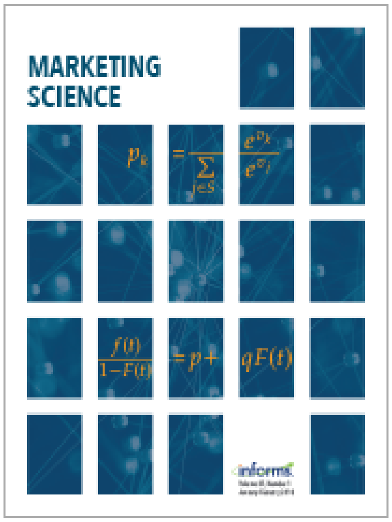
This article was downloaded by: [154.59.124.38] On: 01 July 2021, At: 04:06
Publisher: Institute for Operations Research and the Management Sciences (INFORMS)
INFORMS is located in Maryland, USA



Marketing Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Do Innovations Really Pay Off? Total Stock Market Returns to Innovation

Ashish Sood, Gerard J. Tellis,

To cite this article:
Ashish Sood, Gerard J. Tellis, (2009) Do Innovations Really Pay Off? Total Stock Market Returns to Innovation. Marketing Science 28(3):442-456. https://doi.org/10.1287/mksc.1080.0407

Full terms and conditions of use: https://pubsonline.informs.org/Publications/Librarians-Portal/PubsOnLine-Terms-and-Conditions

This article may be used only for the purposes of research, teaching, and/or private study. Commercial use or systematic downloading (by robots or other automatic processes) is prohibited without explicit Publisher approval, unless otherwise noted. For more information, contact permissions@informs.org.

The Publisher does not warrant or guarantee the article's accuracy, completeness, merchantability, fitness for a particular purpose, or non-infringement. Descriptions of, or references to, products or publications, or inclusion of an advertisement in this article, neither constitutes nor implies a guarantee, endorsement, or support of claims made of that product, publication, or service.

Copyright © 2009, INFORMS

Please scroll down for article—it is on subsequent pages

With 12,500 members from nearly 90 countries, INFORMS is the largest international association of operations research (O.R.) and analytics professionals and students. INFORMS provides unique networking and learning opportunities for individual professionals, and organizations of all types and sizes, to better understand and use O.R. and analytics tools and methods to transform strategic visions and achieve better outcomes.
For more information on INFORMS, its publications, membership, or meetings visit http://www.informs.org

MARKETING SCIENCE
Vol. 28, No. 3, May–June 2009, pp. 442–456
ISSN 0732-2399 | EISSN 1526-548X | 09 | 2803 | 0442

DOI 10.1287/mksc.1080.0407
© 2009 INFORMS

Do Innovations Really Pay Off? Total Stock Market Returns to Innovation

Ashish Sood
Goizueta School of Business, Emory University, Atlanta, Georgia 30322,
ashish_sood@bus.emory.edu

Gerard J. Tellis
Marshall School of Business, University of Southern California, Los Angeles, California 90089,
tellis@usc.edu

Critics often decry an earnings-focused short-term orientation of management that eschews spending on risky, long-term projects such as innovation to boost a firm's stock price. Such critics assume that stock markets react positively to announcements of immediate earnings but negatively to announcements of investments in innovation that have an uncertain long-term pay off. Contrary to this position, we argue that the market's true appreciation of innovation can be estimated by assessing the total market returns to the entire innovation project. We demonstrate this approach via the Fama-French 3-factor model (including Carhart's momentum factor) on 5,481 announcements from 69 firms in five markets and 19 technologies between 1977 and 2006.

The total market returns to an innovation project are $643 million, more than 13 times the $49 million from an average innovation event. Returns to negative events are higher in absolute value than those to positive events. Returns to initiation occur 4.7 years ahead of launch. Returns to development activities are the highest and those to commercialization the lowest of all activities. Returns to new product launch are the lowest among all eight events tracked. Returns are higher for smaller firms than larger firms. Returns to the announcing firm are substantially greater than those to competitors across all stages. We discuss the implications of these results.

Key words: innovation; market returns; event study; Fama-French 3-factor model; high-tech marketing
History: Received: April 25, 2007; accepted: February 29, 2008; processed by Donald R. Lehmann. Published online in *Articles in Advance* January 12, 2009.

Introduction

Innovation is probably one of the most important forces in fueling the growth of new products, sustaining incumbents, creating new markets, transforming industries, and promoting the global competitiveness of nations. Even so, many researchers, analysts, and managers fear that firms do not invest enough in innovation. According to the MIT Technology Review's annual survey of research and development (R&D) in 2004, corporate R&D spending across a broad cross-section of industries is on the decline. Some go so far as to complain that the United States may be losing its competitive edge and its famed leadership in innovation because of declining investment in R&D relative to other nations (Hall 1993; Council on Competitiveness Report 2004). Firms may underinvest in R&D because of the high costs, the long delay in reaping market returns if any, the uncertainty of those returns, and the difficulty of adequately measuring them. The increasing speed of diffusion across global markets (Chandrasekaran and Tellis 2008) and the diverse patterns of consumer adoption across products and countries (Sood et al. 2009) exacerbate the challenges for firms to predict returns to new products. Moreover, some critics assert that an earnings-focused, short-term orientation on boosting stock price may undercut investments in innovation that typically have a long payoff. Such critics assume that the market does not reward efforts in innovation that typically take time to pay off. However, accurately assessing the market returns to innovation may be critical to understanding how markets respond to innovation and motivating firms to invest in innovation.

The abnormal stock market returns to innovation are one of the best means of assessing the true rewards to innovation. Past research has examined the effect of innovation on firm performance measures like sales, profits, or market share. However, these measures are subject to many other strategic and environmental factors so that the path of causality is not clear. Under the assumption that the stock market is efficient, such returns can be assessed by the event study (Fama 1998). The event study estimates the abnormal stock market returns to new information in an event, which is assumed to be proportional to the net present value of the new information. In an early application of this method, Chaney et al. (1991) report market returns of 0.25% to an isolated event,

Table 1 Events During Initiation, Development, and Commercialization Activities of Innovation Projects

Phase	Initiation	Development	Commercialization
Events unique to this study	Funding (grants, advanced order, funded contracts) Expansion (new development or manufacturing facilities)	Prototypes (working prototypes, identification of new materials, processes or equipment, demonstration in exhibitions)	New product Launch (shipments, new applications)
	This research (positive and negative events are recorded separately for announcements of all activities)		
Events covered by prior research	Alliances (joint ventures, acquisitions)	Patents Preannouncements (more than one week ahead of future events)	New product Launches Awards (external recognition of quality)
Prior research	Hirschey (1982) Jaffe (1986) Cockburn and Griliches (1988) Doukas and Switzer (1992) Chan et al. (1992) Hall (1993) Das et al. (1998) Chan et al. (2001) Suárez (2002)	Pakes (1985) Jaffe (1986) Erickson and Jacobson (1992) Kelm et al. (1995)	Eddy and Saunders (1980) Wooldridge and Snow (1990) Chaney et al. (1991) Zantout and Chaganti (1996) Hendricks and Singhal (1996) Koku et al. (1997) Przasnyski and Tai (1999) Nicolau and Sellers (2002) Sorescu et al. (2003) Bayus et al. (2003) Pauwels et al. (2004) Sorescu et al. (2007) Tellis and Johnson (2007)

new product introduction. Past research has also estimated returns to other isolated events of an innovation project (see Table 1).

There are three limitations to this approach. First, returns to specific events (e.g., launch of new products) do not reveal the total returns to innovation, which is really the sum of all events in an innovation project. A focus on returns to specific events in the innovation project may be one reason why markets appear to undervalue innovation. Second, a focus on specific events cannot reveal how returns are distributed over the entire project. Such knowledge is useful to both understand which event of an innovation project gets the most returns and what announcement strategy firms should adopt. Third, returns to specific events may be deflated because of excessive announcements or inflated because of few announcements in the innovation project. We can ascertain this effect only by recording all announcements of all firms throughout the innovation project and estimating returns to an event after controlling for other events and strategic and structural variables.

Hence, a researcher may arrive at erroneous estimates of the true rewards to innovation by limiting the scope of study to announcements of only a new product's introduction or any other single event. As far as we know, there is no study on market returns to all events in an innovation project. This is the goal of the current study. In particular, it seeks answers to the following questions:

- How do stock markets react to each event in an innovation project, after controlling for other events?
- What are the total market returns to the innovation project?
- What are the market returns to sets of activities of the innovation project?
- What structural (e.g., size) and strategic (e.g., research productivity) variables affect the market returns to innovation?
- How do the market returns of competitors compare to those of the announcing firm?

The rest of the paper is organized as follows: The next three sections present the theory, method, and findings. The last section discusses the findings, limitations, and implications of the research.

Conceptual Background

This section reviews prior findings and expectations about markets returns to innovation. To better lay out the area, it begins by defining the key terms and assumptions of the study.

Definitions

We define four key terms: technology, innovation project, event, and announcement.

Following Sood and Tellis (2005), we define a technology as a distinct principle or platform for producing products to serve a consumer need. For example, neon lamps are based on fluorescence technology that produces light by the distinct scientific principle of fluorescence. Halogen lamps are based on incandescence technology that produces light by the distinct scientific principle of incandescence (see Appendix A for details). Several new products and models (e.g., hard disks, floppy drives, tapes, etc.) could be developed on the platform of one technology (e.g., magnetic storage).

We define an *innovation project* as the total of a firm's activities in researching, developing, and introducing any new product based on a new technology, from the initiation of the technology to about a year after introduction of the new product(s). For example, all of Philips' research efforts in initiating, developing, and commercializing a compact fluorescent lamp (a new product based on fluorescence technology) comprises the innovation project for that new product.

We define an *event* as some progress in the project (e.g., patents or product launch). We identify seven such events detailed in later sections.

We define an *announcement* as the availability of information about an event either from the firm directly or through other sources.

Market Returns to Innovation Events, Activities, and Projects

We identify three distinct sets of activities in the innovation project—initiation, development, and commercialization. Each set of activities includes key events related to the overall set and may occur any time during the innovation project. For example, firms may decide to enter into new alliances any time during the innovation project. Moreover, these events may be either positive (patent registration) or negative (patent denial) (see Appendix B for details). Total market returns to the entire innovation project are the sum of returns to all activities during the innovation project. Currently, the literature reports rival findings about whether returns to each of these events is negative or positive, as summarized below.

Initiation activities include events about alliances (including joint ventures and acquisitions), funding (including grants, advanced orders, and funded contracts), and expansions for new innovation projects. Announcements about initiation activities may lead to negative returns because of high investments, long gestation periods, associated uncertainty, and high risk of failure (Crawford 1977, Kelm et al. 1995). On the other hand, such announcements may lead to positive returns as they enable market expansion, deter competitor entry, improve probability of success and enhance firms' competitive position (Aaker 1995, Suárez 2002, Anand and Khanna 2000, Das et al. 1998, Doukas and Switzer 1992). The rival arguments for positive and negative market returns to initiation activities suggest the need for empirical research to resolve the conflict.

Development activities include events about prototypes (working prototypes, demonstration in exhibitions, and new materials, equipment, and processes), patents, and preannouncements (more than one week ahead of future events). Announcements about development activities may lead to negative returns because they alert competitors of progress, reduce the element of surprise, trigger imitators, or lead to excessive discounting of the technical content. On the other hand, returns to development activities may be positive because of reduction in overall uncertainty, signaling confidence, competence, and optimism about the future (Zantout and Chaganti 1996, Paulson Gjerde et al. 2002, Austin 1993, Pakes 1985, Sorescu et al. 2007). The rival arguments for positive and negative market returns to development activities suggest the need for empirical research to resolve the conflict.

Commercialization activities include events about new product launch (including launches, initial shipments, and new applications), and awards (external recognition of quality). Announcements about commercialization events may lead to negative returns because launched products fall below expectations, costs of promotion and launch seem high, or the competitive advantages from launch seem fleeting (Crawford 1977, Berenson and Mohr-Jackson 1994). On the other hand, announcements of commercialization events may lead to positive returns because they signal the competitiveness of the firm, the successful completion of innovation project, and the expansion of the product portfolio (Sharma and Lacey 2004, Chen et al. 2005, Akigbe 2002, Zantout and Changanti 1996, Chaney et al. 1991, Tellis and Johnson 2007, Hendricks and Singhal 1996, Urban and Hauser 1980, Chan et al. 1992, Sankaranarayanan 2007, Keller and Lehmann 2006). The rival arguments for positive and negative market returns to commercialization activities suggest the need for empirical research to resolve the conflict.

Total Returns to Innovation

Past research has estimated returns to isolated events of an innovation project (see Table 1). This approach may lead to a substantial underestimation of the total returns to innovation. We propose that the total returns to innovation can only be estimated if all events in all sets of activities of the innovation project are included in the analysis. If the returns to the entire innovation project could be estimated from a single, target event during the project, then returns for other events would not be significantly different from zero. That target event would be critical with important implications for firms and investors. On the other hand, if firms continue to experience incremental returns to various events over the innovation project, ignoring certain events would result in underestimating the total returns to innovation. It would also mean that firms (and investors) should pay close attention to all innovation-related events and optimize their announcement (and investment) strategy.

The total returns to innovation are the sum of returns to all events in an innovation project. Similarly, if a firm has multiple innovation projects running concurrently, the total returns to innovation to the firm are the total return to all innovation projects of the firm.

In addition to completeness, the benefit of considering all events in an innovation project is that it compensates for suboptimal or strategic announcements of the firm. For example, if the firm underpromises in early stages of an innovation project and overdelivers in later stages, the possibly low market returns in early stages will be compensated by high returns in later stages. Conversely, if a firm overpromises and then underdelivers, taking all events into consideration will compensate for possibly too-high returns in earlier stages.

Activities with the Highest Returns

Researchers and managers may want to know which type of activities attracts the highest returns. We are not aware of any specific study that examines this question or any specific theory that concludes that one particular set of activities does better than others. However, past research seems to suggest that announcements of commercialization activities may experience the highest returns for several reasons. First, only commercialization activities signal culmination in terms of revenues from sales of the new product (Sharma and Lacey 2004, Chan et al. 1992). Second, based on research to date, commercialization activities get the most attention from reporters.

Control Variables

Market returns during the innovation project may also be affected by the firm's announcement strategy or structure. For this reason, we include two strategic variables (announcement frequency and research productivity) and two structural variables (size of firm and age of technology) as control variables.

Announcement Frequency. Firms vary in their announcement strategy. Microsoft announces all events related to the project. Other companies, for example, like Apple, aggregate many events into one big announcement. Some literature suggests that frequent announcements reflect transparency and timeliness and thus would either enhance returns or at least not lead to penalty in returns (Kelm et al. 1995, Tucker 2007, Givoly and Palmon 1982). Moreover, frequent and multiple announcements lead to dilution of returns over a larger number of events and thus lower realized returns per announcement (Chaney et al. 1991). We use two alternate measures for announcement frequency: number of prior announcements and days since last announcement. We expect returns to be negatively correlated to the first measure and positively correlated to the second measure.

Size of Firms. Prior research suggests that the size of firm is an important structural variable that affects the market returns to innovation. Prior research suggests that returns for smaller firms are higher than the returns for larger firms because of higher salience of any single event in a small firm than a large firm (Austin 1993). Large firms are also better tracked by analysts and in general have much smaller "surprise" in event returns. We use two alternate measures of the size of firm—annual sales and the number of different technologies in which a firm invests.

Research Productivity. A high level of research productivity could increase the returns of a firm for a couple of reasons. First, customers may perceive an innovative firm as having superior quality products and thus drive up demand for its new innovations (Barney 1986, John et al. 1999). Second, a firm with a reputation for a regular stream of innovative products increases the likelihood of fruitful strategic alliances (Dollinger et al. 1997), which could increase the probability of success with the current innovation. Hence, market returns may be high to firms with high research productivity. We measure research productivity by the number of new product launches per year prior to the date of the current event.

Age of Technology. Market returns to innovation projects may differ across old and new technologies. Prior research suggests that technologies mature with time (Chandy and Tellis 2000, Foster 1986, Christensen 1992) and that the focus of innovation changes from product to process innovation as a technology matures (Utterback 1974, Adner and Levinthal 2001). Hence, the improvements in product performance might be less for older technologies. In contrast, new technologies improve rapidly, open new opportunities and markets, and can disrupt old technologies (Christensen 1997). Thus, market returns to new technologies may be higher than those to old technologies. We measure age of technology as the number of years since the first new product launched based on the technology.

Method

This section describes the method for estimating abnormal returns to announcements during the innovation project in five subsections: logic of the event study, model for data analysis, and sample, sources, and procedure for the data collection.

Logic of Event Study

The event study (Fama et al. 1969) is one of the most widely used analytical tools in financial research. The basic assumption underlying the method is the efficient market hypothesis, which states that a stock price at a particular point in time fully reflects all available information up to that point (Sharpe 1964, Fama 1998). Thus, any change in the price of a stock because of arrival of new information reflects the present value of all expected current and future profits from that new information. The method has been widely used in the finance, accounting, economics, management, and marketing literatures to assess the market value of information contained in various events of interest. The market return to an event of a firm is the change in the stock price of that firm due to that event, above that due to the general market at the time of the event. The next subsection explains how we compute such market returns to an event. Total returns to innovation are the cumulative returns to all events within an innovation project.

Model

We estimate abnormal returns to the event using the Fama-French 3-factor model (Fama and French 1993) including Carhart's momentum factor (Carhart 1997). Prior studies in event studies have relied on the standard capital asset pricing model that assumes that the market portfolio is the benchmark for normal returns to a stock (McKinlay 1997). However, the Fama-French 3-factor model expands the completeness of the model by adding two more factors: market capitalization and value. More recently, Carhart proposed the addition of a fourth factor, price momentum, to account for the persistence effect in returns reported by Jegadeesh and Titman (1993). Thus, the combined Fama-French-Momentum 4-factor (FFM4) model is

$$\begin{aligned} R_{it} - R_{ft} &= \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i} SMB_t \\ &\quad + \beta_{3i} HML_i + \beta_{4i} UMD_i + \varepsilon_{it} \qquad (1) \\ E[\varepsilon_{it}] &= 0; \quad \mathrm{Var}[\varepsilon_{it}] = \sigma^2_{\varepsilon_i}, \end{aligned}$$

where

- t: Subscript for time of the estimation window, such that $-270 \le t \le -6$;
- i: Subscript for announcement
- R_i: Returns to announcement i on day t;
- R_m: Returns to corresponding daily equally weighted S&P 500;
- R_f: Theoretical rate of return attributed to an investment with zero risk;
- SMB: Returns on a portfolio of small stocks minus returns on large stocks;
- HML: Returns on a portfolio of stocks with high book-to-market ratio minus the returns to a portfolio of stocks with low book-to-market ratio;
- UMD: Carhart's price-momentum factor that captures one-year momentum in returns.

ε_{it} is the disturbance term and α_i, β_{1i}, β_{2i}, β_{3i}, β_{4i}, and σ^2 are the parameters of the model to be estimated. The risk-free rate represents the interest that one expects from a risk-free investment over a specified period of time. The interest rate on a three-month U.S. Treasury bill is commonly used as a proxy for the risk-free rate because short-term government-issued securities have virtually zero risk of default.

The returns variables are also computed at the level of project, p. We have suppressed subscripts for this level in the first four equations, for ease of reading.

We estimate the parameters of Equation (1) using an estimation period from 270 to 6 days prior to the announcement. For some new firms that were listed on the stock exchange for a short period before the announcements, we use a shorter estimation period. However, we remove any announcement with an estimation period of fewer than 30 days.

We next compute abnormal returns (AR_{it}) to an event as the difference between the normal returns that would have occurred on that day given no event and the returns that did occur because of the event; thus,

$$\begin{aligned} AR_{it} &= R_{it} - E[R_{it}] \\ &= R_{it} - R_{ft} - [(\hat{\alpha}_i + \hat{\beta}_{1i}(R_{mt} - R_{f_t}) + \hat{\beta}_{2i} SMB_t \\ &\quad + \hat{\beta}_{3i} HML_t + \hat{\beta}_{4i} UMD_t] \quad \text{for } -1 \le t \le 1, \qquad (2) \end{aligned}$$

where AR_{it}, R_{it}, and $E(R_{it})$ are the abnormal, observed, and normal returns, respectively, for announcement i and event window t. We also try windows centered on the date of announcement of varying widths, ± 1 and ± 2 days before and after the event.

We estimate average abnormal returns and the t-statistic θ (Brown and Warner 1985) for the portfolio of N announcements of an event; thus,

$$AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{it}, \qquad (3)$$

$$\theta = \frac{AAR_t}{\mathrm{SD}(AAR_t)} = \frac{AAR_t}{\sqrt{\frac{1}{(T_0-1)} \sum_{t=1}^{t=T_0} (AAR_t - \overline{\overline{AAR}})^2}}, \qquad (4)$$

where

AAR_t is the average (abnormal) returns for an event; and T_0 is the number of days in the estimation window, which in our case is $270 - 5 = 265$, and $\overline{\overline{AAR}} = (1/T_0) \sum_{t=1}^{T_0} AAR_t$.

Note that this portfolio t-test statistic explicitly takes into account any potential cross-sectional dependence in the abnormal returns.

We compute cumulative average abnormal returns (CAR_i) in the event window as follows:

$$CAR_i = \sum_{t=t_1}^{t=t_2} AR_{it}, \qquad (5)$$

where t_1 and t_2, respectively, denote the beginning and end of the event window.

Table 2 Sample Characteristics

Category	External lighting	Display monitors	Desktop memory	Data transfer	Printers
Number of firms	19	17	18	17	11
Total number of announcements	696	1,100	1,239	1,323	1,123
Sample period	1977–2006	1980–2006	1979–2006	1982–2006	1981–2006
Initiation activities	155	278	270	327	117
Development activities	171	305	274	183	126
Commercialization	370	517	695	813	880
Number/type of platform technologies	5	5	5	3	4
	Incandescence, arc-discharge, gas-discharge, LED, MED	CRT, LCD, PDP, OLED	Magnetic, magneto-optical, optical	Copper/aluminum, fiber optics, wireless	Dot matrix, inkjet, laser thermal

Note. LED, light-emitting diode; MED, microwave electrodeless discharge; CRT, cathode ray tube; LCD, liquid crystal display; PDP, plasma display panel; OLED, organic light-emitting diode.

We also estimate the cumulative average abnormal returns using alternative models, which are explained in the Results section. We estimate the following model to ascertain the effect of hypothesized independent variables on cumulative abnormal returns (CAR_{ijp}); thus,

$$\begin{aligned} CAR_{ijp} = {} & \alpha + \beta_1 AL_{ijp} + \beta_2 FN_{ijp} + \beta_3 EP_{ijp} + \beta_4 PR_{ijp} \\ & + \beta_5 PT_{ijp} + \beta_6 PA_{ijp} + \beta_7 PL_{ijp} + \beta_7 RQ_{ijp} \\ & + \beta_8 AF_j + \beta_9 SZ_j + \beta_{10} RP_j + \beta_{11} AT_p + \eta_{ijp}, \end{aligned} \quad (6)$$

where

AL_{ijp}: Announcements of alliances;
FN_{ijp}: Announcements of funding;
EP_{ijp}: Announcements of expansion;
PR_{ijp}: Announcements of prototypes;
PT_{ijp}: Announcements of patents;
PA_{ijp}: Preannouncements;
PL_{ijp}: Announcements of new product launch;
RQ_{ijp}: Announcements of awards;
AF_j: Announcement frequency;
SZ_j: Size of firm;
RP_j: Research productivity of the firm;
AT_p: Age of technology;

where subscripts refer to announcement i, firm j, and project p, respectively.

Sample

We use two criteria to select product categories: a reasonable number of emerging technologies and data availability. We select product categories where a number of technologies have emerged in the last few decades and the key global players are in U.S. markets. The first requirement is essential to ensure that we have a large sample of announcements and the second is essential because we require the firm to be listed on U.S. stock markets to assess the market value. On the basis of these criteria we collected data using the historical method (Golder 2000, Golder and Tellis 1993) on 19 technologies from five industries—external lighting, display monitors, computer memory, data transfer technologies, and desktop printer product categories (see Appendix A). We identify 69 firms in the five industries and collect 5,481 announcements from 1977 to 2006 (see Table 2). There is substantial innovative activity in all the categories during this period.

The present study goes further than previous studies in two important aspects. First, we identify all major firms and all technologies within each industry. Second, we collect all announcements related to innovation projects made by the firms for each activity of the project.

Sources

Although many studies limit their focus to *a single* source of announcements, we posit that the information on innovation projects reaches the markets through a variety of sources. So, limiting the source to only one publication may not capture the date when information is first released to the markets. Indeed, Glascock et al. (1987) show how the *Wall Street Journal* does not publish all the news and that there is a lag of three days between a change in bond rating by Moody's and an announcement by the *Wall Street Journal*. Hence, in the interests of accuracy and comprehensiveness, we include other sources of information as well. The primary sources are FACTIVA (which includes the *Wall Street Journal*), Lexis-Nexis, and company websites for press releases/announcements on technological innovations. We also include all newswire services such as PR Newswire, Business Newswire, and Reuters. We collect company background information from General Business File ASAP and Yahoo! Finance.

Procedure

After the selection of the industry, we identify all major firms in the industry and collect information on each firm. We use the following key words to identify all the announcements: name or ticker symbol of firm, names of technology, and events of the innovation project. We first sort the results based on oldest press report to identify the first release of information to the market. We exclude press reports appearing in nondaily publications because of the inherent inaccuracy of determining the exact date of release of information. Of the remaining press reports, when multiple reports contain identical information about an event, we retain only the first press report, which we treat as the announcement. However, an event may have multiple announcements because of new information in each announcement. Finally, we include announcements in the analysis of only firms whose data are available from the Center for Research in Security Prices (CRSP) (firms traded on NYSE, AMEX, or NASDAQ) because we need price information to estimate returns.

We examine each announcement to classify it by firm, innovation project of the firm, activity of the innovation project, and event within the set of activities.

Results

Market response to announcements using the event study method suggests that the cumulative average abnormal returns to all announcements in the sample are positive (see Table 3). Across all categories, the cumulative average abnormal returns to all announcements are 0.4% on the event day. This result holds even when examined at the individual category level. Moreover, the returns are the highest on the day of the announcement and not significantly different from zero for event windows longer than five days (±2 days around the day of announcement) (see Table 3 and Figure 2). Hence, in the rest of the paper, we use the abnormal returns for an event window of only one day and use the term *returns* to mean abnormal returns. The returns that we report are for the FFM model (Equation (1)), although a subsequent subsection explores returns by other methods.

We present the results in four subsections: analysis of returns, analysis of total returns, additional analyses, and test of robustness.

Analysis of Returns

We separate the announcements based on the content into positive or negative information. The number of negative announcements across all three sets of activities was approximately 5% of the number of positive announcements. We estimate the cross-sectional average return to each event in each set of activities using the univariate method (Equation (3)) and the multivariate method after controlling for various strategic and control variables (Equation (6)).

Both results are consistent with each other and returns to most of the set of activities and events are significantly different from zero (see Table 4). Initial examination of the data suggests heteroskedasticity. So we used Proc general linear models (GLMs) in SAS. Table 4 reports these consistent estimates (refer to section on regression diagnostics for more details). The adjusted R^2 for the models is at least 2.2%, which is comparable to prior studies (Chaney et al. 1991, Koku et al. 1997, Sorescu et al. 2007).

Initiation Activities. Across all categories, the returns to all events in the initiation activities are 0.6% ($t = 3.7$). The findings indicate that firms gain by announcing their plans about such activities. On average, returns to initiation occur 4.7 years ahead of launch. At the event level, market returns are high for positive announcements of alliances (0.6%, $t = 5.5$), funding (0.9%, $t = 2.3$), and expansion plans (0.6%, $t = 2.2$) (see Table 4). On the other hand, the returns were not significantly different from zero for the negative announcements of either breakup or termination of alliances (−0.3%, $t = -0.9$), decrease/delay of funding to projects (−1.3%, $t = -0.6$), or expansion plans (−0.6%, $t = -0.9$). A possible reason for these results is that while firms may keep information on forthcoming joint ventures under wraps, investors have other indicators of the forthcoming negative events, such as the dissolution of existing joint ventures before the actual formal announcement. So when the actual negative event is announced, its impact is not that bad.

Table 3 Descriptive Statistics: Abnormal Returns to an Average Event by Category for Various Windows

		AAR (event day)					CAAR (±1 day)		CAAR (±2 days)	
Category	*N*	Est. (%)	*t*-value	*p*-value[a]	Percentage of positive	*p*-value[b]	Est. (%)	*t*-value	Est. (%)	*t*-value
All	5,481	0.4	7.4	<0.0001	52	<0.0001	0.5	14.7	0.5	3.3
Lighting	696	0.9	6.3	<0.0001	56	<0.0001	1.1	13.7	1.4	3.6
Monitors	1,100	0.8	3.5	<0.0001	51	0.015	0.7	5.7	0.4	0.7
Memory	1,239	0.3	2.7	0.0135	51	0.004	0.5	9.3	0.4	1.4
Data transfer	1,323	0.2	2.8	0.0047	51	0.004	0.2	4.6	0.3	1.5
Printers	1,123	0.1	1.8	0.1301	51	0.026	0.1	1.6	0.3	1.5

[a]The *p*-value is estimated using the Brown-Warner (1985) approach.

[b]The *p*-value is estimated by sorting the 265 average abnormal returns from minimum to maximum and calculating how far away from the tail in rank the event average abnormal return is for these 265 values. We thank the anonymous reviewer for suggesting this.

Table 4 Average Abnormal Returns to Various Events During Innovation Projects

	Univariate (Equation (3))						Multivariate (Equation (6))					
	Positive only			Negative only			Positive only		Negative only		All[b]	
Announcements	*N*	Est. (%)	*t*-value[a]	*N*	Est. (%)	*t*-value[a]	Est. (%)	*t*-value	Est. (%)	*t*-value	Est. (%)	*t*-value
Intercept							−0.02	−0.1	0.6	4.6	0.2	1.0
Alliances	878	0.6	5.1	34	−0.02	−0.1	0.5	3.3	0.2	0.4	0.4	2.6
Funding	154	0.9	2.3	18	−1.3	−0.6	0.7	2.1	−1.1	−1.4	0.4	2.4
Expansion	181	0.6	2.2	29	−0.6	−0.9	0.4	1.1	−0.3	−0.2	0.2	0.7
Prototypes	776	1.0	9.0	21	−4.2	−5.9	0.6	3.5	−2.3	−2.4	0.5	2.6
Patents	218	1.6	4.0	85	−1.6	−2.5	1.4	4.9	−1.8	−4.4	0.4	1.6
Preannouncements	762	1.2	8.8	39	−4.7	−9.6	0.9	5.3	−3.2	−4.3	0.6	3.6
Launch	2,106	0.2	2.5	16	−4.7	−7.2	0.2	1.6	−2.2	−2.2	0.01	0.1
Awards	488	1.2	5.2				0.8	3.9	0.0	1.8	0.7	3.0
Announcement frequency[c]							1.8E–05	1.0	−7.9E–08	−3.9	2.4E–05	1.4
Size of firm[d]							−8.6E–08	−4.2	−8.0E–05	−1.07	−8.2E–08	−4.0
Research productivity							−5.8E–05	−0.8	1.3E–05	0.4	−5.7E–05	−0.8
Age of technology							3.4E–05	1.1	1.3E–05	0.4	2.6E–05	0.8
Adj. R^2							2.48		2.24		1.48	

[a]Estimated using the Brown-Warner (1985) method (Equation (4)).
[b]Announcement frequency measured as the number of prior announcements.
[c]Positive announcements coded as "1" and negative announcements coded as "−1."
[d]Size of firm was also measured as the number of different technologies in which a firm invests.

Development Activities. Across all categories, the returns to all development activities are 0.9% ($t = 5.5$). At the event level, we find that market returns are strongly positive for announcements of successful demonstration of prototypes (1.0%, $t = 9.0$), patents (1.6%, $t = 4.0$), and preannouncements (1.2%, $t = 8.8$) (see Table 4). A majority of the positive announcements on patents are from firms announcing award of patents. Surprisingly, negative returns for negative announcements are even higher in absolute value than positive returns. For example, returns are −4.2% ($t = -5.9$) for delays in product development deadlines or failure to meet expected performance levels, −1.6% ($t = -2.5$) for denial of patents or patent infringement suits, and −4.7 ($t = -9.6$) for postponement, delay, deferral, shelving, or suspension of launches.

Commercialization. Across all categories, the returns to all commercialization activities are 0.3% ($t = 2.5$). At the event level, market returns are positive for announcements of launch of new products (0.2%, $t = 2.5$) and receipts of awards (1.2%, $t = 5.2$) (see Table 4). In contrast, market returns to delays in product launches, cancellation of plans to launch products, and product recalls because of malfunctions have a negative return of −4.7% ($t = -7.2$).

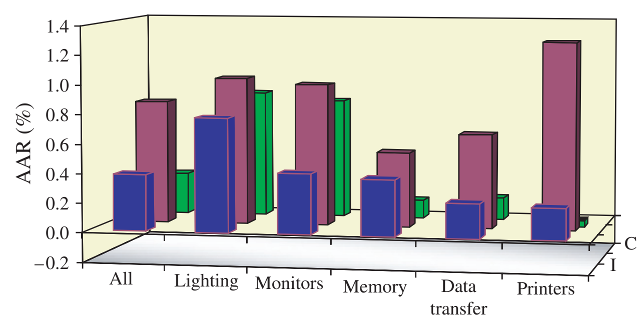
In summary, we find that market returns to negative announcements are negative across all events. However, the absolute value of the market returns is higher for negative announcements than for positive announcements. This result is consistent with theory and findings that losses loom larger than gains (Kahneman and Tversky 1979).

Activities with the Highest Returns. We find that the highest returns are for development activities (see Figure 1). Across all categories, the returns for the development (D) activities are significantly greater than those for the initiation (I) activities ($t = 2.7$) and the commercialization activities ($t = 4.0$). At the individual category level, the returns to development are more than commercialization (C) activities or initiation activities in all five categories.

Results for Strategic and Structural Variables. The results of the analysis of strategic and structural variables estimated via the model in Equation (6) (see Table 4) are as follows:

• A higher (or lower) number of prior announcements or longer time since the last announcement

Figure 1 Average Abnormal Returns (AAR) in Each Set of Activities of Innovation Project



	All (%)	Lighting (%)	Monitors (%)	Memory (%)	Data transfer (%)	Printers (%)
I	0.4	0.8	0.4	0.4	0.2	0.20
D	0.8	1.0	1.0	0.5	0.6	1.30
C	0.3	0.9	0.8	0.1	0.2	0.04

within a project does not lead to higher returns. The results remain similar even if we code the prior number of positive or negative announcements separately.

• Returns are higher for smaller firms than for larger firms.

• The age of technology does not have an effect on the market returns to innovation.

• Firms with higher research productivity (across projects) do not have higher returns per announcement than firms with lower research productivity.

We used alternative measure of research productivity—the number of technologies a firm invests in. We find that returns for firms that invest in a few technologies is higher than for firms that invest across a broad set of technologies ($t = -3.2$).

Analysis of Total Returns

The sum of returns to all events *within* an innovation project of a firm provides the total returns to that innovation project. We exclude firms where data on shares outstanding are not available from CRSP. We then calculate the returns to each project as the sum of returns to all announcements for that project; thus,

$$TR_{jp} = RAL_{jp} + RFN_{jp} + REP_{jp} + RPR_{jp} + RPT_{jp} + RPA_{jp} + RPL_{jp} + RRQ_{jp}, \quad (7)$$

where TR_{jp} is total returns to firm j for project p, and RAL_{jp}, RFN_{jp}, REP_{jp}, RPR_{jp}, RPT_{jp}, RPA_{jp}, RPL_{jp}, and RRQ_{jp} are returns to all announcements of alliances, funding, expansion, prototypes, patents, preannouncements, new product launch, and awards for project p, respectively.

We estimate the average return to a project across the sample as

$$ATR_p = \frac{\sum TR_{jp}}{J}, \quad (8)$$

where J is the total number of projects in the sample. Table 5 shows that the total returns (averaged across all categories) is 10.3%. The total returns by category is about 13.1% for projects in lighting, 19.8% for projects in monitors, 7.02% for projects in memory products, 7.4% for projects in data transfer, and 3.8% for projects in printers. More important, the simple average return for any event is 0.6%, which is comparable to estimates of returns to innovation reported by prior studies. However, *this value is substantially lower than the mean of 10.3% for the whole innovation project*. Hence, ignoring the totality of events of innovation when estimating returns severely underestimates the total returns to innovation.

Table 5 **Total Abnormal Returns to Innovation by Category**

Stage	Total abnormal returns (%) (Equation (7))	Total abnormal returns ($M) (Equation (8))
All	10.3	972
Lighting	13.1	712
Monitors	19.8	1,275
Memory	7.02	446
Data transfer	7.4	2,635
Printers	3.8	432

To estimate the dollar value of returns to projects, we first compute dollar returns to announcements; thus,

$$CARD_{ijp} = CAR_{ijp} * SO_j * SP_j, \quad (9)$$

where

$CARD_{ijp}$: Returns in dollars for announcement i;
SO_j: Number of shares outstanding for firm j on day of announcement i;
SP_j: Price of shares for firm j at the end of that trading day.

We then follow the same procedure as described above to compute the dollar value of returns to an event or an innovation project and that for the whole project. Across the five markets, the average return to an event is $49 million, while the average total return to any project is $643 million. Again, taken across or within categories, returns to projects are substantially more than the returns to individual events.

Additional Analyses

We now present two additional analyses: returns of first relative to later announcements and returns relative to competitors.

First Announcement. Readers may suspect that the first announcement of an innovation project would yield higher returns than any other announcement. The reason may be that the first announcement tells of a whole new project or product by the firm. Subsequent announcements may not have as big an informational or signaling impact (Kleine and Leffler 1981, Le Nagard-Assayag and Manceau 2001). We test this hypothesis. We define the first announcement as the first ever release of information on an innovation project and later announcements as all other announcements during the project.

We find that the difference between the returns to the first announcement of any project and the returns to any later announcement (second, third, or all subsequent) are not significantly different from zero. We also compare the returns to the first announcement in each set of activities with later announcements within the same set of activities and the results are similar. These results belie the expectation that the first announcement is more important. A possible reason might be that later announcements may have equally large (or larger) returns because what they lack in "news" value they make up for by indicating increasing confidence that the project will succeed.

Table 6 Effect of Innovation on Abnormal Returns to Competitors

		Competitors		Difference in abnormal returns to competitors vs. announcing firm	
Category	Phase	Est. (%)	t-value	Diff. (%)	t-value
All	I	0.1	0.7	−0.3	2.5
	D	0.1	2.5	−0.7	5.1
	C	0.1	2.3	−0.2	2.2
Lighting	I	−0.1	−0.6	−0.9	2.3
	D	0.0	−0.4	−1.1	2.9
	C	0.1	1.6	−0.7	2.4
Monitors	I	0.1	1.1	−0.4	1.3
	D	0.1	0.7	−4.7	3.1
	C	0.1	0.8	−0.8	3.1
Memory	I	0.1	1.6	−0.3	0.9
	D	0.1	1.1	−0.4	1.7
	C	0.0	−0.1	−0.1	0.8
Data transfer	I	0.0	0.3	−0.1	0.6
	D	0.2	1.2	−0.4	1.8
	C	0.1	1.5	−0.1	0.5
Printers	I	−0.2	−1.5	−0.5	1.7
	D	0.5	3.1	−0.9	2.0
	C	0.1	1.5	0.2	−1.5

Note. I, initiation; D, development; C, commercialization.

Returns Relative to Competitors. How do the returns of the announcing firm affect returns to competitors in each of the three set of activities? Most past studies suggest that competitors experience negative returns in such a situation (Zantout and Tsetsekos 1994, Chen et al. 2005, Ferrier and Lee 2002, Akhigbe 2002). We extend the analysis to examine the returns to a firm relative to its competitors at various sets of activities of the innovation project. We create a portfolio of all firms that made no announcement on the day the focal firm makes an announcement.

Consistent with the findings of prior literature, we find that in all three sets of activities, the returns to competitors are negative (see Table 6). These results hold even if we expand the definition of competitors to include all firms across categories in our sample not making the announcement or use wider windows around the day of the announcement (e.g., ±1 or ±2 days).

Tests of Robustness

We carry out a number of analyses to test the robustness of the results including regression diagnostics, alternative method to estimate returns, alternate market index, nonparametric tests, and accounting for the lack of clean estimation period.

Regression Diagnostics. We examine the impact of residuals (outliers) on the outcome and accuracy of the regression results. First, we repeat the regression after trimming the dependent variable by symmetrically capping each tail at the 1% and 2.5% levels. Second, we repeat the regression after removing observations with large residuals (outliers with potentially undue influence and/or high leverage on the results) with values of Cook's distance higher than $4/n$ (Cook 1979). The results are similar to original results in both cases for all variables except for new funds, where the coefficient is still positive but no longer significant.

We also test for presence of autocorrelation of errors using the Durbin-Watson statistic after removing these outliers. The tests fail to reject both null hypotheses of no autocorrelation in the errors against the alternative hypotheses of positive and negative autocorrelation, respectively, for ith order autocorrelation where $0 \leq i \leq 4$.

The White test is significant ($\Pr > \chi^2 =< 0.0001$) and suggests potential heteroskedasticity of residuals. We plot the residuals versus fitted values to investigate any patterns of increasing residuals. No such patterns are visible. We also reestimate the model after removing observations to maintain a constant bound on the variance of residuals; the results are similar.

In both the level of set of activities and individual events of analysis, multicollinearity is not a problem among the control variables, as indicated by the coefficient variance-decomposition analysis and the condition indices.

Alternative Methods to Estimate Market Returns. We use three other models to estimate the "normal" returns to verify the robustness of our results—mean, market adjusted, and market model (McKinlay 1997). First, we used the mean return model (Equation (10)) in which the firm is expected to generate the same return that it averaged during a previous estimation period. Second, we used the market-adjusted return model (Equation (11)) in which the firm is expected to generate the same return as the rest of the market. Third, we used the market model where the firm is expected to generate the same return as a portfolio of stocks used to represent the overall market (Equation (12)). Thus,

$$R_{it} = R_i + \varepsilon_{it}, \tag{10}$$

$$R_{it} = R_{mt} + \varepsilon_{it}, \tag{11}$$

$$R_{it} = \alpha_i + R_{mt} + \varepsilon_{it}, \tag{12}$$

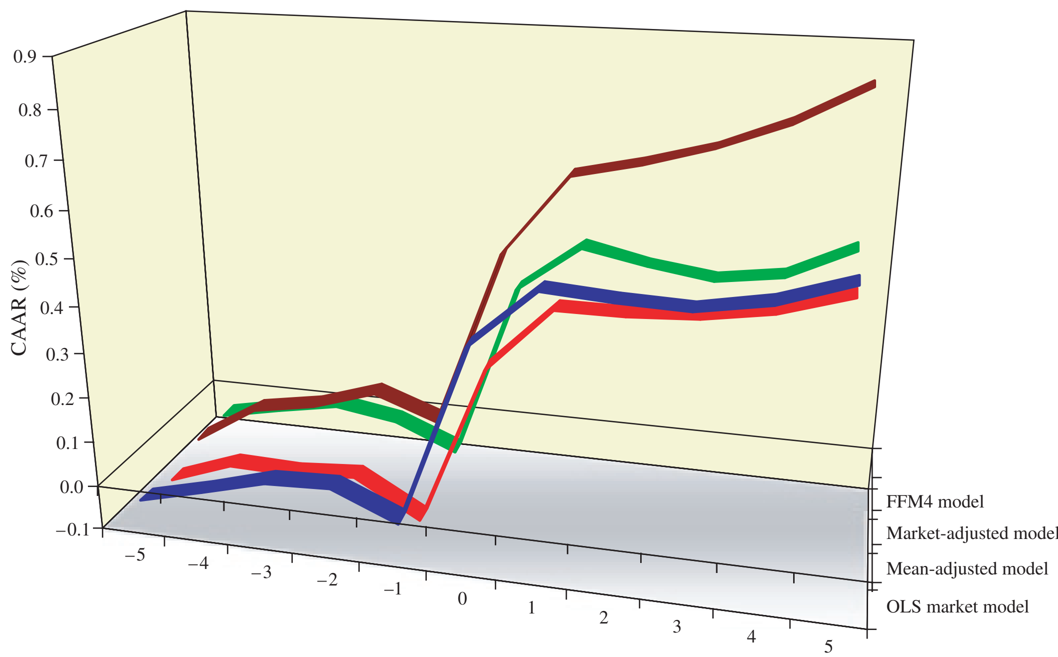
where R_{it} and R_{mt} are the period t returns on security i and the market portfolio, respectively, and ε_{it} is the zero mean disturbance term. The estimation window for all three models is the same as for Equation (1). For each firm i and event date t, we have

$$AR^*_{it} = R_{it} - \hat{R}_i, \tag{13}$$

$$AR^*_{it} = R_{it} - R_{mt}, \tag{14}$$

$$AR^*_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt}), \tag{15}$$

Figure 2 Cumulative Average Abnormal Returns (CAAR) Using OLS Market, Mean Adjusted, Market Adjusted, and FFM4 (±) Models



where AR^*_{it}, $\hat{R}_i$, $\hat{\alpha}_i$, and $\hat{\beta}_i$ are the abnormal return, mean firm return, and parameter estimates of market-adjusted model, respectively. The plots of CAAR in Figure 2 using all models—mean, market, and market-adjusted models—demonstrate that the CAAR was not much different with the use of these models. Similarly, there were no significant differences in the reported results for the hypotheses with the use of these alternate models as well.

Alternate Market Index. We use the equally weighted market index to estimate the abnormal returns in Equation (1) as recommended by Brown and Warner (1980, 1985). We also reestimate the returns using the value-weighted market index to ensure robustness. The results are not materially different from those presented.

Nonparametric Tests. We use the Wilcoxon sign-rank test to test the null hypothesis that the observed returns are symmetrically distributed around 0 and the proportion of observed sample securities having positive returns is equal to 0.5. This situation would be true if markets do not respond favorably to positive news of technological innovations. The Wilcoxon sign-rank test uses both the sign and the rank information and is therefore more powerful than the simpler binomial sign test. The results reject the null ($p = 0.001$) and support our findings that market returns to innovation are positive.

Accounting for the Lack of Clean Estimation Period. An assumption intrinsic to the market-adjusted model is that the estimation period used to estimate market parameters prior to the event are clean; i.e., there is no other announcement made by the firm in that period. Because we examine multiple announcements made by the same firm over the entire innovation project, this assumption is violated. We remove the dates of all prior announcements made by the firm from the estimation period (Brown and Warner 1985) and reestimate the returns. The results do not change much with this correction.

Discussion

This section summarizes our findings and discusses implications and limitations.

Summary of Findings

The current research leads to these major findings:

- Total market returns to an innovation project are \$643 million, substantially greater than \$49 million, the returns to an average event in the innovation project.
- Of three sets of activities of innovation (initiation, development, and commercialization), returns to the development activities are consistently the highest across and within categories and the returns to commercialization the lowest. Moreover, returns to initiation occur, on average, 4.7 years ahead of launch.
- Returns to the new product launch are the lowest among all eight events tracked.
- Returns to negative events are higher in absolute value than those to positive events.

• Returns are consistently higher for small firms than for large firms, and for those that focus on a few rather than many technologies.

• Returns to the announcing firm are substantially greater than those to competitors across all stages.

• The number of prior announcements or time since the last announcement has no effect on the market returns to innovation.

• Returns to the first announcement of an innovation project are not different from returns to later announcements. Similarly, results for older technologies and projects are not different from those for newer ones.

Implications and Contributions to Practice

This study has several implications for managers.

First, markets respond promptly and substantially to announcements about innovation at all stages of the innovation project. When considering the value of innovation, it is *inappropriate* to limit the analysis to only one or another event in the innovation project. The frequently cited "undervaluation" of innovation (Hall 2009, 1993; Hall et al. 1993) may be due not to markets not appreciating the full value of innovations immediately, but to researchers computing returns to isolated events in an innovation project. Following the approach described in this study, managers can compare the costs of an innovation project to the average returns they can get to better assess the value of any innovation project they plan to undertake.

For example, AXT Inc. develops and markets three product lines of high-performance compound semiconductor substrates—gallium arsenide (GaAs) substrates, indium phosphide (InP) substrates, and single-element substrates. Between 2000 and 2003, the firm made various announcements on the development of new products, allocation of resources to the three innovation projects, and expansion of manufacturing facilities. With our approach, we estimate the total return to the three innovation projects to be \$29.3 million. These returns are substantial when compared to total R&D expenditures of \$11.9 million during this period.

Second, the findings on various announcement strategies indicate that a mere increase or decrease in either the frequency or total number of announcements does not lead to an increase or decrease in returns. The median number of prior announcements in our sample is 2 and the 90th percentile is 9. Moreover, the first announcement of a project is no more important than later announcements. These results imply that the markets are efficient, and firms cannot game the system by overannouncing or through multiple announcements of a single event.

Third, the absolute value of a negative announcement is greater than that for a positive announcement. Thus, firms should be careful not to exaggerate progress in their innovation projects or to resort to vaporware. However, because returns are positive for all positive announcements and significantly different from zero for all but two of the positive announcements, firms should make it a point to announce these events. Otherwise, they lose the opportunity for increasing market capitalization involved in such announcements. These findings are also consistent with recent findings in marketing literature that suggests markets react positively to new product introductions, but discount short-term promotions.

Fourth, returns are highest for developmental activities. Returns are higher for development activities over startup activities probably because startup activities involve heavy up front commitment of expenditures and resources with the payoff uncertain and several years away. Returns are higher for development activities over commercialization activities because development activities reflect the greatest reduction of uncertainty and already capture some of the expected returns from future market capitalizations. Thus, it is important that firms exploit the progress in development by fully announcing all such developments.

Fifth, when announcing innovations, small firms do not seem to suffer any disadvantage relative to large firms. Rather, small firms seem to gain higher returns than large firms, ceteris paribus. A possible reason for this is that large firms are intensely researched and covered by the investment community. Thus, good news from small firms is more likely to come as a positive surprise than that from large firms.

Limitations and Future Research. This study has several limitations that can be basis of future research. In all categories, the highest average returns are consistently for announcements in the development activities. However, we could find no strong theory for why this occurs. Second, we limit our analyses to five industries because of the difficulty in collecting a comprehensive set of announcements on all events about innovation projects. Third, the data do not include firms not listed on the stock markets. Future research might explore whether the same results hold for such firms. Fourth, the results may be affected by a potential selection bias as firms can be more selective about the type of announcements made during initiation and development than during the market stage.

Acknowledgments

The study benefited from grants by Don Murray to the University of Southern California (USC) Marshall Center for Global Innovation, the Funk Research Fellowship of the Center for Research in Technology and Management, Kellogg School of Management, and the Marketing Science Institute, and from the research assistance of Shashi Mohindra, Ron Harris, Angie Zerillo, and Ade Lawal-Solarin.

Appendix A. Operating Principles of Sampled Technologies

Technology	Principle
External lighting	
Incandescence	Generate light by heating up thin metallic wires with an electric current
Arc-discharge	Emit light by arc formed between two electrodes oppositely charged by an electric current in a high-pressure gas chamber
Gas-discharge	Electrons excited by passing an electric current in a low-pressure gas chamber emit light
Light emitting diode	Emission of the light in *n-p* transition zone under influence of an electric potential
Microwave electrodeless discharge	Emission of light by microwaves from induction coil inside the bulb to excite the gas
Display monitors	
Cathode ray tube	Form an image when electrons, fired from the electron gun, converge to strike a screen coated with phosphors of different colors
Liquid crystal display	Create an image by passing light through molecular structures of liquid crystals
Plasma display panel	Generate images by passing a high voltage through a low-pressure electrically neutral highly ionized atmosphere using the polarizing properties of light
Organic light emitting diode	Generates light by combining positive and negative excitons (holes emitted by anodes and electrons emitted by cathodes) in a polymer dye through the principle of electroluminescence
Desktop memory	
Magnetic	Record data by passing a frequency modulated current through the disk drive's magnetic head, thereby generating a magnetic field that magnetizes the particles of the disk's recording surface
Optical	Store data using the laser modulation system, and changes in reflectivity are used to store and retrieve data
Magneto-optical	Record data using the magnetic-field modulation system but read the data with a laser beam
Computer printers	
Dot-matrix	Create an image by striking pins against an ink ribbon to print closely spaced dots that form the desired image
Inkjet	Form images by spraying ionized ink at a sheet of paper through micro-nozzles
Laser	Form an image on a photosensitive surface using electrostatic charges, then transfer the image on to a paper using toners, and then heat the paper to make the image permanent
Thermal	Form images on paper by heating ink through sublimation or phase change processes
Digital data transfer	
Cu/Al	Transmit data in the form of electrical energy as analog or digital signals
Fiber optics	Transmit data in the form of light pulses through a thin strand of glass using the principles of total internal reflection
Wireless	Encode data in the form of a sine wave and transmits it with radio waves using a transmitter-receiver combination

Source. Adapted from Sood and Tellis (2005).

Appendix B. Examples of Positive and Negative Announcements

Joint Ventures
Positive: Cree Research and Philips sign joint agreement; new laser diodes will increase optical storage capacity; ARPA provides $4 million funding.

Negative: Hitachi, GE dissolve lighting joint venture.

New Funds
Positive: Intel to invest $100 million in Hitachi, Ltd.'s joint venture Elpida Memory Inc.-DJ.

Negative: Storage Technology loses loan.

New Prototypes
Positive: IBM says it set record for bits of data on disk.

Negative: Gentex delays new LED technology.

New Patents
Positive: Universal Display Corporation announces issuance of the 14th patent in the organic light emitter project.

Negative: Seagate files patent infringement lawsuit against Storage Computer Corp.

Preannouncements
Positive: Sony Corporation of Japan said on Tuesday it will launch a home-use optical-type videodisc player, "Laser Max," on April 21.

Negative: Sony to delay mass production of digital audio tape (DAT) heads.

Product Launch
Positive: Sony expands 5.25-inch magneto optical library line to include permanent WORM configurations.

Negative: Sony to delay mass production of DAT heads.

Quality Awards

Positive: EPA names Lexmark International "energy star printer partner of the year."

References

Aaker, D. A. 1995. *Strategic Market Management*, 4th ed. John Wiley & Sons, New York.

Adner, R., D. Levinthal. 2001. Demand heterogeneity and technology evolution: Implications for product and process innovation. *Management Sci.* **47**(5) 611–628.

Akhigbe, A. 2002. New product innovations, information signaling and industry competition. *Appl. Financial Econom.* **12**(5) 371–378.

Anand, B. N., T. Khanna. 2000. Do firms learn to create value? The case of alliances. *Strategic Management J.* **21**(Special Issue) 295–315.

Austin, D. 1993. An event study approach to measuring innovative output: The case of biotechnology. *Amer. Econom. Rev.* **83**(2) 253–258.

Barney, J. B. 1986. Strategic factor markets: Expectations, luck, and business strategy. *Management Sci.* **32**(10) 1231–1241.

Bayus, B. L., G. Erickson, R. Jacobson. 2003. The financial rewards of new product introductions in the personal computer industry. *Management Sci.* **49**(2) 197–210.

Berenson, C., I. Mohr-Jackson. 1994. Product rejuvenation: A less risky alternative to product innovation. *Bus. Horizons* **37**(6) 51–58.

Brown, S., J. Warner. 1980. Measuring security price performance. *J. Financial Econom.* **8**(3) 205–258.

Brown, S., J. Warner. 1985. Using daily stock returns: The case of event studies. *J. Financial Econom.* **14**(1) 3–31.

Carhart, M. 1997. On the persistence of mutual fund performance. *J. Finance* **52**(1) 57–82.

Chan, L., J. Lakonishok, T. Sougiannis. 2001. The stock market valuation of research and development expenditures. *J. Finance* **56**(6) 2431–2457.

Chan, S., J. Kissinger, J. Martin. 1992. The market rewards promising R&D—And punishes the rest. *J. Appl. Corporate Finance* **5**(2) 59–66.

Chandrasekaran, D., G. J. Tellis. 2008. The global takeoff of new products: Culture, wealth, or vanishing differences. *Marketing Sci.* **27**(5) 844–860.

Chandy, R., G. J. Tellis. 2000. The incumbent's curse? Incumbency, size and radical product innovation. *J. Marketing* **64**(3) 1–17.

Chaney, P. K., T. M. Devinney, R. S. Winer. 1991. The impact of new product introductions on the market value of firms. *J. Bus.* **64**(4) 573–610.

Chen, S. S., K. W. Ho, K. H. Ik, C. Lee. 2005. The wealth effect of new product introductions on industry rivals. *J. Bus.* **78**(3) 969–996.

Christensen, C. M. 1992. Exploring the limits of the technology S-curve, part I: Component technologies. *Production Oper. Management* **1**(4) 334–357.

Christensen, C. M. 1997. *The Innovator's Dilemma*: *When New Technologies Cause Great Firms to Fail*. Harvard Business School Press, Boston.

Cockburn, I., Z. Griliches. 1988. Industry effects and appropriability measures in the stock market's valuation of R&D and patents. *Amer. Econom. Rev.* **78**(2) 419–423.

Cook, R. D. 1979. Influential observations in linear regression. *J. Amer. Statist. Assoc.* **74** 169–174.

Council on Competitiveness. 2004. Innovation: The new reality for national prosperity. 21st Century Innovation Working Group recommendations, version 2.1, December 15, Council on Competitiveness, Washington, DC.

Crawford, M. 1977. Marketing research and the new product failure rate. *J. Marketing* **41**(2) 51–61.

Das, S., P. K. Sen, S. Sengupta. 1998. Impact of strategic alliances on firm valuation. *Acad. Management J.* **41**(1) 27–42.

Dollinger, M. J., P. A. Golden, T. Saxton. 1997. The effect of reputation on the decision to joint venture. *Strategic Management J.* **18**(2) 127–140.

Doukas, J., L. Switzer. 1992. The stock market's valuation of R&D spending and market concentration. *J. Econom. Bus.* **44** 95–114.

Eddy, A. R., G. B. Saunders. 1980. New product announcements and stock prices. *Decision Sci.* **11**(1) 90–97.

Erickson, G., R. Jacobson. 1992. Gaining comparative advantage through discretionary expenditures: The returns to R&D and advertising. *Management Sci.* **38**(9) 1264–1279.

Fama, E. 1998. Market efficiency, long-term returns, and behavioral finance. *J. Financial Econom.* **49**(3) 283–306.

Fama, E., K. French. 1993. Common risk factors in the returns on stocks and bonds. *J. Financial Econom.* **33**(1) 3–56.

Fama, E., L. Fisher, M. C. Jensen, R. Roll. 1969. The adjustment of stock prices to new information. *Internat. Econom. Rev.* **10**(1) 1–21.

Ferrier, W., H. Lee. 2002. Strategic aggressiveness, variation, and surprise: How the sequential pattern of competitive rivalry influences stock market returns. *J. Managerial Issues* **14**(2) 162–180.

Foster, R. 1986. *Innovation*: *The Attacker's Advantage*. Summit Books, New York.

Givoly, D., D. Palmon. 1982. Timeliness of annual earnings announcements: Some empirical evidence. *Accounting Rev.* **57**(3) 486–508.

Glascock, J. L., W. N. Davidson III, G. V. Henderson, Jr. 1987. Announcement effects of Moody's bond rating changes on equity returns. *Quart. J. Bus. Econom.* **26**(Summer) 67–78.

Golder, P. N. 2000. Historical method in marketing research with new evidence on long-term market share stability. *J. Marketing Res.* **37**(2) 156–72.

Golder, P., G. J. Tellis. 1993. Pioneering advantage: Marketing fact or marketing legend. *J. Marketing Res.* **30**(2) 158–170.

Hall, B. H. 1993. The stock market's valuation of R&D investment during the 1980's. *Amer. Econom. Rev.* **83**(2) 259–264.

Hall, B. H. 2009. The financing of innovation. S. Shane, ed. *The Blackwell Handbook of Technology and Innovation Management*. Blackwell Publishers, Oxford, UK. Forthcoming.

Hall, B. H., E. Mansfield, A. B. Jaffe. 1993. Industrial research during the 1980s: Did the rate of return fall? M. N. Baily, P. C. Reiss, C. Winston, eds. *Brookings Papers on Economic Activity*: *Microeconomics*, Vol. 2. Brookings Institution, Washington, DC.

Hendricks, K. B., V. R. Singhal. 1996. Quality awards and the market value of the firm: An empirical investigation. *Management Sci.* **42**(3) 415–436.

Hirschey, M. 1982. Intangible capital aspects of advertising and R&D expenditures. *J. Indust. Econom.* **30**(4) 375–390.

Jaffe, A. B. 1986. Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits, and market value. *Amer. Econom. Rev.* **76**(5) 984–1001.

Jegadeesh, N., S. Titman. 1993. Returns to buying winners and selling losers: Implications for stock market efficiency. *J. Finance* **48**(1) 65–91.

John, G., A. M. Weiss, S. Dutta. 1999. Marketing in technology-intensive markets: Toward a conceptual framework. *J. Marketing* **63**(Special Issue) 78–91.

Kahneman, D., A. Tversky. 1979. Prospect theory: An analysis of decisions under risk. *Econometrica* **47**(2) 263–291.

Keller, K. L., D. R. Lehmann. 2006. Brands and branding: Research findings and future priorities. *Marketing Sci.* **25**(6) 740–759.

Kelm, K. M., V. K. Narayanan, G. E. Pinches. 1995. Shareholder value creation during R&D and commercialization stages. *Acad. Management J.* **38**(3) 770–786.

Klein, B., K. B. Leffler. 1981. The role of market forces in assuring contractual performance. *J. Political Econom.* **89**(4) 615–641.

Koku, P., H. Jagpal, P. V. Viswanath. 1997. The effect of new product announcements and preannouncements on stock price. *J. Market Focused Management* **2**(2) 183–199.

Le Nagard-Assayag, E., D. Manceau. 2001. Modeling the impact of product preannouncements in the context of indirect network externalities. *Internat. J. Res. Marketing* **18**(3) 203–219.

McKinlay, C. A. 1997. Event studies in economics and finance. *J. Econom. Literature* **35**(March) 13–39.

Nicolau, J. L., R. Sellers. 2002. The stock market's reaction to quality certification: Empirical evidence from Spain. *Eur. J. Oper. Res.* **142**(3) 632–641.

Pakes, A. 1985. On patents, R&D, and the stock market rate of return. *J. Political Econom.* **93**(2) 390–409.

Paulson Gjerde, K. A., S. A. Slotnick, M. J. Sobel. 2002. New product innovation with multiple features and technology constraints. *Management Sci.* **48**(10) 1268–1284.

Pauwels, K., J. Silva-Risso, S. Srinivasan, D. M. Hanssens. 2004. New products, sales promotions, and firm value: The case of the automobile industry. *J. Marketing* **68**(4) 142–156.

Przasnyski, Z. H., L. S. Tai. 2002. Stock performance of Malcolm baldrige national quality award winning companies. *Total Quality Management* **13**(4) 475–488.

Sankaranarayanan, R. 2007. Innovation and the durable goods monopolist: The optimality of frequent new-version releases. *Marketing Sci.* **26**(6) 774–791.

Sharma, A., N. Lacey. 2004. Linking new product outcomes to market valuation of the firm: The case of the U.S. pharmaceutical industry. *J. Product Innovation Management* **21**(5) 297–308.

Sharpe, W. F. 1964. Capital asset prices: A theory of market equilibrium under conditions of risk. *J. Finance* **19**(3) 425–442.

Sood, A., G. J. Tellis. 2005. Technological evolution and radical innovation. *J. Marketing* **69**(3) 152–168.

Sood, A., G. M. James, G. J. Tellis. 2009. Functional regression: A new model for predicting market penetration of new products. *Marketing Sci.* **28**(1) 36–51.

Sorescu, A., V. Shankar, T. Kushwaha. 2007. New product preannouncements and shareholder value: Don't make promises you can't keep. *J. Marketing Res.* **44**(3) 468–489.

Suárez, M. M. V. 2002. Stock market response to the formation of global alliances: Evidence from Spanish corporations. *Eur. Bus. Rev.* **14**(6) 401–408.

Tellis, G. J., J. Johnson. 2007. The value of quality. *Marketing Sci.* **26**(6) 758–773.

Tucker, J. W. 2007. Is openness penalized? Stock returns around earnings warnings. *Accounting Rev.* **82**(4) 1055–1087.

Urban, G. L., J. R. Hauser. 1980. *Design and Marketing of New Products*. Prentice Hall, Englewood Cliffs, NJ.

Utterback, J. M. 1974. Mastering the dynamics of innovation. *Science, New Series* **183**(4125) 620–626.

Woolridge, J. R., C. Snow. 1990. Stock market reaction to strategic investment decisions. *Strategic Management J.* **11**(5) 353–363.

Zantout, Z., R. Chaganti. 1996. New product introductions, shareholders' wealth, and first-mover advantages. *J. Financial Strategic Decisions* **9**(3) 49–61.

Zantout, Z. Z., G. P. Tsetsekos. 1994. The wealth effects of announcements of R&D expenditure increases. *J. Financial Res.* **17**(2) 205–216.