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# IMPACTS OF INNOVATING FIRMS' STRATEGIC SIGNALS ON MARKET PARTICIPANTS' MARKET SUCCESS IN THE CONTEXT OF A STANDARDS WAR

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## **Abstract**

*To increase the likelihood of success of their market-focused innovations, firms that develop innovations for targeted markets regularly communicate with market participants in order to reduce the uncertainties participants hold regarding the firms' innovations. Strategic market signals are one of the tactics used by these firms. While an innovating firm's own signals can have significant impacts on the firm's market success, signals delivered by the firm's competitors could exert negative impacts on the firm's market success in different ways. To examine such negative impacts, the paper develops three types of uncertainty (technical, market and standards) associated with the market-focused innovations as well as hypotheses related to the impacts of competitors' innovation-focused strategic signals on innovating firms' market success during the standards war. The findings have implications for both theory and practice.*

*Keywords: Signaling, standards war, business success*

# 1. Introduction

The development and commercialization of market-focused technological innovations, i.e., new technology-based products targeted at customers' realized and as yet unrealized needs, is challenging because of the significant uncertainties present (Tushman and Rosenkopf, 1992; Utterback, 1994; Tegarden, Harfield, and Echols, 1999; Dowell and Swaminathan, 2006). A primary tactic available to the innovation-producing firms to influence market participants' assessments is strategic signaling (Heil and Robertson, 1991; Robertson, Eliashberg, and Rymon, 1995; Schatzel and Calantone, 2006). As a consequence, innovation-based competitive arenas are rife with signals (Calantone and Schatzel, 2000; Prabhu and Stewart 2001; Basdeo, Smith, Grimm, Rindova, and Derfus, 2006). A strategic signal is commonly understood as "... any action by a competitor that provides a direct or indirect indication of its intentions, motives, goals, or internal situation" (Porter, 1980, p. 75). Strategic signals take many forms but generally involve either messages about intended and completed actions or the taken actions themselves (Heil and Robertson, 1991; Anton and Yao, 2003; Basdeo et al., 2006; Sorescu et al., 2007).

Competition among innovating firms is particularly fierce during the standards war, when a few innovating firms (technology leaders) develop and actively maneuver to have their innovations accepted as the de facto standard of the industry, with the remaining market participants (technology followers) taking positions with regard to these competing innovations. Using strategic market signals to address the uncertainty during the standards war, innovating firms not only can influence the success likelihood of their products, but also that of their competitors. Thus strategic market signals could influence the evolution and standardization process of innovations. Examining the effectiveness of strategic signals from the other side of the competition, we focus in this paper on addressing the research question: *How do innovating firms' innovation-focused strategic market signaling behaviors influence competitors' perceived market success during a standards war?*

## 2. The Dominant Design and the Standards War

### 2.1. The standards war

Over the last few decades, we have observed the occurrence of several standards wars between competing technologies to gain acceptance as "the standard" for an emerging technology. For example, such wars have been observed in the development of home video cassette system, flash memory card, and more recently, between HD-DVD and Blu-ray. The winning technologies of these battles are called dominant designs – that is, the designs to which most competitors, producers of complementary products and users adhere. During a standards war, competing designs are sponsored by innovation producers, each of whom hold proprietary interests in specific designs and seeks to persuade other market participants to adopt these producers' designs as the dominant design (Utterback, 1994; Van de Ven, Polley, Garud, and Venkataraman, 1999; Suarez, 2004; Gallagher and West, 2009). The design that wins over others becomes the de facto standard. A classic example of a standards war is the battle between Sony's Beta and JVC's VHS for video cassette recorder (VCR) formats. While Beta was introduced before VHS and gained an early market share lead, JVC's more effective strategic maneuvering resulted in VHS being adopted as the dominant design (Cusumano, Mylonadis, and Rosenbloom, 1992).

### 2.2. Strategic market positions during the standards war

Within the competitive dynamics of a standards war, two innovation-producer roles have been identified: the few technology leaders sponsoring competing designs, and the more numerous technology followers applying the technology leaders' designs within their own innovations (Porter, 1983; Link and Tassej, 1987; Afuah and Utterback, 1997). Technology leaders are typically endowed with superior technical capabilities and have, over time, built the competitive equity (Calantone and

Schatzel, 2000) enabling them to influence and shape technology regimes (Constant, 1980). And, once a dominant design has emerged from the midst of a standards war, winning technology leaders can enjoy substantial rents for extended periods of time (Utterback, 1994; Das and Van de Ven, 2000; Srinivasan et al., 2006).

During a standards war, the competing designs produced by technology leaders are adopted by technology followers. Here, ‘followership’ is defined in terms of the competing product/service designs and not the technology leaders. While some of these technology followers may actively contribute to the development of a technology leader’s design, most do not but instead take positions reflective of the extent to which these designs are incorporated within these followers’ own products and services. We treat all technology followers as a single innovation-producer category regardless of which design they support because technology followers generally do not commit to a single design during a standards war (Hatfield, Tegarden, and Echols, 2000). Even after announcing a commitment to a particular design, technology followers typically resist the temptation to invest extensively on specialized assets (resources and capabilities) associated with that design but leave open options to modify their product/service designs (and associated capabilities) in case a committed-to design fails to win the standards war (Teece, 1986; Tegarden et al., 1999; Bayus and Agarwal, 2007). For example, in the flash memory card standards war, technology followers (e.g., PNY, Kingston, Lexar, etc.) offered flash memory cards using each of the competing formats.

### 3. Uncertainties Associated with Market-focused Innovations

The development and commercialization activities associated with market-focused technological innovations are subject to considerable uncertainty. Greater uncertainty reflects decision environments that lack distinctive patterns and predictability, and that are subjected to unexpected changes (Dess and Beard, 1984; Keats and Hitt, 1988; Canella et al., 2008). With greater uncertainty, decision makers possess incomplete understanding of the relationships among the elements comprising a decision situation and limited ability to predict future changes regarding these elements (Milliken, 1987; Buchko, 1994; Buganza, Dell’Era, and Verganti, 2009). Prior research has identified three primary sources of innovations’ uncertainty (Tushman and Rosenkopf, 1992; Suarez and Utterback, 1995; Tegarden et al., 1999; Das and Van de Ven, 2000; Sheremata, 2004; Carbonell and Rodriguez-Escudero, 2009): an innovation’s technical functionalities, the competitive market within which an innovation is applied, and the prevailing technical standards associated with the competitive market and/or the innovation. The elements comprising these three uncertainty sources are briefly described in Table 1.

<b>Uncertainty Dimension</b>	<b>Sub-dimension coding</b>
<b>Technology</b>	<i>T1</i> : Statements of technical superiority (Relative advantage of technical characteristics versus competing technologies)
<b>Market</b>	<i>M1</i> : Statements reflecting that products meet market demands (Products that meet existing/potential market needs)
	<i>M2</i> : Statements describing actions to increase sales and/or market share (Competitive strategy to increase sales and market share of existing products)
<b>Standard</b>	<i>S1</i> : Compatible with standards/widely accepted design
	<i>S2</i> : Promoting a standards to become the dominant design (Strategy to increase installed base & complementary products/technologies)

Table 1. Definitions of Uncertainty Dimensions

Technology-centered approaches to innovation evolution (Christensen and Rosenbloom, 1995; Das and Van de Ven, 2000) explain innovation adoption largely based on an innovation’s technical superiority, relative to competing innovations. Innovating firms that work with nascent technologies

undergoing rapid change are prone to seek competitive advantage through technical superiority (Jaworski and Kohli, 1993). For example, during the earliest period of VCR technology, many formats existed and competed fiercely with one another on technical features (Cusumano et al., 1992). However, perceptions of technical advantage are fraught with uncertainty, especially early in the innovation life cycle (Utterback, 1994; Das and Van de Ven, 2000; Dowell and Swaminathan, 2006). The threat is ever present that today's technical advantage might vanish tomorrow given a lack of technical progress with a focal innovation, the technical advancements of competing innovations, or both (Atuahene-Gima and Li, 2004; Lee and Veloso, 2008). *Technical uncertainty*, thus, refers to the extent of instability that exists regarding both an innovation's superiority regarding technical performance in comparison with competing innovations and the competitive value of this technical superiority.

While technical inferiority may result in an innovation's market failure, technical superiority does not guarantee market success (Das and Van de Ven, 2000). Competitive market developments and changes laying beyond the control of any single firm (Podolny, 1994; Beckman, Haunschild, and Phillips, 2004) can significantly impact an innovation's market success. *Market uncertainty* refers to the ambiguity that exists with regard to fluctuations in customer needs and preferences as well as to turbulence in the competition market created by competitors' strategic actions (Song, Xie, and Di Benedetto, 2001; Chen et al., 2005). These two sources of market uncertainty are respectively referred to as demand uncertainty and competitive uncertainty (Beckman et al, 2004).

Demand uncertainty reflects the unpredictability of fit between an innovation's functionalities and customers' preferences (and demands) for these functionalities (Atuahene-gima and Li, 2004; Buganza et al., 2009). While conceptually simple, this notion is pragmatically complex since what is desired by market participants is invariably a moving target (Utterback, 1994; Beckman et al. 2004) because of changes occurring with a focal innovation, with competing innovations, and with complementary innovations. For example, while Sony initially developed Beta video tape with a one-hour playing time capacity, changes in customer demand resulted in Sony having to expand the capacity of their technology, eventually providing a two-hour playing time capacity (Cusumano et al., 1992).

Competitive uncertainty reflects the unpredictability of rivals' strategic actions and the impacts of such actions within a competitive market (Li and Tang, 2010). In entering and attempting to build sustainable positions in a market, firms engage in a variety of strategic moves, including both taking actions and messaging about intended actions, aimed at increasing the likelihood that their market-focused technological innovations will prove successful (Smith, Grimm, Gannon, and Chen, 1991; Teece, Pisano, and Shuen, 1997; Sorescu et al., 2007). Most typically, such competitive moves involve enhancing technical performance, market position, or both (Dixit, 1980; Gilbert and Newberry, 1982; Schmalensee, 1983; Smith et al., 1991).

Gaining technical performance superiority, meeting specific customers' needs and establishing strategic market positions all contribute in meaningful ways to innovating firms' success. However, in the standards war context, expectations of market success quickly fade if the innovation design developed or adopted by a firm does not become the dominant design. *Standards uncertainty*, thus, contributes directly to the commercial uncertainty of the product design that an innovating firm develops or adopts.

Two related issues pertain to standards uncertainty in the context of the standards war: the extent to which a focal innovation conforms to a competing design, and the likelihood that this 'conformed-to' design will win the standards war (Link and Tasse, 1987; Tushman and Rosenkopf, 1992; Tegarden et al., 1999; Bayus and Agarwal, 2007). The absence of a dominant design in the face of non-compatible alternatives dramatically increases uncertainty for both technology leaders and technology followers as it is unclear which alternative design will eventually be accepted as the dominant design, causing losses to the producers and followers of the losing designs (Tushman and Rosenkopf, 1992; Tegarden et al., 1999). For example, as different flash memory card formats (CompactFlash, Secure Digital, Smart Media, Memory Stick etc.) competed for dominant design status during the late 1990s

and early 2000s, considerable standards uncertainty confronted the developers of these formats (e.g., SanDisk, Toshiba, Sony, etc.) as well as the followers that adopted these competing formats for their flash memory card products (e.g. Kingston, Lexar, etc.), and complementary product producers (e.g., Canon, Kodak, Panasonic, Pentax, etc.).

## **4. Market Signals' Impacts on Perceived Market Success**

### **4.1. Strategic signals to address uncertainty**

Given the discussed uncertainties facing innovating firms, a market-focused innovation's success depends to a large extent on how well innovating firms communicate with and influence market participants' perception of uncertainties facing their innovations. Thus, firms regularly make announcements or take actions that are interpreted by market participants (Calantone & Schatzel, 2000; Prabhu & Stewart 2001). Strategic signals take many forms but generally involve either messages (about intended and actual behaviors) to external constituencies or observable behaviors (i.e., strategic moves) (Heil & Robertson, 1991). Announcements of intended actions are not expensive to deliver and have been found to have significant preemptive potential that influence stakeholders' perception and behaviors (Heil & Robertson, 1991; Calanton & Schatzel, 2000). Thus, these announcements have potential to form relevant stakeholders' perception of the signaling firm's innovation and their perception of competitors' innovations. In this research, we focus on innovating firms' verbal statements: communications regarding recent actions or anticipated strategic moves (Arndt & Bigelow, 2000; Calantone & Schatzel, 2000; Heil & Robertson, 1991).

Decision making the strategic decision making literature argue that reducing uncertainty is one of the most critical tasks facing managers. When faced with a more uncertain environment, managers are more likely to rely on rational decision making - involving collecting environmental information relevant to the decisions and then systematically analyzing this information (Eisenhardt, 1989; Dean and Sharfman, 1996; Atuahene-Gima and Li, 2004). Different studies have found significant impacts of innovating firms' signaling behaviors on these firms', as well as on competitors', market success (Dranove and Gandal, 2003; Homburg, Borneman, and Totzek, 2009). Consequently, we expect an innovating firm's innovation market success is influenced not only by the firm's strategic signals but also by its competitors' signals. Thus, innovating firms are expected to deliver three corresponding types of innovation-focused market strategic signals to address the three types of discussed uncertainty dimensions. These signals are expected to have impacts on market success of both the firms delivering them and other competitors on the market.

### **4.2. The impacts of strategic signals on firms' market success**

As we focus on the impacts of competitors' strategic signals on an innovating firm's market success, we expect the different types of strategic signals to have different patterns of impacts on an innovating firm's market success differently, depending on how the different types of signals changes the firm's uncertainty as perceived by market participants. The standards war is characterized by an innovation's continued technical progress and by the emergence of both viable target markets for the innovation and a standards war. With innovations' core functionalities becoming increasingly codified, market participants expect to observe regular, incremental technical advances (Utterback, 1994; Afuah and Utterback, 1997). As such, both technology leaders and followers are capable of being competitive technically with their incremental innovations. Therefore, signals about technical enhancements are expected to reduce the technical uncertainty perceived by the stakeholders of the innovating firms delivering the signals (Soh, 2010), but can potentially increase the perceived technical uncertainty of other competitors in the market, resulting in a reduction in perceived market success of the competitors.

Viable markets for an innovation have begun to take shape during the standards war (Srinivasan et al., 2006), resulting in the emergence of diverse market demands (Agarwal et al., 2002; Suarez and

Lanzolla, 2007). However, the rapid increase of the number of producers (Utterback, 1994) creates a highly dynamic competitive arena within which innovating firms need to effectively communicate the alignment of their products with product-market needs properly or lose the market opportunities to other competitors. Therefore, technology leaders and technology followers alike can benefit by transmitting market signals about meeting market needs, but can also be influenced by other competitors meeting these market needs.

With an increase in the number of competitors and the level of competition, it is critical for innovating firms to build strong market positions (Agarwal et al., 2002; Suarez and Lanzolla, 2007) by developing alliances with complementary product producers (Galagher and Park, 2002) and with supply chain partners (Christensen et al., 1998; Agarwal and Audretsch, 2001). Strategic signals communicating innovating firms' success in developing such agreements can preempt competitors from diverting market participants' attention and resources to competing products (Garud, Jain, and Kumaraswamy, 2002; Soh, 2010). Such signals by competitors could thus increase market uncertainty for an innovating firm, reducing its perceived market success by stakeholders (Heil and Robertson, 1991; Suarez, 2004; Sorescu et al., 2007).

Finally, with the onslaught of a standards war, standards uncertainty surfaces as a critical issue for market participants (Dowell and Swaminathan, 2006; Srinivasan et al., 2006). While strategic signals that reveal events and developments promising to better position an innovation's design as either becoming the de facto standard or as conforming to what appear to be the de facto standard are likely to gain the attention of market participants and reduce the standards uncertainty perceived by these participants (Dranove and Gandall, 2003; Sorescu et al., 2007), such signals by competitors on a competing standard would increase the uncertainty associated with a design that an innovating firm develops or supports, decreasing the perceived success likelihood of the design. These arguments lead to:

*Hypothesis 1: During the standards war, competitors' innovation-focused strategic signals will negatively impact perceived market success of an innovating firm.*

The standards war is characterized by the emergence of viable markets for the innovation (Srinivasan et al., 2006). However, the rapid increase of the number of producers (Utterback, 1994) creates a highly dynamic competitive arena. As a result, while technical superiority is still important to innovating firms, the nature of competition has shifted from a singular attention on technical progress to focusing on multiple factors including aligning an innovation's features with the unsettled needs of emerging target markets, and gaining the support of complementary producers (Katz and Shapiro, 1986; Gallagher and Park, 2002). Therefore, it seems, innovating firms and the evolution of the innovation are influenced more by signals about competitors' abilities to effectively respond to a variety of emerging market requirements (Afuah and Utterback, 1997; Suarez and Lanzolla, 2007), and about their market positioning successes (Katz and Shapiro, 1986; Afuah and Utterback, 1997; Schilling, 2002; Suarez and Lanzolla, 2007; Soh, 2010).

While standards issues are critical to firms during the standards war, impacts of competitors' standards signals on an innovating firm's perceived market success are not expected to be as strong as that of market signals for several reasons. First, while technology followers' innovations are linked to the designs competing for dominant design status (Tegarden et al., 1999; Srinivasan et al., 2006), technology followers tend to refrain from confining themselves to a single competing design but instead strive to keep their options open by adopting hedging strategies, i.e., supporting multiple designs during the standards war (Tegarden et al., 1999; Hatfield et al., 2001). Consequently, while technology followers benefit from signalling their innovations' compatibility with a popular design/standard, competitors' signals regarding their compatibility with a design or standards or signals promoting a design might not have as strong influence on technology followers' market success as competitors' market signals. For technology leaders who develop and promote their own designs, it is expected that they benefit significantly from their own signals promoting their design's likelihood to become the dominant design. However, competitors' standards signals' impacts on

technology leaders are expected to be less than that of market signals. While one follower deliver a signal endorsing a technology leaders' design, the same follower can deliver a signal endorsing a competing technology leaders' design, given its hedging strategy. Such arguments lead to:

*Hypothesis 2: During the standards war, competitors' market-oriented strategic signals will negatively impact perceived market success of an innovating firm to a greater extent than will technical-oriented and standards-oriented strategic signals.*

## 5. Research Methodology

Event study methodology is used to assess the impact of competitors' signals on innovating firms' perceived market success, which was measured by abnormal returns in firms' stock price as the results of investors' reactions to delivered signals. Each signal is considered an unanticipated event that will potentially have significant impacts on the firms' abnormal stock price return. The following sections describe the data collection approach and analytic procedures.

### 5.1. Standards war context chosen

Flash memory card technology was chosen for this study for several reasons. First, the competition for dominant design status of flash memory card is left to the market where firms continue to engage in a standards war to drive their designs (e.g. CompactFlash, Memory Stick, etc.) to be accepted as the dominant design. Additionally, flash memory card technology is a recently introduced technology; thus, data on innovating firms' strategic signals and their stock prices are available. Table 2 lists the major competing flash card formats.

Standards	Release Date	Producer
CompactFlash	Oct. 24, 1994	SanDisk
SmartMedia/SSFDC	Nov. 13, 1995	Toshiba
Miniature Card	Jan. 24, 1996	Intel
MultiMediaCard (MMC)	Nov. 5, 1997	Siemens and SanDisk
Memory Stick	Oct. 7, 1998	Sony
Secure Digital (SD)	Aug. 25, 1999	Matsushita, SanDisk and Toshiba

*Table 2. Major competing flash card formats*

By 2005, Secure Digital occupies about 50% of the flash memory card industry market share. Hence, it is widely agreed that 2005 was the year that Secure Digital won the standards war and became the dominant design for flash memory card.

Sandisk and Lexar, respectively a technology leader and a technology follower, were chosen for the study to examine the impacts of competing flash memory card producers' signals on their stock prices. Both are public companies relying heavily on flash memory card sales for their revenues, thus the impacts of signals regarding flash memory products on the firms' stock price are more likely to be observed.

### 5.2. Data collection and coding

Signals from flash memory card producers were collected from Business Wire and PR Newswire. The signals are flash memory card producers' messages, delivered in the form of press releases, addressing different aspects of their flash memory card products. The signals data were collected from the period between 1997 and 2005. The identified press releases (announcements) were coded as carrying technology-oriented, market-oriented, and/or standards-oriented signals. The coding rules were developed based on the definitions of the uncertainty dimensions that the signals were used to address (see Table 1). Two people coded the signals independently. Afterwards, coding results of the two coders were compared, inter-rater reliability (Cohen's Kappa) ranges from 0.71 to 0.80, reflecting excellent inter-rater reliability.

### 5.3. Analysis and results

Two separate event studies were used to analyze the impacts of different types of competitors' signals on Sandisk's and Lexar's stock price. 3-day and 1-day windows were used to examine the impacts of competitors' signals on the firms' abnormal stock returns. The original dataset includes 227 announcements delivered by all firms during the 1997-2005 data collection period. To retrieve a clean data set for each event study analysis, confounding events need to be controlled for (McWilliams and Siegel, 1997). Signals that are delivered by Sandisk or Lexar were removed from the two data sets. Also, signals that are confounded by signals delivered by Sandisk and Lexar in a three-day window surrounding the delivery dates were removed from the data sets. Additionally, confounding effects of other announcements delivered by Sandisk and Lexar, such as quarterly financial reports, changes in management team, etc., are also controlled for. After controlling for all confounding events, the final two data sets include 89 press releases for Sandisk's and 80 press releases for Lexar's data set.

Market-model cumulative abnormal returns (CARs) and z-statistics are shown for the day before (-1), the day of (0), and the day after (+1) the announcements, together with cumulate returns over the (-1, 0, +1) periods. Statistical tests are performed using standardized residuals. *p < .10; ** p < .05; *** p < .01				
Window	Day -1	Day 0	Day +1	Days -1, 0, &+1
<b>Sandisk: N=89</b>				
Mean CARs	0.02%	-0.89%	0.16%	-0.71%
z-statistic	(-0.26)	(-1.70)**	(0.32)	(-0.95)
<b>Lexar: N=80</b>				
Mean CARs	-0.39%	-2.27%	-0.89%	-3.55%
z-statistic	(-0.34)	(-1.92)**	(-0.14)	(-1.38)*

Table 3. Cumulative Abnormal Returns (CAR) for Sandisk and Lexar

Two separate event study analyses were run, using EVENTUS program, with the two data sets to investigate the abnormal returns of SanDisk's and Lexar's stock prices as a result competitors' signals. Table 3 reports results of the event study analyses with Sandisk's and Lexar's abnormal returns.

Dependent variable 1-day CARs (0). For each independent variable, value = 1 signifies a signal; 0 otherwise. Unstandardized regression coefficients are shown with standard errors in parentheses. *p < .10; ** p < .05; *** p < .01		
Independent Variables	Sandisk	Lexar
Intercept	-0.804 (0.033)	-0.374 (0.022)
T1: Statements of technical superiority	-0.019 (0.026)	-0.006 (0.018)
M1: Statements reflecting that products meet market demands (customer-oriented perspective)	-0.041 (0.028)	-0.039** (0.018)
M2: Statements describing actions to increase sales and/or market share (competitor-oriented perspective)	0.026 (0.028)	-0.042** (0.017)
S1: Compatible with current standards or widely-accepted designs	0.032 (0.024)	0.024 (0.017)
S2: Promoting a standard to become the dominant design	-0.132* (0.073)	0.040 (0.031)
Adjusted R <sup>2</sup>	1.3%	8.5%
F Statistic	1.211	2.387
p-value	0.312	0.047**

Table 4. Multiple Regression Analysis Results

Abnormal returns are reported for individual days from day -1 to day +1 surrounding the day of the announcements as well as the cumulative abnormal returns during the three-day period. While

abnormal returns of Sandisk's and Lexar's stock prices were not significantly different from 0 for the 3-day windows, abnormal stock returns were significantly less than 0 during the day of the signals for both Sandisk's (CAR= -0.89 %,  $p < 0.05$ ) and Lexar's (CAR=-2.27%,  $p < 0.05$ ). These results support hypothesis 1, which states that an innovating firm's perceived market success is negatively influenced by competitors' innovation-focused strategic signals.

The next step is to match the coded announcements to the CARs to examine the impacts of different types of coded signals on Sandisk's and Lexar's CARs using multiple regression analysis. Each announcement was coded to carry technical, market, and/or standards signals. Market and standards signals include two sub-categories. Variables for the subcategories were used in the regression analysis. Table 4 represents the multiple regression analysis results. One-day market-model returns were used as the dependent variable. The dependent variable was not normally distributed. Therefore, a log transformation was applied.

Hypothesis 2, which argues that market-oriented signals will have stronger negative impacts on an innovating firm's perceived market success than will technical-oriented and standards-oriented signals, is partially supported. While both types of market-oriented signals have significant negative impacts on technology followers Lexar's stock price (Beta = -0.039 and -0.042,  $p < 0.05$ ), technical and standards signals were not found to have significant impacts on Lexar's stock price. Meanwhile, such patterns of impacts were not found with technology leader Sandisk's stock price.

## **6. Discussion and conclusion**

The following section will discuss our findings and the study's implications for theory and practice. First, competitors' signals were found to have significant negative impacts on an innovating firms' perceived market success during the standards war. However, different types of signals were found to have different patterns of impacts. While competitors' market signals have significant negative impacts on technology followers Lexar's stock price, such patterns of impacts were not observed for technology leader Sandisk's stock price. One possible explanation for that is that the level of impacts of competitors' signals on Sandisk's stock price (-0.89%) was not as strong as that on Lexar's stock price (-2.27%), making it more difficult to separate the differential impacts of different signal types.

### **6.1. Implications for research**

The paper's theoretical development and empirical findings have important implications for theory. By integrating insights from technology management, strategic signaling, and marketing literature, the study helps advance signaling theory by placing the theory in the context of standards development along the innovation life cycle. The study provides theoretical and empirical insights that signals delivered by competitors could have significant impacts on an innovating firm's market success during the standards war. This shows that innovating firms', leaders and followers alike, innovation-focused strategic signals not only have influence on the delivering firms' market success but also have influence on the evolution of an innovation and the standards war. Therefore, future research on innovating firms' signals should study the impacts of the signals on both the signal delivering firms and other competitors. Additionally, our research has also shown that the intensity of competitors' signals' influence on technology leaders and followers are different.

The study also shows that different types of signals addressing different dimensions of uncertainty during the standards war would have different patterns of impacts on innovating firms' market success as well as the innovation evolution process. Consequently, future research should examine such different types of signals separately.

The study also lays the background for further research which aims at investigating innovating firms' signaling strategy in different contexts of standards development/evolution. This study focuses on the development of *de facto* standards. Strategic signaling behaviors in other contexts are also important (e.g. open standards, *de jure* standards) and need to be investigated in future research. Additionally,

this research focuses on one aspect of signaling: addressing uncertainty. However, there might be other aspects that competitive signals strive to address such as first movers advantage (Suarez & Lanzolla, 2007), or reaction to radical change (Benner, 2007), etc.

## **6.2. Implications for practice**

Our research also has implications for practice. The study shows that signals addressing the different uncertainty dimensions facing innovating firms during the standards war can have impacts not only on the firms delivering the signals but also on other competitors. Additionally, different types of signals could influence competitors' market success differently. Consequently, to help improve the success likelihood of their firms' innovations, managers of innovating firms during a standards war need to develop appropriate signalling strategy to help inform market participants about their companies' innovations. Such strategy should aim at reducing the different dimensions of uncertainty perceived to be associated with the firms' innovations.

Additionally, since the study shows that competitors' signals could have significant impacts on a firm's innovation market success, it is also important that innovating firms develop appropriate strategy to scan the environment to recognize and react to different types of strategic signals of competitors. Our ideas and propositions should prove useful to innovating firms' choices regarding investments in and use of systems, structures and processes enabling and supporting environmental scanning. Since social media has become increasingly popular among firms as a communication tool, insights from our study also helps innovating firms' managers develop appropriate ways to use social media as a platform to communicate appropriately with various stakeholders about the uncertainties and success likelihood associated with their innovations.

## **6.3. Conclusion**

Innovating firms developing and commercializing technological innovations during a standards war face with tremendous uncertainties not only from the internal technological development of the products but also from the strategic actions of all market participants. In order to survive and prosper in this highly dynamic environment, it is critical that innovating firms actively strive to influence the perceptions of market participants about their innovations. Strategic signaling has been seen as an effective means with which to influence market participants. However, little is known about innovating firms' strategic signaling behaviors and how these signaling behaviors can influence firms' market success and the evolution and standardization process of innovations. This study provides theoretical and empirical insights on the relationships between the uncertainty dimensions and innovating firms' strategic signaling behaviors, as well as how these signaling behaviors will influence innovating firms' market success. It is hoped that the research will lead others to direct their attention, both theoretical and empirical, to this important phenomenon.

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