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Product Quality and New Product Performance: The Role of Network Externalities and Switching Costs*

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Research about the critical drivers of new product success is perhaps one of the thorniest issues confronting academic research in the field. Among them, product quality is considered a crucial element to obtain a competitive advantage. However, empirical evidence suggests low returns on product quality investments in new products, and consequent manager claims for an explanation of whether quality investments are fruitful for the firm. Recently, a new research stream has suggested that the role of other complementary products (indirect network externalities) and the critical mass of adopters (direct network externalities) lead to higher market returns than quality itself. Moreover, researchers disagree about the perverse or positive effects that the switching costs associated with the product have on the short- and long-term performance of the firm. In this paper, we propose that, as products and technologies become more interconnected, the associated network effects and switching costs will play an important role with regard to new product performance, both independently and in conjunction with its quality. We empirically test a model that relates product quality, network effects, and switching costs to short-term/long-term new product performance, using data collected from 255 innovative products. The data analysis indicates that network effects, and consumers' switching costs, can modify previous findings with regard to the isolated product quality consequences concerning new product performance. Overall, the results of this study may help firms manage the relationship between quality, network externalities, and switching costs more efficiently, both in the short term and in the long term.

Introduction

In today's mature business environment, product quality is assumed to be of paramount importance to the survival and success of products (Choi and Pucik, 2005; Tellis, Yin, and Niraj, 2009a). Not surprisingly, firms invest extensively in product quality initiatives to ensure the superior quality of the products (Adam and Foster, 2000). "The ISO Survey of Certifications" states that, thus far, firms have put more than 15,900 quality certifications into practice around the world and one of the best known, ISO 9001:2000, has reached a total number of 776,608 in 161 different countries. Moreover, the business press routinely cites quality as the cause of the success and failure of businesses (Mitra and Golder, 2006). While practitioners devote considerable resources to ensuring superior product quality, prior research has shown that these investments do not always achieve their objectives (Henard and Szymanski, 2001; Rust, Moorman, and Dickson, 2002). Tellis and Johnson (2007) provide some insight into why some firms undervalue the importance of quality, mainly due to the difficulties of defining quality or because market response to quality is not instantaneous but occurs over time. Several authors, including Srinivasan (2008), have suggested other reasons to justify these unexpected results: "do the templates and models developed in non-networked products apply to the development of products with network effects?" Although most new product models in marketing literature are autonomous and assume that adoption is not affected by the presence of complementary products, several studies have begun to question these assumptions, as new products rarely function in isolation (Gupta, Jain, and Sawhney, 1999; Shapiro and Varian, 1999; Shocker, Bayus, and Kim, 2004). This debate is far from being resolved, with recent contributions (Tellis et al., 2009a, 2009b) still questioning whether quality or network externalities are more important to explain new product performance. Moreover, the existence of network effects implies that

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consumers' switching costs are more complicated, as they do not only have to value the quality of the new product, but also the utility of other complementary products (Bansal, Taylor, and James, 2005; Bell, Auh, and Smalley, 2005).

Accordingly, in this paper we propose that, in an increasingly interconnected economy, the network effects and switching costs of products, in conjunction with their product quality, will explain why new products do not always perform as intended.

We begin by providing the motivation for our research. First of all, existing studies on product quality tend to view a product as a stand-alone entity (Henard and Szymanski, 2001). However, as the economy becomes more interconnected, products from various industries, especially industries that are technology and knowledge intensive, exhibit network effects (Lee and O'Connor, 2003a; Shocker et al., 2004). Network effects exist when the utility of a product depends not only on its attributes, but also on the number of other consumers who have adopted the product (Shankar and Bayus, 2003) and the availability of complementary products (Basu, Mazumdar, and Raj, 2003). Although there are studies that pay some attention to network effects, they have focused mainly on network effects per se (Srinivasan, Lilien, and Rangaswamy, 2004), rather than analyzing the consequences of the two types of network externalities (direct and indirect) as suggested by recent contributions in this area (Stremersch, Tellis, Franses, and Binken, 2007). In such a situation, intrinsic product quality may play a smaller role than the network effect characteristics of the products. Recently, Tellis et al. (2009a, 2009b) have provided some insights when they questioned whether quality or network externalities are more relevant in explaining new product performance. However, Tellis et al. (2009b) also agree that further research is needed to take the dynamics of changing quality and network effects into account over time.

Secondly, in the presence of network effects, consumers experience switching costs (Ge, 2002). As a result of these network effects, the decision customers have to make, and with it the switching costs, becomes more complicated (Jones, Mothersbaugh, and Beatty, 2002; Pae and Hyun, 2002). To the best of our knowledge, past research into the role of product quality regarding product performance has not taken perceived switching costs into account (Burnham, Frels, and Mahajan, 2003). In addition, switching costs have a significant impact on the strategies managers should (and do) adopt (Eliashberg and Robertson, 1988), on the resulting industry-related and competitive structures (Farrell and Shapiro, 1988) and on consumer commitment (Bansal et al., 2005). Given their importance, it is necessary to take a closer look at the relationships between product quality, network externalities, and switching costs, to gain a better understanding of new product success over time.

Accordingly, in this paper we examine the effects of network effects and switching costs when studying the impact of product quality on new product performance. Product quality is analyzed on the basis of objective characteristics, under the control of the firm. We measure network effects, both the direct network effects, where the value of the product increases with the number of adopters, and the indirect network effects, based on the number of complementary products. In addition, we consider the procedural costs customers associate with the process of switching from one product to another. Finally, we look at both the short-term (introduction and growth stages of product life cycle) and long-term performance (maturity and decline stages of product life cycle) implications of product quality, network effects, and switching costs.

From a theoretical perspective, this study contributes to existing literature by proving that quality and network externalities are both important to increase firms' returns. However, this research demonstrates

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that the trade-off between quality and network externalities obtained in previous studies depends on the time focus (short term and long term) adopted. From a managerial point of view, this research also generates insights on how firms can obtain higher returns from switching costs ensuring the success of products in increasingly networked markets.

Our study is organized as follows. We begin by presenting the theoretical background and hypotheses, after which we discuss the data, method, and hypothesis testing. We conclude with a discussion of the academic and managerial implications of our findings.

Conceptual Background

Product Quality Framework

Although academics and practitioners have devoted much attention to quality, the term quality has been so overused that it is difficult to determine its meaning (Rust et al., 2002). However, at project level, most authors accept Zeithaml's (1988) classification framework of product quality, which defines it as being based either on extrinsic cues (external quality) or on intrinsic cues (internal quality). External quality is based on customers' perception regarding extrinsic cues like brand, price, country of origin, or warranty (Teas and Agarwal, 2000). On the other hand, internal quality cannot be changed without altering the nature of the product itself and is further distinguished as being either objective or subjective. Objective product quality evaluates whether the product performs as it is supposed to, incorporates features customers do not expect, or has a low probability of failing (Curkovic, Vickery, and Dröge, 2000). By contrast, subjective product quality is based on customers' perceptions of things like product image or product design (Brucks, Zeithaml, and Naylor, 2000; Creusen and Schoormans, 2005). A detailed review of the different types of quality, dimensions, and indicators is presented in Table 1. Our study focuses on objective product quality under the firm's control because of the point of view undertaken in this study and its higher relevance for product developers.

In addition, the majority of the empirical measures of product quality are based on Garvin's (1987) work, but the procedure used to derive quality dimensions is the simple reductionist approach of refining reflective scales. However, the analysis of product quality dimensions reveals the strong possibility that they can be more properly defined as a formative scale based on the propositions of Diamantopoulos and Winklhofer (2001), yet empirical demonstration of these properties remains a challenge. This research will consider objective quality based on this latter approach based on formative indicators of quality.

Network Externalities Framework

"Network effects" denotes a phenomenon where the value of the product does not depend on the product itself but on other complementary products or users with whom the customer can interact (Sahay and Riley, 2003). Network effects have been given different names in the past: positive/negative network externalities, centralized/decentralized network externalities, interactive network externalities, and so on. Existing literature is diverse and inconsistent in this respect (Lee and O'Connor, 2003a). A detailed review of the terminology is presented in Table 2. Many studies do not even use an explicit definition, while others (implicitly) provide multiple definitions (Stremersch et al., 2007). However, academics generally agree that network effects can be divided into direct and indirect network externalities. Therefore, the existence of network effects implies that the value of a product increases with the number of adopters (direct network effects) (Katz and Shapiro, 1986) or complementary products (indirect network externalities) (Katz and Shapiro, 1992). With regard to indirect network externalities, prior research has typically referred to the primary product as "hardware" and to any product complementing the primary product as "software" (Basu et al., 2003).

There are a large number of studies, many in the area of economics (Katz and Shapiro, 1986) that have examined the strategic and welfare-related implications of network externalities. Economists have researched various aspects of indirect network effects, including (1) coordination between software and hardware industries, (2) standard-setting, and (3) customers regarding the adoption of technology. Our research, along with other recent similar studies, such as Stremersch et al. (2007), fits into the third research tradition. A consistent finding in these studies is that network externalities change customer behavior, which has important implications for new product performance (Srinivasan et al., 2004).

Switching Costs Framework

Switching costs are defined as the one-time cost that customers associate with the process of switching

Table 1. Types of Quality, Dimensions, and Indicators

	Quality dimensions			
Type of quality	Higher abstraction	Lower abstraction	Quality indicators	Authors
Internal quality (based on intrinsic cues)	Objective quality	• Product based • Manufacturing process based • Engineering design	• Performance • Features • Conformance • Reliability • Service • Durability	Brucks et al. (2000); Calantone and Knight (2000); Curkovic et al. (2000)
	Subjective quality	• Industrial design • Design quality	• Aesthetics • Image • Ergonomics • Distinctiveness	Brucks et al. (2000); Creusen and Schoormans (2005); Zeithaml (1988)
External quality (based on extrinsic cues)	External quality	• Quality based on price • Quality based on brand • Quality based on country of origin	• Price as a quality cue • Brand as a quality cue • Country of origin as a quality cue	Brucks et al. (2000); Teas and Agarwal (2000); Zeithaml (1988)

from one product to another (Sheremata, 2004). Over the last two decades, switching costs have received a great deal of attention. Managing switching costs has been hampered by the absence of a comprehensive typology for conceptualizing, categorizing, and measuring the way consumers perceive these costs (Bansal et al., 2005; Farrell and Shapiro, 1988; Jones et al., 2002). While switching costs must be associated with the switching process, they need not be incurred immediately upon switching. Furthermore, switching costs need not be limited to objective, "economic" costs (Table 3). When consumers simplistically state that "it's just not worth it" to switch providers, they may perceive impediments ranging from "search costs, transaction costs, learning costs, loyal customer discounts, customer habit, emotional cost and cognitive effort, coupled with financial, social, and psychological risk on the part of the buyer" (Bell et al., 2005). Burnham et al. (2003) provide an extensive review of a switching costs typology that identifies three types of switching costs (Table 3), each of which is composed of multiple elements: (1) procedural switching costs (consisting of economic risk costs, evaluation costs, learning costs, and set-up costs), (2) financial switching costs (consisting of benefit loss costs and monetary loss costs), and (3) relational switching costs (consisting of personal relationship loss costs and brand relationships loss costs). Although we acknowledge the multidimensional nature of switching costs coming from a more consumer-oriented perspective, our research focuses on procedural switching costs (evaluation costs, learning costs, and set-up costs) because of the company-related point of view we have adopted in this study.

Hypothesis Development

Relationship among Quality, Network Externalities, and Switching Costs

Once a firm introduces a new product onto the market, customers must decide whether the advantages of that new product are good enough to engage in a learning process that will need time and effort (Pae and Hyun, 2002). Accordingly, Jones et al. (2002) suggest that, if a firm wants to reduce perceived switching costs, it should improve the quality of its products to reduce the evaluation and set-up costs. Thus, Bansal et al. (2005) have argued that, if a firm does not launch high-quality products, it will increase the probability that customers look for other available options. This phenomenon is also explained by Kordupelski, Rust, and Zahorik (1993), who show the positive effects of quality via two primary pathways: the retention of existing customers and the attraction of new ones. A customer who perceives quality at or above expectations is more likely to be retained as a customer and potential customers may be swayed by positive word of mouth from existing customers and be attracted to the product or service. Thus, we propose:

H1: The higher the objective quality, the lower the switching costs associated with a new product.

Table 2. Network Externalities Definitions

Concept	Definition	Authors
Negative network externalities	Firms look for market imperfections to establish monopolistic practices.	Hellofs and Jacobson (1999); Liebowitz and Margolis (1994); Srinivasan et al. (2004)
Centralized network externalities	The firms of the network must follow the rules of the leading firm inside the network.	Langlois and Robertson (1992)
Decentralized network externalities	The firms of the network are not able to establish any rule due to insufficient power inside the network.	
Interactive network externalities	The interaction between the network effects and other related variables (price, advertising, etc.) are analyzed.	Shankar and Bayus (2003)
Direct network externalities	The increase in a consumer's utility from a product when the number of other users of that product increases.	Katz and Shapiro (1986); Lee and O'Connor (2003a); Shapiro and Varian (1999); Sheremata (2004)
Demand economies of scale		Katz and Shapiro (1986)
Positive network externalities		Brynjolfsson and Kemerer (1996); Hellofs and Jacobson (1999); Liebowitz and Margolis (1994); Srinivasan et al. (2004); Xie and Sirbu (1995)
Indirect network externalities (demand and supply side)	The value of the product increases as the number of complementary products appears in the market and vice versa.	Gupta et al. (1999); Nair, Chintagunta, and Dubé (2003); Shankar and Bayus (2003)
Demand-side indirect network externalities	The value of the complementary product positively affects the value of the product.	Basu et al. (2003)
Supply-side indirect network externalities	The value of the product positively affects the value of the complementary product.	Shurmer (1993)

Network externalities are important considerations in product usage decisions, as they may drive consumption-related decisions (Pae and Hyun, 2002). If there are no indirect network externalities, the perceived switching costs will be limited to the intrinsic characteristics of the product itself (Sheremata, 2004). By contrast, when customers buy a product in a market with indirect network externalities, switching costs are not limited to the learning costs associated with the new product (Burnham et al., 2003; Kohli, 1999). In these markets, customers also have to learn to operate the complementary products, and in the end the customer decisions process will be more complicated (Jones et al., 2002; Katz and Shapiro, 1986). Based on these assumptions, we propose the following hypothesis.

H2: The higher the indirect network externalities, the higher the switching costs associated with a new product.

When a firm introduces a new product to a market where direct network externalities exist, different problems related to product take-off may occur (Sheremata, 2004). Customers may be reluctant to buy the product because they are not sure other customers with whom they can interact will also buy the product (Ge, 2002). However, even if this critical mass of adopters exists, customers will have to learn how they can interact with each other to increase the ultimate value of the new product (Economides, 1996). In the end, this will mean that, if the direct network

Table 3. Types of Switching Costs

Concept	Definition	Authors
Procedural switching costs	• Economic risk costs • Evaluation costs • Set-up costs • Learning costs	Bansal et al. (2005); Bell et al. (2005); Eliashberg and Robertson (1988); Kohli (1999); Pae and Hyun (2002)
Financial switching costs	• Benefit loss costs • Monetary loss costs	Bell et al. (2005); Heide and Weiss (1995); Jones et al. (2002)
Relational switching costs	• Personal relationship loss costs • Brand relationship loss costs	Eliashberg and Robertson (1988); Jones et al. (2002)

externalities are strong, the perceived switching costs involved in buying a product will be higher. Based on the previous discussion, we propose the following hypothesis.

H3: The higher the direct network externalities, the higher the switching costs associated with a new product.

The direct network externalities have an effect through the growing number of users adopting the same product. Gupta et al. (1999) show how complementarity is beneficial to consumers by allowing them to build systems that are closer to their ideal configuration. In other words, consumers can assemble complementary components that allow them to better interact with other customers. In fact, the two types of network externalities are so closely related that, as some researches have pointed out (Srinivasan et al., 2004; Stremersch et al., 2007), marketing studies have focused on network effects as such, regardless of whether they are direct or indirect. Others have modeled indirect network effects as if they were direct network effects (Shankar and Bayus, 2003). Based on the previous discussion, we argue that, if indirect network externalities exist in a market, the number of users may increase and customers will experience more value when interacting with each other. Accordingly, we propose:

H4: Indirect network externalities have a positive impact on direct network externalities.

Product Quality and New Product Performance

Product quality is one of the main competitive issues when designing and launching new products, not only in domestic markets (Choi and Pucik, 2005), but also in an international context (Calantone and Knight, 2000). While existing literature is consistent with regard to the positive impact of product quality on new product performance, recent studies in this area suggest considering the implications of quality on short-term and long-term performance (Mitra and Golder, 2006). According to Brucks et al. (2000), objective quality includes search, experience, and credence properties. Thus, customers will find it easier to evaluate some attributes of the product, whereas others need to experience the new product or even follow recommendations from other customers. Mitra and Golder (2006) have also demonstrated that the effect of a change in objective quality is not fully perceived by customers until after about six years. Kordupelski et al. (1993) illustrate the time lag in new product performance by different mechanisms, including word of mouth. Customers do not tell their friends and acquaintances immediately about their experiences with a product or service. Rather, the extent of word of mouth gradually tapers off over time. It may even take several positive reports for customers to change their mind and acquire the new product. Therefore, according to Kordupelski et al. (1993), a high-quality product should not be expected to have its biggest impact immediately. This means that customers will not only consider essential objective quality in the short term, but in the long term as well. Based on these findings, we propose that:

H5: Objective product quality has a positive impact on short-term new product performance.

H6: Objective product quality has a positive impact on long-term new product performance.

Network Externalities and New Product Performance

According to Srinivasan (2008), existing literature has thus far failed to identify the implications of designing networked products on new product performance. Early studies on network externalities in economic literature by Katz and Shapiro (1986, 1992), Farrell and Saloner (1985), and Farrell and Shapiro (1988) used a game theory approach to analyze whether firms become monopolies or merely grow and stay dominant in markets due to network externalities. This stream of research pays special attention to the perverse effects and inefficient markets these externalities generate (Liebowitz and Margolis, 1994). However, it is generally accepted that indirect network effects occur when the introduction of complementary goods increases as the sales of the primary good does (Sheremata, 2004; Shocker et al., 2004). At the initial introduction of a product with network effects, the problem of start-up arises and increases uncertainty for consumers, but the availability of complementary products may reduce this uncertainty (Ge, 2002). Thus, although customers may experience problems in evaluating the product itself, the presence of other products may help their decision, as the final value of the combination will be higher than that of the isolated product (Shocker et al., 2004). Even Stremersch et al. (2007) have pointed out that academics have observed that a critical mass of complementary products is required for a product itself to take off. Based on this assumption, Lee and O'Connor (2003a) suggest that the decision whether or not to adopt in the short term will be influenced to a greater extent by the existence of indirect network externalities than by the product itself. Thus, we propose that:

H7: Indirect network externalities have a positive impact on short-term new product performance.

Particularly fruitful research around network externalities has been aimed at examining the influence on customer behavior and market structure (Shankar and Bayus, 2003). According to Bayus, Jain, and Rao (1997), once an innovation has been accepted by customers, the perceived risks are reduced substantially. Similarly, Hellofs and Jacobson (1999) illustrate the positive signaling effect that this market share has on the utility perceived by the customer. The main consequences of this are related to a higher diffusion pattern of the innovation in question, which ultimately leads to better results (Sahay and Riley, 2003). Direct network externalities motivate consumers to stick with existing technologies as their user bases expand and there will be more opportunities to use the technology and learn from other customers (Pae and Hyun, 2002). This situation is often described as the "chicken and egg paradox" (Tellis et al., 2009a). If the expected network size is too small, consumers will be reluctant to join and, when they are unwilling to do so, the network will remain small. Thus, the positive consequences of direct network externalities are delayed until a critical mass has developed that allows customers to interact with each other (Ge, 2002). Based on this argument, the positive consequences of direct network externalities only emerge once the product has been generally accepted. Accordingly, we propose the following hypothesis.

H8: Direct network externalities have a positive impact on long-term new product performance.

Switching Costs and New Product Performance

Firms regularly make marketing choices that affect consumers' perceived switching costs (Bansal et al., 2005). One of these actions could be the introduction of a new product into the market as customers will be tempted to acquire this new product and switch from the provider of a similar product. However, switching costs may be a significant impediment to the adoption of a new product and they may favor existing competitors (Eliashberg and Robertson, 1988). Therefore, according to Kohli (1999), it is desirable to reduce switching costs to enhance the adoption of the new product. There is extensive theoretical literature giving support to the disutility that switching providers causes to customers (Jones et al., 2002). If switching costs are associated with a new product, consumers must overcome the barriers involved in switching suppliers (contractual, set-up, continuity, and psychological commitment) (Heide and Weiss, 1995). Therefore, high switching costs will reduce the overall intention to acquire a new product from the firm (Bell et al., 2005). To sum up, these types of costs delay the take-off of the new product and in turn impact negatively on short-term new product performance. Thus, we propose that:

H9: Switching costs have a negative impact on short-term new product performance.

From another point of view, long-term relationships lead to an increase in client confidence about what they can expect to receive from the firm (Bell et al., 2005). As stated by Bansal et al. (2005), the benefits of customer retention can be significant and therefore firms should increase consumer commitment to increase switching costs. In this regard, there is evidence that switching costs have a significant impact on repeat choice behavior and a "lock-in" effect emerges (Burnham et al., 2003). It reflects the fact that consumers stay with the firm because they feel they have to, and as several authors, including Jones et al. (2002) have suggested, switching costs can be used to complement customer retention strategies. Others (Eliashberg and Robertson, 1988; Pae and Hyun, 2002) have argued that consumers stay in "constraint-based relationships" because of switching costs, dependence on the firm, and a lack of attractive alternative partners. Consumers may also feel an obligation to stay with a firm because of all the positive experiences they had with this firm and products in the past (Bansal et al., 2005). Conversely, if alternative products are perceived as being more attractive, consumers are less likely to feel "locked in" with their current firms, which increases the likelihood of switching to competing firms (Farrell and Shapiro, 1988). Thus, if a firm is able to generate and maintain these switching costs, customers will not be motivated to modify the repeat choice behavior in the long term and their intention to switch will be reduced. Based on this, we propose the following hypothesis:

H10: Switching costs have a positive impact on long-term new product performance.

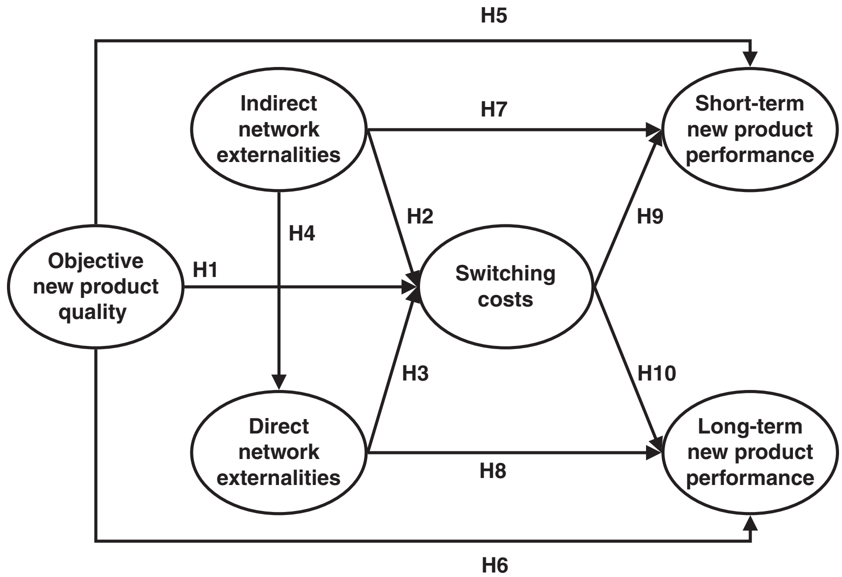

Figure 1. Theoretical Model

This set of relationships is illustrated in Figure 1.

Methodology

Data Collection and Sampling Issues

The data used in this research were provided by a cross-sectional survey as well as a set of case studies. The initial sampling frame was obtained from a database listing the most innovative Spanish firms in four sectors: chemical products, machinery, electrical and electronic machinery, and transport devices. These sectors were also selected because they pay special attention to product quality and because network externalities and switching costs exist in these markets (Lee and O'Connor, 2003a; Sahay and Riley, 2003; Shocker et al., 2004; Srinivasan et al., 2004). We identified 1200 firms through a telephone presurvey. To be eligible, firms had to meet two criteria: they must have developed and launched a new product in the last years (Lee and O'Connor, 2003b) and the product had to be on the market for more than 12 months to ensure they had sufficient data on the product and on the resulting performance (Langerak, Hultink, and Griffin, 2008).

Before collecting the data, we conducted four in-depth case studies, one in each sector, to validate measures. The feedback from these studies, as well as a pretest among ten managers and ten academics, improved the clarity of the questionnaire and ensured an effective, accurate, and unambiguous communication with the respondents. The information was collected through a web-based questionnaire. Respondents were offered a free summary of the most relevant findings of the study and a gift in return for their response. Nonrespondents were called after two weeks to ask if they had received the questionnaire and to remind them of the value of their input (Larson and Chow, 2003). In all, 255 questionnaires were returned, yielding an effective response rate of 21.25%, which is consistent with that obtained in similar studies (Sivadas and Dwyer, 2000). Table 4 presents the sample composition and response summary statistics.

Table 4. Sample Representativeness

SIC Code and Sectors	Population	% population	Respondents	% respondents	Response rate
28. Chemicals	270	22.50%	60	23.53%	22.22%
35. Machinery	300	25.00%	62	24.31%	20.67%
36. Electronic equipment	480	40.00%	98	38.43%	20.42%
37. Transportation equip.	150	12.50%	35	13.73%	23.33%
Total	1200	100%	255	100%	21.25%

A routine check for industry bias indicated no significant differences in the mean responses on any of the constructs across the firms from various industries. In addition, Chi-square distribution analyses revealed no significant differences between our sample and the population it was drawn from in terms of industry distribution, number of employees, and sales volume. We used Armstrong and Overton's (1977) time-trend extrapolation procedure to assess nonresponse bias. When comparing early (first quartile) and late (fourth quartile) respondents, no significant differences emerged in the mean responses on any of the constructs.

To assess the quality of the respondents, we asked them to indicate their degree of knowledge about the new product (Langerak et al., 2008), the new product development process, and launching activities (Atuahene-Gima, Slater, and Olson, 2005) on a 10-point Likert scale (1 = "very limited knowledge," 10 = "very substantial knowledge"). The mean responses were 8.46, 7.08, and 6.71, respectively, thus showing how knowledgeable they were on the new product selected. Together these results suggest that industry bias, nonresponse bias, and respondent knowledge on the new product were no major concerns.

Common Method Variance

Most researchers agree that common method variance is a potentially serious biasing threat in behavioral research, especially with single-informant surveys. We employ several procedures to empirically examine the possibility that common method bias obtained and threatens interpretation of our results: (1) the Harman one-factor test, (2) a confirmatory factor-analytic approach to the Harman one-factor test, (3) the Single Method Factor approach, and (4) an analysis of the correlation between endogenous and exogenous errors.

The rationale for the first test is that, if common method bias poses a serious threat to the analysis and interpretation of the data, a single-latent factor would account for all manifest variables or one general factor would account for the majority of the covariance among the measures. In our case, the one-factor model obtained using principal components analysis revealed several factors in the unrotated factor solution. However, this test is weak, as suggested by Podsakoff, Mackenzie, Lee, and Podsakoff (2003). More recently, some researchers using this technique have used confirmatory factor analysis (CFA) as a more sophisticated test. A worse fit for the one-factor model would suggest that common method variance does not pose a serious threat. The one-factor model yielded a $\chi^2 = 1303.14$ with 119 degrees of freedom (compared with the $\chi^2 = 203.01$ with 104 degrees of freedom for the measurement model). The fit is considerably worse for the unidimensional model than for the measurement model, suggesting that common method bias is not a serious threat in our study.

Despite its apparent appeal, there are several limitations of the previous procedure. Therefore, additional statistical remedies are recommended for this purpose. One of these approaches is the use of latent variable models (Podsakoff et al., 2003). This method involves adding a first-order factor to all of the measures as indicators to the researcher's theoretical model. The single-method factor approach yielded a $\chi^2 = 189.54$ with 81 degrees of freedom (compared to the $\chi^2 = 203.01$ with 104 degrees of freedom for the measurement model). The fit is considerably worse for the single-method factor approach than for the measurement model, suggesting that common method bias is not a serious threat in our study. Although this technique controls for any systematic variance among the items that is independent of the covariance due to the constructs of interest, it does not permit the researcher to identify the specific cause of the method bias.

As a further alternative approach to test for common method variance, we compared the fit of the overall CFA when the errors of the endogenous variable items were allowed to co-vary with those of the exogenous variable items. This test would obtain no significant difference from the original CFA χ^2 result, or a better fit (smaller χ^2), if a "commonness" of instrumentation result obtained from employing single source data. The results obtained proved that instrument bias absence was in evidence. Overall, we can conclude that common method bias does not threaten the interpretation of our data analysis.

Measure Development

Our multi-item scales (see Appendix) were predominantly drawn from prior studies. Based on the extensive literature review, we felt objective product quality should be assessed by a formative scale (Curkovic et al., 2000; Calantone and Knight, 2000). The reflective scale of this construct was obtained from work by Adam and Foster (2000). Finally, a total of four formative indicators and three reflective measures were used to measure objective quality. In order to purify the measure, we followed the procedure by Diamantopoulos and Winklhofer (2001): content specification, indicator specification, indicator collinearity, external validity, and nomological validity. According to Srinivasan et al. (2004), there is no well-established way to measure network externalities. Therefore, based on several contributions of the literature including Basu et al. (2003), Lee and O'Connor (2003a), Shocker et al. (2004), and Stremersch et al. (2007), we have proposed a total of two items to measure the indirect network externalities. With regard to direct network externalities, we also reviewed the work by Sahay and Riley (2003) and Pae and Hyun (2002), and finally a scale with three items was developed. An important discussion is being conducted concerning switching costs (Burnham et al., 2003), as there are different points of view with regard to this variable (Jones et al., 2002). However, we have decided to adopt the proposal by Kohli (1999), which measures switching costs from a managerial point of view. Moreover, the approach by Kohli (1999) is consistent with other research into switching costs using customer evaluations (Bansal et al., 2005; Pae and Hyun, 2002). Finally, to measure new product performance, we reviewed recent studies (Huang, Soutar, and Brown, 2004; Langerak et al., 2008) in this area. We used subjective performance scales based on managers' perception for confidential purpose and also because literature (Song, Dröge, Hanvanich, and Calantone, 2005) shows that they are widely used and that there are high correlations between subjective and objective performance measures. In order to measure short-term new product performance, we asked respondents to evaluate the performance of the new product in the first two stages of its life cycle (introduction and growth stage), and long-term performance as the last two stages of the product life cycle (maturity and decline), as suggested by Lee and O'Connor (2003b).

Scale Purification

To refine our measures, we conducted a confirmatory factor analysis (CFA) using LISREL 8.8 to determine the validity and reliability of our measures. As can be observed from Table 2, the results of the six-factor model provided an acceptable fit ($\chi^2(104) = 203.01$, CFI = .93, RMSEA = .06, RMSEA Range = (.05;.07)). The factor loadings of each individual indicator on its respective construct were statistically significant ($p < .001$) establishing convergent validity. Since our research contains several multi-item reflective scales, we investigated the psychometric properties of these measures through the composite reliability index (Bagozzi and Yi, 1988) and the average variance extracted index (Fornell and Larcker, 1981). Both indexes exceeded the recommended benchmark of .60 and .50, respectively. Evidence of discriminant validity among the dimensions was provided by two different procedures recommended in the literature as follows: (1) the 95% confidence interval constructed around the correlation estimate between two latent variables never includes value 1 (Anderson and Gerbing, 1988), and (2) the comparison of the square root of the AVE (diagonal in Table 5) with the correlations among constructs (i.e., off-diagonal elements) reveals that the square root of the AVE for each component is greater than the correlation between components, in support of discriminant validity (Fornell and Larcker, 1981). These findings provide evidence of discriminant validity among the components and the constructs. Overall, the results obtained from these tests provided evidence reliability for reflective constructs.

Results

We examined the relationships between the constructs using structural equation modeling. The results are

Table 5. Descriptive and Measurement Statistics for Reflective Constructs

	Mean	SD	CR	AVE	1	2	3	4	5	6
1. Objective new product quality	8.02	1.66	.80	.53	.73					
2. Indirect network externalities	4.94	2.43	.88	.78	.03	.88				
3. Direct network externalities	4.75	2.42	.80	.57	.06	.33***	.76			
4. Switching costs	3.89	2.16	.82	.60	−.19***	.24***	.34***	.78		
5. Short-term new product performance	6.51	1.75	.82	.68	.28***	.17**	.09	.10	.83	
6. Long-term new product performance	7.66	1.21	.78	.50	.38***	.10	.24***	.16**	.33***	.71

Significance levels: $^{***}p < 0.01$, $^{**}p < 0.05$.

Notes: Mean = the average score for all items included in this measure; SD = standard deviation; CR = composite reliability; AVE = average variance extracted. The numbers on the diagonal are the square root of the AVE. Off-diagonal elements are correlations among constructs.

presented in Figure 2 and summarized below, while implications for academics and managers are discussed in the following section.

Estimation of the model using LISREL 8.8 resulted in a good overall fit ($\chi^2(172) = 342.33$, CFI = .93, RMSEA = .06, RMSEA Range = (.05;.07)). The results supported most of our hypotheses and prove how network externalities and switching costs increase our understanding of the isolated impact of new product quality on short-term and long-term performance. Therefore, if a firm wants to be competitive, it should focus not only on the positive consequences of quality on short-term ($\beta = .34$) and long-term ($\beta = .44$) new product performance, but on how quality can reduce perceived switching costs ($\beta = -.23$). Moreover, consistent with work by Tellis et al. (2009a), quality alone does not explain performance, as network externalities can also be more important than quality itself. Specifically, we have demonstrated that indirect network externalities play a major role in the short term ($\gamma = .17$), whereas direct network externalities are more determinant in the long term ($\beta = .16$). Nonetheless, managers should not underestimate the effect of network externalities on switching costs, as we have proved that both indirect network externalities ($\gamma = .14$) and direct network externalities ($\beta = .29$) increase perceived switching costs. Also, we proved that indirect network externalities have a positive impact on direct network externalities ($\beta = .32$), which demonstrates how closely related they are albeit being different, as our discriminant analysis shows. We found no support for the hypothesized negative relationship between switching costs and short-term new product performance. A possible explanation of this nonsignificant relationship could be the type of switching costs considered in our research. As we will discuss in the following section, our approach based on procedural switching costs contains a limitation that should be improved in future studies in this area. However, we have proved that the ‘‘lock-in'' effect of switching costs is very relevant in explaining the positive consequences on long-term new product performance ($\beta = .17$).

In addition, there is also an indirect effect of both indirect network externalities ($\beta = .12$) and direct network externalities ($\beta = .08$) on long-term new product performance as can be observed in Table 6. The main consequences of these findings are that the total long-term effect of network externalities and switching costs are even more important than objective quality itself. Therefore, both types of network externalities also induce the ‘‘lock-in'' effect of switching costs. To clarify this, if a customer devoted a lot of effort to learn from other complementary products (indirect network externalities) and from the relationship with other customers (direct network externalities), this would have a positive long-term impact that would go beyond the objective quality of the new product. As Burnham et al. (2003) pointed out, given the limited existing research into switching cost management, it appears that the field has ‘‘blacklisted'' switching costs as customer harming and thus unworthy of study. By contrast, our research demonstrates that switching costs may play an important role in the long term.

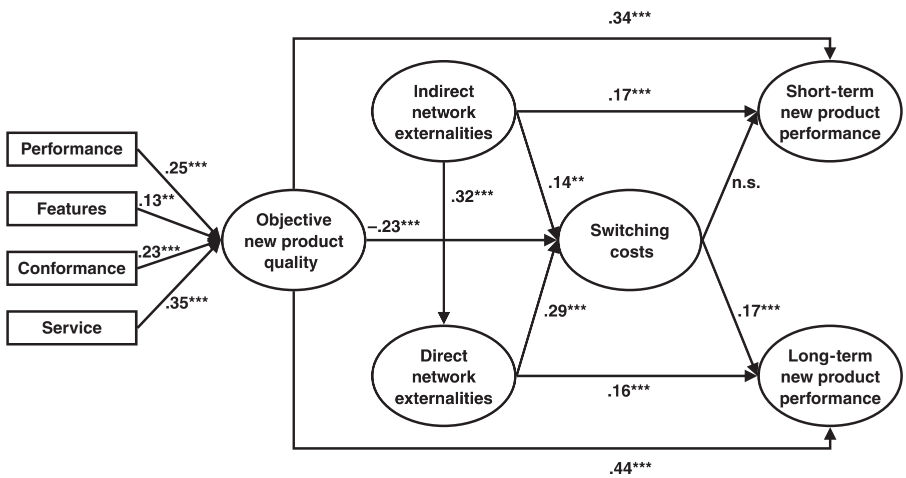

Figure 2. Model Results
$\chi^2(172) = 342.33$, CFI = .93, RMSEA = .06, RMSEA Range = (.05;.07)
Significance levels: $^{***}p<0.01$, $^{**}p<0.05$, n.s. = nonsignificant

Table 6. Direct, Indirect, and Total Effects on Long-Term New Product Performance

Linkages in the model	Direct effects
Objective new product quality → Long-term new product performance	.44***
Direct network externalities → Long-term new product performance	.16***
Switching costs → Long-term new product performance	.17***
Linkages in the model	**Indirect effects**
Objective new product quality → Long-term new product performance	.03
Direct network externalities → Long-term new product performance	.08**
Indirect network externalities → Long-term new product performance	.12***
Linkages in the model	**Total effects**
Objective new product quality → Long-term new product performance	.44***
Total effect of quality = .44***	
Linkages in the model	**Total effects**
Switching costs → Long-term new product performance	.17***
Indirect network externalities → Long-term new product performance	.12***
Direct network externalities → Long-term new product performance	.24***
Total effect of network externalities and switching costs = .53***	

Significance levels: *** $p<0.01$, ** $p<0.05$.

Managerial Implications, Limitations, and Future Research Guidelines

This study offers relevant guidelines from an academic and managerial point of view. From an academic point of view, we have demonstrated that network externalities increase our understanding of the relationship between product quality and new product performance. In addition, the distinction between short-term and long-term new product performance could be useful to managers who want to analyze the implications of product quality, network externalities, and switching costs on new product performance.

From a managerial point of view, our model illustrates how firms can support strategic decision making in technology markets. As stated by Tellis and Johnson (2007), it is essential for firms to introduce new products that are of a minimum quality. However, it has now been well established that it is not quality as such that drives profitability (Mitra and Golder, 2006). In this regard, network externalities are also relevant in explaining the final results of a new product. Thus, as argued by Hellofs and Jacobson (1999), improving quality and network externalities can reinforce mechanisms. In a similar vein, this study also proves that managers should be aware of other products or enter into the "right" alliances if they are to increase the success of their products (Sivadas and Dwyer, 2000). Nowadays, customers pay attention not only to individual product benefits, but also to the possible benefits of using a product in combination with other products or customers. Therefore, managers should aim their efforts at developing new products in accordance with existing or potential new products.

We are aware that there are some limitations to our research. Although it should be noted that perceived product quality is affected by a host of endogenous and exogenous factors, our study has focused mainly upon endogenous or intrinsic factors of the product. Therefore, the analysis of the external view of product quality such as the perception of quality by customers based on brand, price, country of origin, or warranty (Teas and Agarwal, 2000) may offer interesting research guidelines. Thus, further improvements can be made to analyze the interactions of external and internal quality and their impact on performance with regard to the relationships proposed in this research. Another important limitation arises from the fact that we used the perceptions of our respondents to measure performance. Despite the extensive use of such retrospective perceptual data in strategy research (Huang et al., 2004; Langerak et al., 2008), especially in new product research, we should not rule out the shortcomings associated with subjectivity. Also, to ensure the robustness of the results, it would be advisable to use other objective performance indicators (e.g., stock market value, revenues, etc.).

In addition, our research offers interesting future guidelines that may be exploited, and there is clearly much more that can be learned from expanding and refining the relationships we have studied. Future research should consider the perverse effects of network externalities on consumer welfare. As pointed out by Srinivasan (2008), networked markets are associated with stickiness, and new innovations are thwarted because of excess inertia in the markets, which reduces consumer welfare. An interesting issue from a policy perspective is the extent of consumer welfare loss in such situations and what, if any, policy changes can reduce this loss in consumer welfare. It will be interesting to consider broader switching cost typologies and measures (Burnham et al., 2003) for additional insights. Future research should explore how other barriers (incumbent cost advantages, capital requirements, etc.) affect these current results in other contextual situations. Finally, although high switching costs may result in less focal switching (a focal behavior), it is possible that these costs could result in other outcomes (discretionary behaviors) that are not beneficial, and may be harmful to the firm (Bansal et al., 2005). For example, as customer-organization relationships develop, customers become better at evaluating alternative product offerings as expertise and experience with the firm and product category grow (Bell et al., 2005). Thus examining the long-term negative consequences of maintaining high switching costs will also be a fruitful area to investigate.

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Appendix

Objective product quality

Formative indicators:

- The product performed as it was supposed to do.
- The product incorporated features customers do not expect.
- The product was developed according to manufacturing guidelines.
- The product post-purchase service was well organized.

Reflective measure:

- The number of products with physical defects was very low.
- The product had low warranty costs for the firm.
- The product had low return costs for the firm.

Indirect network externalities

- The number of complementary products offered by other companies has increased as our product sales increase.
- The services offered by other companies relating to our product (such as training and support) have increased with our installed base.

Direct network externalities

- The increase in installed base of our product has led directly to more benefits for the user.
- A higher installed base means that our users enjoy more benefits by virtue of the installed base.
- The number of users using the product has increased the utility of the product.

Switching costs
- Customers needed considerable advance planning to buy the product.
- Customers needed a lot of preparation time to use the product.
- Customers needed a learning period to adopt the product.

Short-term new product performance
- Time to market.
- Sales take-off.

Long-term new product performance
- Market share.
- Customer acceptance.
- Customer loyalty.
- Return on investment.

* All the measures were Likert scales (1 = Totally disagree, 10 = Totally agree).