THE DANGER OF FEAST OR FAMINE: MANAGING CUSTOMER PARTICIPATION IN VALUE CO-PRODUCTION

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ABSTRACT

Customer participation in the new product development (NPD) process is becoming more common. Involving customers in the NPD process has been widely considered to enhance market adoption of co-created products and speed up time to market. However, several potential risks relevant to coordination among co-production activities have been raised in recent studies.

Drawing on coordination theory, this dissertation examines the conditions under which customer participation in the NPD process improves or deteriorates new product success. The specific focus is on non-linear relationships between customer participation and market adoption and time to market. Furthermore, this dissertation investigates the differential effects on market adoption and time to market of when customers are engaged, the breadth of customer participation, NPD teams' capability to leverage customer insights, product individuality, and price positioning strategy of co-produced products.

In Study 1, the hypotheses were tested using data from 647 NPD projects from SourceForge.net, a leading open source software development repository in which end users are involved in developing new software. To test generalizability of the results, Study 2 investigated the same hypotheses based on survey data from 159 NPD managers who have worked on NPD projects in which customers have been involved to some extent to co-create new products.

The results of Study 1 show that customer participation enhances market adoption up to a certain point but degrades it beyond that point. Furthermore, the inverted U-shaped relationship between customer participation and market adoption is moderated by breadth of customer participation and the NPD team's co-production capability. With regard to time to market, the

findings of Study 1 demonstrate that customer participation continuously slows time to market, confirming serious risks of customer participation. Although the curvilinear relationship found in Study 1 is not extended to various industries of Study 2, the results of Study 2 still indicate that the relationship between customer participation and market adoption is moderated by the timing and breadth of customer participation, and product individuality. The findings highlight a close analysis of benefits and costs of customer participation and provide insights into how and when customers should be engaged in the NPD process.

LIST OF ABBREVIATIONS AND SYMBOLS

a	Cronbach's index of internal consistency
df	Degrees of freedom: number of values free to vary after certain restrictions have been placed on the data
F	Fisher's *F* ratio: A ration of two variances
ΔF	Change in Fisher's *F* ratio
M	Mean: the sum of a set of measurements divided by the number of measurements in the set
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
r	Pearson product-moment correlation
R^2	Coefficient of determination
ΔR^2	Change in the coefficient of determination
S.D.	Standard deviation
S.E.	Standard error
t	Computed value of *t* test
<	Less than
=	Equal to

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CHAPTER 1

INTRODUCTION

Customer participation in the new product development (NPD) process has become common. More than 120,000 customers around the world served as voluntary members of Boeing's World Design Team and contributed ideas and input regarding the design of its new 787 Dreamliner airplane (O'Hern and Rindfleisch 2009). Each week, Threadless.com, a Chicago-based fashion start-up, markets new T-shirt designs created and chosen by end customers (Fuchs, Prandelli, and Schreier 2010). P&G's Connect + Develop program enables customers to submit their ideas for new product offerings or for P&G's specific needs and offers rewards for the selected ideas. Bounce, P&G's dryer sheets, was introduced through P&G's Connect + Develop program (O'Hern 2009). In the open source software development process, end customers are eagerly involved in developing, improving, and testing new software programs. Linux and Firefox are successful products that resulted from customer participation in the open source software context.

Academic researchers have noticed the benefits of this new approach in the value creation process. Companies which have traditionally managed new product development or innovation as an internal process based on their own skills and capabilities began to open their value creation processes to outside members including end customers and suppliers. Chesbrough (2003) named this approach "open innovation." Drawing on service-dominant logic developed by Vargo and Lusch (2004), researchers in marketing have also focused on customers' contributions in the NPD process (e.g., Alam 2002; Hoyer et al. 2010; O'Hern 2009).

Researchers and managers alike have recognized the value creation approach via customer participation as a viable alternative to create new products and have emphasized the benefits (O'Hern and Rindfleisch 2009; Prahalad and Ramaswamy 2004; Vargo and Lusch 2004). For instance, involving customers in the NPD process enables NPD teams to more closely mirror customer needs and find ways to solve these needs, which in turn increases market acceptance of co-produced products (Enkel, Perez-Freije, and Gassmann 2005; Ernst et al. 2011; Nambisan 2002). Furthermore, because customer participation helps identify and correct need-related problems of products early in the NPD process and customers take charge of certain portions of the development process as co-developers, the time that elapses until the product is launched in the market may be decreased (Alam 2002; O'Hern and Rindfleisch 2009; von Hippel and Katz 2002).

However, customer participation in the NPD process does not come without costs (e.g., Fang 2008; Hoyer et al. 2010). Customer participation in the NPD process may diminish the company's control and increase the complexity of the NPD process (Hoyer et al. 2010). Increasing customer input can potentially overload the process, causing confusion, coordination problems, and duplication of effort (Datar et al. 1996; Sethi 2000). Malone and Crowston (1994) and Heath and Staudenmayer (2000) pointed out difficulties in integrating and coordinating interdependent work between firms and customers in the value co-production process.

Despite these potential costs of customer participation, there has been little research on conditions under which customer participation deteriorates new product success. The conflicting arguments regarding customer participation suggest that it may not always lead to greater market adoption or result in shorter time to market and that these effects might hinge on certain additional conditions. Thus, the objective of this dissertation is to examine the conditions under

which customer participation in the NPD process enhances or deteriorates market adoption, time to market, or both. More formally, the basic research question relates to whether there are nonlinear relationships between the level of customer participation and market adoption and time to market. Customer participation may improve market adoption and speed up the development process to a certain point, but deteriorate them beyond that point.

Furthermore, this dissertation addresses three contextual variables related to how companies implement customer participation in the NPD process and two contextual variables related to product-specific characteristics. First, the timing of when companies engage customers in the NPD process might affect the effects of customer participation on new product success. According to Gruner and Homburg (2000) and Hoyer et al. (2010), customers' main role and their contributions at different NPD stages vary. For example, customer participation in early NPD phases such as ideation and concept development versus in later NPD phases such as product testing may improve market adoption but delay time to market. Second, it is likely that the effects of customer participation depend on the breadth of customer participation in the NPD process. For instance, customer participation in a wide range of activities versus customer participation in just one activity may enhance market adoption but hinder quick launch. Third, the effectiveness of customer participation is expected to be contingent on the NPD team's co-production capability. NPD teams which have a high level of ability to effectively leverage insights from customer participation might not only improve market adoption but also accelerate time to market.

In addition to contextual variables related to customer participation execution, the impacts of customer participation may vary depending on product and market characteristics. The effects of customer participation on market adoption may be more valued in markets in

which highly individualized products are offered or product price is relatively high. This is because reflecting customer's needs through customer participation is more important in these markets (Homburg, Müller, and Klarmann 2011). Therefore, the dissertation tests whether the effects of customer participation on market adoption hinge on two product-specific characteristics (i.e., product individuality and product price positioning).

The research questions are examined with two different samples. In Study 1, the nonlinear relationships and three potential moderating effects related to customer participation implementation are tested using archival data from SourceForge.net, a website created to manage a wide variety of open source software development projects. This is an appropriate context to test the research questions because open source software development projects on the web offer the opportunity for customers to participate by suggesting new features, reporting bugs, developing patches, and so on. However, the findings in one specific context (i.e., open source software development) may not necessarily be generalized to other contexts due to market and product characteristics of software. Study 2 is conducted in an attempt to validate the findings of the first study and assess the potential moderating impacts of industry and product characteristics. Survey data are collected from NPD managers who have worked on NPD projects in which end customers have been involved to some extent. The survey sample includes a variety of industries which show different levels of product individuality and price positioning.

Contributions of the Dissertation

The findings of these studies are expected to make several theoretical contributions. First and foremost, by integrating coordination theory with service-dominant logic, a theoretical explanation can be provided of the conditions under which customer participation enhances or deteriorates new product outcomes. Research on customer participation to date has focused on

showing desirable outcomes of customer participation within service-dominant logic. However, service-dominant logic may not explain the whole story of how the effects of customer participation on new product success hinge on additional circumstances. The concept of coordination neglect suggested by Heath and Staudenmayer (2000) and the coordination theory developed by Malone and Crowston (1994) bridge the gap by identifying psychological barriers that get in the way of integrating individual work into a common goal and coordination problems that occur when coordination mechanisms do not work well.

Second, the findings highlight the importance of a NPD team's co-production capability. Previous literature on co-production has primarily placed emphasis on how to engage customers in more co-production activities. Thus, much attention has been paid to building various places such as online communities for active customer participation and promoting interactions and collaboration between customers and organizations (Ballantyne and Varey 2006; Ramani and Kumar 2008). However, merely involving customers in more co-production activities is not enough to generate positive effects of customer participation. There has been a growing emphasis on reflecting and leveraging input arising from customer participation (Bendapudi and Leone 2003; Fuchs, Prandelli, and Schreier 2010). This dissertation bridges the gap by proposing a new construct which captures a NPD team's co-production capability to leverage customers' input and empirically testing the moderating effect of the NPD team's co-production capability. The findings of Study 1 confirm that companies with a high level of co-production capability can obtain more benefits from customer participation without costs.

Third, the dissertation shifts the boundaries of customer participation from Business to Business (B2B) to Business to Customer (B2C). Previous studies of customer participation in the NPD process have been conducted in the B2B context, specifically focusing on co-production

between manufacturers and suppliers (Hoyer et al. 2010; O'Hern 2009). However, as shown in the cases of Boeing's 787 Dreamliner, Threadless, and open source software development projects, end customers are increasingly involved in various parts of the NPD process. In addition, end customers' participation may differ from suppliers' involvement in NPD in that suppliers are relatively limited in terms of numbers and have extensive knowledge about particular NPD projects compared with end customers. Therefore, efficient coordination, reducing complexity, and maximizing the benefits of divergent ideas might play more important roles in co-production with end customers. The results of this dissertation shed light on the benefits and risks of end customers' participation in the NPD process.

These results also provide managerial implications into how customer participation in the NPD process should be implemented and in which markets companies should engage customers in the NPD process. First, the dissertation sounds a warning to organizations which have jumped on the bandwagon of co-production without a close analysis of the benefits and costs of customer participation. The inverted U-shaped relationship between customer participation and market adoption and continuous increase in time to market found in Study 1 imply that managers need to take into account the trade-off between benefits and costs of customer participation. Because the costs of customer participation on new product success are greater especially in technology-driven industries such as IT and software development, managers need to seriously consider how to engage customers.

Second, the findings provide insights into questions of how customers should be engaged in NPD. In particular, the findings from both studies show a strong moderating impact of breadth in the relationship between customer participation and new product success. As the breadth of customer participation increases, the positive impact of customer participation on market

adoption increases. In contrast, broad customer participation lengthens time to market more than narrow customer participation. The result demonstrates that there is a trade-off among the two different measures of new product success. Broad customer participation contributes to improving market adoption but is detrimental to time to market. Thus, when companies decide how broadly customers are involved in the NPD process, they need to consider their goal. When the goal of a NPD team is to develop a new product which reflects well customers' needs at the cost of time to market, a NPD team needs to engage customers broadly. In industries that emphasize fast launch of new products due to short product life cycle time and heightened competition (Chen, Damanpour, and Reilly 2010), NPD teams could see better benefits by engaging customers narrowly.

Third, the results suggest that the effects of customer participation on market adoption vary depending on the level of product individuality. As shown in Study 2, in markets where individualized products are offered to customers, customer participation improves market adoption, whereas in markets whose products are less individualized, the impact of customer participation on market adoption is immaterial. The results imply that managers need to take into account product characteristics as well when engaging customers in their NPD process.

Finally, the findings from the two complementary samples indicate that the impact of customer participation can depend on industry characteristics. Overall, the results from Studies 1 and 2 show that the costs of customer participation are greater in technology-driven industries such as software development. Ordinary customers may lack the technical expertise and experience required in the technology-driven NPD process. Thus, end customers' participation in technology-intensive product development may increase complexity but not provide insights good enough to be accepted by companies.

Organization of the Dissertation

Chapter 1 provides an introduction to the topic area, contributions of the study, and overall organization of the dissertation. Chapter 2 reviews the literature on co-production, customer participation, and customers' roles in the NPD process and new product success as well as the theoretical foundations of service-dominant logic and coordination theory. Chapter 3 develops the hypotheses and offers logical arguments behind them. The hypotheses are tested using two types of data: archival data from SourceForge.net and survey data from NPD managers. Chapter 4 provides a description of Study 1, including how focal constructs are measured and analyzed using archival data from SourceForge.net. The results using data from SourceForge.net are described and discussed. Chapter 5 offers a description of Study 2 and outlines the measures and analysis method using survey data. The findings based on survey data from NPD managers are given and discussed. Finally, Chapter 6 summarizes main findings from both studies and provides theoretical and managerial implications. Limitations of the dissertation are discussed and new venues for future research are described.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FOUNDATIONS

Co-Production in New Product Development

Traditional marketing thought and practice largely view value creation as an internal, firm-based process in which end customers are relatively passive buyers and consumers (O'Hern and Rindfleisch 2009; Prahalad and Ramaswamy 2004; Vargo and Lusch 2004). In the conventional value creation process, firms and customers had distinct roles of production and consumption, with firms regarded as the only subjects to generate value *for* customers (Prahalad and Ramaswamy 2004). However, this traditional paradigm is currently being challenged by a new perspective in which customers are viewed as active co-creators of the value they buy and use. Value is not generated *for* customers but jointly created *with* customers (Restuccia 2009). In a similar vein, Payne, Storbacka, and Frow (2008) contend that firms are being asked to change their production logic from *Inside-Out* (making, selling and serving) to *Outside-In* (listening and co-creating).

Against this backdrop, companies are increasingly encouraging direct involvement of end customers and high-quality interaction between firms and end customers in the NPD process to co-create value (Restuccia 2009). Boeing's Dreamliner jet, Threadless.com's T-shirts, and P&G's Connect + Develop program, to name a few, are good examples of how companies engage end customers in the NPD process. In this dissertation, co-production in NPD is defined as collaborative new product development activity that actively engages end customers in the NPD process (O'Hern 2009). Co-production in NPD could involve end customers providing new

product ideas or new features, participating in designing new products, engineering new products, testing new products before launch, and commercializing new products.

In the basic definition, co-creation refers to collaborative behaviors when customers and firms are intimately involved in *jointly creating value* (Prahalad and Ramaswamy 2004). In the literature, the terms co-creation and co-production are sometimes used interchangeably, or the concept of co-creation sometimes involves the idea of co-production. However, several researchers distinguish co-production from co-creation (e.g., Etgar 2008; Lusch and Vargo 2006; Saxena 2010). Lusch and Vargo (2006) define co-creation as all cooperative activities between consumers and firms in the *usage* or *consumption stage*, whereas co-production is defined as all cooperative activities between consumers and firms in the *production process* of the core offering itself, which precedes the usage stage. To clarify the phenomenon, end customers' active participation in the development stage of a core offering will be referred to as co-production rather than co-creation throughout the dissertation.

The emphasis on interaction and dialogue between companies and customers is not new. Ideas related to marketing concept, market orientation, and customer orientation have echoed the importance of interaction (e.g., Deshpandé, Farley, and Webster 1993; Jarworski and Kohli 1993; Kohli and Jaworski 1990; Narver and Slater 1990). However, co-production is neither market orientation nor a (mass) customization of products and services (Franke, Keinz, and Steger 2009; Franke, Schreier, and Kaiser 2010; Prahalad and Ramazwamy 2004). In addition, co-production in the NPD process is different from conventional market research in which customers' needs are examined through various research tools such as customer focus groups, direct observation of product use, and interviews with end customers.

First, co-production in the NPD process emphasizes the creative act itself; customers are actively engaged in designing and developing new product improvements. Market orientation and traditional marketing research methods focus on obtaining information from customers by either soliciting their reactions to new product concepts or gathering their ideas and insights (Aaker 1995). Co-production activities, in contrast, require that customers not only engage in a process of *ideation* but also devote substantial energy to the actual *creation* of new product solutions (O'Hern 2009). The other important feature which distinguishes co-production from traditional company-customer interaction is customers' autonomy or empowerment (Piller, Ihl, and Vossen 2010). According to Ramani and Kumar (2008), customers' empowerment refers to giving customers a voice in–and an opportunity to change–a company's general offerings. Although each NPD project grants different degrees of freedom to customers in the NPD process, end customers in the co-production process have some autonomy to influence new products. In a nutshell, co-production in the NPD process is collaborative new product development activity beyond conventional customer participation in the process of ideation in which empowered customers are actively involved in the actual production of new offerings.

Customer Participation

Customer participation refers to the extent to which customers are involved in the NPD process (Fang 2008; Gruner and Homburg 2000). In the co-production context, the terms customer involvement (e.g., Carbonell, Rodriguez-Escudero, and Pujari 2009; Magnusson, Matthing, and Kristensson 2003), customer integration (e.g., Enkel, Perez-Freije, and Gassmann 2005; Moeller 2008), customer interaction (e.g., Alam 2006; Gruner and Homburg 2000), and customer empowerment (e.g., Fuchs, Prandelli, and Schreier 2010; Ramani and Kumar 2008)

have been used interchangeably to describe the phenomenon of customers playing an active role in the value creation process. Table 2.1 provides definitions of similar concepts of co-production.

Table 2.1

Definitions of Similar Concepts of Co-Production

Concepts	Definition	Sources
Co-production	Activity to engage customers as active participants in the organization's work	Auh et al. (2007); Lengnick-Hall, Claycomb, and Inks (2000)
	All cooperation formats between consumers and production partners in the production process which precedes the usage stage	Lusch and Vargo (2006); Etgar (2008)
	Buyer-seller social interaction and adaptability with a view to adding further value	Wikström (1996)
Co-creation	All cooperation formats between consumers and partners in the usage/consumption stage	Lusch and Vargo (2006); Etgar (2008)
	Collaborative new product development activity that actively engages customers in the design and development of a new product offering	O'Hern (2009)
	Collaborative new product development activity in which consumers actively contribute to and select various elements of a new product offering	Hoyer et al. (2010)
Customer Participation	The degree to which the customer is involved in producing and delivering the service	Bendapudi and Leone (2003); Dabholkar (1990)
	The extent to which the customer is involved in the manufacturer's NPD process	Fang (2008)
	The breadth and depth of the customer's involvement in the NPD process	Fang, Palmatier, and Evans (2008)
	Behavioral construct that measures the extent to which customers provide/share information, make suggestions, and become involved in decision making	Chan, Yim, and Lam (2010)
Customer Engagement or Customer Engagement Behaviors	Customer's behavioral manifestations that have a brand or firm focus, beyond purchase, resulting from motivational drivers	Hoyer et al. (2010); van Doorn et al. (2010); Verhoef, Reinartz, and Krafft (2010)

	The intensity of the consumer's participation and connection with the organization's offerings and/or its organized activities	Vivek (2009)
Customer Empowerment	The phenomenon that consumers desire to play a greater role in the process of value creation	Ernst et al. (2011)
	The extent to which a firm provides its customers avenues to (1) connect with the firm and actively shape the nature of transactions and (2) connect and collaborate with each other by sharing information, praise, criticism, suggestions, and ideas about its products, services, and policies	Ramani and Kumar (2008)
	A strategy firms use to give customers a sense of control over a company's product selection process	Fuchs, Prandelli, and Schreier (2010)
Customer Integration	The incorporation of resources from customers into a company's processes	Moeller (2008)
Customer Involvement	The extent to which service producers interact with current or potential representatives of one or more customers at various stages of the new service development process	Carbonell, Rodriquez-Escudero, and Pujari (2009)
Customer Interaction	Interactions between service producers and the representatives of one or more customer firms at various stages of a new service development process	Alam (2006)

Even though considerable research has been conducted on customer participation in a business-to-business context, the existing literature still falls short of offering a clear conceptualization of customer participation because customer participation occurs in many forms and degrees (Fang 2004; Meuter and Bitner 1998). For example, Chan, Yim, and Lam (2010) view customer participation as a behavioral construct to measure the extent to which customers provide or share information, make suggestions, and become involved in decision making. In other words, they assess the degree of customer participation in terms of *amount of information provision*. This definition of customer participation reflects the perspective that customers in co-

production activities are an information resource (Fang 2008; Nambisan 2002). Claycomb, Lengnick-Hall, and Inks (2001) and Hsieh, Yen, and Chin (2004) also note that information provision is an important dimension of customer participation.

In contrast, Gruner and Homburg (2000) and Carbonell, Rodriguez-Escudero, and Pujari (2009) place more emphasis on *intensity of actual interaction* between customers and a company. The number of involved customers, the duration, and the frequency of interaction are main components to capture customer participation. Combining these two dominant ways to assess the degree of customer participation in the value co-creation process, I define customer participation in the NPD process with two dimensions: *amount of information* provided by end customers and *intensity of actual interaction* between end customers and a company. In a similar vein, Sheng (2009) recently measured customer participation using the amount of information that a customer provided, the amount of time that a customer spent, and the extent of effort and work that a customer contributed.

Customer Roles in the NPD Process

Recently, customer participation has been regarded as a new source of a firm's competitive advantage and a differentiator in the future (e.g., Bendapudi and Leone 2003; Ramani and Kumar 2008). In most cases, researchers have examined the merits of active customer participation in the NPD process (Sheng 2009). In particular, the benefits that companies can obtain from customer participation have been explained by two distinct roles of customers in the NPD process: information providers and co-developers (e.g., Lengnick-Hall 1996; Fang 2008; Nambisan 2002).

The former involves activities such as sharing information on customers' needs or new product ideas with the NPD team. As an ultimate target which should be satisfied by a firm, end

customers can supply accurate and diverse information on their needs to NPD teams. Thus, from a firm's perspective, end customers are an excellent source of useful information that should be integrated in the NPD process. The role of co-developers refers to the extent to which end customers play a pivotal role in developing a significant portion of the development tasks. The role of co-developers ranges from product design activities to product engineering activities (Nambisan 2002). For example, in the software industry, enterprise software developers like Microsoft and SAP often have representatives from customers as members of their product development teams (Hoch, Roeding, and Lindner 1999). Because end customers may have valuable developmental technology or skills that NPD teams do not hold in house, firms need to integrate their development technology or skills by engaging customers as co-developers in the NPD process. As a result of this integration, NPD teams may enhance new product success. Table 2.2 summarizes the main roles of customers in the NPD process.

Table 2.2

Customer Roles in the NPD Process

Customer Role	NPD Phase	Key Issues/Managerial Challenges
Customer as information resource	Ideation	· appropriateness of customer as a source of innovation · selection of customer innovator · need for varied customer incentives · infrastructure for capturing customer knowledge
Customer as co-developer	Design and Development	· involvement in a wide range of design and development tasks · nature of the NPD context: industrial/consumer products · tighter coupling with internal NPD teams · managing the attendant project uncertainty · enhancing customers' product/technology knowledge

Adapted from Table 1 of Nambisan (2002)

New Product Success

New product success is a multifaceted concept (Campbell and Cooper 1999; Griffin and Page 1993; see Cooper 1979 and Griffin and Page 1993 for various dimensions of new product success). Griffin and Page (1993) identified various measures of new product success. Combining their literature review on measures of new product success with the results of surveys from companies, they classified measures of new product success into five dimensions: (1) firm-level measures such as percentage of sales by new products; (2) program-level measures; (3) product-level measures including speed to market, product quality, and development cost; (4) measures of financial performance such as new product's profitability; and (5) measures of customer acceptance such as customer satisfaction.

More recent contributors provide broader categorization. Tatikonda and Montoya-Weiss (2001) argue that new product success can be evaluated by operational and market perspectives. Operational outcomes emphasize project work execution, or how effectively and efficiently a NPD project is implemented. They typically assess time to market, development cost, and product quality from an internal perspective (Carbonell, Rodriguez-Escudero, and Pujari 2009; Tatikonda and Montoya-Weiss 2001). In contrast, market outcomes reflect how well customers in the market accept the new product and how much financial success companies can achieve through the new product. In comparison to operational outcomes, market outcome measures assess the development effort from an external perspective (Carbonell, Rodriguez-Escudero, and Pujari 2009; Tatikonda and Montoya-Weiss 2001). Following Tatikonda and Montoya-Weiss (2001), new product success is assessed in this study from both operational and market perspectives. Time to market, defined as the time elapsed between the initial development and the ultimate introduction of a product into the marketplace (Griffin 1997), will be included in an

attempt to evaluate the efficiency of project execution. In addition, market adoption, defined as the extent to which customers buy the new product (O'Hern 2009), will be utilized to measure market outcomes for the new product. Table 2.3 summarizes dimensions of new product success in the literature.

Table 2.3

Dimensions of New Product Success

Dimensions	Focus	Example Measures
Operational Outcome	· efficiency of implementation of NPD projects · work execution · internal perspective	· time to market · development cost · product quality · product performance · launched on schedule
Market Outcome	· customer acceptance of products · financial performance · external perspective	· customer adoption · customer satisfaction · revenue · market share · profitability

Service-Dominant Logic

The service-dominant logic of marketing provides a foundation for value co-creation between customers and NPD teams (Vargo and Lusch 2004). This logic has evolved from the ideas of academics who argue for recognition of the customer's active role in the value creation process (e.g., Lusch, Brown, and Brunswick 1992; Normann and Ramirez 1993; Prahalad and Ramaswamy 2000). This perspective basically emphasizes the inherent collaborative nature among all of the actors in the value creation process (Lusch and Vargo 2006; Vargo 2008; Vargo and Lusch 2008). These are jointly captured in the contentions that "the customer is always a co-creator of value" and "all social and economic actors are resource integrators" in the revised foundational premises of service-dominant logic (Vargo and Lusch 2008, p. 7). Since no entity

has the expertise or relative advantage in terms of competence to perform all value-creating processes, the importance of collaboration and value co-creation by sharing resources with other economic actors becomes evident (Lusch and Vargo 2006; Vargo, Lusch, and Morgan 2006). The role as a firm's resource-integrator is expressed well in the statement that "organizations exist to integrate and transform micro-specialized competencies into complex services that are demanded in the marketplace" (Vargo and Lusch 2006, p. 53).

In the resource-integrating process, operant resources have been of greater importance than operand resources. Operand resources, defined as "resources on which an operation or act is performed to produce an effect," include natural or production resources such as land, plant life, minerals, and other natural resources, whereas operant resources are resources "which are employed to act on operand resources" such as knowledge and skills (Vargo and Lusch 2004, p. 2). Given the current economic thought that a firm's productivity is primarily dependent on knowledge and skills (Capon and Glazer 1987; Nelson, Peck, and Kalachek 1967), service-dominant logic holds that the application of specialized skills and knowledge is the fundamental unit of exchange, and knowledge and skills are viewed as key for competitive advantage (Vargo and Lusch 2004). From a firm's perspective, customers' competences (e.g., knowledge and skills) become valuable operant resources for the firm and goods, and the firm receives support from integrated knowledge and skills (Akaka 2007; Edvardsson, Tronvoll, and Gruber 2011; Lengnick-Hall 1996; Nambisan 2002). Specifically, customers can directly provide market information, which allows the manufacturer to capture their needs more effectively in product design. In addition, customers may provide access to development capabilities and other resources that the manufacturer lacks in-house (Campbell and Cooper 1999). Consequently, co-production between customers and NPD teams generates better value through information and

resource integration. This logic has supported the argument that customer participation in the NPD process has positive effects on new product success.

Coordination Theory

However, service-dominant logic does not take into account coordination problems which may arise from integrating customers in the NPD process. Coordination is a process that is required when one or more *actors* perform *interdependent activities* to achieve *goals* (Crowston 1997; Malone 1988; Malone and Crowston 1990). Specifically, the need for coordination is generated by two types of interdependencies: among actors and among activities. Many organizational researchers have defined interdependency or dependency as arising between multiple actors who attempt to accomplish their goals (Crowston 2003). For example, Victor and Blackburn (1987) defined dependency as the "extent to which a unit's outcomes are controlled directly by or are contingent upon the actions of another unit" (p. 490). McCann and Ferry (1979) similarly defined interdependency as "when actions taken by one referent system affect the actions or outcomes of another referent system" (p. 113). In contrast to most organizational researchers, researchers studying dependency in other fields have analyzed dependency arising between activities. For instance, a software engineer planning to change one module in a computer system must first determine if the change will affect other modules because of interdependency among modules. In developing coordination theory, Malone and Crowston (1994) have also viewed dependence as arising between activities. According to coordination theory, dependencies among activities are primarily generated in four cases: when actors share resources, when producers and consumers design products together, when activities among actors need to occur at the same time, and when multiple actors select the overall goal and divide tasks to achieve it. In sum, interdependency can be generated when actors, activities, or both rely

on the actions of other actors, and coordination is required in these interdependent situations. In this regard, co-production that involves more than two actors (i.e., NPD teams and end customers) sharing resources and assigns tasks to them to co-develop new products is viewed as a context that demands harmonious coordination among actors and activities.

At the heart of coordination is managing dependencies among actors or activities and integrating divided efforts into a common goal through coordination mechanisms (Crowston, Rubleske, and Howison 2006; Heath and Staudenmayer 2000; Lewis et al. 2001; Malone and Crowston 1994). However, the integration and harmonious adjustment of individual work efforts toward accomplishing a larger goal is not that easy (Singh 1992). First of all, there may be psychological barriers that get in the way of integrating divided work into a common goal (Heath and Staudenmayer 2000). Heath and Staudenmayer (2000) named these psychological problems "coordination neglect." Individuals who participate in interdependent work neglect the importance of coordination mechanisms and consequently fail to integrate their individual work into a completed goal. They exhibit coordination neglect because they tend to focus more on partitioning a task than on the process of integration (i.e., partition focus) and concentrate on individual components when they try to diagnose problems or intervene to provide a solution (Heath and Staudenmayer 2000). For example, when individuals who are assigned to certain jobs in the co-production process have partition focus and component focus, they may not understand the overall flow of the entire system (Pasquale 2001) and may not be aware of the decision procedures of the other actors. In addition, different languages and perspective among actors may lead to inadequate communication and insufficient translation which finally results in failures to integrate individual work into a common goal (Heath and Staudenmayer 2000; National Science Foundation 1989). Goal conflict among different actors is another cognitive

block which may lead to coordination neglect. If different goals among actors are not coordinated within the overall goal, the actors cannot achieve the final objective of the process.

Coordination neglect can be applied to the NPD co-production context between NPD teams and end customers. When several individual jobs are assigned to end customers in NPD, customers may have a greater tendency to focus on partitioning and components. Because customers lack a firm goal to develop a new product by integrating individual work compared with NPD team members, they may only focus on individual work assigned to them. Furthermore, because NPD teams and end customers generally have different languages and perspective, communication among them may be inadequate and insufficiently translated. In sum, customers' cognitive problems such as partition and component focus and inadequate communication may lead to coordination neglect, which results in failure to develop the new product through co-production with end customers. As such, the integration of work that is divided up to pursue a common goal is by its nature hard for NPD teams to do.

Even when NPD teams overcome this difficult problem and integrate individual work, developing better outcomes is still difficult because although each decision from individual actors is locally optimal, it may not be globally optimal. In addition, actors may generate mutually conflicting decisions (Pasquale 2001). This problem is evident in the case of software development (DeMarco 1995; DeMarco and Lister 1987). When companies develop new software, they usually divide the entire development process into several modules and assign development of each module to individual specialists. Even though each module developed by specialists demonstrates locally optimal performance, integrating all modules into complete software may cause mutual conflicts among modules and unanticipated inadequate design (Boehm and Papaccio 1988; Kemerer 1997). As such, actors who fail to harmoniously

coordinate their activities may co-create products with sub-optimal features or performance (Carley 2001; Malone and Crowston 1994).

In terms of time elapsed until development, additional work and efforts required to mitigate coordination problems and integrate individual work may delay the overall NPD process (Crowston et al. 2005). Various modes of coordination have been discussed in the literature. Making mutual adjustments through formal and informal meetings, conducting direct supervision, and standardizing work processes, outputs, norms and skills based on plans and rules are examples of steps organizations often take to coordinate activity (Mintzberg 1979; Van de Ven, Delbecq, and Koenig 1976). Regardless of modes of coordination, conducting formal and informal meetings, supervising activities of other actors, and setting up plans and norms demand additional time for companies who want to coordinate work activities in the NPD process.

CHAPTER 3

HYPOTHESIS DEVELOPMENT

Nonlinear Relationship: Customer Participation and New Product Success

Through customer participation, NPD teams attempt to accelerate time to market and improve market adoption, both of which are key objectives for new product success (Carbonell, Rodriguez-Escudero, and Pujari 2009). For the purpose of this study, market adoption is defined as the extent to which customers buy the co-produced product (O'Hern 2009), and time to market represents the time elapsed between the initial development and the ultimate introduction of a product into the marketplace (Griffin 1997). As an information resource, customers can play a pivotal role in the NPD process by providing accurate information about their needs. Information directly from customers themselves enables NPD teams to more closely reflect customer needs, thus contributing to enhanced product market fit (Enkel, Perez-Freije, and Gassmann 2005; Hoyer et al. 2010; Nambisan 2002). Furthermore, involving various customers in NPD can generate more divergent insights and ideas, which increases the possibility of creating a better product (Magnusson, Matthing, and Kristensson 2003; Troy, Hirunyawipada, and Paswan 2008). Thus, according to service-dominant logic, integrating customers as a good information resource is expected to enhance market adoption.

However, as more interactions and more information are involved in the NPD process, coordination theory suggests that dependencies of activities between NPD teams and customers become more complex, and managing the dependencies becomes more challenging (Malone and Crowston 1994). Issues arising from coordination neglect (Heath and Staudenmayer 2000) make integrating individual work divided between NPD teams and end customers into a completed

product difficult by nature. Thus, some NPD teams which engage end customers in the NPD process may hold the NPD projects for a long time without accomplishing the final goal (i.e., development of the new product). Even when NPD teams overcome coordination neglect and introduce new products into the market, the outcomes of the co-produced products could be unsatisfactory. Assigning NPD tasks among a large number of customers is likely to make it difficult for NPD teams to grasp the overall flow of the entire system and to generate an optimal solution from a wide variety of customer input due to mutually conflicting decision problems and goal conflicts (Pasquale 2001). For example, Crowston, Rubleske, and Howison (2006) pointed out that actors may suggest features of new software without being aware that the new features may unintentionally negatively affect other features. Consequently, NPD teams may end up with suboptimal solutions in circumstances in which excessive customer participation makes harmonious coordination among co-production activities impossible. This will lead to lower market adoption. Customer participation in the NPD process is thus expected to enhance market adoption up to a certain point where harmonious coordination is optimal, but begin to degrade it beyond that point.

H_1: There will be an inverted U-shaped relationship between customer participation and market adoption.

Building on coordination theory, similar arguments can be applied to the relationship between customer participation and time to market. Through active participation, customers provide NPD teams with accurate accounts of their needs and requirements. This shortens NPD teams' iterative searching process to discover customers' needs (Nambisan 2002). Because customer participation is likely to help identify and correct problems early in the NPD process, NPD teams can reduce the risk of having to redo the whole NPD process (Alam 2002; O'Hern

and Rindfleisch 2009; von Hippel and Katz 2002). Moreover, customers as co-developers are sometimes in charge of developing certain portions of the new product (Nambisan 2002). This customer role as an information resource and co-developer is expected to speed up the overall NPD process.

However, coordination neglect would suggest that NPD teams may not even achieve launch of the new product (Heath and Staudenmayer 2000). Due to the psychological barriers in integrating individual tasks into a common goal, many NPD projects are left in the development process for a long time or stopped without developing new products. In the real world, several new software development projects in SourceForge.net which engaged end customers remain inactive without launching new software. Coordination theory also suggests that customer participation beyond a certain point robs NPD teams of the effort and time needed to understand the entire NPD process, harmonize mutually conflicting ideas and goals, and communicate with various customers (Malone and Crowston 1994; Pasquale 2001). The time and resource demands required by the strong need for coordination among co-production activities may offset benefits of customer participation (Datar et al. 1996; Sethi 2000; Troy, Hirunyawipada, and Paswan 2008). Thus, customer participation is expected to shorten development time up to the point where serious coordination problems do not take place, but increase it beyond that point.

H_2: There will be a U-shaped relationship between customer participation and time to market.

Contextual Effect: Stages of Customer Participation

Customers play an important role at various stages of the NPD process, but their main role and their contributions to NPD differ depending on the stage. In the early phases of NPD such as ideation, customers primarily contribute by providing divergent and creative ideas about

customers' needs and new ways to meet these needs (Gruner and Homburg 2000; Hoyer et al. 2010). Quantity of information (i.e., large number of ideas) is regarded as more important than quality of information (Troy, Szymanski, and Varadarajan 2001). In contrast, the main role of customers at later stages such as product testing is to recognize problems and suggest incremental modifications within a range of already developed prototypes, as well as make the product error-free (Jeppesen and Molin 2003; O'Hern and Rindfleisch 2009). Quality rather than quantity of information is emphasized (Troy, Szymanski, and Varadarajan 2001). However, "at a very late stage, customers' input is reduced to mere incremental improvement of the prototype and can no longer be radical" (Enkel, Perez-Freije, and Gassmann 2005, p. 432).

With regard to market adoption, customer participation in the initial stage is expected to enhance market adoption because a large amount of innovative and divergent input has greater potential to find alternative ways to satisfy customers' needs (Arnold, Fang, and Palmatier 2011). Conversely, customer participation in the later phase is limited to mere incremental improvements of the developed product. The wrong product concept chosen in the initial phase cannot be overthrown, which may not improve market adoption of the co-produced product.

When it comes to time to market, however, the opposite effect is expected. Determining and launching a final solution from a large number of ideas requires more time due to difficulty in sharing ideas among participants and building a consensus (Crowston, Rubleske, and Howison 2006; Pasquale 2001). Especially when the ideas are very diverse, deciding on a final solution from many options is extremely difficult. Arnold, Fang, and Palmatier (2011) mentioned that diversity of ideas maximizes any confusion or complexity in the innovation process by making it more difficult to establish formal, structured coordination mechanisms. Thus, a large number of

divergent ideas in the early stage of NPD may delay time to market, whereas relatively homogenous ideas in later NPD phases may not generate serious coordination problems.

H_3: The effect of customer participation on market adoption will increase as the ratio of customer participation at early stages to late stages increases.

H_4: The effect of customer participation on time to market will increase as the ratio of customer participation at early stages to late stages increases.

Contextual Effect: Breadth of Customer Participation

Relevant research to date on customer participation has rarely addressed breadth of customer participation, focusing instead on intensity of customer participation. However, Fang, Palmatier, and Evans (2008) and Hoyer et al. (2010) argue that customer participation should be understood with breadth representing the scope of participation as well as intensity representing the level of involvement. Breadth of customer participation is defined as the extent to which customers are involved in a wide range of activities in the NPD process (Fang, Palmatier, and Evans 2008). More specifically, breadth is assessed by the number of NPD stages that end customers actively participate in. For example, when customers are engaged in just one activity (e.g., idea generation), breadth of customer participation is 1. When customers are involved in a wide range of activities from idea generation to product testing, breadth of customer participation increases.

From a NPD team's perspective, customer participation in a wide variety of NPD activities provides opportunities to capture customers' specific requirements expressed at various NPD stages (De Luca and Atuahene-Gima 2007; Kogut and Zander 1992). For example, when customers are engaged in various activities including ideation, development of the parts of the new product, and product testing, NPD teams can get ideas about ideal features of a new product,

suggestions about solutions to satisfy customers' needs, and information on problems related to usage situations. Although narrow customer participation within a particular NPD activity tends to provide NPD teams with sophisticated information on a particular area, it may limit input or ideas which can be captured within a particular NPD activity (Wang and von Tunzelmann 2000). Furthermore, customers who participate broadly are likely to develop a stronger feeling of psychological ownership of the new product, which leads to stronger demand for the new product (Fuchs, Prandelli, and Schreier 2010). As a result, broad customer participation may improve market adoption, whereas narrow customer participation may not improve market adoption as much.

However, broad customer participation might hinder quick launch of new products. Coordination theory suggests that when customers are involved in a wide variety of NPD activities, NPD teams need to manage interdependencies that arise from the various NPD activities (Malone and Crowston 1994). Communication and coordination between NPD teams and customers in each activity take significant time and managerial resources, and this problem can never be eliminated completely (Pasquale 2001). Conversely, narrow customer participation within a particular NPD activity may not delay the overall NPD process because the need for coordination is limited to a particular activity and sophisticated information from customers allows the NPD team to move forward quickly to the next stage.

H_5: The effect of customer participation on market adoption will increase as the breadth of customer participation increases.

H_6: The effect of customer participation on time to market will increase as the breadth of customer participation increases.

Contextual Effect: NPD Team's Co-Production Capability

A NPD team's ability to effectively and efficiently manage customer participation is increasingly being recognized as a source of lasting competitive advantage (Prahalad and Ramaswamy 2000, 2004; Ramani and Kumar 2008; Rayport and Jaworski 2005; Van Doorn et al. 2010; Zhang and Chen 2008). However, research on how companies can manage customer participation as a source of competitive advantage is very limited. As a notable exception, Ramani and Kumar (2008) proposed a new concept of interaction orientation, defined as "a firm's ability to interact with its individual customers and to take advantage of information obtained from them through successive interactions" (p. 27). As one important dimension of interaction orientation, they emphasized a firm's ability to facilitate the process of allowing customers to share feedback on products and services and to participate actively in designing products and services. Mathwick, Wiertz, and de Ruyter (2008) also contended that companies need to encourage customers to be involved in co-production behaviors by providing various places for them to express their ideas and thoughts. As such, extant literature has focused on how companies can encourage customers to be involved in the co-production process.

However, previous researchers have overlooked the value of a firm's ability to leverage customer input through co-production behaviors. Encouraging customers to be engaged in co-production is necessary but not sufficient to nurture and harness the positive potential of customer participation in the NPD process. To nurture the benefits, companies need to *recognize* the value of input from customer participation and effectively *apply* it to new products. In the dissertation, this concept is reflected in a NPD team's co-production capability, which is defined as a firm's ability to effectively leverage customer input through co-production behaviors in the NPD process. Specifically, this capability captures a process to recognize the value of customer

input and apply the input to commercial ends. Similar to the concept of absorptive capacity (Cohen and Levinthal 1990), the process emphasizes not information itself but transformation and exploitation of information to commercial ends.

Currently, the capability to leverage customers' input has been growing in importance. First of all, if a NPD team is not able to leverage the insights, valuable information from customer participation becomes useless. Furthermore, Bendapudi and Leone (2003) and Fuchs, Prandelli, and Schreier (2010) demonstrated that if the outcome of the co-creation activity does not adequately reflect customers' needs or preferences, customers have a negative attitude toward the co-produced product and the company. Consequently, NPD teams may benefit from customer participation only when they have high co-production capability. Moreover, a NPD team's ability to leverage customers' input may accelerate the overall NPD process because NPD teams can quickly proceed to the next phase of the NPD process by using customers' valuable input and efficiently coordinate the co-production process.

H_7: The effect of customer participation on market adoption will increase as the NPD team's co-production capability increases.

H_8: The effect of customer participation on time to market will decline as the NPD team's co-production capability increases.

Table 3.1 presents the concepts related to co-production capability.

Table 3.1

Conceptualization of Co-Production Capability

	Co-Production Capability
Definition	· NPD team's ability to leverage customers' input to develop the new product in the NPD process
Focus	· Quality perspective · Transform and exploit various ideas from customers into effective strategy
Sample Activities	(1) Recognizing the value of customers' insights · Recognizing the usefulness of insights from customers · Valuing insights and ideas from customers
	(2) Applying insights or ideas from co-production to commercial ends · Developing products that reflect customers' unmet needs and wants expressed through co-production · Selecting feasible and appropriate ideas from a wide variety of customers' suggestions

Contextual Effect: Product Individuality

In addition to contextual variables related to customer participation execution, specific characteristics of products may also moderate the relationships between customer participation and market adoption. Product individuality is suggested as a potential product-specific moderator. In this study, product individuality refers to the extent to which a NPD team offers individualized products rather than standardized ones (Homburg, Müller, and Klarmann 2011).

In some industries, products themselves are highly individualized to meet the customers' specific needs (Tuli, Kohli, and Bharadwaj 2007). In environments in which highly individualized products are offered, identifying customers' needs and applying them to commercial ends are crucial in improving market outcomes of the new product. Thus, obtaining information on customers' specific needs through active customer participation may be much more valuable for individualized products. The argument of Verbeke et al. (2008) that a salesperson's ability to understand specific customer needs is more strongly related to sales

performance in industries in which highly individualized products are sold lends support. Along the same lines, Homburg, Müller, and Klarmann (2011) recently found that a salesperson's customer orientation is much more valuable in enhancing sales performance if products are individualized rather than standardized.

However, this situation is different for standardized products. In situations in which products are standardized, customers may not be aware of new features or ideas of the products or they may perceive highly complex and individualized products in such situations as inadequate or useless (Verbeke et al. 2008). Thus, companies may not obtain valuable insights on new products from customer participation in the NPD process and customer participation may simply increase complexity of the NPD process without benefits. On the basis of this logic, the effect of customer participation on market adoption is expected to be stronger if the co-produced product is individualized rather than standardized.

H_9: The effect of customer participation on market adoption will increase as the individuality of the co-produced product increases.

Contextual Effect: Product's Price Positioning

The relationship between customer participation and market adoption may vary depending on the co-produced product's overall price positioning. The co-produced product's overall price positioning is defined as the overall price level of the co-produced product compared to that of competitors' products (Homburg, Müller, and Klarmann 2011). From a customer's point of view, a product's general price level indicates its quality and, accordingly, the equivalent value a customer receives (Rao and Monroe 1989). Consequently, if a product's price level is substantially above the market average, customers expect additional benefits in return for accepting higher prices (Homburg, Müller, and Klarmann 2011).

In situations in which the overall price level of a co-produced product is higher than the market average, companies need to more closely reflect customers' specific needs in order to satisfy customers' high expectations. In contrast, if the co-produced product's price level is below the market average, companies attempt to compete in the market on the basis of lower prices. Therefore, identifying customers' specific needs and applying them to the co-produced product through customer participation in the NPD process seems to be much less valuable. Rather, lowering prices by maintaining only fundamental functions of the product may be a highly useful strategy. Furthermore, customers do not expect additional benefits from products with lower prices. Thus, the efforts that companies make to engage end customers in the NPD process in an attempt to seek information about lower-priced products might not be evaluated highly. Consequently, the effect of customer participation on market adoption is expected to be stronger when the overall price level of the co-produced product is high.

H_{10}: The effect of customer participation on market adoption will increase as the price level increases.

CHAPTER 4

STUDY 1

Overview of Studies 1 and 2

The hypotheses were tested using two complementary samples. The first sample comes from SourceForge.net, the leading open source software repository, which provides websites that allows NPD teams who develop new software and users to organize and coordinate open source software development (Grewal, Lilien, and Mallapragada 2006). The open source software development context in which end users co-create new software by suggesting new features, developing portions of the new software, reporting bugs, developing patches, and so on has been considered a prototypical example of collaborative co-production (O'Hern and Rindfleisch 2009). SourceForge.net has accumulated information on co-production activities in which end users participated in new software development. Thus, data from SourceForge.net are expected to provide a good context to test the hypotheses regarding the impact of customer participation in the NPD process.

However, co-production with end customers in the NPD process takes a wide variety of forms in terms of the degree to which companies allow customer contribution activity, who mainly selects the final product, and so on (O'Hern and Rindfleisch 2009; Piller, Ihl, and Vossen 2010). Given the variety of co-production forms and different characteristics of the co-produced product and industry, the results from one specific setting (i.e., open source software development) may not be extended to other contexts. In order to validate the findings of the first study and examine whether there are product- or industry-specific variables to moderate the

effect of customer participation on new product success, survey data from a wide variety of industries are collected using a Qualtrics panel. Comparing the results of data from SourceForge.net with the Qualtrics survey data allows the effect of customer participation in the NPD process on market adoption and time to market to be thoroughly investigated. First, the analysis approach and findings from SourceForge.net are provided in this chapter.

Context and Data Source of Study 1

The hypotheses were tested in the context of open source software development. This seems to be a reasonable context for several reasons. First and foremost, open source software development represents well the phenomenon of customer participation in the NPD process (Kogut and Metiu 2001; Lee and Cole 2003; Mallapragada 2008; O'Hern 2009; von Hippel 2005; von Hippel and von Krogh 2003). Core developers in the open source software development context usually initiate software development projects on public online development sites and anyone from anywhere in the world can participate in the software development process (O'Mahony and Bechky 2008). In this process, users (i.e., end customers) are actively engaged in suggesting features for a new product (i.e., software), developing the product, and testing it across the entire NPD process. "Ideas emerge from a diverse pool of distributed contributors and are accepted or rejected by the core developers" (O'Mahony and Bechky 2008, p. 428). The open source software development process is very similar to the NPD process in which end customers are actively involved in that ordinary individuals are voluntarily engaged in the NPD process, share their ideas with firms (core developers in case of open source software development), and firms gather ideas from ordinary individuals and finally decide to accept or reject them. In suggesting a typology of customer co-creation, O'Hern and Rindfleisch

(2009) noted that open source software development is a good example of the most active type of customer co-creation.

Second, open source software development is a good context to show the need for coordination (O'Mahony and Ferraro 2007). Basically, because any individuals from anywhere in the world can participate in the open source software development process, managing interdependence to achieve a common goal (i.e., new software development) is not easy. In addition, core developers in the open source development context must integrate individual contributions into a common pool, which can heighten interdependencies and the need for coordination mechanisms (e.g., O'Mahony and Ferraro 2007; Thompson 1967).

Third, open source software development features a wide variance in terms of the degree of user participation. In some software development projects which require specific skills, customer participation is limited and a few developers take charge of the whole development process. On the other hand, customers tend to be actively engaged in other software development projects which usually do not need complex expertise. Thus, an open source development project is viewed as an adequate unit of analysis in testing the effect of increasing customer participation on new product success.

Finally, open source software development projects keep track of cumulative data on customer participation in the new software development process and make the data publicly available. SourceForge.net is the leading open source repository that provides websites for NPD teams and users to organize and coordinate open source software development (Grewal, Lilien, and Mallapragada 2006). As of February 2012, more than 3.4 million users had participated in open source development processes in more than 324,000 projects reported on SourceForge.net. The collaborative tools that the website provides enable a project founder to recruit volunteer

users and organize the development of the product via the Internet. Von Hippel and von Krogh (2003) suggested that SourceForge.net could be utilized as an attractive venue for research into open innovation models which encourage customers to actively participate in the firm's innovation process. Based on their suggestions, there have been several recent studies in which data from SourceForge.net were used and analyzed (e.g., Grewal, Lilien, and Mallapragada 2006; Mallapragada 2008; O'Hern 2009). I have been granted access to secondary data from its data warehouse, which records and organizes all activities on the site (Madey 2005).

Sample of Study 1

To avoid inconsistencies and confounds from different start times, only new projects initiated from January 2007 to March 2007 were included in the sample frame for this study. These projects were tracked over a period of four years from January 2007 to March 2011. Given that Mallapragada (2008) traced the projects in the SourceForge for 42 months, the period of 48 months seems to be reasonable. In total, 6,163 new projects were launched during the first quarter of 2007. Of these, 1,008 new software development projects included end customers as participants in any co-production behavior (e.g., bug reports, feature requests, support requests, and patch submission), meaning that 16.36% of the NPD projects listed in SourceForge.net during the period allowed customers to engage in co-production activities. Among these 1,008 projects, 342 projects were deleted from the study due to incomplete data, resulting in 666 new software development projects to be included in the sample. Extreme values were identified following Cook's distance (Cook 1977, 1979) and Bollen and Jackman's (1990) guideline to cut off outliers (i.e., Cook's distance > 4/n, n = the number of observations). Seventeen outliers for market adoption and nineteen outliers for time to market were detected, and the results were compared with and without outliers. There is no specific reason that the detected extreme values

are distorted, and the findings from both samples with and without outliers are consistent. However, because the detected extreme values tend to amplify the multicollinearity between independent variables and interaction terms, the hypotheses are tested based on a total of 649 projects for market adoption and 647 projects for time to market after deleting the extreme values.

Measures of Study 1

Customer participation. Customer participation is measured as the sum of any co-production behavior (i.e., bug report, patch submission, new feature suggestions, and support suggestions) that registered users made on the new software development project, following Chan, Yim, and Lam (2010).

Market adoption. Market adoption, representing the market-based performance of the co-produced product, is assessed as the number of downloads of the co-produced software over the life-span of the project (Grewal, Lilien, and Mallapragada 2006; O'Hern 2009). Given that the co-produced software is distributed only through SourceForge.net and freely available, the number of downloads could be used as a surrogate for sales (Chandrashekaran et al. 1999).

Time to market. Time to market is measured as the hours from the beginning of development to the first package release of the co-produced software, following Mallapragada (2008). SourceForge.net provides information on time of project registration and time of first package software release for the project, so the hours that elapse between the initial development and the first introduction of a product into the marketplace can be calculated. Hours are utilized as a unit of measure instead of days because some new software development projects indicated the first package release of the new software in a few hours. In particular, when new software is based on previously developed codes, the release time of software is relatively short.

Stages of customer participation. Stages of customer participation are measured as the ratio of feature suggestions divided by average feature suggestions to bug reports divided by average bug reports. Suggesting new features for a software product mainly takes place in the early phase, whereas reporting bugs in the developed software occurs in the later NPD phase. Thus, the number of feature suggestions of a project divided by average feature suggestions that users made in the sample projects reflects the degree to which users are involved in the early stage. Similarly, the number of bug reports in a project divided by average bugs reported by users in the sample project represents the degree of customer participation in the later NPD stage. Consequently, the ratio of feature suggestions divided by average feature suggestions to bug reports divided by average bug reports captures the extent to which end users are involved in the early phase of the new software development process as opposed to in the later stage.

Breadth of customer participation. Breadth of customer participation is assessed as the number of activities in the project that users actively participate in. SourceForge.net records five different activities users can be involved in: new feature suggestion, bug reporting, patch development, idea posting in the forum, and support suggestion. If the number of times users within a project participate in a particular activity out of the five activities is greater than the average of the particular activity in the sample projects, users within the project can be considered to be actively participating in the activity. If each NPD project in the sample evaluates its participation in the five activities in such a way, breadth of customer participation of each project can range from zero to five. Zero means that customers do not actively participate in any co-production activities among the five different activities, whereas five means that customers are engaged in all five co-production activities. This is consistent with the approach of

Fang, Palmatier, and Evans (2008) in measuring breadth of customer participation based on the number of NPD process activities customers participated in.

Co-production capability. A NPD team's capability to leverage customers' input is measured as the ratio of the closed suggestions to all the suggestions that users in the project made. In other words, compared with projects which have many suggestions generated by users left open, projects which are able to reflect or close more users' suggestions could be regarded as having a high level of co-production capability to leverage customers' input. The number of all the suggestions from users refers to the sum of the numbers of bugs reported by users, patches developed by users, supports suggested by users, and new software features suggested by users. For the co-production capability, the ratio of how many users' suggestions (i.e., reported bugs, developed patches, suggested support, and suggested features) are closed by the project's developers is calculated. Table 4.1 summarizes the measures of focal constructs of interest.

Table 4.1

Definitions and Measures of Focal Constructs of Study 1

Constructs	Definition	Measures
Customer Participation	The extent to which customers are involved in the NPD process (Fang 2008; Hoyer et al. 2010)	The sum of any co-production behavior (i.e., bug report, patch submission, new feature suggestions, and support suggestions) that registered users made on the new software development project
Market Adoption	The extent to which customers accept the co-produced product (O'Hern 2009)	The number of downloads of the co-produced software over the life span of the project
Time to Market	The time elapsed between the initial development and the ultimate introduction of a product into the marketplace (Griffin 1997)	The hours until the first package release of the co-produced software
Stages of Customer Participation	Stage (initial ideation vs. later product testing) at which customers are involved	The ratio of feature suggestions divided by average feature suggestions to bug reports divided by average bug reports
Breadth of Customer Participation	The extent to which customers are involved in a wide range of activities in the NPD process (Fang, Palmatier, and Evans 2008)	The number of activities in the project users actively participate in out of the five activities (i.e., new feature suggestion, bug reporting, patch development, idea posting in the forum, and support suggestion)
NPD team's Co-Production Capability	NPD team's ability to leverage customer's input to develop the new product	The ratio of closed suggestions to all suggestions (i.e., new feature suggestion, bug reporting, patch development, and support suggestion) made by users in the project

Control Variables of Study 1

To rule out other effects on market adoption, several control variables are included. Because market adoption measured by number of downloads is likely to increase with the age of the project, number of months since the inception of the project is utilized to control for the age of the project (Grewal, Lilien, and Mallapragada 2006). In addition, to control for different levels of market potential of new software, number of page views is collected because this directly signals the general interest level in the project and its market potential (Grewal, Lilien, and Mallapragada 2006). Because the degree of complexity of products may influence how easily customers adopt the products, this is assessed by size of the released software files for the project in megabytes. Finally, to control for open source software characteristics, type of open source license of projects is included in the model. In the open source software setting, different licenses grant various degrees of control over the source code to users (Stewart, Ammeter, and Maruping 2006; Subramaniam, Sen, and Nelson 2009). The most common licenses include the generally public license (GPL) and the less restrictive limited general public license (LGPL). Because GPL is the most widely used, I coded the license type variable as a dichotomous variable, where 1 indicates use of GPL and 0 otherwise. This is consistent with Mallapragada's (2008) approach. Table 4.2 summarizes the control variables included in the model.

Time to market is also influenced by several variables other than focal constructs. First of all, overall experience of developers in the NPD project could affect time to market (Mallapragada 2008). Because greater experience of developers is expected to shorten time to market, overall experience of developers is controlled for in the model for time to market. The overall experience of developers is assessed by using the cumulative time (i.e., days) since they registered in the open source community (Mallapragada 2008). Time to market may also depend

on the degree of complexity of products and prior code availability for the project. More complicated or more difficult projects need more development time prior to release of the product. Following Mallapragada (2008), complexity of projects is measured by the size of the released project files for the project in megabytes. Some projects lead to product releases immediately after registration because the development team has been working on the source code before registering the site. To control for this prior code availability, data about the status of the project at the time of its registration are obtained. A dichotomous variable indicates if prior code was available at the time of registration, equal to 1 if prior code was available and 0 otherwise (Subramaniam, Sen, and Nelson 2009). Finally, to control for open source software project characteristics, type of open source license is included. Consistent with the model for market adoption, the license type variable is coded as a dichotomous variable, where 1 indicates use of GPL and 0 otherwise (Mallapragada 2008). Table 4.2 indicates control variables included in the models of Study 1.

Table 4.2

Control Variables of Study 1

Model	Control Variables	Measure
Dependent Variable: Market Adoption	Age of the Project (Grewal, Lilien, and Mallapragada 2006)	Number of months since the inception of the project
	Market Potential (Grewal, Lilien, and Mallapragada 2006)	Number of page views
	Complexity of Products (Mallapragada 2008)	Size of the released project files for the project in megabytes
	License_dummy (Mallapragada 2008)	1 indicates use of GPL license and 0 otherwise
Dependent Variable: Time to Market	Overall Experience of Developers (Mallapragada 2008)	Cumulative time (days) since developers registered in the open source community

	Complexity of Products (Mallapragada 2008)	Size of the released project files for the project in megabytes
	Prior Code Availability (Mallapragada 2008; Subramaniam, Sen, and Nelson 2009)	A dichotomous variable: equal to 1 if prior code was available at the time of project registration, and 0 otherwise
	License_dummy (Mallapragada 2008)	1 indicates use of GPL license and 0 otherwise

Data Analysis of Study 1

Two different models are specified for the two dependent variables (i.e., market adoption and time to market). To examine the relationships among customer participation, various moderators, and market adoption, moderated hierarchical OLS regression is employed. In general, when the outcome variable is count data, count models such as Poisson and a negative binomial regression are preferred to OLS regression because count data are often analyzed incorrectly with OLS regression (O'Hern 2009). In the current dissertation, because market adoption as a dependent variable is count data which is assessed as the number of downloads of the co-produced software, a Poisson or negative binomial regression model may be appropriate. However, if the values of the outcome variable are dispersed as in the data used in this study, the results of OLS regression are expected to be correctly estimated although the dependent variable is count data. In addition, in Poisson and negative binomial regression models, including the interaction terms between the squared term (i.e., CP^2) and moderating variable causes interpretation problems. Therefore, the relationship between customer participation and market adoption is analyzed using OLS regression after log-transforming market adoption. In addition, because focal variables for this model (i.e., market adoption and customer participation) are

censored, the results of the censored regression are also compared with those of OLS analysis to check the robustness of the results.

To analyze the relationship between customer participation and time to market, a survival model (i.e., hazard model) is specified. Because the dependent variable (i.e., time to market) is strictly positive, the estimates from a regression-based approach may be biased and inconsistent (Datar et al. 1996). When the dependent variable is a measure of the duration from one time to another, as in the data used in this study, the hazard function model has been widely used (e.g., Datar et al. 1996; Mallapragada 2008). To check robustness of the result, OLS regression after log-transforming time to market and censored regression are also conducted.

Descriptive Analysis of Study 1

Figures 4.1, 4.2, and 4.3 indicate frequencies of focal constructs, customer participation, market adoption, and time to market.

Figure 4.1

Frequency of Customer Participation

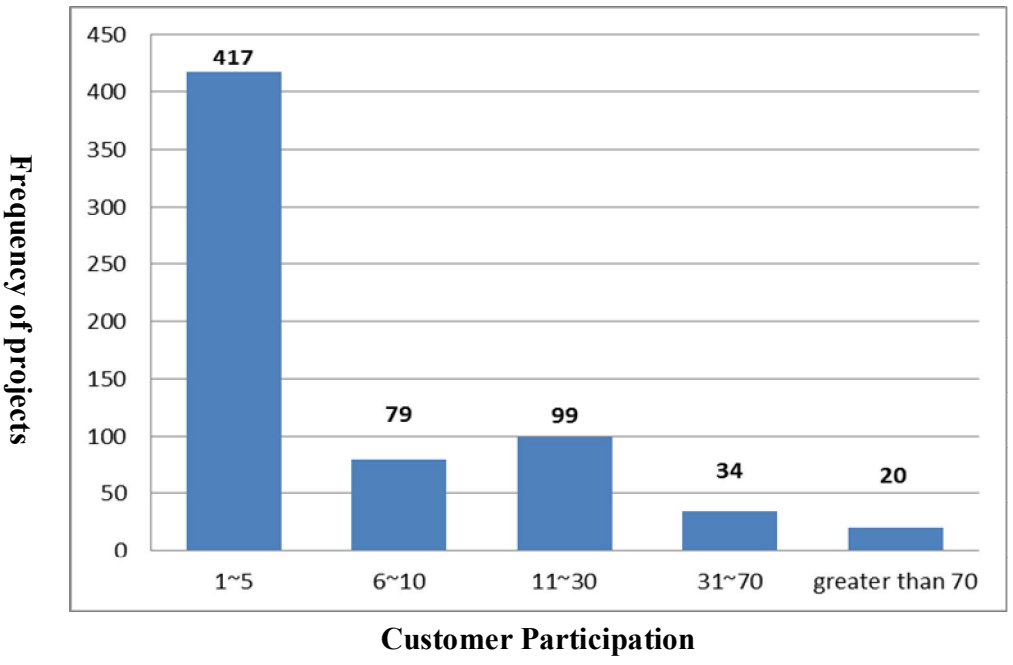


Figure 4.2

Frequency of Market Adoption

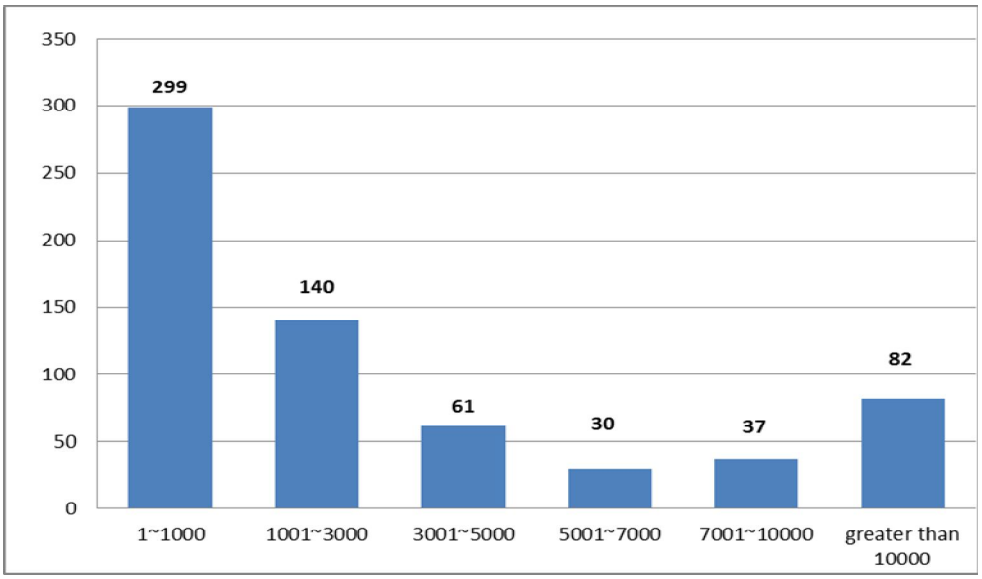


Figure 4.3

Frequency of Time to Market

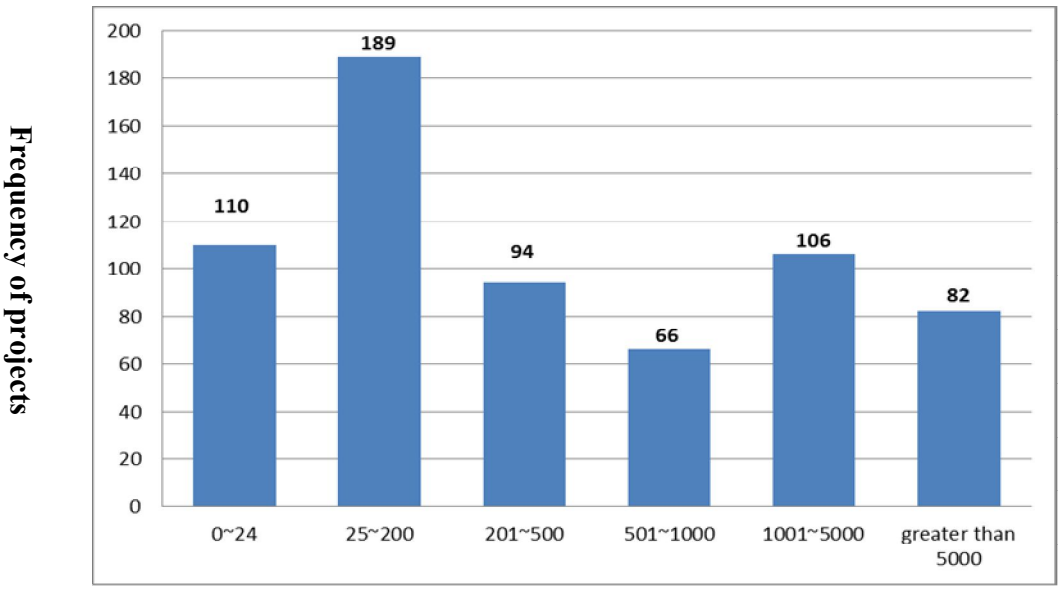


Table 4.3 presents means and standard deviations of all the variables in Study 1. On average, end users in the 649 sample projects participated in 11.17 co-production behaviors for each project, including bug reporting, support requests, new feature suggestions, and patch development. However, as shown in Figure 4.1, customers are relatively less engaged in co-production behaviors in most projects. Between 1 and 5 co-production behaviors were conducted in 64.25% of the projects (417 of 649 projects). In contrast, more than 70 co-production behaviors took place in 20 projects. The mean of market adoption is 5,713.06. However, as seen in Figure 4.2, the level of market adoption (i.e., number of downloads) varies from project to project. Of the 649 projects, 46.07% (299 projects) have fewer than 1,000 cumulative downloads, whereas 12.63% (82 projects) had more than 10,000 downloads. Time to market also differs according to projects. The mean time to market is 1,739.36 hours (i.e., 72.47 days). While 110 projects took less than 24 hours to release the first package of the co-produced software, 82 projects spent more than 5,000 hours (i.e., 208.33 days).

Table 4.3

Means and Standard Deviations of Constructs in Study 1

Variables	N	Mean	S.D.
Customer Participation	649	11.17	24.22
Market Adoption	649	5713.06	15813.86
Time to Market (hour)	647	1,739.36	3,439.22
Stage	649	1.84	2.80
Breadth	649	2.56	.90
Co-production Capability	649	.44	.40
Age of the Project (month)	649	36.09	21.75
Market Potential (1,000 pages)	649	84.69	542.62
Complexity of Products (10,000 megabytes)	649	435.54	1408.89
Overall Experience of Developers (days)	649	479.93	746.97
Prior Code Availability 1: code availability 0: otherwise	649	.17	.38
License_dummy 1: type of license is GPL 0: otherwise	649	.64	.48

Table 4.4 shows correlations of the variables in Study 1. The correlations provide first insights into the relationships of interest. As shown in Table 4.4, customer participation is positively related with market adoption ($r = .22$, $p < .01$) and log-transformed market adoption ($r = .21$, $p < .01$). The more end customers are engaged in co-production behaviors, the more the product is adopted in the market. The correlation between customer participation and time to market is not significant ($r = .05$, $p > .10$). However, customer participation is positively related with time to market after log-transformation ($r = .10$, $p < .05$), implying that the more customers are involved in co-production behaviors, the longer it takes for the product to be launched into the market.

The correlations in Table 4.4 also show the relationships between dependent variables and control variables. As expected, products which have high market potential are positively related with market adoption ($r = .44$, $p < .01$). Complexity of products has significant positive relationship with time to market ($r = .10$, $p < .01$), demonstrating that products which are complicated require longer time to be introduced in the market. Prior code availability also shows the expected negative association with time to market ($r = -.23$, $p < .01$). In other words, if new software is based on previously developed code, time until the launch of the software in the market is short. Figures 4.4 and 4.5 present the scatter plot among customer participation, market adoption, and time to market. In particular, the scatterplot between customer participation and market adoption in Figure 4.4 demonstrates the possibility of non-linear relationship between the two variables.

Table 4.4

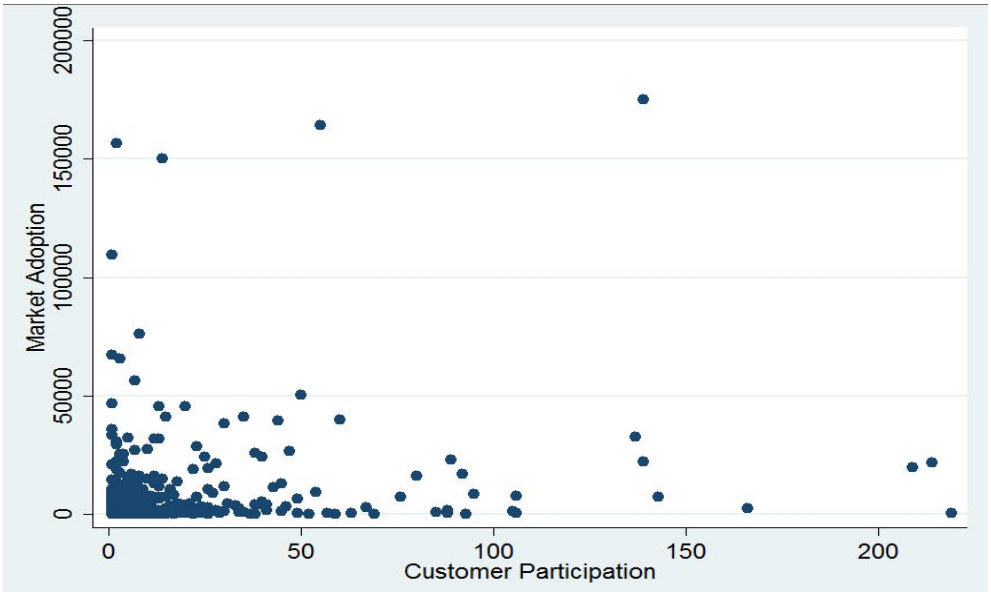
Correlations of Study 1

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CP	1														
2. CP Squared	.90**	1													
3. Stage	.03	.01	1												
4. Breadth	.33**	.16**	-.06	1											
5. Capability	.19**	.12**	-.08*	.07	1										
6. Market Adoption	.22**	.16**	-.00	.20**	.03	1									
7. Time to Market	.05	.01	.03	.05	.06	-.03	1								
8. Log (Market Adoption)	.21**	.15**	-.05	.32**	.05	.58**	-.04	1							
9. Log (Time to Market)	.10*	.06	.02	.10*	.04	-.03	.70**	-.03	1						
10. Age of Project	-.06	-.06	.05	-.05	.06	-.02	-.04	-.03	-.05	1					
11. Market Potential	.32**	.31**	-.01	.15**	.01	.44**	-.04	.22**	-.01	-.02	1				
12. Developer Experience	-.05	-.06	-.02	.01	.00	-.04	-.04	-.07	-.08	-.01	-.04	1			
13. Complexity of Product	-.01	-.03	-.04	-.03	.02	.02	.10**	.02	.13**	.06	-.02	-.06	1		
14. Prior Code Availability	-.05	-.03	-.01	-.13**	-.03	.03	-.23**	.04	-.67**	.00	-.03	.02	-.09*	1	
15. License Dummy	-.03	-.04	-.02	-.05	.08*	.10*	-.10*	.09*	-.12**	.07	-.01	-.08	-.04	.05	1

CP: Customer Participation
N = 647 (listwise)
** $p < .01$, * $p < .05$

Figure 4.4

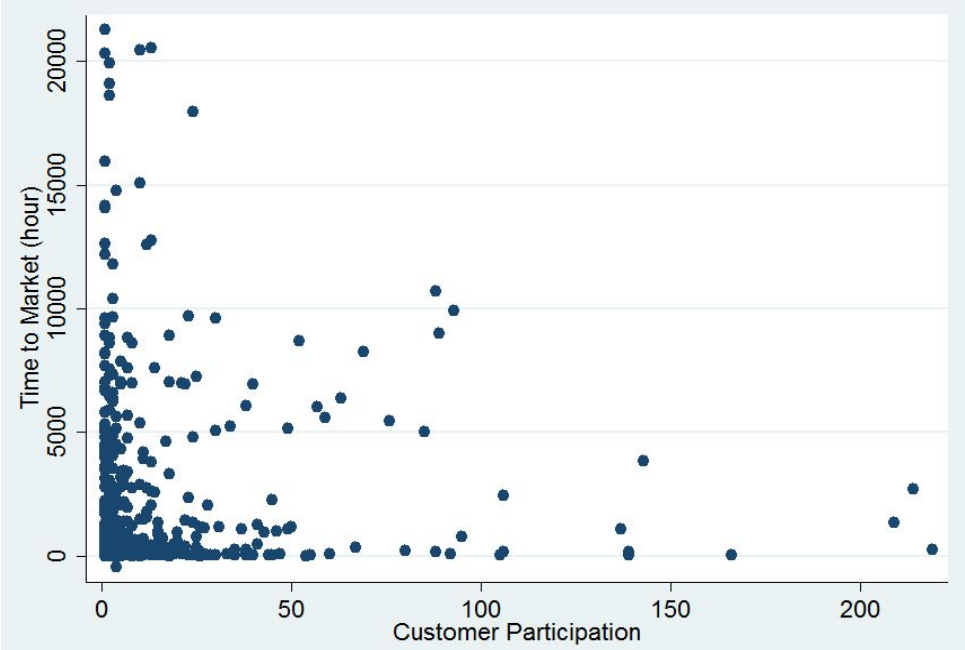
Scatter Plot between Customer Participation and Market Adoption



N = 649

Figure 4.5

Scatter Plot between Customer Participation and Time to Market



N = 647

Hypotheses Tests for Market Adoption in Study 1

The two models for market adoption and time to market were conducted to investigate the non-linear relationships between customer participation and market adoption and time to market, and moderating effects in the non-linear relationships. Therefore, we need to statistically test for the presence of non-linear relationships before testing the hypotheses.

The Ramsey Regression Equation Specification Error Test (RESET) is a general specification test for the linear regression model (Ramsey 1969). More specifically, it tests whether non-linear combinations of the fitted values help explain the dependent variable. The idea behind the test is that if non-linear combinations of the independent variables have any power in explaining the dependent variable, the model is mis-specified. The null hypothesis for the RESET is that the model has no omitted variables related to non-linear combinations of the independent variables. Thus, rejection of the null hypothesis means that the model has omitted variables related to non-linear combinations of the independent variables.

To first test the presence of non-linear relationship between customer participation and market adoption, a RESET test was conducted. Control variables, independent variables, and all possible two-way interactions among independent variables were introduced in the model in order to investigate the possibility of non-linearity after ruling out the effects of all possible interactions among independent variables (Aiken and West 1991; Baer and Oldham 2006; Luo and Donthu 2006; Ritter and Walter 2012). The result of the RESET shows that the model includes non-linearity ($F(3,631) = 9.19$, $p < .01$). Thus, I proceeded to a formal moderated hierarchical regression analysis to test the nonlinearity between customer participation and market adoption and the moderating effects of stage, breadth, and capability in the nonlinear relationship.

Table 4.5 presents the results of the moderated hierarchical regression analysis used to test the hypotheses. The control variables were introduced into a regression equation (step 1). In step 2, after centering the independent variables (Aiken and West 1991), the main effect variables and the linear two-way interactions were entered in order to control for linear trends (Baer and Oldham 2006; Luo and Donthu 2006; Ritter and Walter 2012). Next, to test the prediction that customer participation would have a curvilinear relation to market adoption (Hypothesis 1), the quadratic customer participation term was introduced in step 3 of the regression equation. Finally, the relevant quadratic-by-linear interactions (i.e., CP^2 x Stage, CP^2 x Breadth, CP^2 x Capability) were introduced in steps 4, 5, and 6 to investigate the moderating roles of stage, breadth and co-production capability in the inverted U-shaped relationship.

As shown in Table 4.5, the coefficient associated with the quadratic customer participation term was statistically significant ($\beta = -.503$, $p < .05$), showing the inverted U-shaped relationship between customer participation and market adoption. The results demonstrate that in line with hypothesis 1, customer participation increases market adoption up to a certain point, but decreases market adoption beyond that point.

Table 4.5

Results of Hierarchical Regression Analysis of Study 1 for Log (Market Adoption)

Variable	β	ΔR^2	ΔF
Step 1		.059	10.170***
Age of the Project	-.011		
Market Potential	.324***		
Complexity of Product	.038		
License_dummy	.113***		
Step 2		.112	8.528***
CP	.333***		
Stage	-.078		
Breadth	.246***		
Capability	-.095*		
CP x Stage	.056		
CP x Breadth	.085		
CP x Capability	-.247**		
Stage x Breadth	-.062		
Stage x Capability	.100**		
Breadth x Capability	.042		
Step 3		.001	.515
CP^2 (H_1)	-.503**		
Step 4		.002	1.566
CP^2 x Stage (H_3)	-.098		
Step 5		.009	6.791***
CP^2 x Breadth (H_5)	-.219*		
Step 6		.010	7.913***
CP^2 x Capability (H_7)	.563***		
Constant	6.903***		

N =649, R^2 =.193

*** $p < .01$, ** $p < .05$, * $p < .10$

To check for robustness, I compared the result from the moderated hierarchical regression with those from the regression using robust standard error and the censored regression.

Tables 4.6 and 4.7 demonstrate the regression results based on robust standard error and censored regression result. Consistent with the result in Table 4.5, the results in Tables 4.6 and 4.7 indicate that customer participation has a positive impact on log-transformed market adoption (b = .025, $p < .05$), whereas the square term of customer participation has a negative effect on log-transformed market adoption (b = -.027, $p < .10$).

Table 4.6

Regression Analysis using Robust S.E. of Study 1 for Log (Market Adoption)

Variable	Coefficient	Robust S.E.
Age of the Project	-.001	.003
Market Potential	.011[a]***	.003
Complexity of Product	.005[b]	.005
License_dummy	.425***	.135
CP	.025**	.011
Stage	-.050	.036
Breadth	.489***	.087
Capability	-.427	.275
CP x Stage	.001	.003
CP x Breadth	.006	.007
CP x Capability	-.052*	.028
Stage x Breadth	-.045	.037
Stage x Capability	.207**	.089
Breadth x Capability	.214	.225
CP^2 (H_1)	-.027[c]*	.015
CP^2 x Stage (H_3)	.003[c]	.003
CP^2 x Breadth (H_5)	-.012[c]*	.007
CP^2 x Capability (H_7)	.084[c]**	.035
Constant	6.903***	.176

N =649, R^2 =.193
[a]Market Potential was divided by 10,000.
[b]Complexity of Product was divided by 1,000,000.
[c]CP^2 and interactions with CP^2 were divided by 100.
*** $p < .01$, ** $p < .05$, * $p < .10$

Table 4.7

Censored Regression Analysis of Study 1 for Log (Market Adoption)

Variable	Coefficient	Robust S.E.
Age of the Project	-.001	.003
Market Potential	.011[a]***	.003
Complexity of Product	.005[b]	.004
License_dummy	.427***	.134
CP	.025**	.010
Stage	-.050	.036
Breadth	.489***	.086
Capability	-.429	.272
CP x Stage	.001	.003
CP x Breadth	.006	.007
CP x Capability	-.053*	.028
Stage x Breadth	-.045	.037
Stage x Capability	.207**	.088
Breadth x Capability	.214	.222
CP^2 (H_1)	-.027[c]*	.015
CP^2 x Stage (H_3)	.003[c]	.003
CP^2 x Breadth (H_5)	-.013[c]*	.007
CP^2 x Capability (H_7)	.084[c]**	.035
Constant	6.901***	.174

N = 649

[a]Market Potential was divided by 10,000.

[b]Complexity of Product was divided by 1,000,000.

[c]CP^2 and interactions with CP^2 were divided by 100.

*** $p < .01$, ** $p < .05$, * $p < .10$

Furthermore, to ensure that the nonlinear relationship between customer participation and market adoption is an inverted U-shape (one turn) and not an S-shape (two turns), a cubed IV term was included as well. The results demonstrated that the squared term is significant but the

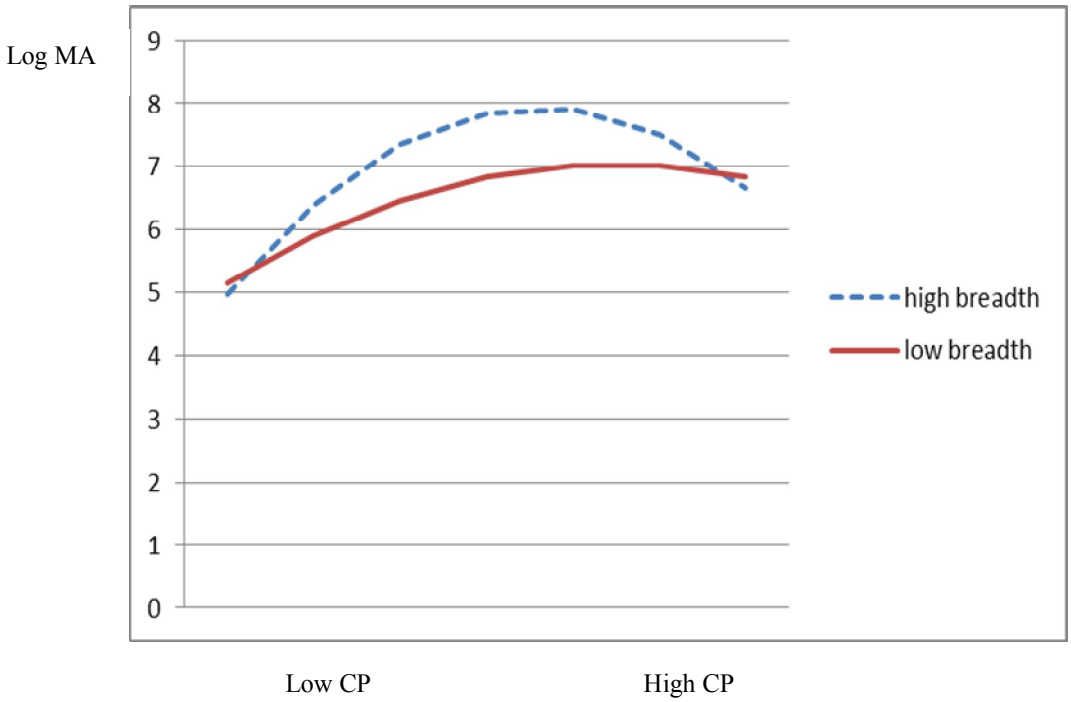
cubed term is not. Thus, we can say that the nonlinear relationship between them follows an inverted U-shape.

Hypotheses 3, 5, and 7 predict that stage when end customers are engaged in the NPD process (Hypothesis 3), how broadly end customers are involved in the NPD process (Hypothesis 5), and a NPD team's capability to leverage customers' insights (Hypothesis 7) would moderate the inverted U-shaped relationship between customer participation and market adoption. As indicated in Table 4.5, the interaction term between CP^2 and stage was not significant ($\beta = -.098$, $p > .10$), rejecting Hypothesis 3. In contrast, the coefficients of interaction terms between CP^2 and breadth and co-production capability were significant (for breadth: $\beta = -.219$, $p < .10$, for co-production capability: $\beta = .563$, $p < .01$), supporting Hypotheses 5 and 7. As seen in step 5 of Table 4.5, the addition of the interaction term between CP^2 and breadth explains significant additional variance in market adoption ($\Delta R^2 = .009$, $\Delta F = 6.791$, $p < .01$). The addition of the interaction term between CP^2 and co-production capability also demonstrates significant increase in R^2 ($\Delta R^2 = .010$, $\Delta F = 7.913$, $p < .01$). Finally, the results based on robust standard error and the results from censored regression also confirmed the same conclusions related to Hypotheses 3, 5, and 7.

To facilitate the interpretation of the moderating effect of breadth, the relationship between customer participation and market adoption was plotted, where high and low levels of breadth were indicated as those above and below one standard deviation from the mean (Aiken and West 1991). Figure 4.6 displays the moderating effect of breadth in the non-linear relationship between customer participation and market adoption.

Figure 4.6

The Moderating Effect of Breadth between Customer Participation and Market Adoption



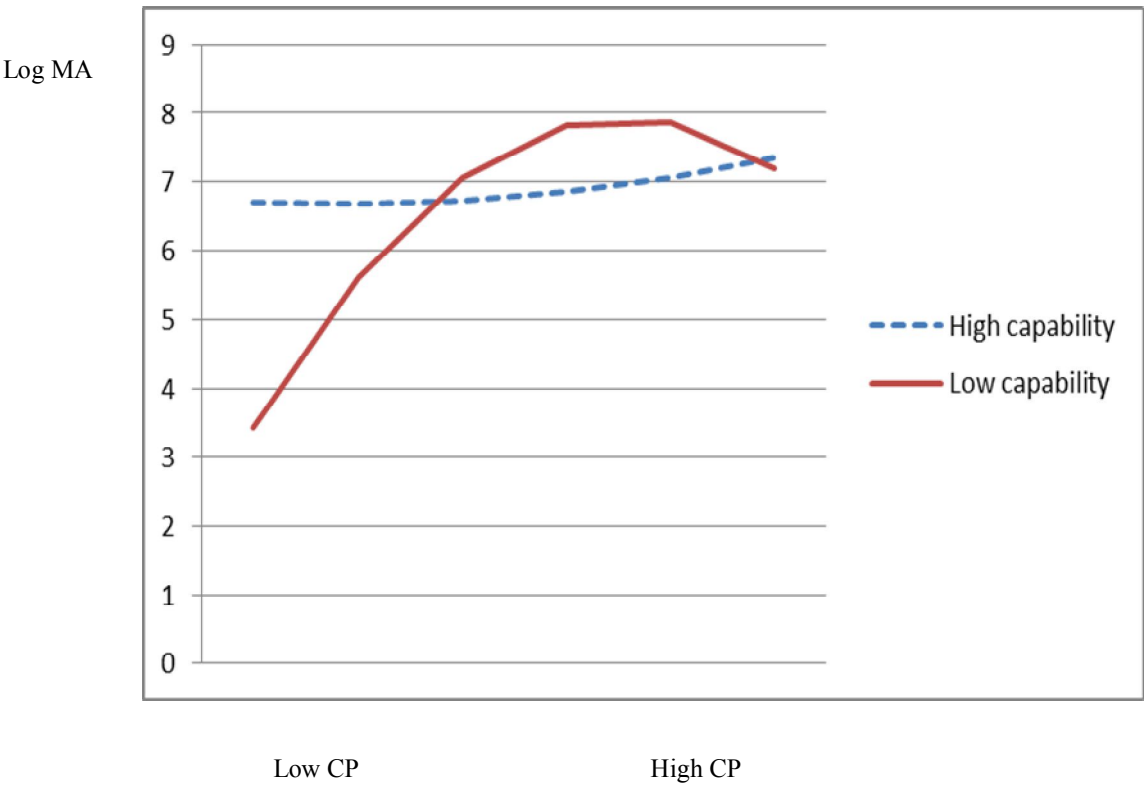
The direction of the moderation is as expected. Overall, NPD teams can benefit more from high level of breadth in terms of market adoption. I also computed the optimum level of customer participation based on the first derivative of the OLS regression equation (Aiken and West 1991; Homburg, Müller, and Klarmann 2011). In other words, the level of customer participation was calculated when making the first derivation of the OLS regression equation zero. For high level of breadth, the optimum level of customer participation is 39.19, whereas the optimum level of customer participation for low level of breadth is 60.75. Even though broad customer participation overall can help improve market adoption, the optimum level of customer participation for high level of breadth is lower than that for low level of breadth. High level of breadth can provide opportunity to obtain various insights from broad customer participation but at the same time may increase coordination problems from a wide variety of customer

participation. Thus, compared with low level of breadth where the possibility of coordination problems is less, the optimum level of customer participation for high level of breadth is low.

Similarly, to better understand the moderating effect of co-production capability, the relationship between customer participation and market adoption was plotted, where high and low levels of co-production capability were indicated as those above and below one standard deviation from the mean (Aiken and West 1991). Figure 4.7 displays the moderating effect of co-production capability in the non-linear relationship between customer participation and market adoption.

Figure 4.7

The Moderating Effect of Co-production Capability between Customer Participation and Market Adoption



As shown in Figure 4.7, when a NPD team has a low level of co-production capability, the effect of customer participation on market adoption follows the inverted U shape. In contrast, when a NPD team has a high level of co-production capability, the effect of customer participation on market adoption slightly increases as customer participation increases. Because a NPD team with a high level of co-production capability can effectively leverage and coordinate various insights from customers, the team improves market adoption as customer participation increases. The result confirms the importance of NPD team's co-production capability.

Hypotheses Tests for Time to Market in Study 1

To first test for a non-linear relationship between customer participation and time to market, a Ramsey RESET was conducted (Ramsey 1969). Consistent with the test for market adoption, control variables, independent variables, and all possible two-way interactions among independent variables were introduced in the model in an attempt to test the possibility of non-linearity after ruling out the effects of all possible interactions among independent variables (Aiken and West 1991; Baer and Oldham 2006; Luo and Donthu 2006; Ritter and Walter 2012). The result of the Ramsey RESET indicates that the model does not include any combination of non-linearity ($F(3,629) = 1.34$, $p > .10$). This finding is contrary to Hypothesis 2 which predicts a U-shaped relationship between customer participation and time to market, rejecting Hypothesis 2. Contrary to my expectation, customer participation continuously increases time elapsed until the launch of co-produced products. This finding sounds a serious warning about the potential costs of customer participation in the NPD process in terms of time to market.

Because the result of RESET indicated no non-linear relationship between customer participation and time to market, I only tested the moderating roles of stage, breadth, and NPD team' co-production capability in the linear relationship between customer participation and time

to market. To test the hypotheses, a COX proportional hazards model (Cox 1972), which is a widely used survival model, was first analyzed. However, one of the main assumptions of the Cox proportional hazard model is proportionality, which assumes that the unique effect of a unit increase in an independent is multiplicative with respect to the hazard rate. To test the proportionality assumption, I conducted Schoenfeld's (1982) test to show whether the model satisfies the proportionality assumption as a whole and each predictor in the model satisfies the proportionality assumption. The result of the global test indicates that we cannot reject proportionality ($\chi^2 = 10.50$, d.f. = 10, $p > .10$), supporting the assumption of proportional hazard. However, the results of Schoenfeld's (1982) test for individual predictors demonstrate that complexity of products ($\chi^2 = 1311.80$, d.f. = 1, $p < .01$), NPD team's co-production capability ($\chi^2 = 8.53$, d.f. = 1, $p < .01$), and interaction between customer participation and stage ($\chi^2 = 3376.17$, d.f. = 1, $p < .01$) do not satisfy the proportionality assumption. Therefore, I tested hypotheses related to time to market based on parametric survival models rather than the proportional hazards model. Table 4.8 displays the results of the parametric survival models. Based on values of log-likelihood, two parametric survival models were reported in Table 4.8. One is based on gamma survival distribution, whereas the other is based on lognormal survival distribution. The findings from both parametric survival models are consistent. All control variables are significant and show expected directions. For instance, the overall experience of developers as well as prior code availability decreases time to market, whereas complexity of products increases time to market.

Table 4.8

Parametric Survival Models of Study 1 for Time to Market

	Parametric Survival Model (Gamma distribution)		Parametric Survival Model (Lognormal distribution)	
Variable	**Coefficient**	**Robust S.E.**	**Coefficient**	**Robust S.E.**
Overall Experience of Developers	-.018[a]**	.009[a]	-.019[a]**	.009[a]
Complexity of Products	.010[a]**	.005[a]	.010[a]**	.005[a]
Prior Code Availability	-3.698***	.184	-3.924***	.113
License_Dummy	-.392***	.143	-.438***	.140
CP	.012***	.004	.011**	.005
Stage	-.006	.024	-.005	.025
Breadth	-.038	.083	-.031	.084
Capability	.022	.171	.070	.176
CP x Stage (H_4)	.002*	.001	.002**	.001
CP x Breadth (H_6)	-.008**	.003	-.007*	.004
CP x Capability (H_8)	-.004	.010	-.004	.011
Constant	10.342***	.238	10.671***	.137

[a] Overall Experience of Developers and Complexity of Products were divided by 100.
N = 647
*** $p < .01$, ** $p < .05$, * $p < .10$

Furthermore, customer participation had a significant positive effect on time to market (for parametric survival model based on gamma distribution: b = .012, $p < .01$; for parametric survival model based on lognormal distribution: b = .011, $p < .05$), implying that customer participation continuously increases time required until the product launch. In addition, the significant moderating roles of stage and breadth were found from both models. In the parametric survival model using gamma distribution, the ratio of customer participation in early stages as opposed to that in later stages moderated the relationship between customer participation and time to market (b = .002, $p < .10$), and the breadth of customer participation

also significantly moderated the customer participation-time to market link (b = -.008, $p < .05$). Similarly, I found that both stage (b = .002, $p < .05$) and breadth (b = -.007, $p < .10$) significantly moderated the relationship between customer participation and time to market in the parametric survival model using lognormal distribution. To check the robustness of the above results, moderated hierarchical OLS regression, regression using robust standard error, and censored regression analysis were conducted and the results are reported in Tables 4.9, 4.10, and 4.11.

Table 4.9

Results of Hierarchical Regression Analysis of Study 1 for Log (Time to Market)

Variable	β	ΔR^2	ΔF
Step 1		.459	136.326***
Overall Experience of Developers	-.061**		
Complexity of Products	.062**		
Prior Code Availability	-.650***		
License_Dummy	-.093***		
Step 2		.004	1.169
CP	.121**		
Stage	-.006		
Breadth	-.012		
Capability	.012		
Step 3		.005	2.190*
CP x Stage	.047		
CP x Breadth	-.083**		
CP x Capability	-.014		
Constant	10.671***		

N = 647, R^2 =.469
*** $p < .01$, ** $p < .05$, * $p < .10$

First, a moderated hierarchical regression approach was used as suggested by Aiken and West (1991). All predictor variables were centered to reduce multicollinearity among the

predictor variables and the interaction term. The maximum variance inflation factor (VIF) was 3.325, which is below the rule of thumb cutoff of 10 (Kutner, Nachtsheim, and Neter 2004). This indicates that multicollinearity is not a serious threat in estimating the coefficients. In the first step, the control variables of overall experience of developers, complexity of products, prior code availability and license_dummy were entered into the regression equation. Next, in step 2, the main effect variables of customer participation, stage, breadth, and co-production capability were introduced. Finally, in step 3, the linear two-way interactions between customer participation and moderators were introduced.

As seen in Table 4.9, control variables explain significant variance of time to market (ΔR^2 = .459, ΔF= 136.326, $p < .01$). As expected, the longer the overall experience of developers, the shorter the time to market (β = -.061, $p < .05$). As products are complex, a NPD team requires a longer time to launch the products in the market (β = .062, $p < .05$). Consistent with expectation, prior code availability has a negative impact on time to market, implying that the presence of prior code shortens time elapsed until the launch of products (β = -.650, $p < .01$).

The results in step 3 shown in Table 4.9 indicate the moderating effects of stage, breadth, and co-production capability in the linear relationship between customer participation and time to market. First, the addition of three moderating effects in step 3 shows a significant increase in explaining the variance of time to market (ΔR^2 = .005, ΔF= 2.190, $p < .10$). Furthermore, breadth of customer participation significantly moderated the relationship between customer participation and time to market (β = -.083, $p < .05$).

To test the moderating impacts more rigorously, regression analysis using robust standard errors was implemented. The finding of the regression is more robust by testing the significance

of coefficients based on robust standard errors which take into account heteroscedasticity. Table 4.10 presents the regression results using robust standard errors.

Table 4.10

Regression Analysis using Robust S.E. of Study 1 for Log (Time to Market)

Variable	Coefficient	Robust S.E.
Overall Experience of Developers	-.019[a]**	.009[a]
Complexity of Products	.010[a]**	.005[a]
Prior Code Availability	-3.924***	.114
License_Dummy	-.438***	.141
CP	.011**	.005
Stage	-.005	.025
Breadth	-.031	.085
Capability	.070	.177
CP x Stage	.002**	.001
CP x Breadth	-.007*	.004
CP x Capability	-.004	.011
Constant	10.671***	

[a] Overall Experience of Developers and Complexity of Products were divided by 100.
N = 647, R^2 = .469
*** $p < .01$, ** $p < .05$, * $p < .10$

Overall, the results in Table 4.10 are in line with the findings in Table 4.9. One difference is that the findings based on robust standard errors indicate significant moderating impacts of when end customers are engaged in the NPD process (b = .002, $p < .05$) as well as breadth of customer participation (b = -.007, $p < .10$). The results from censored regression analysis as shown in Table 4.11 also demonstrate that both stage and breadth of customer participation moderate the relationship between customer participation and time to market. Taken together, we

can confirm the moderating roles of stage and breadth in the linear relationship between customer participation and time to market.

Table 4.11

Censored Regression Analysis of Study 1 for Log (Time to Market)

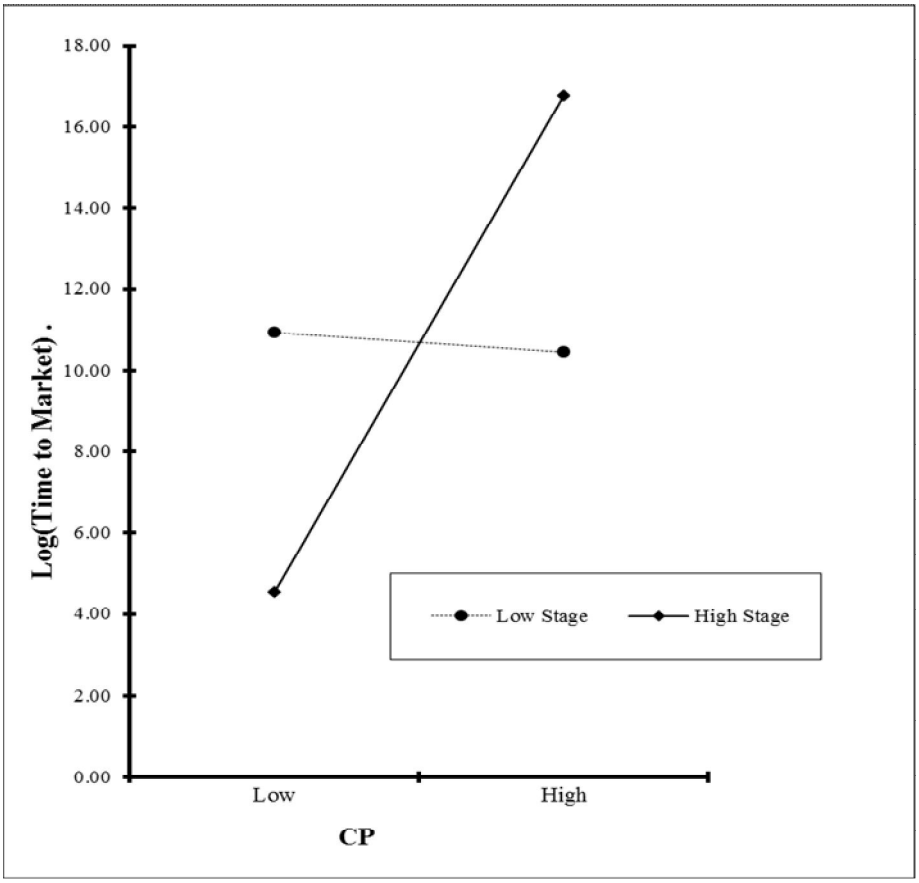
Variable	Coefficient	Robust S.E.
Overall Experience of Developers	-.019[a]**	.009[a]
Complexity of Products	.010[a]**	.005[a]
Prior Code Availability	-3.929***	.114
License_Dummy	-.435***	.140
CP	.011**	.005
Stage	-.005	.025
Breadth	-.029	.084
Capability	.071	.176
CP x Stage	.002**	.001
CP x Breadth	-.007*	.004
CP x Capability	-.004	.011
Constant	10.670***	.137

[a] Overall Experience of Developers and Complexity of Products were divided by 100.
N = 647
*** $p < .01$, ** $p < .05$, * $p < .10$

To facilitate the interpretation of the moderation effects, the customer participation-time to market relationships were plotted, where high and low levels of stage and breadth respectively were indicated as those above and below one standard deviation from the mean (Aiken and West 1991). Figures 4.8 and 4.9 show the moderating impacts of stage and breadth.

Figure 4.8

The Moderating Effect of Stage between Customer Participation and Time to Market

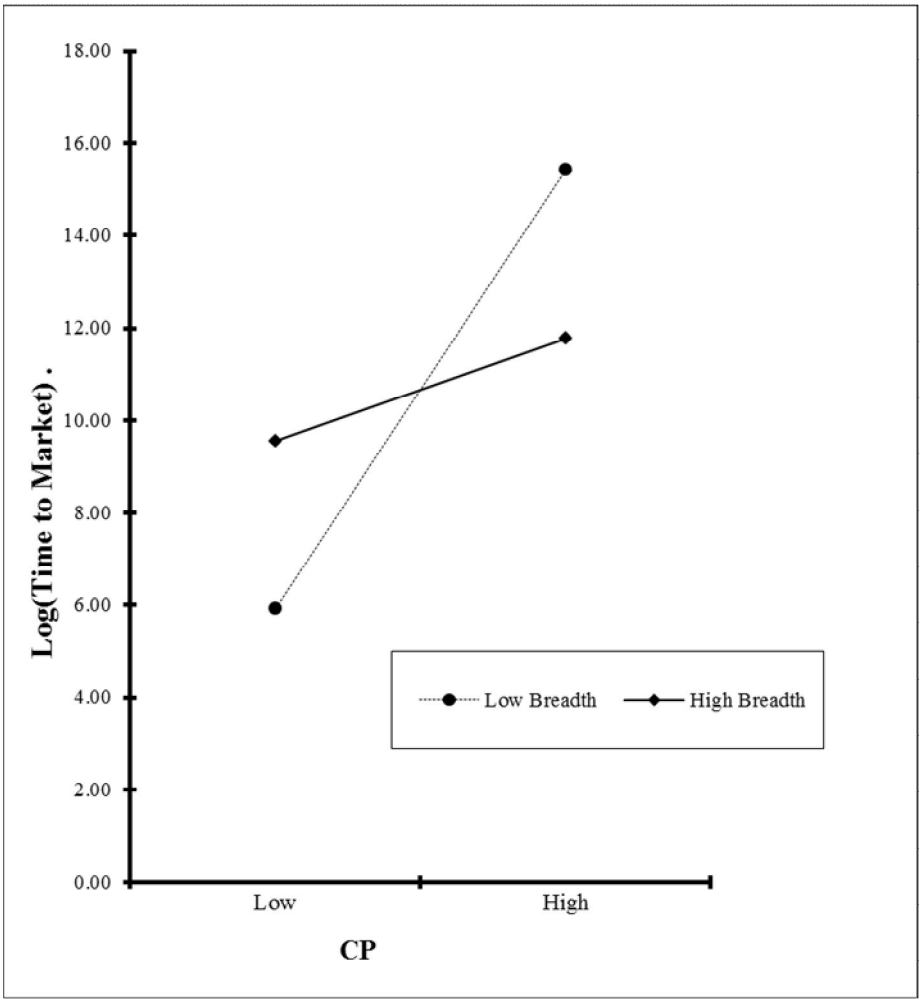


As seen in Figure 4.8, when the ratio of how much end customers are involved in early stage as opposed to later stage is high, customer participation has a positive impact on time to market. In other words, when end customers are mainly engaged in the early NPD process, customer participation increases time required until the product launch. On the other hand, when the ratio of how much end customers are involved in early stage as opposed to later stage is low, customer participation does not increase time to market. I further analyzed this interaction by evaluating simple slopes. Following Aiken and West (1991), simple slopes at two levels of stage where low is one standard deviation below the moderator and high is one standard deviation

above the moderator were estimated. Results indicate that when the ratio of customer participation in early stages as opposed to in later stages is high, the simple slope of the regression shows significant positive value (b = .012, t = 2.290, $p < .05$). In contrast, when the ratio of customer participation in early stages is low, the simple slope of the regression is not significantly different from zero (b = .006, t = 1.040, $p > .10$). Consistent with my expectation, compared with customer participation in later stages, customer participation in early stages tends to lengthen time to market.

Figure 4.9

The Moderating Effect of Breadth between Customer Participation and Time to Market



As seen in Figure 4.9, for both high and low breadth, customer participation seems to lengthen time elapsed to the new product launch. To statistically test whether each slope of the regression lines is significantly different from zero, simple slope tests were conducted. When end customers are broadly involved in the NPD process, simple slope of the regression line is not significant ($b = .004$, $t = 1.056$, $p > .10$). On the other hand, for low breadth, simple slope is significantly different from zero ($b = .023$, $t = 2.833$, $p < .01$). These findings are very interesting. For high breadth where end customers are involved in a wide variety of co-production activities, the impact of customer participation on time to market is consistent regardless of the level (intensity) of customer participation. Even at a low level, broad customer participation seriously impacts time to market. However, for low breadth where involvement of end customers concentrates on a limited number of co-production activities, customer participation significantly lengthens time elapsed until the new product launch.

CHAPTER 5

STUDY 2

Study 1 investigated a sample in one specific industry (i.e., open source software development). Although open source software development is a good context to vividly show customer participation in the NPD process, the findings of Study 1 may not be valid in other contexts because of the unique characteristics of the open source software industry. Therefore, Study 2 tests the generalizability of the findings from Study 1 and moderating effects of product individuality (H_9) and price positioning (H_{10}) by collecting survey data from a wide variety of industries.

Pretest Sample and Data Collection of Study 2

A pretest of the survey was conducted to check the validity of survey measures and procedures. The survey data for pretest were collected from NPD managers using Zoomerang. Zoomerang.com is an online survey tool that allows users to create and send surveys online and analyze the results on-demand. The website also offers commercial online panels composed of people who are pre-recruited to participate in online surveys. These online panels encompass managers in various industries as well as general customers. Therefore, I collected survey data from NPD managers in a Zoomerang online panel who have worked on a NPD project in which end customers have been involved to some extent to co-produce new products. The NPD managers cover a wide variety of industries. They were asked to respond to survey questions based on the most recently launched NPD project in which end customers were involved.

For the pretest of survey measures and procedures, 100 questionnaires were collected from July 22 to July 27, 2011. From a total of 689 NPD managers who got invitations for the online survey, 100 completed the survey for a response rate of 14.51%. Seven questionnaires out of the 100 questionnaires were removed because the same answers were selected for all the items in the survey. Another 12 responses were deleted because respondents' knowledge of the particular NPD project that they had in mind when completing the questionnaire is below 4 on a 7-point scale, indicating they were not knowledgeable of the particular NPD project. After these deletions, 81 responses were left to be analyzed for the pre-test. The mean of 81 respondents' knowledge of the particular NPD project is 5.93 on a 7-point scale (S.D. = .972). Table 5.1 presents the respondents' characteristics.

Table 5.1

Sample Composition of Pretest of Study 2

	%
A. Industries	
Manufacturing	41.54
Information Technology	21.54
Health Care	9.23
Engineering	9.23
Services (e.g., consulting, travel agency)	12.31
Others	6.15
B. NPD Team Size (the number of active people on the NPD team)	
5 or fewer than 5 people	23.1
6 – 15 people	35.9
16 – 30 people	19.2
31 – 50 people	16.7
more than 50 people	5.1
C. Firm Size (the number of full-time employees)	
fewer than 100 employees	25.9
100 – 499 employees	18.5

500 – 1,000 employees	19.8
more than 1,000 employees	35.8
D. Length of time the respondent worked on the project	
6 or fewer than 6 months	48.48
7 – 12 months	25.76
13 – 24 months	19.70
more than 24 months	6.06
F. Length of time the respondent has worked in NPD	
fewer than 5 years	31.88
5 – 10 years	31.88
11 – 15 years	11.59
16 – 20 years	8.70
more than 20 years	15.94

N = 81

Measures of Study 2

All of the measures used in this study except co-production capability were adapted from existing scales. Items for co-production capability were newly developed for this study. All measures used a 7-point scale with the anchors such as 1 = strongly disagree to 7 = strongly agree, 1 = not at all to 7 = a great extent, 1 = low to 7 = high, or 1 = much lower to 7 = much higher. All measures are provided in Appendix A.

Customer participation. Customer participation is assessed with the initial seven items adapted from Chan, Yim, and Lam (2010) and Gruner and Homburg (2001). In this dissertation, customer participation is defined in terms of amount of information provision and intensity of actual interaction between a NPD team and end customers. Three items capturing how much information end customers provide to NPD teams come from Chan, Yim, and Lam (2010), and four items representing the intensity of interaction are adapted from measures developed by Gruner and Homburg (2001).

Market adoption. Market adoption is measured using three items from Lau, Tang, and Yam (2010). Market adoption represents market outcomes reflecting how much customers in the market accept the new product and how much financial success companies can achieve through the new product. Thus, these items assess the extent to which the NPD team achieves sales or profit compared with its goal. These perceptual performance measures have been used to effectively evaluate a firm's performance. Given that firms are likely to be reluctant to share objective performance data due to confidentiality issues (Ward, Bickford, and Leong 1996) and differences in objective performance might vary in different industries (Ledwith 2000; Pagell and Krause 2004), comparing market performance of NPD teams in different industries using perceptual measures versus their goals is appropriate.

Time to market. Time to market is assessed using three items adapted from Fang (2008). Specifically, the items ask respondents to rate their perceived speed of development of the new product compared with the industry norm or typical product development time. Given the difference in the speed of development of the new product in different industries, perceptual measures compared to the industry norm or typical development time rather than objective development time are expected to more effectively evaluate time to market.

Stages of customer participation. Stages in which customers are involved are assessed by rating the degree to which end customers participated in each of the seven stages of the NPD process (i.e., idea generation, concept screening, product design, product engineering, product testing, market testing, and commercialization). This approach is consistent with Gruner and Homburg (2000) and Fang, Palmatier, and Evans (2008). Similar to the approach used in Study 1, the ratio of the degree to which customers are involved in early NPD stages (i.e., the sum of scores in idea generation, concept screening, product design, and product engineering divided by

four) to the degree to which customers are engaged in later phases (i.e., the sum of scores in product testing, market testing, and commercialization divided by three) is generated. In other words, as the ratio increases, customers on the project tend to be engaged in early NPD phases.

Breadth of customer participation. Breadth of customer participation is operationalized as the sum of the number of activities which end customers actively engaged in (Fang, Palmatier, and Evans 2008). On the basis of the NPD literature, seven activities central to the NPD process (i.e., idea generation, concept screening, product design, product engineering, product testing, market testing, and commercialization) are identified. For each activity, respondents are asked the extent to which end customers are involved in the activity (rated on a scale of 1 = "not at all" to 7 = "a great extent"). The sum of the number of activities that the customer was engaged in to some extent (i.e., activities rated between 5 and 7 on the scales) is used to represent the breadth of customer participation.

Co-production capability. The scale for co-production capability was newly developed for this dissertation. On the basis of the literature review and discussion with academic and professional experts in this area, the concept of co-production capability was clarified and five items were generated to capture the construct. Co-production capability is defined as a NPD team's ability to leverage customer input to develop the new product in the NPD process. Specifically, co-production capability is composed of a process by which the NPD team *recognizes* value of input from end customers and *applies* it to the new product. Two items captures the NPD team's ability to recognize the value of input and three items represent the NPD team's ability to apply input to a new product.

Product individuality. To assess product individuality, NPD managers evaluated the degree to which the co-produced product is individualized rather than standardized using three items adapted from Homburg, Müller, and Klarmann (2011).

Product price positioning. Product price positioning is measured with a single item from Homburg, Müller, and Klarmann (2011) that assesses the overall price level of the co-produced product compared with competitors' products. Because product price positioning refers to a concrete and singular concept, there is expected to be no difference in the predictive validity of the multiple-item and single-item measures (Bergkvist and Rossiter 2007). Table 5.2 presents the source and number of items of focal constructs.

Table 5.2

Survey Measures of Study 2

Constructs	Source	Number of Items (Initial)
Customer Participation	Chan, Yim, and Lam (2010) Gruner and Homburg (2000)	7
Market Adoption	Lau, Tang, and Yam (2010)	3
Time to Market	Fang (2008)	3
Stages of Customer Participation	Gruner and Homburg (2000) Fang, Palmatier, and Evans (2008)	7
Breadth of Customer Participation	Fang, Palmatier, and Evans (2008)	7
NPD team's Co-Production Capability	Newly developed	5
Product Individuality	Homburg, Müller, and Klarmann (2011)	3
Product's Price Positioning	Homburg, Müller, and Klarmann (2011)	1

Control Variables of Study 2

To control for effects of other variables on new product success (i.e., market adoption and time to market), several control variables are included. At the project level, new product innovativeness, which refers to the extent to which the co-produced product differs from competing alternatives in the industry (Dewar and Dutton 1986; Sethi, Smith, and Park 2001), may influence market adoption and time to market. I measured new product innovativeness using a three-item, seven-point Likert scale adapted from Moorman's (1995) new product creativity scale. The scale items ask respondents about the extent to which the co-produced new product is novel to the industry and offers new ideas.

Several researchers suggest that product quality enhances market adoption (e.g., Li and Calantone 1998; Sethi 2000). Therefore, to control for the quality of co-produced product, I assessed product quality using four items adapted from Atuahene-Gima and Wei (2011). Measures for product quality evaluate it in terms of reliability, durability, and functionality of the co-produced product. Finally, this dissertation controlled for project size, which is measured by the number of people in the NPD project. Because large teams have more cognitive and other resources, they may be capable of developing better new products, which leads to a higher level of new product success (Atuahene-Gima and Wei 2011).

In addition to characteristics at the project level, firm-specific characteristics may influence new product success (Fang 2008). Building on previous literature, a firm's size, measured by the number of full-time employees, was controlled for.

At the environmental level, environmental turbulence was included because of its influence on new product success (Gatignon and Xuereb 1997). This was measured with three, seven-point Likert scales adapted from the work of Fang (2008) and Atuahene-Gima and Wei

(2010). These items rated the extent of change and predictability of customers' preference and the market. Finally, industry dummy was included in order to rule out industry-specific effects. This is important to do given the possibility of the different impact of customer participation in new service development and new product development processes (e.g., Melton and Hartline 2010; Schleimer and Shulman 2011). Table 5.3 indicates control variables and their sources.

Table 5.3

Control Variables of Study 2

Model	Control Variables	Sources	Number of Items (Initial)
Project level	New Product Innovativeness	Moorman (1995)	3
	Product Quality	Atuahene-Gima and Wei (2011)	4
	Project Size	Atuahene-Gima and Wei (2011)	1
Firm level	Firm Size	Fang (2008)	1
Environmental level	Environmental Turbulence	Atuahene-Gima and Wei (2011); Fang (2008)	3
	Industry_dummy		1

Measure Assessment of Pretest

To test reliability and validity of the measures, confirmatory factor analysis (CFA) was conducted including independent variable (i.e., customer participation), dependent variables (i.e., market adoption and time to market), and several moderating and control variables. After dropping three items from customer participation, two items from NPD team's co-production capability, and one item from environmental turbulence, the selected measures provided good explanations for each construct. Table 5.4 presents the results of CFA.

As seen in Table 5.4, all item loadings are positive and statistically significant, indicating unidimensionality and establishing convergent validity (Anderson 1987). In addition, there are

no negative variances (Bagozzi and Yi 1988). Latent variables are measured reliably. Average variance extracted (AVE) of all latent variables is above .50 and composite reliabilities (CR) of all focal constructs except environmental turbulence (CR = .68) are well above the recommended threshold of .70 (Nunnally and Bernstein 1994). Squared multiple correlations (SMC) for most measures are also above .50 except TIME1 (SMC = .49), QUAL2 (SMC = .49), and TURB3 (SMC = .35). Even though the measures for environmental turbulence should perhaps be revised for the main study, the measures exhibit good psychometric properties overall. In addition, the fit of the CFA model containing all constructs is satisfactory (χ^2 = 242.17, d.f.= 188, $p < .01$, χ^2/d.f. = 1.29, comparative fit index (CFI) = .94, non-normed fit index (NNFI) = .93, root mean square error of approximation (RMSEA) = .06, standardized root mean square residual (SRMR) = .066).

Table 5.4

Confirmatory Factor Analysis of Pretest of Study 2

Construct	Items	Standardized Loadings	SMC	Cronbach's α	CR	AVE
Customer Participation	CP2	.71**	.50	.82	.82	.54
	CP5	.71**	.50			
	CP6	.77**	.60			
	CP7	.75**	.56			
Market Adoption	MA1	.91**	.82	.93	.93	.82
	MA2	.94**	.88			
	MA3	.87**	.76			
Time to Market	TIME1	.70**	.49	.85	.86	.67
	TIME2	.84**	.71			
	TIME3	.91**	.83			
Co-production Capability	CAP3	.85**	.73	.87	.87	.69
	CAP4	.82**	.67			
	CAP5	.83**	.70			
Product Innovativeness	INNOV1	.84**	.70	.87	.88	.71
	INNOV2	.92**	.84			
	INNOV3	.76**	.58			
Product Quality	QUAL1	.75**	.56	.86	.86	.62
	QUAL2	.70**	.49			

	QUAL3	.82**	.67			
	QUAL4	.86**	.74			
Environmental	TURB1	.84**	.70	.66	.68	.53
Turbulence	TURB3	.59**	.35			

Fornell and Larcker's (1981) method was used to evaluate discriminant validity. In this method, the amount of variance within the scale must be greater than the amount of variance between two variables to find support for discriminant validity. Table 5.5 presents correlations among focal constructs and square root of the AVEs on the diagonal. The results show discriminant validity because the square roots of the AVEs on the diagonal are greater than the corresponding latent variable correlations in the same row and column. Overall, survey measures show reliability and validity. Thus, survey measures except environmental turbulence which are included in main study were not changed. However, due to low loading and low reliability of items on environmental turbulence, the measures on environmental turbulence were changed. Specific changes are reported in the main study section.

Table 5.5

Means, Standard Deviations, and Correlations of Pretest

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Customer Participation	4.88	1.20	.74												
2. Market Adoption	5.12	1.35	.34**	.91											
3. Time to Market	4.67	1.37	.36**	.32**	.82										
4. Stage	1.00	.70	.06	.18	.21	N.A.									
5. Breadth	4.36	2.19	.38**	.40**	.51**	.04	N.A.								
6. Co-production Capability	5.16	1.11	.45**	.61**	.44**	.22	.42**	.83							
7. Individuality	5.61	1.08	.46**	.32**	.36**	.19	.20	.52**	N.A.						
8. Price Strategy	4.78	1.25	.45**	.08	.34**	-.00	.41**	.04	.18	N.A.					
9. Product Innovativeness	5.00	1.39	.49**	.31**	.47**	.11	.42**	.51**	.51**	.25*	.84				
10. Product Quality	5.56	1.02	.32**	.53**	.26*	.18	.09	.61**	.41**	.06	.37**	.78			
11. Environmental Turbulence	4.48	1.36	.42**	.39**	.54**	-.02	.60**	.45**	.30*	.36**	.55**	.25*	.73		
12. NPD Team's Size	2.42	1.14	.18	.07	.20	.00	.10	.04	.02	.06	.10	-.12	.06	N.A.	
13. Firm Size	2.62	1.22	-.01	-.19	.01	.16	-.22	-.25*	-.26*	-.04	-.11	-.22	-.21	.44**	N.A.

The square roots of the AVEs are on the diagonal.
N = 74 (listwise)
**$p < .01$, *$p < .05$

Common Method Variance (CMV) of Pretest

I collected survey data on customer participation and new product success from the same source (i.e., NPD managers) at the same time using the same method. Thus, common method variance (CMV) may inflate the relationships between the variables of interest (Podsakoff et al. 2003). I conducted two tests to examine the possibility of common method bias.

First, a Harman one-factor test was employed to determine whether a single factor would account for a large part of the variance of all manifest variables (Podsakoff et al. 2003). The one-factor model yielded a chi-square of 761.67 with d.f. = 209 (see Model 3: Method only in Table 5.6), and a model (see Model 2: Trait in Table 5.6) in which I specified all relevant constructs individually led to a significant improvement in fit ($\Delta\chi^2 = 519.5$ with 21 difference in d.f., $p < .01$). This suggests that CMV is not a serious threat.

Second, I added a method factor to the measurement model to see if it improves the fit of a measurement model. To test whether CMV exists, four models were employed and their chi-squares were compared. They are Model 1: Null model (there are no factors underlying the data), Model 2: Trait model (in which all items are going to the corresponding factors), Model 3: Method only model (in which all of the items are loaded on one factor, i.e., CMV factor), and Model 4: Trait and Method model (in which a method factor is added to a trait model). The results of the chi-square difference tests are presented in Table 5.6. The logic behind these chi-square difference tests is that if CMV exists, the method only model (Model 3) should explain significantly more variance in the data than the trait model (Model 2). As shown in the two chi-square difference tests, both these conditions hold, indicating that CMV exists in the data. However, the common method variance accounts for only 5% of the variance. Given that Williams, Cote, and Buckley (1989) found that an average of 25% of the variance in the articles

they examined was due to CMV, only 5% of CMV does not seem to be a serious threat to the results.

Table 5.6

Common Method Variance Results of Pretest

	χ^2	d.f.	$\Delta\chi^2$	Δd.f.
Model 1: Null	2934.60	231	-	-
Model 2: Trait	242.17	188	-	-
Model 3: Method only (one factor model)	761.67	209	-	-
Model 4: Trait and Method	202.06	166	-	-
Model 1 vs. Model 3	-	-	2172.93**	22
Model 2 vs. Model 3	-	-	519.50**	21
Model 2 vs. Model 4	-	-	40.11*	22

** $p < .01$, * $p < .05$

Main Study Sample and Data Collection of Study 2

The survey data for the main study were collected from NPD managers in a Qualtrics online panel. Like Zoomerang which was utilized for the pretest, Qualtrics also offers commercial online panels composed of people who are pre-recruited to participate in online surveys. I collected survey data from NPD managers in a Qualtrics online panel who have worked on a NPD project in which end customers have been involved to some extent to co-produce new products. Survey data for the pretest and the main study were collected from different online panels because I wanted to avoid the possibility that the same sample responds to both the pretest and main study. Therefore, a Qualtrics online panel was purchased for the main study. The NPD managers in the Qualtrics online panel represent a wide variety of industries.

The NPD managers were first screened by using a qualification question: “Have you worked on a New Product Development (NPD) project in which end customers have been involved to some extent to co-create new products? Co-creation of new products could involve end customers providing new products ideas or new features, participating in designing new

products, engineering new products, testing new products before launch, and commercializing new products." Only qualified NPD managers who responded yes to the screening question are asked to respond to survey questions based on the most recently launched NPD project in which end customers were involved.

For the main study, a total of 2,096 managers who work on NPD teams were contacted to take the survey. From these, 289 questionnaires were collected from January 17 to January 23, 2012, resulting in a response rate of 13.79%. To examine the possible effects of nonresponse bias (i.e., people who respond differ substantially from those who do not, Armstrong and Overton 1977), responses from people responding later were compared with those from people responding readily (Ferber 1948). The logic behind this approach is that people responding later are assumed to be more similar to nonrespondents (Ferber 1948). Given that the second invitation letter which asks online panels to take survey was sent on January 20, and 90.29% of responses were collected by January 19, responses collected between January 20 and January 23 were viewed as late responses. The results of ANOVA test indicate that there is no significant difference between early responses and late responses in terms of NPD team size, firm size, industry, department, and length of time that the respondent has worked in the company. Thus, nonresponse bias is not a serious threat for this study.

First, out of the 289 completed questionnaires, questionnaires which were completed in less than 4 minutes were removed, resulting in 206 valid questionnaires. Given that the average length of survey is 7 minutes after excluding several extreme cases, 4 minutes is considered to be a reasonable cutoff. Following Cook's distance (Cook 1977, 1979) and Bollen and Jackman's (1990) guideline to cut off outliers (i.e., Cook's distance > 4/n, n = the number of observations), extreme values were identified. As a result, 45 extreme values were deleted and final analyses

were based on a total of 161 samples. Knowledge level of the particular NPD project that respondents in the final sample had in mind when completing the questionnaire is above 5 on a 7-point scale and the average level of knowledge is 6.04 on a 7-point scale (S.D. = .745). Table 5.7 presents the respondents' characteristics for the main study.

Table 5.7

Sample Composition of Main Study of Study 2

	Frequency	%
A. Industry		
Manufacturing	56	34.8
Information Technology	66	41.0
Services	30	18.6
Other	9	5.6
B. NPD Team Size (the number of active people on the NPD team)		
5 or fewer than 5 people	16	9.9
6 - 15 people	42	26.1
16 - 30 people	51	31.7
31 - 50 people	39	24.2
more than 50 people	12	7.5
Missing	1	0.6
C. Firm Size (the number of full-time employees)		
fewer than 300 employees	42	26.1
300 - 999 employees	58	36.0
1,000 - 3,000 employees	44	27.3
more than 3,000 employees	16	9.9
Missing	1	0.6
D. Department the respondent was in		
Marketing/Sales	76	47.2
R & D	16	9.9
Engineering	14	8.7
Design	21	13.0
Production/Operation	24	14.9
Other	10	6.2

E. Length of time the respondent worked on the project		
Less than 3 months	6	3.7
3 - 6 months	47	29.2
7 - 12 months	63	39.1
13 -24 months	31	19.3
more than 24 months	14	8.7
F. Length of time the respondent has worked in NPD		
less than 3 years	28	17.4
3 - 6 years	73	45.3
7 - 10 years	29	18.0
11 - 15 years	17	10.6
16 – 20 years	5	3.1
more than 20 years	9	5.6
G. Length of time the respondent has worked in the company		
less than 5 years	27	16.8
5 – 10 years	81	50.3
11 -15 years	31	19.3
16 -20 years	11	6.8
more than 20 years	11	6.8

N = 161

Measures of Main Study

Because all the measures in the main study except environmental turbulence were utilized without changes from the pretest (see Table 5.8), I only explain the revised measures of environmental turbulence in this section. With regard to environmental turbulence, because items to assess environmental turbulence demonstrated low loadings, SMCs, and reliability among items in the pretest, items on environmental turbulence were revised. The three items involved in the pretest were: (1) Customers' preferences change quickly over time in the market for this product (2) Market demand and consumer tastes in the market were unpredictable, and (3) Actions of competitors in the market were unpredictable. It is possible that the measures of environmental turbulence did not work well because the measure attempts to capture different

two concepts: speed of change and unpredictability of customers' preferences. Taking into account this problem, Moorman and Miner (1997) utilized items of environmental turbulence which only focus on the pace of changes in the industry.

In addition, the items included in the pretest only focused on turbulence from the customers or market perspective. However, Moorman and Miner (1997) pointed out that environmental turbulence needs to be assessed by combining technological with market turbulence. In line with Moorman and Miner (1997), Im and Workman (2004) also emphasized the impact of technological turbulence on new product performance. Following these suggestions, four items which reflect the pace of technological change and customer preference changes were introduced for the main study (see Table 5.8 for the specific measures). These items were adapted from measures of Jaworski and Kohli (1993) and Moorman and Miner (1997).

Table 5.8

Measures for Main Study of Study 2

Constructs	Source	Measures
Customer Participation	Chan, Yim, and Lam (2010) Gruner and Homburg (2000)	1. Our customers shared a lot of information about their needs during the NPD process.* 2. Our customers provided us with many suggestions for improving the new product during the NPD process.* 3. Our customers provided us with extensive consultation during the NPD process. 4. Our customers communicated intensively with the NPD team. 5. Many customers were involved in the NPD process. 6. Our customers were involved in the NPD process for a long time. 7. Our customers met the NPD team frequently for co-creation.
Market Adoption	Lau, Tang, and Yam (2010)	1. The new product achieved our sales goal. 2. The new product achieved our profit goal. 3. The product had great profitability.
Time to Market	Fang (2008)	1. The new product was developed slower than the industry norm. 2. The new product was developed behind of where we would be had we gone it alone. 3. The new product was developed slower than our typical product development time.

Stages of Customer Participation	Gruner and Homburg (2000) Fang, Palmatier, and Evans (2008)	For each of the following activities in the NPD process for this product, please indicate the extent to which end customers participated in this activity. 1. Idea generation 2. Concept screening 3. Product design 4. Product engineering 5. Product testing 6. Market testing 7. Commercialization
Breadth of Customer Participation	Fang, Palmatier, and Evans (2008)	
NPD Team's Co-Production Capability	Newly developed	1. Our NPD team recognized the usefulness of insights that customers suggested.* 2. Our NPD team valued insights that customers suggested.* 3. Our NPD team could easily address the new needs that customers specified. 4. Our NPD team could take corrective action immediately when customers suggested modification of a product or service. 5. Our NPD team could effectively satisfy customers' demands.
Product Individuality	Homburg, Müller, and Klarmann (2011)	1. The new product was highly adapted to our customers' needs. 2. The major characteristics of the new product were highly adjusted to our customers. 3. The new product was highly individualized.*
Product Price Positioning	Homburg, Müller, and Klarmann (2011)	1. The overall price level of the new product compared to that of competitors' products was much higher.

Controls		
Product Innovativeness	Moorman (1995)	1. The new product was very novel for our industry. 2. The new product was challenging to existing ideas in our industry. 3. The new product was very creative.*
Product Quality	Atuahene-Gima and Wei (2011)	1. In our internal tests, the new product performed exactly as it was designed to do.* 2. The new product had little probability of malfunctioning in use.* 3. The new product's performance characteristics met established industry standards. 4. The expected product use life met the required specifications.
Project Size	Atuahene-Gima and Wei (2011)	How many people from your firm were actively on the NPD team?
Firm Size	Fang (2008)	How many full-time employees does your company have?
Environmental Turbulence	Jaworski and Kohli (1993); Moorman and Miner (1997)	1. Customers' product preferences in the market changed quite a bit over time.* 2. Our customers tend to look for new products all the time.* 3. The technology in our market changed rapidly. 4. A large number of new product ideas had been made possible through technological breakthroughs in our market.
Industry_dummy		Which industry is your company in?

* This item was eliminated.

Measure Assessment of Main Study

To test reliability and validity of the measures for the main study, confirmatory factor analysis (CFA) was conducted. After dropping two items from customer participation, two items from NPD team's co-production capability, one item from product individuality, one item from product innovativeness, two items from product quality, and two items from environmental turbulence, the selected measures provided good explanations for each construct. Table 5.9 presents the results of CFA.

Table 5.9

Confirmatory Factor Analysis Results for Main Study of Study 2

Construct	Items	Standardized Loadings	SMC	Cronbach's α	CR	AVE
Customer Participation	CP3	.765**	.585	.87	.87	.58
	CP4	.808**	.653			
	CP5	.760**	.578			
	CP6	.701**	.491			
	CP7	.763**	.582			
Market Adoption	MA1	.793**	.628	.81	.81	.59
	MA2	.768**	.590			
	MA3	.740**	.547			
Time to Market	TIME1	.793**	.629	.91	.91	.78
	TIME2	.866**	.751			
	TIME3	.980**	.961			
Co-production Capability	CAP3	.758**	.575	.78	.78	.54
	CAP4	.718**	.515			
	CAP5	.732**	.535			
Product Individuality	IND1	.799**	.639	.74	.74	.59
	IND2	.734**	.539			
Product Innovativeness	INNO1	.781**	.610	.73	.73	.57
	INNO2	.730**	.533			
Product Quality	QUAL3	.841**	.707	.78	.78	.64
	QUAL4	.754**	.569			
Environmental Turbulence	TURB1	.734**	.539	.81	.82	.70
	TURB2	.924**	.854			

Note: $\chi^2 = 258.01$, d.f.= 181, $p < .01$, χ^2/d.f. = 1.43, comparative fit index (CFI) = .98, non-normed fit index (NNFI) = .97, root mean square error of approximation (RMSEA) = .05, standardized root mean square residual (SRMR) = .05

As seen in Table 5.9, all item loadings are positive and statistically significant, indicating unidimensionality and establishing convergent validity (Anderson 1987). In addition, there are no negative variances (Bagozzi and Yi 1988). Average variance extracted (AVE) of all latent variables is above .50 and both Cronbach's alpha and composite reliabilities (CR) of all focal constructs are well above the recommended threshold of .70 (Nunnally and Bernstein 1994). Squared multiple correlations (SMC) are also above .50 except CP6 (SMC = .49). The measures exhibit good psychometric properties overall. In addition, the fit of the CFA model containing all constructs is excellent ($\chi^2 = 258.01$, d.f. = 181, $p < .01$, χ^2/d.f. = 1.43, comparative fit index (CFI) = .98, non-normed fit index (NNFI) = .97, root mean square error of approximation (RMSEA) = .05, standardized root mean square residual (SRMR) = .05).

Fornell and Larcker's (1981) method was used to evaluate discriminant validity. Table 5.10 presents the correlations among focal constructs and square root of the AVEs on the diagonal. The results show discriminant validity because the square roots of the AVEs on the diagonal are greater than the corresponding latent variable correlations in the same row and column. Overall, survey measures for the main study show reliability and validity.

Table 5.10

Means, Standard Deviations, and Correlations of Study 2

	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Customer Participation	5.35	1.01	.76												
2. Market Adoption	5.67	.82	.58**	.77											
3. Time to Market	4.20	1.47	.19*	.03	.88										
4. Stage	.93	.21	-.03	-.02	.21**	N.A.									
5. Breadth	3.64	2.28	.64**	.44**	.22**	.15	N.A.								
6. Co-production Capability	5.71	.85	.53**	.46**	.12	.09	.57**	.74							
7. Individuality	5.84	.86	.45**	.55**	.02	.09	.45**	.47**	.77						
8. Price Strategy	5.06	1.48	.47**	.35**	.30**	.06	.46**	.30**	.19*	N.A.					
9. Product Innovativeness	5.28	1.18	.48**	.38**	.27**	.14	.49**	.37**	.38**	.37**	.76				
10. Product Quality	5.88	.85	.55**	.52**	.07	-.02	.52**	.58**	.53**	.26**	.50**	.80			
11. Environmental Turbulence	5.37	1.18	.45**	.50**	.26**	.12	.44**	.41**	.24**	.45**	.45**	.50**	.83		
12. NPD Team's Size	2.92	1.10	.36**	.30**	.07	-.01	.37**	.32**	.18*	.30**	.35**	.37**	.33**	N.A.	
13. Firm Size	2.22	.95	.28**	.24**	.02	.06	.23**	.15	.07	.29**	.25**	.24**	.36**	.49**	N.A.

The square roots of the AVEs are on the diagonal.
N = 159 (listwise)
**$p < .01$, *$p < .05$

Common Method Variance (CMV) of Main Study

Common method variance (CMV) may inflate the relationships among the variables of interest because survey data on customer participation and new product success were collected from the same source (i.e., NPD managers) at the same time using the same method (Podsakoff et al. 2003). To examine the possibility of common method bias, a Harman single-factor test and several chi-square difference tests were conducted.

First, a Harman one-factor test was employed to determine whether a single factor would account for a large part of the variance of all manifest variables (Podsakoff et al. 2003). The one-factor model yielded a chi-square of 987.40 with d.f. = 209 (see Model 3: Method only in Table 5.11), and a model (see Model 2: Trait in Table 5.11) in which I specified all relevant constructs individually led to a significant improvement in fit ($\Delta\chi^2 = 729.39$ with 28 difference in d.f., $p < .01$). This suggests that CMV is not a serious threat.

Second, I added a method factor to the measurement model to see if it improves the fit of a measurement model. To test whether CMV exists, four models were employed and their chi-squares were compared. They are Model 1: Null model (there are no factors underlying the data), Model 2: Trait model (in which all items are going to the corresponding factors), Model 3: Method only model (in which all of the items are loaded on one factor, i.e., CMV factor), and Model 4: Trait and Method model (in which a method factor is added to a trait model). The results of the chi-square difference tests are presented in Table 5.11. The logic behind these chi-square difference tests is that if CMV exists, the method only model (Model 3) should explain significantly more variance in the data than the trait model (Model 2). As shown in the two chi-square difference tests, both these conditions hold, indicating that CMV exists in the data. However, the common method variance accounts for only 5% of the variance. Given that

Williams, Cote, and Buckley (1989) found that an average of 25% of the variance in the articles they examined was due to CMV, only 5% of CMV does not seem to be a serious threat to the results.

Table 5.11

Common Method Variance Results of Main Study

	χ^2	d.f.	$\Delta\chi^2$	Δd.f.
Model 1: Null	4625.49	231	-	-
Model 2: Trait	258.01	181	-	-
Model 3: Method only (one factor model)	987.40	209	-	-
Model 4: Trait and Method	196.67	159	-	-
Model 1 vs. Model 3	-	-	3638.09**	22
Model 2 vs. Model 3	-	-	729.39**	28
Model 2 vs. Model 4	-	-	61.34**	22

** $p < .01$

Hypotheses Test for Market Adoption in Study 2

Before testing hypotheses based on survey data, RESET was conducted in order to examine the presence of non-linearity between customer participation and market adoption (Ramsey 1969). Similar to the approach implemented in Study 1, control variables, independent variables, and all possible two-way interactions among independent variables were introduced in the model (Aiken and West 1991; Baer and Oldham 2006; Luo and Donthu 2006; Ritter and Walter 2012). The result of the RESET indicates that the model does not include non-linearity ($F(3,126) = 1.05$, $p > .10$). This result is not consistent with that from Study 1 and implies that the inverted U-shaped relationship between customer participation and market adoption may not be generalized to various industries but is caused by technology-focused industry characteristics such as an open source software context. In technology-driven industries which require specialized knowledge, end customers who may lack a deep understanding of technological knowledge may not help improve new product success (Vanhaverbeke and Du 2010). Rather,

ordinary customer participation in the development process of technological products may be detrimental to new product development. In a similar vein, von Hippel (1986) also contended that lead users differ from ordinary users. Due to this characteristic, it may be more likely to find the inverted U-shaped relationship between customer participation and market adoption in an open source software context.

To investigate this possibility, I broke down survey data into subsamples according to industry and then examined nonlinearity between customer participation and market adoption only using the IT (Information Technology) industry subsample. Table 5.12 indicates the results of hierarchical regression analysis using the IT industry subsample. Even though this subsample includes just 66 NPD projects, the possibility of a curvilinear relationship between customer participation and market adoption is found.

Table 5.12

Hierarchical Regression Analysis for Market Adoption Using IT Industry Sample

Variable	β	ΔR^2	ΔF
Step 1		.457	9.930***
Product Quality	-.145		
Turbulence	.176		
Firm Size	.166		
NPD Size	.166		
Innovativeness	.055		
Step 2		.157	1.998*
CP	.105		
Stage	.000		
Breadth	-.166		
Capability	.544***		
CP x Stage	.079		
CP x Breadth	.279*		
CP x Capability	.096		
Stage x Breadth	-.037		
Stage x Capability	.112		

Breadth x Capability	-.194		
Step 3		.029	3.893*
CP^2	-.333*		
Constant	5.082***		

N = 66, R^2 =.643
*** $p < .01$, * $p < .10$

Because the main purpose of Study 2 is to test generalizability of the results in Study 1, hypotheses tests in Study 2 are based on a total survey sample including various industries. Given that the results of RESET demonstrate absence of nonlinearity in the model, I only tested the moderating roles of stage, breadth, NPD team's co-production capability, product individuality, and product price positioning in the linear relationship between customer participation and market adoption.

To test the hypotheses, a moderated hierarchical regression approach was used as suggested by Aiken and West (1991). First, all predictor variables were centered to reduce multicollinearity among the predictor variables and the interaction term. In the first step, the control variables of product quality, environmental turbulence, firm size, NPD size, product innovativeness, and industry_dummy were entered into the regression equation. Next, in step 2, the main effect variables of customer participation, stage, breadth, co-production capability, product individuality, and product price positioning were introduced. Finally, in step 3, linear two-way interactions between customer participation and moderators were introduced. Table 5.13 demonstrates the results of the moderated hierarchical regression analysis.

Table 5.13

Results of Moderated Hierarchical Regression Analysis of Study 2 for Market Adoption

Variable	β	ΔR^2	ΔF
Step 1		.398	12.379***
Product Quality	.068		
Turbulence	.347***		
Firm Size	.003		
NPD Size	.096		
Innovativeness	-.027		
Industry_dummy1 (Manufacturing)	-.403***		
Industry_dummy2 (Information Technology)	-.425***		
Industry_dummy3 (Services)	-.322***		
Step 2		.130	6.579***
CP	.210**		
Stage	-.070		
Breadth	.020		
Capability	.017		
Product Individuality	.338***		
Product Price Positioning	.046		
Step 3		.054	3.565***
CP x Stage (H_3)	-.196**		
CP x Breadth (H_5)	.229**		
CP x Capability (H_7)	-.125		
CP x Individuality (H_9)	.239***		
CP x Price (H_{10})	-.113		
Constant	4.422***		

N = 159, R^2 = .581

*** $p < .01$, ** $p < .05$, * $p < .10$

To check the robustness of the results in Table 5.13, regression analysis using robust standard errors was conducted. Table 5.14 shows the results.

Table 5.14

Results of Regression Analysis Using Robust S.E. of Study 2 for Market Adoption

Variable	Coefficient	Robust S.E.
Product Quality	.065	.097
Turbulence	.239***	.055
Firm Size	.002	.056
NPD Size	.071	.053
Innovativeness	-.018	.053
Industry_dummy1 (Manufacturing)	-.685**	.264
Industry_dummy2 (Information Technology)	-.703***	.263
Industry_dummy3 (Services)	-.668**	.272
CP	.170**	.072
Stage	-.197	.154
Breadth	.008	.032
Capability	.016	.080
Product Individuality	.322***	.071
Product Price Positioning	.025	.041
CP x Stage (H_3)	-.284**	.132
CP x Breadth (H_5)	.075**	.038
CP x Capability (H_7)	-.096	.078
CP x Individuality (H_9)	.250***	.073
CP x Price (H_{10})	-.053	.044
Constant	4.421***	.586

N = 159, R^2 = .581
*** $p < .01$, ** $p < .05$, * $p < .10$

As seen in Table 5.13, the additions of independent variables in step 2 (ΔR^2 = .130, ΔF = 6.579, $p < .01$) and interactions in step 3 (ΔR^2 = .054, ΔF = 3.565, $p < .01$) explain substantial variance in market adoption. Overall, the results from Tables 5.13 and 5.14 are consistent. When end customers are engaged in the NPD process (β = -.196, $p < .05$ in Table 5.13, b = -.284, $p < .05$ in Table 5.14), how broadly end customers are involved in co-production (β = .229, $p < .05$ in Table 5.13, b = .075, $p < .05$ in Table 5.14), and product individuality (β = .239, $p < .01$ in Table 5.13, b = .250, $p < .01$ in Table 5.14) moderated the linear relationship between customer

participation and market adoption. To better understand the significant moderating relationships, moderating plots were generated where high and low levels of stage, breadth, and product individuality respectively were indicated as those above and below one standard deviation from the mean (Aiken and West 1991).

Figure 5.1 graphically displays the moderating role of stage between customer participation and market adoption. Following simple slope analyses (Aiken and West 1991), customer participation has significant positive impact on market adoption for both high (b = .534, t = 7.442, $p < .01$) and low stage (b = .662, t = 7.402, $p < .01$). However, contrary to my prediction that market adoption will be greater when the ratio of customers participation in early stages as opposed to later stages is high (H_3), the findings demonstrate that the impact of customer participation on market adoption was greater when the ratio of customer participation in later stages is high. This result implies that customers' involvement in making the new product error-free in later stages can make a greater contribution to improve market adoption. These findings are reflected in a comment by the late Apple CEO Steve Jobs: "We do no market research. We don't hire consultants" (Smith 2010). Customers' contributions in the early idea generation stage improve market adoption. However, customer involvement in early stages may not lead to as great improvement in market adoption as we expected.

Figure 5.1

The Moderating Effect of Stage between Customer Participation and Market Adoption in Study 2

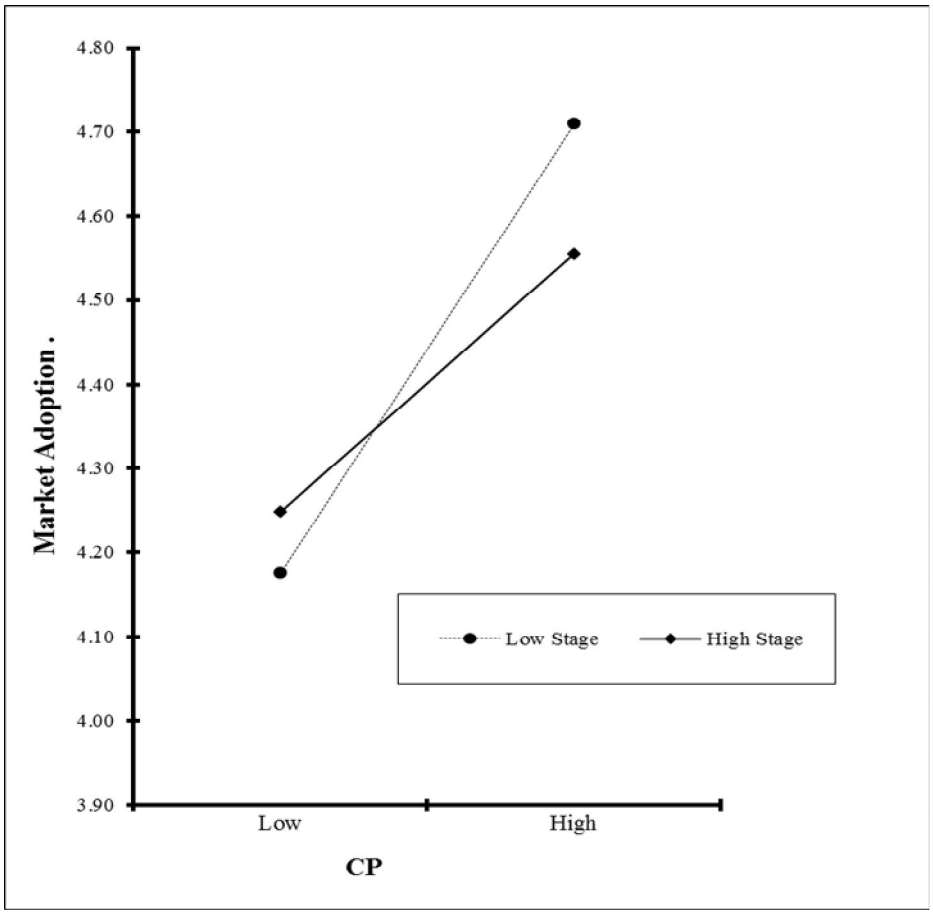
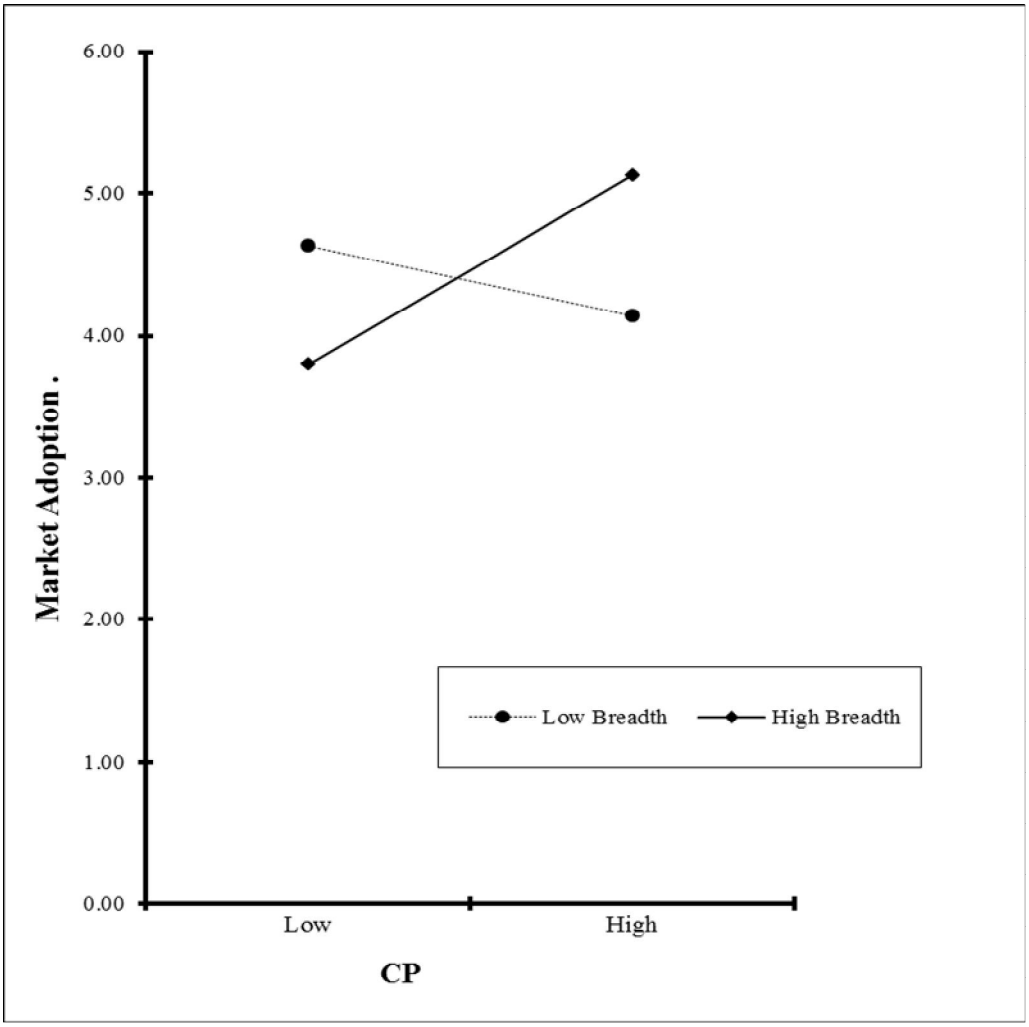


Figure 5.2 displays the moderating impact of breadth between customer participation and market adoption. When customer participation is low, customer participation in a limited area can improve market adoption more than diverse involvement of customers in a wide variety of co-production activities. In contrast, when customer participation is high, broad customer participation can benefit more from customers' insights on various aspects including new features, design, and product testing. However, when customers participate in a limited area to a

great extent, companies have a hard time coordinating customer participation and selecting optimal product problem. Thus, for low breadth, customer participation decreases market adoption. Overall, these findings are consistent with $H_{5,}$ which assumes that broad customer participation helps improve market adoption. A simple slope analysis indicates that two simple slopes for high breadth and low breadth are significantly different from zero respectively (for high breadth: b = .753, t = 7.077, $p < .01$ and for low breadth: b = -.404, t = - 4.391, $p < .01$).

Figure 5.2

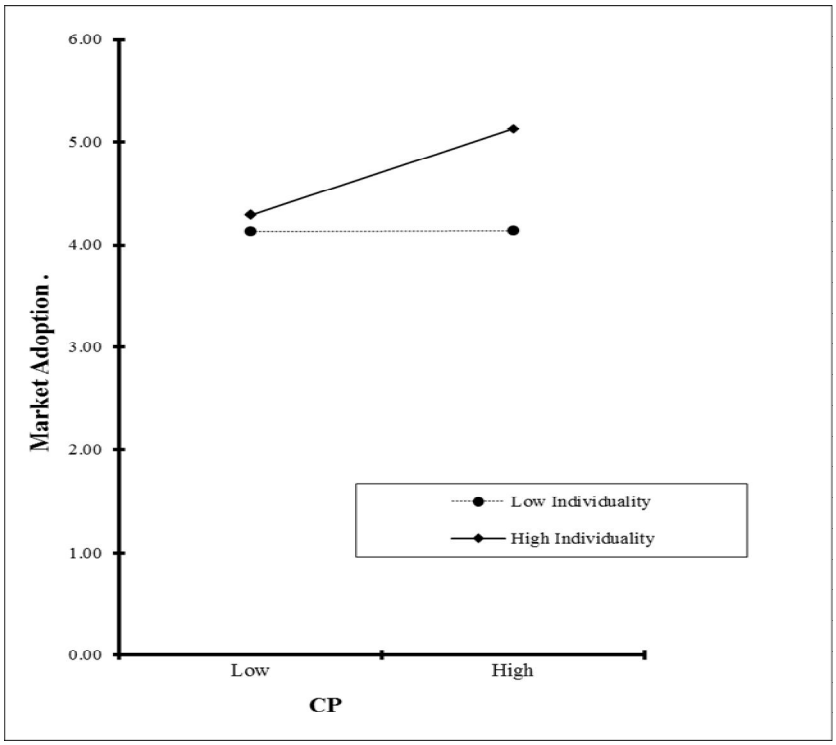
The Moderating Effect of Breadth between Customer Participation and Market Adoption in Study 2



The findings on the moderating effect of product individuality between customer participation and market adoption provide support for H_9, which predicts that the impact of customer participation on market adoption is greater as product individuality increases. As seen in Figure 5.3, for high product individuality, the effect of customer participation on market adoption is always higher than that for low product individuality. This result shows that when companies introduce highly individualized products, getting insights on customer needs directly from customers is more important. In addition, the results of a simple slope test indicate that the simple slope for high product individuality is significant at the .01 level (b = .523, t = 6.067, $p < .01$), whereas the simple slope for low product individuality is barely significant at the .10 level (b = .196, t = 1.868, $p < .10$).

Figure 5.3

The Moderating Effect of Product Individuality between Customer Participation and Market Adoption in Study 2



Hypotheses Test for Time to Market in Study 2

RESET was implemented in order to examine the presence of non-linearity between customer participation and time to market (Ramsey 1969). The result of RESET shows that the model does not include non-linearity ($F(3,135) = 1.10$, $p > .10$). Thus, I tested the moderating effects of stage, breadth, and NPD team's co-production capability in the linear relationship between customer participation and time to market.

To test interactions, a moderated hierarchical regression was implemented. The results are shown in Table 5.15. Each step demonstrates significant improvement in explaining variance of time to market. In step 1, several control variables which may influence time to market were first entered and explained 22.7% of the variance of time to market ($\Delta R^2 = .227$, $\Delta F = 5.434$, $p < .01$). In step 2, independent variables including customer participation, stage, breadth, and NPD team's co-production capability were introduced ($\Delta R^2 = .050$, $\Delta F = 2.474$, $p < .05$). Finally, interactions between customer participation and three moderators (i.e., stage, breadth, and co-production capability) were entered; these improved R^2 significantly ($\Delta R^2 = .049$, $\Delta F = 3.429$, $p < .05$). As seen in Table 5.15, only breadth of customer participation moderated the relationship between customer participation and time to market ($\beta = .227$, $p < .05$). This finding is in line with that from the regression analysis using robust standard errors as shown in Table 5.16.

Table 5.15

Results of Hierarchical Regression Analysis of Study 2 for Time to Market

Variable	β	ΔR^2	ΔF
Step 1		.227	5.434***
Product Quality	-.259**		
Turbulence	.060		
Firm Size	.060		
NPD Size	-.088		
Innovativeness	.372***		
Industry_dummy1(Manufacturing)	.334		
Industry_dummy2 (Information Technology)	.303		
Industry_dummy3 (Services)	.265		
Step 2		.050	2.474**
CP	.108		
Stage	.033		
Breadth	.265**		
Capability	.055		
Step 3		.049	3.429**
CP x Stage (H_4)	-.024		
CP x Breadth (H_6)	.227**		
CP x Capability (H_8)	.078		
Constant	3.129***		

N = 157, R^2 = .326

*** $p < .01$, ** $p < .05$, * $p < .10$

Table 5.16

Results of Regression Analysis Using Robust S.E. of Study 2 for Time to Market

Variable	Coefficient	Robust S.E.
Product Quality	-.387***	.144
Turbulence	.071	.103
Firm Size	.089	.113
NPD Size	-.110	.096
Innovativeness	.398***	.081
Industry_dummy1 (Manufacturing)	.934**	.463
Industry_dummy2 (Information Technology)	.831*	.474
Industry_dummy3 (Services)	.885*	.473
CP	.149	.137
Stage	.182	.420
Breadth	.185***	.062
Capability	.089	.158
CP x Stage (H_4)	-.095	.269
CP x Breadth (H_6)	.166***	.060
CP x Capability (H_8)	.131	.118
Constant	3.129***	1.126

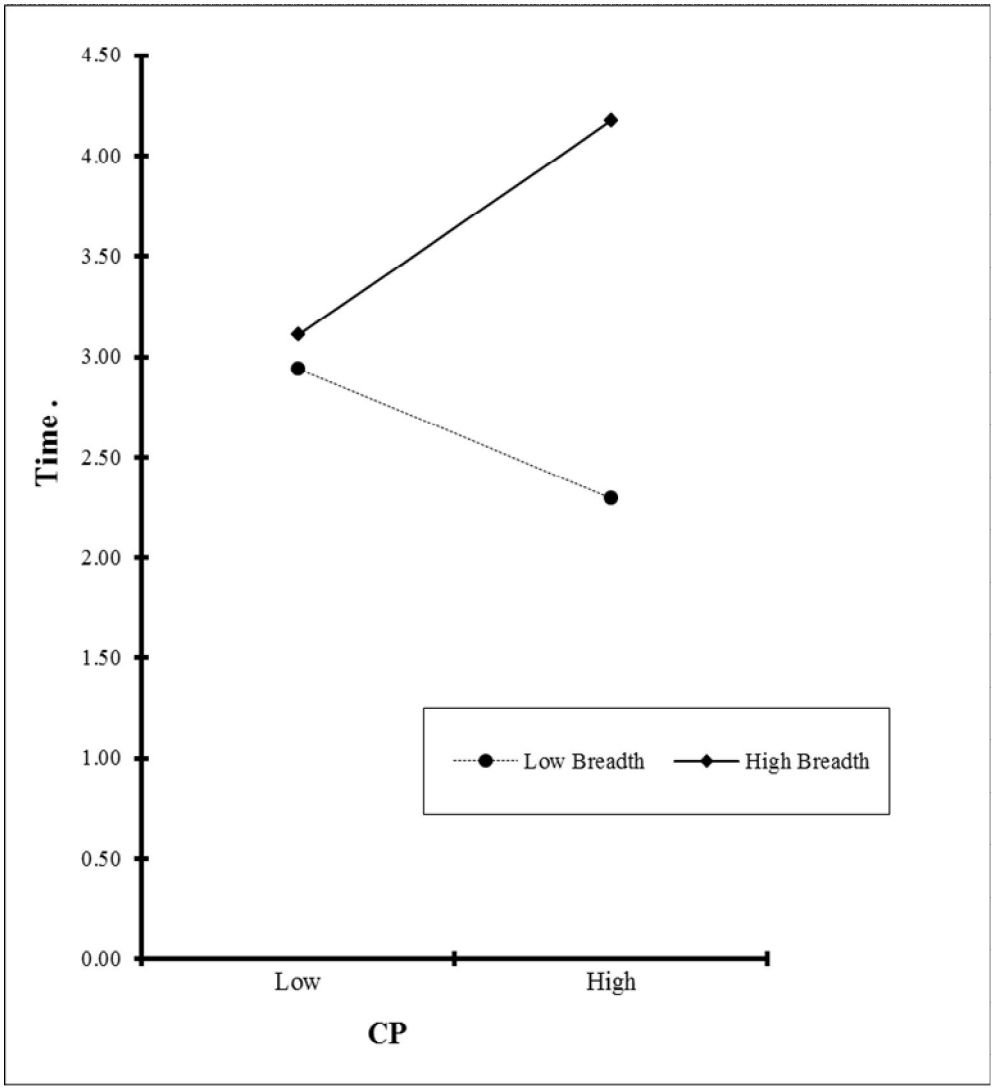
N = 157, R^2 = .326
*** $p < .01$, ** $p < .05$, * $p < .10$

Following Aiken and West (1991), a moderating plot was created where high and low levels of breadth were indicated as those above and below one standard deviation from the mean. Figure 5.4 graphically displays the moderating role of breadth of customer participation. Consistent with H_6 which predicts that the impact of customer participation on time to market increases as breadth of customer participation increases, customer participation always shows a longer time until product launch for high breadth than for low breadth. In addition, for high breadth, customer participation increases time to market (simple slope result: b = .449, t = 3.944,

$p < .01$), whereas for low breadth, customer participation does not increase time to market (simple slope result: b = -.128, t = -.976, $p > .10$).

Figure 5.4

The Moderating Effect of Breadth between Customer Participation and Time to Market in Study 2



CHAPTER 6

DISCUSSION

In this chapter, I first discuss the findings from the two studies conducted in this dissertation. Next, I discuss the theoretical and managerial implications of the results. Finally, I address some of the potential limitations and future research directions.

Discussion of Findings

In this section, the findings from the hypothesis testing of the two studies are combined and compared. Table 6.1 compares the hypothesis testing results from Studies 1 and 2.

In Hypothesis 1, I proposed an inverted U-shaped relationship between customer participation and market adoption. The finding from the open source software context provided support for the curvilinear relationship, whereas the result from NPD managers in a wide variety of industries did not support the hypothesis. Rather, the result from Study 2 indicates that customer participation continuously increases market adoption, emphasizing the merits of customer participation. However, further analysis using an IT subsample of survey data revealed that customer participation increases market adoption up to a point, but decreases it beyond that point. Taken together, the inverted U-shaped relationship between customer participation and market adoption cannot be generalized to all industries. However, in technology-intensive industries, the involvement of ordinary customers who may lack technology expertise and experience, is more likely to deteriorate new product success (Magnusson 2009; Vanhaverbeke and Du 2010; von Hippel 1986).

Table 6.1

Hypothesis Test Comparison between Two Studies

Hypothesis	Supported? In Study 1	Supported? In Study 2	Implications	Relationship/ Effects Tested
H_1	Yes	No, but Yes in IT industry	• The inverted U-shaped relationship between customer participation and market adoption was found only in technology-driven industries. • In general, customer participation continuously increases market adoption.	There will be an inverted U-shaped relationship between customer participation and market adoption.
H_2	No, continuously increase	No	• In Study 1, customer participation continuously increases time to market, implying serious costs of customer participation.	There will be a U-shaped relationship between customer participation and time to market.
H_3	No	No, significant but not expected direction	• Contrary to H_3, customer contributions at late stages had greater positive impact on market adoption.	The effect of customer participation on market adoption will increase as the ratio of customer participation at early stages to late stages increases.
H_4	Yes	No	• In Study 1, when the ratio of customer participation in early stages as opposed to late stages is high, customer participation increases time to market more than when the ratio is low.	The effect of customer participation on time to market will increase as the ratio of customer participation at early stages to late stages increases.

H_5	Yes	Yes	•	In both studies, customer participation in a wide variety of activities had greater positive impact on market adoption.	The effect of customer participation on market adoption will increase as the breadth of customer participation increases.
H_6	No, significant but not expected direction	Yes	•	In Study 2, customer participation in a wide variety of activities slows down time to market more than customer participation in a limited number of activities.	The effect of customer participation on time to market will increase as the breadth of customer participation increases.
H_7	Yes	No	•	In Study 1, when NPD teams have high co-production capability to leverage customers' insights, the effect of customer participation on market adoption is greater.	The effect of customer participation on market adoption will increase as the NPD team's co-production capability increases.
H_8	No	No	•	NPD team's co-production capability did not moderate the relationship between customer participation and time to market.	The effect of customer participation on time to market will decline as the NPD team's co-production capability increases.
H_9	Not Tested	Yes	•	In markets where individualized products are offered, the positive effect of customer participation on market adoption is greater.	The effect of customer participation on market adoption will increase as the individuality of the co-produced product increases.
H_{10}	Not Tested	No	•	Product price positioning strategy did not moderate the relationship between customer participation and market adoption.	The effect of customer participation on market adoption will increase as the price level increases.

The findings on Hypothesis 2, which assumes a non-linear relationship between customer participation and time to market, can be interpreted similarly to the findings for Hypothesis 1. Overall, the results from both studies did not reveal any non-linear relationship between the two. In Study 2 including a wide variety of industries, the effect of customer participation on time to market is so diverse that I cannot find any significant pattern between customer participation and time to market. This finding seems to reflect well differences among industries. For example, Melton and Hartline (2010) found that the extent of customer involvement in the new service development process improves project efficiency (i.e., the new service had less launch time than planned) through service marketability and launch preparation. Consistent with this result, Carbonell, Rodriguez-Escudero, and Pujari (2009) also found that customer involvement in new service development has a positive effect on innovation speed. Taken together, customer participation in the new *service* development context may continuously decrease time to market, but involving end customers in the new technology intensive product development process may slow down time to market. Given that survey data from Study 2 includes services industries as well as manufacturing and IT, finding no pattern between customer participation and time to market may be expected.

In contrast, in the technology-driven industry of Study 1, there was a significant positive impact of customer participation on time to market. In other words, involving customers in the development process of a technology-intensive product generates serious costs in terms of time elapsed until product launch. Overall, the results on Hypotheses 1 and 2 imply that the relationships between customer participation and new product success depend on industry characteristics; especially in technology-intensive industries, the costs to engage end customers into the NPD process should be thoroughly considered.

Hypothesis 3 proposes that the effect of customer participation on market adoption will increase as the ratio of customer participation at early stages to late stages increases. While the moderating effect of stage was not significant in Study 1, the result from Study 2 showed a significant moderating role of stage though the direction of the moderation was contrary to my expectation. I had hypothesized that customer participation in early stages as opposed to in late stages has greater impact on improving market adoption, but customer involvement in late phases had a more positive effect than customer participation in early stages. In fact, both early and late stages of the NPD process have great potential to improve market adoption from different perspectives (e.g., Lettl, Herstatt, and Gemuenden 2006; Yli-Renko and Janakiraman 2008). This is because in the early idea generation phase, customers are the source of new product ideas (Von Hippel 1978) and in the later testing phase of new product development, customers can serve as the testing ground for the new product's relevance and acceptance in a variety of user contexts (Yli-Renko and Janakiraman 2008). The findings of this dissertation suggest that making new products error-free and hassle-free through engaging customers in later stages can make a greater contribution to improving market-related performance.

With regard to Hypothesis 4, which predicted that the effect of customer participation on time to market will increase as the ratio of customer participation at early stages to late stages increases, the result from Study 1 provided support. When customers are involved in early stages as opposed to in late stages, customer participation tends to slow down the entire development process. Even though there has been little research on comparing magnitudes of the effects, some previous research on the effects of interdepartmental integration (e.g., joint involvement of marketing-R&D in the NPD process) on new product development time suggests a potential

moderating effect of stage between customer involvement and new product development time (Song, Thieme, and Xie 1998; Swink and Song 2007).

In both studies, breadth of customer participation turned out to be a powerful moderator between customer participation and new product success. The findings of Studies 1 and 2 provided support for Hypothesis 5, which proposed that the effect of customer participation on market adoption will increase as the breadth of customer participation increases. Involving customers in a wide variety of co-production activities rather than customer involvement in just a few activities can achieve greater market adoption.

However, these results need to be understood by taking into account the influence of broad customer participation on time to market. As shown in the supporting results from Study 2 for Hypothesis 6, customer participation in a wide variety of activities slows down time to market more than customer participation in a limited number of activities. In sum, broad customer participation contributes to improving market adoption but is detrimental in terms of time to market. Therefore, the decision whether a company should engage end customers broadly or not fully hinges on the company's goal for the new product development process. Should companies launch new products as soon as possible in the market and take first-mover advantage or should they launch better products at the cost of development time? Given that there has been a dearth of research dealing with the breadth of customer participation, the findings of Hypotheses 5 and 6 provide new insights to managers.

Hypothesis 7 assumed that the effect of customer participation on market adoption will increase as the NPD team's co-production capability increases. The results from Study 1 supported the hypothesis by showing that for low co-production capability, the relationship between customer participation and market adoption follows an inverted U-shape, whereas for

high co-production capability, customer participation appears to continuously improve market adoption. In other words, because NPD teams with a high level of co-production capability have enough ability to effectively leverage customers' insights from diverse ideas, they can improve market adoption without experiencing the costs of high customer participation.

However, I did not find a significant moderating effect of a NPD team's co-production capability between customer participation and time to market in both studies. One potential reason to reject the hypothesis may be related to the concept of co-production capability itself. In this dissertation, NPD team's co-production capability was defined as a NPD team's ability to *leverage* customers' input to develop the new product in the NPD process. More specifically, co-production capability is composed of two processes: recognizing the value of input from customer participation and effectively applying it to new products. Because this concept itself focuses on a NPD team's ability to find valuable ideas from customer participation and apply it to new products, the influence of co-production capability on new product success was found only for market adoption.

Another possible reason for the lack of effect is that there may be conflicting effects of co-production capability between customer participation and time to market. For instance, because NPD teams with a high co-production capability do not have to spend more time in searching for appropriate ideas and applying them to new products, they may speed up time to market. In contrast, compared with neglecting all input from customers, recognizing and applying a few valuable ideas may require substantial time. Given these two conflicting arguments, the moderating effect of co-production capability in the link between customer participation and time to market may disappear.

The contextual effects of product individuality and price positioning strategy were tested only in Study 2. The finding indicated that in markets where highly individualized products are offered, the effect of customer participation on market adoption is much greater, supporting Hypothesis 9. This result is consistent with the implication from Homburg, Müller, and Klarmann (2011), who discovered that the effect of customer orientation with regard to sales performance is higher for salespeople selling individualized products. As such, insights directly from end customers are more valued when selling individualized products. However, the finding of Study 2 did not provide support for Hypothesis 10, which predicted that the effect of customer participation on market adoption will increase as the product price level increases.

Theoretical Implications

This dissertation provides several theoretical implications. First and foremost, this dissertation adds theoretical explanation to why customer participation does not always lead to desirable new product outcomes by combining service-dominant logic with coordination theory. Drawing on service-dominant logic, previous literature in marketing on customer participation has focused on showing desirable effects of customer participation (e.g., Alam 2002; Hoyer et al. 2010; O'Hern 2009). Roles of customers as information sources and co-developers in the NPD process have provided the main arguments for desirable contributions of customer participation (Fang 2008; Nambisan 2002).

However, coordination theory demonstrates that co-production in the NPD process that involves more than two actors (i.e., NPD teams and end customers) sharing resources and assigns tasks to co-develop new products is a context that demands harmonious coordination among actors and activities. If the coordination mechanisms are neglected or do not work well, co-production would be stopped without developing a new product or end up with sub-optimal

performance even when co-production achieves its goal (i.e., new product development). Specifically, this dissertation makes theoretical contributions by explaining potential risks of co-production in the NPD process utilizing the concept of coordination neglect and coordination theory.

Coordination neglect explains some psychological barriers such as partition and component focus and inadequate communication and translation that get in the way of integrating and coordinating interdependent work into a common goal (Heath and Staudenmayer 2000). According to the concept of coordination neglect, because integrating and coordinating divided work is by its very nature hard for NPD teams to do, NPD teams and customers neglect the importance of coordination. As a consequence, a co-production project between a NPD team and customers may end without developing their planned new product or a company which initiated a co-production project may not be able to use the results of co-production. In the real world, NPD projects accompanying co-production are frequently stopped or abandoned. SourceForge.net data also confirms that a substantial number of projects do not release even the first package of new software for a long time and are left alone without any development activities. As such, this dissertation provides additional explanation by pointing out the risk that co-production projects may end up with nothing due to coordination neglect. This topic has been ignored by researchers.

Coordination theory explains why even when NPD teams overcome coordination neglect and develop new products, the results through co-production may not be desirable outcomes (Malone and Crowston 1994). Local optimal may not be global optimal, and the coordination mechanism itself requires substantial time and effort, so the outcomes generated through co-production could be better or worse. In sum, this dissertation provides theoretical reasons why

customer participation in the NPD process does not always lead to better outcomes by combining service-dominant logic with the concept of coordination neglect and coordination theory.

Second, this dissertation developed a new concept, NPD team's co-production capability, and empirically tested its moderating effect in the link between customer participation and new product outcomes. While extant literature put an emphasis on how to engage customers in more co-production activities by building places for customer participation, researchers have recently begun to pay attention to a company's ability to recognize and leverage good ideas out of diverse inputs through customer participation (Bendapudi and Leone 2003; Fuchs, Prandelli, and Schreier 2010). As customer participation becomes more common, merely involving customers in the NPD process is not enough to lead to desirable new product outcomes. The firm's ability to manage and effectively take advantage of customer contribution in the co-production process can determine the amount of benefits or costs of customer participation.

In particular, the concept of co-production capability adds value to the co-production literature in that it is distinct from a firm's coordination capability. Effectively and efficiently coordinating and integrating interdependent work in the co-production process is important if the firm wishes to maximize the benefits from co-production. However, the capability to recognize and leverage valuable customer input in co-production is differentiated from coordination capability. The findings of Study 1 confirmed the importance of a NPD team's co-production capability in improving market adoption by showing that companies with a high level of co-production capability continuously increase the positive effect of customer participation on market adoption, whereas companies with a low level of co-production capability cannot obtain any benefits from customer participation beyond a certain point.

Managerial Implications

There are several managerial implications from the findings of this study. First, the main effect of customer participation on new product success hinges on the type of industry. The findings for Hypotheses 1 and 2 from both studies suggest that the costs of customer participation can be greater in technology-driven industries. Do the results mean that companies in these industries should not engage ordinary customers who lack technology expertise but should recruit lead users who have substantial expertise? The answer is not that simple. In terms of market adoption and time to market, involving ordinary end customers in the NPD process may generate coordination problems and increase the complexity of the development process. However, Magnusson (2009) argues that ordinary customers compared with lead users have a high propensity to produce radical ideas that challenge the prevailing dominant logic in the market. Ordinary users are not expected to contribute ideas that can be directly put into the new product development process; rather, ordinary customer involvement may be regarded as a process whereby a company learns about radical ideas and is inspired to innovate. Therefore, even in technology-driven industries, involving end customers in the co-production process should be still considered as an alternative value creation process for creating radical products.

Second, this dissertation provides managers with insights into at which stage in the NPD process end customers should be involved. The findings suggest that NPD mangers need to place more emphasis on engaging end customers in the later NPD phases such as product testing and commercial testing in order to improve market adoption and shorten time to market. Previous literature on co-production has focused on customer involvement in the fuzzy front end of the NPD process (e.g., Khurana and Rosenthal 1997; Kim and Wilemon 2002; Reid and de Brentani 2004) because understanding customer's needs and judging the marketability of new ideas have

been regarded as key success factors. Despite the lack of academic interest in customers' contribution in later NPD phases, the results of this dissertation show that companies can stably increase market acceptance without the hassle of co-production. Thus, managers need to pay more attention to maximizing the benefits of customer participation by engaging customers in validating the product concept, eliminating performance problems prior to market introduction, serving as an effective sales promotion device (Dolan and Matthews 1993). However, the results do not negate the customer contribution in early stages but highlight the value of customer participation in later phases.

Third, the findings suggest that companies need to implement co-production differently in terms of breadth of customer participation according to their NPD project's goal. The results indicate that customer participation in a wide variety of co-production activities can contribute to improving market adoption but may be detrimental to time to market. Thus, the decision on how broadly end customers should be involved in the NPD process should be in line with the NPD team's goal. When the goal is to launch better products and improve market adoption, companies need to engage end customers in a wide variety of co-production activities with the costs of time to market. In contrast, when the goal is to introduce new products as soon as possible and benefit from first-mover advantage, involving customers in just a few co-production activities which really require end customers' input would be a better strategy.

Finally, the findings highlight that every company does not have to engage customers in its NPD process. However, companies which offer highly individualized products in the market need to more effectively utilize customer participation in the NPD process. The result for Hypothesis 9 suggests that for less individualized products, the effect of customer participation on market adoption did not significantly increase, whereas for highly individualized products,

customer participation significantly improves market adoption. Given that engaging customers in the NPD process requires additional resources and time, only companies which offer highly individualized products need to utilize co-production as an alternative NPD process.

Limitations and Future Research

Some of the limitations of this dissertation provide opportunities for future research. First, future researcher need to test the costs of customer participation found in Study 1 in other high technology industries. The results of both studies indicate that the effects of customer participation vary from industry to industry and there is a possibility that it generates more risks in technology-driven industries. Even though the results of survey data using an IT sub-sample confirmed this possibility, I could not test the moderating effect of breadth and co-production capability in the curvilinear relationship between customer participation and market adoption found in Study 1 using an IT sub-sample due to the small sample size (i.e., 66 IT sub-sample). Therefore, the inverted U-shaped relationship and the interactions in the curvilinear relationship in the new software development process should be confirmed by testing the generalizability of Study 1 using either survey data from technology-driven industries or other secondary data from high technology industries.

Second, this dissertation did not pay attention to the interactions among moderators. Even though this dissertation thoroughly examined the interactions between customer participation and various moderators such as stage, breadth, and co-production capability, it hardly investigated the possibility of interactions among moderators. For instance, stage may be associated with breadth. In this dissertation, breadth of customer participation was measured by the simple sum of the number of activities (stages) which end customers actively engaged in. In other words, each co-production activity was assumed to have the same effect on new product success from

the breadth perspective. However, even though NPD teams have the same level of breadth, the effect of breadth on new product success may differ according to the stages at which end customers are involved. For example, there are two NPD projects whose level of breadth of customer participation was 1. One of these projects engaged customers only in the ideation stage, whereas the other engaged customers only in the product testing stage. These two NPD projects may show different effects of the breadth on new product success. Thus, the interactions among moderators included in the dissertation should be considered for future study.

Third, this dissertation needs to investigate the impact of customer participation on new product outcomes other than market adoption and time to market. For example, new product innovativeness, defined as the degree to which new product developed through co-production is novel to the industry (Fang 2008), could be considered as another interesting outcome variable. According to Magnusson (2009), end customer participation in the NPD process can be a good opportunity to obtain ideas about radical new products. In addition, at which stage and how broadly end customers are involved in the NPD process may moderate the relationship between customer participation and new product innovativeness. For instance, customer participation in the early ideation stage contributes to introducing radical new products, whereas customer participation in the later product testing phase contributes to introducing incremental new products. While involving customers broadly can facilitate radical innovations due to a diversity of customer ideas, narrow customer participation may relatively contribute to incremental innovations.

Finally, future researchers need to investigate the mechanism by which customer participation influences new product outcomes. This dissertation did not investigate any potential mediators between customer participation and market adoption and time to market. As in the

findings of Melton and Hartline (2010) which showed the mediating roles of service marketability and launch preparation between customer participation and new service outcomes in the new service development context, there may be mediators in the direct link.

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APPENDIX A

Actual Survey for Main Study of Study 2

Informed Consent Form
Information Letter for Marketing Research Survey
University of Alabama
Department of Management and Marketing

You have been recruited to participate in a research study with the goal of investigating **end customer's involvement in the New Product Development (NPD) process.** This research is being conducted by Woojung Chang, a doctoral candidate at the University of Alabama, and supervised by Dr. Robert M. Morgan, a marketing professor at the University of Alabama.

If you are over 19 years old and agree to participate in the study, you will be asked to answer screening questions first. According to the screening questions, you will be asked to answer further questions or finish the survey. If you respond to all the questions, it will take approximately 15 to 20 minutes to fill in the entire survey.

The questions in the survey may be completed at your own pace. Please read the directions for each section and answer **ALL** the questions. There are no right or wrong answers.

All the information collected in this survey will be held confidentially and securely and will be used only by the researchers for educational purposes. Furthermore, the information obtained will not be linked to the subject.

There are no foreseeable risks or benefits associated with participation in the survey.
Participation is completely voluntary. If you participate, you will be paid on the basis of the Qualtrics incentive policy which you have already agreed with in exchange for participation. If you decide to participate, you may withdraw at any time without affecting your relationship with the researcher, the person who recruited you for this study, or Qualtrics.

If you have any questions about this research, please contact Woojung Chang at 205-534-2012 (wchang@cba.ua.edu) or Dr. Robert Morgan at 205-348-9557 (rmorgan@cba.ua.edu). If you have any questions about your rights as a research participant, you may contact Ms. Tanta Myles, the University of Alabama Research Compliance Officer, at 205-348-8461 or toll free at 877-820-3066.

You may print this form to keep your records if you like. If you consent to participate, please click on "I agree." Then begin the survey by clicking on the 'Next' button below.

I have read this form and agreed to participate in this survey.

- ○ I agree
- ○ I do not agree

Screener Questions

Q: Have you worked on **a New Product Development (NPD) project in which end customers have been involved to some extent to co-create new products**? Co-creation of new products could involve end customers providing new products ideas or new features, participating in designing new products, engineering new products, testing new products before launch, and commercializing new products.

- ○ Yes
- ○ No

Please think about **the completely launched New Product Development (NPD) project in which end customers were involved**, and complete the questionnaire with that NPD project in mind.

Q: How would you rate your knowledge of this particular NPD project?

very low	low	somewhat low	neither low nor high	somewhat high	high	very high
○	○	○	○	○	○	○

Main Questions

*Items were eliminated for final analysis.

Please think about **the most recently completed New Product Development (NPD) project** in which end customers were involved, and complete the questionnaire with that NPD project in mind.

Customer Participation

Please indicate the extent to which you agree with the following statements regarding **customer participation during the NPD process** (1= strongly disagree; 7= strongly agree)

1. Our customers shared a lot of information about their needs during the NPD process.*
2. Our customers provided us with many suggestions for improving the new product during the NPD process.*
3. Our customers provided us with extensive consultation during the NPD process.
4. Our customers communicated intensively with the NPD team.
5. Many customers were involved in the NPD process.
6. Our customers were involved in the NPD process for a long time.
7. Our customers met the NPD team frequently for co-creation.

Market Adoption

Please indicate the extent to which you agree with the following statements regarding **the financial performance of the new product** (1= strongly disagree; 7= strongly agree)

1. The new product achieved our sales goal.
2. The new product achieved our profit goal.
3. The product had great profitability.

Time to Market

Please indicate the extent to which you agree with the following statements regarding **the speed of development of the new product** (1= strongly disagree; 7= strongly agree)

1. The new product was developed slower than the industry norm.
2. The new product was developed behind of where we would be had we gone it alone.
3. The new product was developed slower than our typical product development time.

Breadth and Stages of Customer Participation

For each of the following activities in the NPD process for this product, please indicate the extent to which end customers participated in this activity (1= not at all; 7= a great extent). Each activity is defined as follows.

(1) Idea generation: the stage at which new ideas for products are brainstormed.
(2) Concept screening: the stage at which product ideas are tested for technical and commercial success.
(3) Product design: the stage at which a firm specifies designs and development of a proposed product
(4) Product engineering: the stage at which a firm's engineers work to refine the design and perfect a new product
(5) Product testing: the stage at which prospective customers evaluate test versions of a proposed product
(6) Market testing: the stage at which the complete marketing plan for a proposed product is tested in a small geographic area
(7) Commercialization: the stage at which a proposed new product is launched into the market

Q9. For each of the following activities in the NPD process for this product, please indicate the extent to which end customers participated in this activity.

	not at all	very little	a little	somewhat	moderately	much	a great extent
1.Idea generation	○	○	○	○	○	○	○
2.Concept screening	○	○	○	○	○	○	○
3.Product design	○	○	○	○	○	○	○
4. Product engineering	○	○	○	○	○	○	○
5.Product testing	○	○	○	○	○	○	○
6.Market testing	○	○	○	○	○	○	○
7.Commercialization	○	○	○	○	○	○	○

NPD Team's Co-production Capability

Please indicate the extent to which you agree with the following statements regarding **the NPD team's capability during the NPD process for this product** (1= strongly disagree; 7= strongly agree)

1. Our NPD team recognized the usefulness of insights that customers suggested.*
2. Our NPD team valued insights that customers suggested.*
3. Our NPD team could easily address the new needs that customers specified.
4. Our NPD team could take corrective action immediately when customers suggested modification of a product or service.
5. Our NPD team could effectively satisfy customers' demands.

Product's Individuality

Please indicate the extent to which you agree with the following statements regarding **the new product developed in the NPD process** (1= strongly disagree; 7= strongly agree)

1. The new product was highly adapted to our customers' needs.
2. The major characteristics of the new product were highly adjusted to our customers.
3. The new product was highly individualized.*

Product's Price Strategy

How do you evaluate the overall price level of the new product compared to that of competitors' products? (1= strongly disagree; 7= strongly agree)

1. The overall price level of the new product compared to that of competitors' products was much higher.

Control Variables

New Product Innovativeness

Please indicate the extent to which you agree with the following statements regarding **the innovativeness of this new product** (1= strongly disagree; 7= strongly agree)

1. The new product was very novel for our industry.
2. The new product was challenging to existing ideas in our industry.
3. The new product was very creative.*

Product Quality

Please indicate the extent to which you agree with the following statements regarding **the quality of this product** (1= strongly disagree; 7= strongly agree)

1. In our internal tests, the new product performed exactly as it was designed to do.*
2. The new product had little probability of malfunctioning in use.*
3. The new product's performance characteristics met established industry standards.
4. The expected product use life met the required specifications.

Environmental Turbulence

Please indicate the extent to which you agree with the following statements regarding **the development environment of this product** (1= strongly disagree; 7= strongly agree)

1. Customers' product preferences in the market changed quite a bit over time.*
2. Our customers tend to look for new products all the time.*
3. The technology in our market changed rapidly.
4. A large number of new product ideas had been made possible through technological breakthroughs in our market.

Questions about respondents and the project

Q14. What was your role (job title) in this project?

Q15. What department were you in?

- Marketing / Sales
- R & D
- Engineering
- Design
- Production / Operation
- Other

Q16. How many people from your firm were actively on the NPD team?

- 5 or fewer
- between 6 and 15
- between 16 and 30
- between 31 and 50
- more than 50

Q17. Which industry is your company in?

- Manufacturing
- Information Technology
- Services
- Other

Q18. How many full-time employees does your company have?

- fewer than 300
- 300 - 999
- 1,000 - 3,000
- more than 3,000

Q19. How long did you work on the project (**number of months**)?

- less than 3 months
- between 3 and 6 months
- between 7 and 12 months
- between 13 and 24 months
- more than 24 months

Q20. How long have you worked with the company (**number of years**)?

- less than 5 years
- between 5 and 10 years
- between 11 and 15 years
- between 16 and 20 years
- more than 20 years

Q21. How long have you worked in NPD (**number of years**)?

- less than 3 years
- between 3 and 6 years
- between 7 and 10 years
- between 11 and 15 years
- between 16 and 20 years
- more than 20 years

APPENDIX B

Institutional Review Board Approval Documentation

Office for Research

Institutional Review Board for the Protection of Human Subjects

THE UNIVERSITY OF ALABAMA RESEARCH

November 15, 2011

Woojung Chang
Department of Management & Marketing
College of Commerce & Business Administration
Box 870225

Re: IRB #: EX-11-CM-091, "The Danger of Feast or Famine: Managing Customer Participation in Value Co-Production"

Dear Mrs. Chang:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given exempt approval according to 45 CFR part 46.101(b)(2) as outlined below:

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

This approval expires on November 14, 2012. If the study continues beyond that date, you must complete the appropriate portion of the Continuing Review Form. If you modify the application, please complete the Modification of an Approved Protocol Form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, please complete the appropriate Closure form.

Should you need to submit any further correspondence regarding this application, please include the assigned IRB application number.

Good luck with your research.

Sincerely,

Carpantato T. Myles, MSM, CIM
Director & Research Compliance Officer
Office of Research Compliance
The University of Alabama

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