back there, and young engineers are working hard now in start-up firms. With the help of Taiwanese professionals, new scientific parks in mainland China have clustered numerous IT manufacturers together. Taiwan's successful experience is being duplicated in mainland China, on a bigger scale. Referring to the Taiwan IT experience, it is believed that mainland China can shorten its learning curve and accelerate its development. Mainland China owns the biggest potential market and has grown rapidly very recently. Multinational corporations (MNCs) are aggressively extending their market territory there. This study can provide valuable suggestions to them.

6.1. Managerial implication

This study provides several important managerial implications on R&D and marketing cooperation in the NPD process. First, through continuous education and training, the perceived importance of R&D–marketing cooperation has been a consensus in the IT industry. Merely having a higher level of perceived importance of R&D–marketing cooperation does not assure that an NPD project will gain a better performance. Only those NPD projects that have effective R&D and marketing cooperation can achieve a higher successful rate. To gain a better NPD performance, R&D and marketing personnel must effectively cooperate together. How to educate and train the NPD team members to achieve the cooperation is the essential task of managers. Top management should think about how to design an organizational structure to enhance cross-functional cooperation, and then improve the NPD performance. This is the most important insight contributed by this study.

Second, an innovation strategy has little impact on the perceived importance of R&D–marketing cooperation in the IT industry, but it does have a strong relationship with NPD performance. Firms that adopt the Defender strategy have the worst NPD performance in comparison with firms that adopt the Prospector or Analyzer strategy. If a firm has the position as a standard creator, it should be as a Prospector to catch the market opportunity and to obtain the utmost benefits. When a firm is not in the position to set up a standard, it must at least be an Analyzer to gain a better performance. NPD managers who are able to appropriately fit their innovation strategies with a market position will obtain a higher NPD successful rate. Firms with a Defender strategy should strengthen their R&D and marketing investment, so that they can upgrade to be an Analyzer or a Prospector and then improve their NPD performance.

Third, environmental uncertainty is a big challenge to the IT industry. Due to an extremely short product life, there is no room for an NPD team to redesign new products. R&D and marketing personnel must work closely from the beginning to the end to react against technical and market uncertainty. Furthermore, environmental uncertainty is the nature of the IT industry. NPD managers must think of how to strengthen their integrating mechanism to cope with uncertainty. For example, using information and communication technologies (ICT), such as Internet, intranet, and videoconference facilities, can speed up information collection and exchange.

6.2. Limitations and suggestions for future research

Some potential limitations of this study should be explicitly recognized and taken into account when interpreting the findings. First, the results must be interpreted with caution because the study focuses on Taiwan's IT industry. The setting is in an intensely competitive industry and in a newly developing country. One must be careful when extending the results to other countries or other industries. However, the IT industry is the fastest growing industry worldwide, and many developing countries are interested in improving their country development. As such, Taiwan's IT experience is a valuable reference. Another concern is the possibility of bias by using perceptual measures on the variables of NPD performance. Although using objective measures might overcome this concern, they are difficult to be implemented because many firms are reluctant to provide private financial data, particularly at the project level. Moreover, it is difficult to make meaningful comparisons of objective performance measures across different industries.

The results suggest general directions for firms seeking to improve their NPD activities. Further study in this research stream can be devoted to develop specific action plans from these results. Future research can be conducted in other Asian emerging countries, as the region contains about one third of the world's population, and each country is struggling to transform itself from a developing country to a developed country. Currently, mainland China is very aggressive in developing its high-technology infrastructure. With the same language and the same race, but a different economic structure, Taiwan's successful experience is now being duplicated in China and is accomplishing good results. However, any modification of Taiwan's NPD experience that has been successfully applied to mainland China is an interesting topic for continuous investigation. The R&D and marketing managers of Taiwanese IT firms exhibit similar perspectives on R&D–marketing cooperation. Does this phenomenon have any relationship with their outstanding performance? It is worthwhile to examine this issue further.

Acknowledgements

The authors thank Peter J. LaPlaca, the editor-in-chief, and three anonymous reviewers for their constructive comments on an earlier version of this article.

Appendix A. Measurement items in brief and their sources

Constructs	Measurements	Sources
R&D–marketing cooperation	Feasibility study	Song and Parry (1992) and this study
	R&D and marketing jointly discuss the customers' requirement.	
	R&D and marketing jointly generate new product ideas.	
	Product planning	
	Marketing provides information to R&D on regulatory and legal restrictions.	
	Marketing is involved with R&D in establishing NPD schedule.	
	Marketing is involved with R&D in setting NPD goals and priorities.	
	Product development	
	Marketing is involved with R&D on product implementation trade-off.	
	R&D is involved with marketing in modifying products according to market's request.	
	Prototyping	
	Marketing is involved with R&D on product performance evaluation.	
	Marketing is involved with R&D on product cost evaluation.	
	Pilot run	
	R&D is involved with marketing in designing user and service manuals.	
	Marketing provides information to R&D on market testing results.	
	Mass production	
	R&D is involved with marketing in training users of new products/technologies.	
	Marketing provides information to R&D on competitors' strategies and reactions.	
	Marketing regularly provides information to R&D on feedback from customers.	
	(All are seven-point Likert scales, 7 = *strongly agree*)	
Environmental uncertainty	Market uncertainty	Jaworski and Kohli (1993) and this study
	It is hard to know customers' needs.	
	It is hard to understand competitors' strategies.	
	It is hard to predict competitors' product announcement.	
	Technical uncertainty	
	It is difficult to acquire technology.	
	Technology changes rapidly.	
	(All are seven-point Likert scales, 7 = *strongly agree*)	
NPD performance	Timeliness	Griffin and Hauser (1996)
	Profitability	
	Overall success	
	(All are seven-point Likert scales, 7 = strongly agree)	

References

Atuahene-Gima, K., & Felicitas, E. (2000). Cross-functional influence in new product development: An exploratory study of R&D and marketing perspectives. *Management Science*, *46*(10), 1269–1284.

Bargh, J. A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: Direct effects of trait construct and stereotype priming on action. *Journal of Personality and Social Psychology*, *71*(2), 230–244.

Calantone, R. J., & Di Benedetto, A. C. (1988). An integrative model of the new product development process: An empirical validation. *Journal of Product Innovation Management*, *5*(3), 201–215.

Chang, C. Y., & Yu, P. L. (2001). *Made by Taiwan: Booming in information technology era*. Singapore: World Scientific Publishing (Chap. 12).

Cooper, R. G. (2001). *Winning at new products: Accelerating the process from idea to launch* (3rd ed.). Massachusetts: Persus Publishing.

Cooper, R. G., & Kleinschmidt, E. J. (1987). New products: What separates winners from losers? *Journal of Product Innovation Management*, *4*(3), 169–187.

Cooper, R. G., & Kleinschmidt, E. J. (1995). Benchmarking the firm's critical success factors in new product development. *Journal of Product Innovation Management*, *12*(5), 374–391.

Gereffi, G. (1999). International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics*, *48*(1), 37–70.

Griffin, A., & Hauser, J. R. (1996). Integrating R&D and marketing: A review and analysis of the literature. *Journal of Product Innovation Management*, *13*(3), 191–215.

Gupta, A. K., Raj, S. P., & Wilemon, D. (1986). A model for studying R&D–marketing interface in the product innovation process. *Journal of Marketing*, *50*(2), 7–17.

Hise, R. T., O'Neal, L., Parasuraman, A., & McNeal, J. U. (1990). Marketing/R&D interaction in new product development: Implications for new product success rate. *Journal of Product Innovation Management*, *7*(2), 142–155.

Hofstede, G. H. (1980). *Culture's consequences: International differences in work related value*. Beverly Hills, CA: Sage Publications.

Jaworski, B. J., & Kohli, A. K. (1993). Market orientation: Antecedents and consequences. *Journal of Marketing*, *57*(3), 53–70.

Li, H., & Atuahene-Gima, K. (2001). The impact of interaction between R&D and marketing on new product performance: An empirical analysis of Chinese high technology firms. *International Journal of Technology Management*, *21*(1/2), 61–75.

Li, T. (1999). The impact of the marketing–R&D interface on new product export performance: A contingency analysis. *Journal of International Marketing*, *7*(1), 10–33.

Mathews, J. A. (1997). A silicon valley of the east: Creating Taiwan's semiconductor industry. *California Management Review*, *39*(4), 26–54.

McGrath, M. E. (1996). *Setting the PACE in product development* (Rev. ed.). Massachusetts: Butterworth-Heinemann (Chap. 3).

Menon, A., Jaworski, B. J., & Kohli, A. K. (1997). Product quality: Impact of inter-departmental interactions. *Journal of the Academy of Marketing Science*, *25*(3), 187–200.

MIC/ITIS, A. K. (2002). *2001 Marketing research of Taiwan's IT industry*. Taipei: Marketing Intelligence Center, Institute for Information Industry.

Miles, R. E., & Snow, C. C. (1978). *Organizational strategy, structure and process* (p. 29). New York: McGraw-Hill.

Moenaert, R. K., Souder, W. E., DeMeyer, A., & Deschoolmeester, D. (1994). R&D–marketing cooperation mechanisms, communication flows, and innovation success. *Journal of Product Innovation Management*, *11*(1), 31–45.

Neter, J., Kutner, M. H., Nachtsheim, C. J., & Wasserman, W. (1996). *Applied linear statistical models* (4th ed.). Chicago: Irwin/McGraw-Hill.

Olson, E. M., Walker Jr., O. C., & Ruekert, R. W. (1995). Organizing for effective new product development: The moderating role of product innovativeness. *Journal of Marketing*, *59*(1), 48–62.

Olson, E. M., Orville, C., Walker Jr., O. C., Ruekert, R. W., & Bonner, J. M. (2001). Patterns of cooperation during new product development among marketing, operations and R&D: Implication for project performance. *Journal of Product Innovation Management*, *18*(4), 258–271.

Pinto, M. B., Pinto, J. K., & Prescott, J. E. (1993). Antecedents and consequences of project team cross-functional cooperation. *Management Science*, *39*(10), 1281–1296.

Rochford, L., & Rudelius, W. (1997). New product development process: Stages and success in the medical products industry. *Industrial Marketing Management*, *26*(1), 67–84.

Ruekert, R. W., & Walker Jr., O. C. (1987). Marketing interaction with other functional units: A conceptual framework and empirical evidence. *Journal of Marketing*, *51*(1), 1–19.

Song, X. M., Montaya-Weiss, M. M., & Schmidt, J. B. (1997). The role of marketing in developing successful new products in South Korea and Taiwan. *Journal of International Marketing*, *5*(3), 47–69.

Song, X. M., Neeley, S. M., & Zhao, Y. (1996). Managing R&D–marketing integration in the new product development processes. *Industrial Marketing Management*, *25*(6), 545–553.

Song, X. M., & Parry, M. E. (1992). The R&D–marketing interface in Japanese high-technology firms. *Journal of Product Innovation Management*, *9*(2), 91–112.

Song, X. M., Thieme, R. J., & Xie, J. (1998). The impact of cross-functional joint involvement across development stages: An exploratory study. *Journal of Product Innovation Management*, *15*(4), 289–303.

Souder, W. E. (1988). Managing relations between R&D and marketing in new product development projects. *Journal of Product Innovation Management*, *5*(1), 6–19.

Souder, W. E., Sherman, J. D., & Davies-Cooper, R. (1998). Environmental uncertainty, organizational integration, and new product development effectiveness: A test of contingency theory. *Journal of Product Innovation Management*, *15*(6), 520–533.

Tatikonda, M. V., & Montoya-Weiss, M. M. (2001). Integrating operations and marketing perspectives of product innovation: The influence of organizational process factors and capabilities on development performance. *Management Science*, *47*(1), 151–172.

Tushman, M. L., & Rosenkopf, L. (1992). Organizational determinants of technological change: Toward a sociology of technological evolution. *Research in Organizational Behavior*, *14*, 311–347.

Ulrich, K. T., & Eppinger, S. D. (1995). *Product design and development* (pp. 15–7). New York: McGraw-Hill.

Yap, C. M., & Souder, W. E. (1994). Factors influencing new product success and failure in small entrepreneurial high-technology electronics firms. *Journal of Product Innovation Management*, *11*(5), 418–432.

Yeh, R -S. (1988). Values of American, Japanese and Taiwanese managers in Taiwan: A test of Hofstede's framework. *Academy of Management* (Best Papers Proceedings), 106–110.

Yusuf, S. (2003). *Innovative East Asia: The future of growth* (p. 287). Washington, D.C.: World Bank and Oxford University Press.

Louis Y.Y. Lu is now a Ph.D. student and has had more than 20 year's practical experience in the IT industry.

Chyan Yang is currently a professor in the Institute of Business and Management at National Chiao Tung University.