THE IMPACT OF TECHNOLOGICALLY NEW PRODUCTS ON STOCK PRICES AND OPERATING PERFORMANCE

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CERTIFICATE OF ORIGINALITY

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______________________________(Signed)

________XIN YING 忻莹______ _(Name of Student)

To my dearest parents — Mr. and Mrs. XIN

To my beloved husband — Danny JI

To my lovely little cousin — QIAO Ying

Abstract

Technological development has been regarded as one of the major sources for economic growth and a potent way to help firms create substantial financial value. The development of technologically new products (TNPs), in which advanced or breakthrough technologies are incorporated, has been considered as one of the best ways to help firms grow. TNPs allow firms to leverage their core technologies in other future product introductions and give a signal to firms' shareholders that they are committed to developing technology innovations. However, the development of TNPs requires substantial R&D investment and is also regarded as a highly risky process. Innovators must face the fact that other firms might imitate their actions, typically earning a share of the profits that is much greater than their initial investment. Studies also have cast doubt on whether firms' efforts in developing TNPs yield positive economic returns. Therefore it is important to investigate whether the introductions of TNPs follow the prediction that TNPs help enhance firm performance as these products are expected to meet unmet customer demands or there are negative economic consequences due to the high risks and market uncertainties associated with developing and commercializing TNPs.

This study aims to fill in this research gap regarding the financial consequences of introducing TNPs. Based on the objective financial data of a

sample of 884 firms that announced TNPs, we examined stock market returns, return on assets (ROA), return on sales (ROS), and sales over assets (SOA) of these products. We investigated whether industry characteristics would moderate such financial impacts. In particular, we focused specifically on two major industrial sectors that were under rapid technology development in the past decades - the pharmaceutical and medical devices related industries (PMIs) and the electrical and electronics related industries (EEIs).

Through the theoretical lens of knowledge-based view of the firm and adopting the event study research methodology, we first examined the short-term stock market returns to introductions of TNPs. We found that the stock market responded favorably to these introduction announcements. The abnormal returns in the first two days upon the announcements were about 2.11% in the EEIs and 3.39% in the PMIs. Overall, the stock market reacted positively to TNPs announcements in both industries.

We further examined the long-term operating performance associated with TNPs. By selecting a portfolio of control firms for each sample firm with similar firm performance and firm size, we compared the performance changes between sample firms and their corresponding control portfolios. We found that TNPs did not necessarily bring higher abnormal financial gains – while TNPs led to an abnormal jump of 5.39% in ROA in the PMIs in the first two years of their introductions, they led to a drop of -2.34% in ROA in the EEIs during the same period of time. While stock market reacted positively to TNPs in the EEIs, they did not necessarily lead to higher profits. Industry characteristics is a major factor that affects the abnormal operating performance from TNPs. We also discussed the theoretical and managerial implications of the research findings of this study.

Publications Arising From The Thesis

Published Journal Papers:

Jenny, Y. Xin, Andy, C. L. Yeung and T. C. E. Cheng (2008), Radical Innovations in New Product Development and Their Financial Performance Implications: An Event Study of US Manufacturing Firms, *Operations Management Research*, Vol. 1, pp. 119-128.

Jenny, Y. Xin, Andy, C. L. Yeung and T. C. E. Cheng (2010), First to Market: Is Technological Innovation in New Product Development Profitable in Health Care Industries? *International Journal of Production Economics*, Vol. 127, pp. 129-135.

Published Conference Proceedings:

Jenny, Y. Xin, Andy, C. L. Yeung and T. C. E. Cheng (2008), Explorative Innovative Products and Their Financial Implications, *Proceedings of 2nd International Conference on Operations and Supply Chain Management, July 29 – Aug 2, 2008, Taipei, Taiwan, China.*

Jenny, Y. Xin, Andy, C. L. Yeung and T. C. E. Cheng (2009), Technological Innovations and Financial Rewards: A Comparison of Two Industries, *Proceedings of 20th Annual Conference of the Production and Operations Management Society, May 1-4, 2009, Orlando, Florida, U.S.A.*

Jenny, Y. Xin, Andy, C. L. Yeung and T. C. E. Cheng (2010), Is Technologically New Product A Glut? An Event Study and Some Preliminary Results, *Proceedings of The 2010 International Conference on Innovation, Management and Service (ICIMS 2010), Feb 26-28, 2010, Singapore.*

Working Papers:

Technologically New Products and Short-term Market Value of the Firm: An Empirical Investigation

Technologically New Products and Long-term Shareholders' Value Creation and Firm's Equity Risk: An Empirical Investigation

Does Stock Market Over-react? An Empirical Examination on the Difference between What Stock Markets Reveal and What Annual Financial Statements Report.

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List of Abbreviations

ROA	Return on Assets
ROS	Return on Sales
SOA	Sales over Assets
TNPs	Technologically New Products
PMIs	Pharmaceutical and Medical Devices Related Industries
EEIs	Electrical and Electronics Related Industries
KBV	Knowledge-based View

Chapter 1 Introduction

1.1 Background and Importance of the Study

Technological development has been regarded as one of the major sources for economic growth and a critical way to help firms create substantial financial values. The development of technologically new products (TNPs), in which advanced or breakthrough technologies are incorporated, has been remarkably rapid in some industries such as electronics and pharmaceuticals. Firms ramp up their research budgets in the hope of developing the next blockbuster product, which will help them to prevail in the competitive marketplace. Managers view the development of new technologies both as a platform for future product introductions as well as a signal to firms' shareholders that they are committed to developing technology innovations. Financial analysts keep a close eye on firms' product pipelines in the hope of finding the next soaring company stock (Sorescu et al., 2003). The business press is teemed with claims that technological development is the best way to create vast economic benefits. At the same time, academics regarded developing TNPs as strategic "options" (Bowman and Hurry, 1993) for firms to leverage in other future product introductions that might lead to firm growth.

The empirical findings presented in this study are important for a number of reasons. First, little research exists to date has been done on measuring the financial implications of TNPs. Although studies have documented the financial consequences of new product introductions, TNPs introductions are very different from them. New products could include nothing technologically new or innovative, but are introduced with new packages or marketing strategies.

Second, studies on the financial impacts of new product introductions produced mixed results. Some researchers find that new product introductions could enhance firm performance (e.g., Chaney et al., 1991). Other researchers, however, argue that the frequency of new product introductions failures is high. Sivadas and Dwyer (2000) find that two thirds of the new product introductions fail in two years. In 1992, *Wall Street Journal* also reported that almost 90% of the nearly 16,000 new products introduced in 1991 did not reach their business objectives. These research studies echo the findings of some researchers that new product introductions do not contribute significantly to the value of firms (e.g., Eddy and Saunder, 1980). Therefore, it is important to investigate whether the introductions of TNPs follow the predication of firm performance enhancing since these products are expected to meet unmet customer demands, or there are some negative economic benefits due to the high risks and market uncertainties associated with developing and commercializing TNPs.

Finally, the closest research done so far to our study is Sorescu et al. (2003). However, in their study, they only examined the net present value, estimated from stock market measures, of TNPs in the pharmaceutical industries. We argue that the financial measures used in their study could only reflect the expectations of investors and managers but not the actual financial performances of TNPs. Although there are some studies on the impacts of research and development (R&D) investments and expenses in the electrical and electronics related industries (e.g. computers), little research existed to date has directly explored the financial consequences of TNPs in these industries. The importance of industry characteristics in explaining firm profitability has been addressed by a number of studies (e.g. Gatigon and Xuereb, 1997); but there is none study which compares the cross-industry differences in generating financial values from TNPs. Single-industry studies could produce a lot of valuable insights to a specific industry in interest; however the implications from one industry might not be applicable to other industries. Therefore, in this study, we argue that the success in appropriating financial returns from TNPs is contingent on industry characteristics. We would examine the differences in long-term abnormal operating performance between two major different industrial settings, which are 1) Pharmaceutical and Medical devices related industries (PMIs) (SIC 28 and SIC 38), such as drugs (SIC 283) and Medical Instruments (SIC 384); 2) Electrical and Electronics related industries (EEIs) (SIC 35 and SIC 36), such as computers

(SIC 357).

1.2 Research Objectives

The objective of this study is to extend the earlier research on new product introductions with a focus on TNPs in a number of ways. This is the first study that directly examines the impact of introducing TNPs on financial performance, including stock market returns, return on assets (ROA), return on sales (ROS) and sales over assets (SOA), based on objective data. This study further attempts to investigate whether industry characteristics moderate the financial impacts associated with TNPs. Finally, we would examine other factors at both firm-level and industry-level that might moderate the impact of TNPs on long-term abnormal operating performance.

1.3 Main Research Methodology

Event study is the major research methodology in this study. The main idea of event study is to calculate the abnormal returns that are associated with the event of interest by comparing the performance of samples firms with the performance of their selected market portfolios or control firms. Event study was initially introduced by Fama et al. (1969) in their seminal article on the impact of stock split announcements on stock prices. After that, event study has become a frequently employed tool by financial economists to measure the effects of various economic announcements or events on the market value of a firm. An abundance of empirical evidence from event studies have shown that, on average, daily stock prices do react to new announcements or events and generally within a period of one day relative to the event (Fama, 1991). Besides examining changes in daily stock returns within a short event period (usually a two-day event period), Barber and Lyon (1996) evaluated event study that employ accounting-based measures of long-term operating performance. Based on their findings, non-parametric tests (e.g. Wilcoxon signed-rank *T* test) are more powerful than parametric tests (e.g. Student's *T* test) due to the existence of extreme values in the accounting-based operating performance measures. These non-parametric test statistics are also well specified when sample firms are matched to control firms of similar pre-event performance. After their study, a number of empirical studies have emerged to investigate the long-term operating impacts of firm specific events or decisions (e.g. strategic alliances, mergers or acquisitions). In the field of Operations Management (OM), several researchers have applied event study methodology to assess the financial implications of OM issues (e.g. Corbett et al., 2005; Hendricks and Singhal, 2008). In this study, we applied event study methodology to assess, firstly, the short-term market reactions on the introductions of TNPs and secondly, the long-term operating performance of TNPs based on accounting data.

1.4 Thesis Structure

This thesis is organized as follows:

Chapter 2 presents the literature review and hypothesis development. In this chapter, we would start with the discussion on the link between TNPs and firm performance through the theoretical lens of the knowledge-based view (KBV). We then address the importance of industry characteristics on this relationship and develop hypotheses grounded in pertinent theories and empirical works accordingly.

Chapter 3 describes the sample selection and data collection in this study. In this chapter, we would explain in detail how we selected the pieces of TNPs introduction announcements. We also present the steps on how we did the secondary source evaluation for each piece of announcements to ensure the reliability and objectivity of our sample selection. Examples of TNPs announcements and corresponding secondary source evaluation documents are also provided in this chapter.

Chapter 4 presents the research findings and discussions on short-term stock market reactions on the introductions of TNPs.

Chapter 5 discusses the research findings on the effect of introducing TNPs on operating performance. We also discuss the results on the cross-sectional analysis of variables that can further explain the abnormal operating performance in this chapter.

Chapter 6 is the final chapter of this thesis. We address the main findings, implications and conclusions in this chapter. We also list the limitations of this study and suggest future research directions.

Chapter 2 Literature Review and Hypothesis Development

Previous studies have provided some empirical evidence and theories that TNPs and firm profitability are likely to be related. We would develop the hypotheses grounded in pertinent theories and empirical works accordingly in this chapter.

2.1 Mixed Findings on the Financial Implications of Technologically New Products

Firms need to continuously renew themselves if they are to survive and prosper in the current business environment where customers, technologies, and competitions change rapidly. Developing TNPs has been recognized as a primary means of firm renewal (Dougherty, 1992), and as a 'driver of renewal' (Bowen et al., 1994). Although studies have theoretically explored the antecedents of technology development success, very little is known about their financial consequences. There remain suspicions that the rents to technology innovations may be scarce (Golder and Tellis, 1993; Schrage, 2000). It echoes the view of Brown and Eisenhardt (1995), who suggest that despite the large body of research on product development effectiveness, there is limited evidence that links different dimensions of product development performance, such as product innovations, development costs, product quality, and new features, to financial metrics, such as profits, sales and costs.

There are several studies that have documented the impacts on shareholder value brought by technology innovations. Based on a sample of 255 new products introduced by 66 publicly traded firms in drugs industry, Sorescu et al. (2003) found that technologically innovative drug products have a higher mean value in terms of net present value (NPV) compared to market breakthrough drugs (i.e. drugs provide substantially greater benefits but their core technologies are not significantly new). From the perspective of R&D expenditure which is assumed to be an important determinant of a firm's technology intensity, Chan et al. (1990) found that stock price changes to announcements of increased R&D spending is significantly positive on average. In line with this finding, the event studies of Eberhart, et al. (2004) and Yew et al. (2005) suggested that the increases in R&D expenditures are positively related to higher stock returns.

Yet, despite the widespread assumption that technology innovations bring positive financial rewards to for-profit firms, studies have cast doubt on whether firms' efforts in developing technology innovations are yielding positive economic returns (Golder and Tellis, 1993; Schrage, 2000). Previous research has suggested that firms actively involving in breakthrough technology development did not necessarily outperform other organizations. Breakthrough technologies require substantial research and development (R&D) budgets, and introducing technologically new products is highly risky (Cooper, 2000; Zahra and Nielsen, 2002).

Innovators must face the fact that other firms might imitate their actions, typically earning a share of the profits that is much greater than their initial investment (Chaney et al., 1991; Teece, 1986). For example, Liu (2006) examines the stock market reactions to U.S. biotechnology firms' innovation news announcements (e.g., FDA approval and patent grant). He identifies a medium-horizon negative drift (after an initial rise) in the stock price subsequent to firms' innovative events and proposes an expectational error hypothesis to explain the observed puzzle. Adopting a contingency perspective, Feng (2005) explained that technology innovations were only positively related to firms' stock prices in industries where the time lag between technological breakthroughs and profit realization is short (e.g., computers and semiconductors), but not in sectors where the time lag is long (e.g., biotech and pharmaceuticals).

From a strategic point of view, different profiles of innovators represent different strategic choices of firms and they can be equally effective (Miller, 1988). For example, Chaney et al. (1991) has suggested that strong operating firms - firms that cleverly use existing products and product lines with a minimum of investment - could potentially outperform truly innovating firms. Chan et al. (2001) compared stock returns of firms doing R&D with stock returns of firms doing no R&D and found that their average returns did not differ. Their findings suggest that a highly touted technology firm on average does not outperform a more mundane cement company.

2.2 Knowledge-based View and Hypothesis Development

Over the last decade management research has increasingly emphasized the roles of knowledge in developing firm's resource base, as many of the capabilities that give rise to competitive advantages are knowledge-based (Geroski et al., 1993; Grant, 1996). Management theorists argue that the basis for sustained competitive advantages is a firm's ability to develop rare and valuable knowledge through learning, and to subsequently apply the rare knowledge to product, process or organizational development (Bogner and Bansal, 2007). Knowledge-based intangibles, such as technical know-how, design expertise, largely determine the value of most products (Quinn, 1992).

We organize our theoretical arguments around the knowledge-based view (KBV) of the firm, which is a recent approach to understanding the existence of firms and the relationship between firm capabilities and firm performance.

The KBV provides a new theoretical lens through which we may view and understand the primary rationale for the existence of firms – the creation, transfer and application of knowledge (Decarolis and Deeds, 1999). The KBV may also be seen as an extension of the resource-based view (RBV) of the firm. The RBV has focused significant attention on intangible resources which play a critical role in creating competitive advantages. Knowledge, a major type of intangible resources, is regarded as the most strategically important of the firm's resources (Grant, 1996; Hill and Deeds, 1996).

In particular, the KBV of the firm suggests that specialized, complex, and tacit knowledge generates more durable advantages because it is difficult to imitate (Winter, 1987; Reed and DeFilippi, 1990). Introducing TNPs symbolizes the creation of tacit, complex and specific technological knowledge (McEvily and Chakravarthy, 2002). These three characteristics of knowledge have been frequently linked to the height of imitation barriers. Since knowledge advantages cannot be easily dissected and analyzed, it becomes highly "sticky" to the innovating firms, protecting the knowledge-based advantage of the firms and conferring above-average performance (Dierickx and Cool, 1989; McEvily and Chakravarthy, 2002).

Through developing technology innovations, firms can establish "flows" of resources and a "stock" of specific and heterogeneous knowledge base

(Dierickx and Cool, 1989). The focal firms could learn internally how to make their technological knowledge most productive when used in conjunction with other complementary resources. Specificity of certain technological knowledge may prolong a firm's competitive advantage by increasing the immobility of its distinctive resources (Peteraf, 1993). The process of developing technology innovations would also help strengthen a firm's internal capabilities, by enhancing its ability to learn about the market potentials of new technologies, exploring other improvement possibilities, and increasing flexibilities to match technological possibilities with demand needs.

Complexity is usually defined as the level of difficulty of understanding how a system (e.g. device or technology) functions or produces some outcome. A technological or scientific breakthrough is generally followed by a period of highly uncertain R&D in which firms experiment with the best way to exploit the technological and market opportunities it might create (Abernathy an Utterback, 1978; Rosenberg, 1982). Successful research efforts typically take many years to build, depend on a complex set of skills, and often rely on idiosyncratic search routines that may be very difficult to transfer across organizations (Collis, 1991; Hitt et al., 1991). MacMillan et al. (1985) argue that competitors find it harder to imitate products when their development relies on a complex set of skills. Even if other competitive firms may develop a similar technology through other search routines (e.g. reverse engineering), such a substitute will be extremely rare since it must also be based on a similar level of technological knowledge. Complexity may slow performance replication by obscuring the sources of superior performance (Dierickx and Cool, 1989).

Two dimensions of tacitness are commonly discussed in the literature. The first dimension refers to the inability to articulate what one knows about how to achieve an observed performance outcome (Polanyi, 1962; Nelson and Winter, 1982). The procedures involved in developing a new technology by a focal firm may be inaccessible for competitive firms. Even if the competitive firms could figure out the basic steps, it may be insufficient for them to achieve the same level of product performance. Technical experts or developers in the focal firm might subconsciously attend to cues and make judgments that are not communicated or observable in the process of developing and improving new technologies. The second dimension of tacitness is the personal nature of knowledge. There is a growing consensus that new technology development are often an outgrowth of a deeply held and highly personal form of knowledge, lying below the surface of conscious thought and is accumulated through a lifetime of experience and learning (Leonard and Sensiper, 1998; Zien and Buckler, 1997). Fundamental to Simon's (1962) principle of bounded rationality is the recognition that human brain has limited capacity to acquire, store and process knowledge. The efficiency in knowledge creation requires that individuals specialize in particular areas of knowledge. The result is that the creation of tacit, complex and specific knowledge in the newly developed technology makes it hard for competitors to replicate. Thus, it helps the focal firm to sustain competitive advantages.

In an efficient market, stock prices reflect all available information about firms. Any new information received by the market is instantaneously incorporated into the stock price (Fama, 1991). Under the efficiency market assumption, a change in the stock price is an unbiased reflection of changes in the expected future cash flows of a firm (Chaney *et al.*, 1991). If TNPs could lead to superior long-term operating performance as we postulate from the theoretical lens of the KBV, it will be firstly reflected in the unbiased market evaluation upon the announcements of TNPs introductions.

Based on the above discussion, we would investigate the financial impacts of TNPs on firm performance by assessing the following four different measures. The first measure is the daily stock return, which measures the daily stock market gain for a security. The second one is return on assets (ROA), which is an overall profitability indicator commonly used to measure how effective the management is in using its assets to generate profits. The third one is return on sales (ROS), which is a ratio widely used to evaluate a firm's operating profit margin and provides insight into how much profit is being produced per dollar of sales. A higher ROS indicates a firm is growing more rapidly and financial healthy. The last measure is sales over assets (SOA), borrowed from Hendricks and Singhal (2008), which indicates how efficient a firm is at using its assets to generate revenues, a primary source of profit.

The corresponding four hypotheses are as follows:

Hypothesis 1: Technologically new products will lead to higher daily stock returns.

Hypothesis 2. Technologically new products will lead to higher ROA.

Hypothesis 3. Technologically new products will lead to higher ROS.

Hypothesis 4. Technologically new products will lead to higher SOA.

2.3 Role of Industry Characteristics in Explaining Financial Performance

In the recent new product development (NPD) literature, it is recognized that the performance impact of NPD involving new technology innovations on business success also depends on many other factors such as industry demand characteristics, industry competition intensity (Terwiesch et al., 1998). Indeed, many industry characteristics have direct impacts on the NPD performance (Gatignon and Xuereb, 1997). The ability to integrate technology innovation and marketing competence to address industry characteristics is regarded as one of the key determinants for new product advantages (Li and Calantone, 1998). In this paper, based on intensive reviews on numerous case studies related to technology innovations in different industrial settings, we argued that the TNPs in the PMIs such as drugs and medical instruments could bring more financial returns to introducing firms compared to the TNPs in the EEIs such as industrial machinery and computers. This difference is mainly contingent on the industry characteristics.

In the EEIs such as industrial machinery and computers, the product life cycle is getting shorter and shorter. Firms compete on introducing new products with increasing performance at a relatively stable product price. For example, during the period of 1992 to 1996, the average unit price for a personal computer as well as a VCR remained stable throughout the period though the computing power more than quadrupled for personal computers and new features were introduced into VCRs (Adner and Levinthal, 2001). In computer industries, the advances of knowledge strongly improved price-performance ratios of computer products and facilitated the introduction of new computing technologies. Similar histories could be complied for other products in the EEIs such as fax machines, modems, machineries and copiers.

Technology innovation development is commonly pushed by advances in scientific and technological knowledge in the EEIs (Adner and Levinthal, 2001; Ende and Dolfsma, 2005; Workman, 1993), where a newly developed technology leads an innovative product or process into the market place. In certain cases, it is possible that the newly developed technology, when is transformed into new product or process innovations, creates it own new market.

However, in the EEIs, consumers might not have the knowledge required to intelligently answer the questions raised in market research (Wilton and Pessemier, 1981). It becomes difficult to collect information with regard to customer requirements and potential market acceptance when starting off with a new technology innovation development (Lynn and Heintz, 1992; Lynn et al., 1996). Marketing's role is also found very limited in the EEIs (Workman, 1993). For example, in Workman's study on a large computer systems firm, he found that marketing just played a marginal role in influencing product development decisions. His finding suggests a contradiction to the implicitly assumption in the marketing research literature that marketing should have a significant role in product development decisions and guide the activities of other groups in firms. In his study, the marketing department in that computer systems firm was only assigned the role of designing marketing programs and strategies for pushing the newly developed products into markets and promoting the newly developed products among customers.

Due to the knowledge-push nature of most of the TNPs developed in the EEIs, it generally creates high market uncertainty (Herstatt and Lettl, 2004). Future customers might need sufficient re-schooling before their adoption of the TNPs, which would raise the risk level of the TNPs success. The market acceptance of the technology innovations would be difficult to anticipate and estimate. There is ample of examples of major product flops in the EEIs. For example, Nokia introduced the N-Gage in 2003. Nokia spotted an opportunity to combine cellphone and game functionality in one unit, attempting to lure gamers away from the *Game Boy Advance*. However, N-Gage turned out to be a product failure. One part of the reasons was related to the buttons. They were designed for a phone but not well-suited for gaming. Retailers such as GameStop and Electronics Boutique began offering US$100 rebates just within 17 days of the product release. Another more recent example happened in Intel Corp. In 2001, Intel Corp introduced the Itanium processor, which was based on 7 years of R&D and billions of dollars of research expenses. However, customers found this processor costly, with limited software availability and poorly performed. Therefore, only a few thousand systems were sold. Itanium processor proved to be a technical and commercial failure and was ironically labeled by some business presses as "*Itanic*", invoking the ill-fated ocean liner Titanic.

During the last 50 years, the PMIs, which are the largest sector of the US economy (Gupta et al., 2007; Pedroso and Nakano, 2009), have undergone a technological revolution. Along with the economic growth, demand for medicines and medical care also increased rapidly. The PMIs are knowledge-intensive industries where new technologies and innovations are the lifeblood (Clarie, 2004; Scherer, 1980). They produce a wealth of products used to treat and diagnose diseases, assist health care workers, and improve the quality of human health in all the fields.

Contrast to the knowledge-push product development as the mainstream in the EEIs, the PMIs such as drugs and medical instruments represent another stream of TNPs development where the market demand triggers the product development and the technology advance facilitates the demand fulfillment. It seems impossible for a firm in the PMIs starts off a technology development project which aims at an unknown disease or a medical need. There is good reason to argue that a new technology development in the PMIs is initiated by the identification of the "customer needs" (or patient needs) in the market place based on the analysis of ample national statistics reports (e.g. the number of new cancer patients each year). The identification of these needs occur first and are then followed by the required development activities (Chidamber and Kon, 1994). For example, the H1N1 vaccine was being developed only after the worldwide spread of the swine flu. Lead User design, where new product innovation ideas are collected from users at the leading edge of the target markets, has also been commonly observed in the PMIs. Some of the products were even developed by innovative users in some medical fields. Shaw (1985) found that nearly 53% of the product innovations in medical sector were actually proposed or even developed by doctors and physicians.

Therefore, technology innovation development in the PMIs could be regarded as demand-triggered as well as knowledge-facilitated. Since the innovation development commonly focuses on meeting current market demands (e.g. new discovered diseases), the market acceptance of the TNPs would be easier to anticipate and estimate.

Based on the above reasoning, we set the following hypotheses:

Hypothesis 5. Technologically new products will lead to higher daily stock returns in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

Hypothesis 6. Technologically new products will lead to higher ROA in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

Hypothesis 7. Technologically new products will lead to higher ROS in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

Hypothesis 8. Technologically new products will lead to higher SOA in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

Chapter 3 Sample Selection and Data Collection

3.1 Sample Selection

Lexis Nexis (Academic) is our primary source for the sample of firms that have announced TNPs. *Lexis Nexis (Academic)* is a well-known full-text information searching database. It provides a searchable access to a comprehensive spectrum of full-text business news, legal information and others from over 5,600 sources, including the Business Wire, PR Newswire, Washington Post and USA Today. It has been widely used to collect relevant event news by other researchers (e.g. Staw and Epstein, 2000). Before large-scale searching, we studied a few pieces of announcements of TNPs introductions to identify the keywords which are commonly used to describe such a product. After this initial search and identification, we used keywords, such as "revolutionary/breakthrough/innovative" and "product/technology", in conjunction with words such as "introduce, unveil and launch," company names retrieved from *CompuStat* and other relevant phrases, to search in *Lexis Nexis (Academic)* from 1985 to 2008. Any records in our databases containing the keywords are regarded as "candidate announcements". We carefully read the full text of all "candidate announcements" and eliminate the following types of announcements:

1. Announcements in which firms did not explicitly announce TNPs. (Some of the announcements discussed firms' future plans of developing and introducing TNPs to markets. Other articles simply discussed in general the importance of developing breakthrough technologies to the survival and success of firms.)

2. Follow-up announcements referring to the market response about previously announced TNPs. In this case, we keep the earliest announcement.

3. Duplicate announcements of a firm introducing TNPs that appear in more than one news source. In such cases, we retained the announcement with the earliest publication date since this date probably was the earliest when the information about the TNPs was released to the public.

4. Since we estimate operating performance changes over a four-year window, if a firm has made multiple product introductions involving different TNPs within a span of four years, the more recent announcements are excluded from the analysis. It aims to avoid the overlapping time periods and cross-sectional dependencies that could bias our results (Hendricks and Singhal, 2008).

5. Since our “candidate announcements” include those announcing TNPs developed in the medical devices and drugs industries. The main dimension on which they differ from many other product introductions in other industries is the severe regulation by the federal government, especially in the United States by the Food and Drug Administrative (and similar agencies in other countries) in regard to quality standards. Before a drug or a medical device being qualified for market introduction, it should provide several rounds of clinical reports to prove its efficacy and safety for future customer use (Roberts and Hauptman, 1987; Sorescu et. al., 2003). During the clinical rounds, there is sufficient customer-developer interaction for product improvements. In this study, we only include the product announcements which have clearly stated in the context that the products have been cleared for market introduction in any country. For example, Product A firstly got a market approval in one Asian country before it successfully got qualified to market in the United States. We then recorded the introduction date when Product A was released in this Asian market. It enables us to capture the earliest financial impact brought by this product.

3.2 Verifications on the Reliability of Technologically New Products Announcements

Due to the self-reported nature of most of our “candidate announcements”, we took every possible effort to find independent or third-party product evaluation or analysis from secondary sources to avoid including those product announcements only serving as "window-dressing" roles (i.e., the new products may not be really technologically innovative as the introducing firms claim). We searched for independent, secondary sources of evaluations on the products in terms of their technical effectiveness or technological innovativeness. The following briefly explained the process of searching.

First, we identified the product name and name of its introducing firm for each announcement. Second, we searched secondary sources for each announcement in *Lexis Nexis* by using the keywords such as evaluation and analysis combined with the product name and company name identified in the first step. Third, we read each retrieved piece of secondary document very carefully to judge whether it could be classified as a product evaluation or review document. We started with 1077 "candidate announcements". We could find positive product evaluation and review reports for 835 announcements (77.5%) in *Lexis Nexis*. Fourth, if we could not find any relevant secondary documents for a product in the databases, we extended our searching on the Internet. Product evaluation and review reports for another 49 announcements (4.5%) were found in this step. The final sample consists of 884 announcements (82.1%); in which 665 sample announcements have complete year, month and day information and 219 sample announcements only have year information. Some of our sample announcements are collected from news sources which are not published on a daily basis (e.g. trade magazines). We do not want to exclude these 219 sample announcements since we still could use them to examine the changes in long-term operating performance. Two examples of the announcements and their secondary source evaluation documents are shown below:

Example 1:

Announcement

"Medwave Inc today introduces an innovative Vasotrac system, a non-invasive device for monitoring a patient's blood pressure with accuracy comparable to an invasive arterial catheter. (Feb 8, 2000, ***PR Newswire)"***

Secondary Source Evaluation

"...study has compared readings taken with Medwave's Vasotrac non-invasive blood pressure monitor against the "gold standard" intra-arterial catheter and a traditional blood pressure cuff, and ... showed that Medwave's Vasotrac monitor provided advantages over both." (American Journal of Emergency Medicine)

Example 2:

Announcement

"The Clorox Company launches breakthrough technology in fighting bacteria. Clorox Disinfecting Spray is the first disinfectant that continues to kill 99.9% of bacteria on surfaces for up to 24 hours, even after surfaces have been repeatedly touched and re-contaminated". (Oct 26, 1999, Business Wire)

Secondary Source Evaluation

"Among the three brands of disinfectant spray (Clorox, Lysol and Safeway), Clorox Disfecting Spray was found statistically the most effective of all the disinfectants in eliminating Salmonella bacteria as measured by zone of inhibition after being incubated for 24 and 48 hours." (Beth, M. L., 2006, Saint Martin's University Biology Journal)

3.3 Data Source Description

We collected all of the daily stock return data from Center for Research in Security Prices (CRSP) database available from the University of Chicago. CRSP is renowned for its expertise in building and maintaining historical and academic research quality stock market databases. It contains end-of-day and month-end prices for all listed NYSE, Amex, and NASDAQ common stocks along with basic market indices, and includes the most comprehensive distribution information available, with the most accurate total return calculations. It has become the major data source for studies based on stock market reactions.

We extracted company accounting data from Compustat (North America), which provides complete annual accounting data of all the publicly traded US and Canadian firms. This database, produced by Standard and Poor's Institutional Market Services, is a prestigious and widely-used database to retrieve objective financial data by academic researchers and practitioners. The principal contents of the data files are the items reported by companies in standard financial reports, such as quarterly and annual income statements, balance sheets and cash flow statements. The Compustat database is widely used in studies in various disciplines where objective performance measures are required (e.g. Corbett, et al., 2005; Hendricks & Singhal, 1997; Mikhail, et al., 2004; Aaker and Jacobson, 1994).

Chapter 4 Research Part One – Technologically New Products and Short-term Stock Market Reactions Changes

In this chapter, we would look into the short-term financial impacts of technologically new products. Specifically, we would examine reactions of stock market when a firm announces the introduction of a technologically new product. We test the two hypotheses developed in Chapter 2, which are:

Hypothesis 1: Technologically new products will lead to higher daily stock returns.

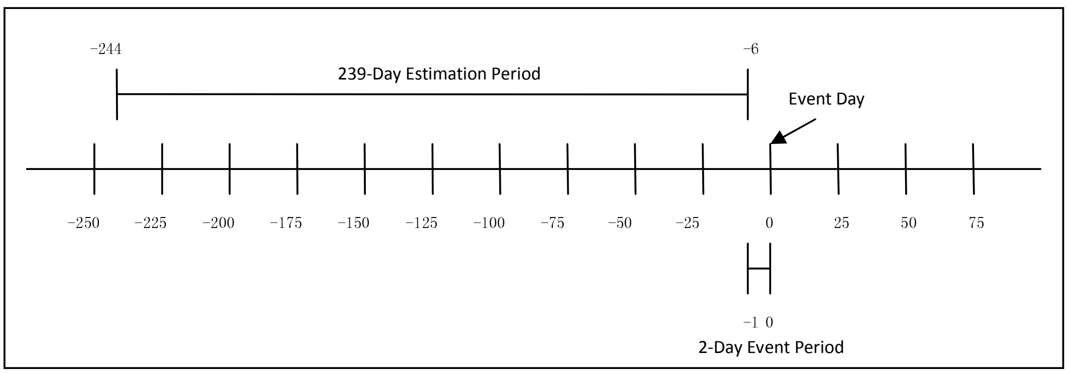
Hypothesis 5. Technologically new products will lead to higher daily stock returns in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

4.1 Short-term Event Study on Stock Market Return Changes

The expectations of investors regarding the financial consequences of introducing TNPs are assessed using short-term event study methodology – stock market reactions. Short-term event study methodology provides a rigorous foundation to isolate the component of stock return due to firm-specific event (the abnormal return) by adjusting stock returns for market-wide movements (Hendricks and Singhal, 1997). The essential idea is to test whether the average abnormal returns around an event date is statistically significant for a set of firms which experience the same type of firm-specific events. Our study follows the standard short-term event study procedures as described by Brown and Warner (1985).

The first step is defining the event of interest and establishing the period over which the stock market reactions will be examined. For this study, the event is defined as the public release of the TNPs announcement in a daily news source (e.g. *PR Newswire, Business Newswire, Wall Street Journal*). For each announcement, the calendar date for its public release is translated to event time using the following conventions. The day on which the announcement is made is called the *event day* and is designated as day 0 (see *Figure 4.1*). Days prior to the announcement on which trading took place are given negative values and trading days following the announcement are given positive values. For example, a trading date 2 days before an announcement is day -2, and a trading date 5 days after an announcement is day 5. The stock market reactions to the TNPs announcement is measured over a two-day event period which includes the public release date of the announcement (day 0) and the preceding trading day (day -1). It cannot be determined from published sources whether day -1 or day 0 represents the date that the TNPs announcements was initially available to the market while trading was open. There is good reason to examine the days prior to the *event day*. For example, investors have gotten words of the introduction of TNPs prior to its public release and have begun to act upon it, an initial stock market reaction on the introduction can be expected on day -1, and further reactions on day 0 as news spreads. This two-day event window has also been extensively used to study the effects of a variety of events. We would also examine the abnormal stock returns from day -5 to day -2 to check for any leakage of information.

Figure 4. 1 Estimation and Event Periods



In additional to identifying the event of interest and event period, there is also a need to identify the estimation period. Following Brown and Warner (1985), we used a maximum of 250 daily return observations for the period around each TNPs announcement, starting at day -244 and ending at day 5 relative to the event day (day 0). The first 239 days in this period (day -244 through day -6) is denoted as the “estimated period”. If the announcement is associated with abnormal stock returns, the period near the announcement should not be included in the estimation period to prevent biasing the estimates. Typically, periods of 5 to 15 trading days are used to separate the estimation period from the event day (Hendricks and Singhal, 2008). In this study, each estimated period ended one week (5 trading days) prior to the date of the announcement. We believe that this one week interval is reasonably large to effectively isolate the estimates from the effects of the announcement. For a firm with TNPs introductions to be included in our sample, it must have stock price information available in CRSP database, at least 30 daily returns in the entire 250 day period, and no missing return data in the last 20 days. We start with 665 announcements with complete year, month and day information. 473 out of 665 announcements (71.1%) have daily stock price information in CRSP database. We deleted 9 announcements which do not have at least 30 daily returns in the entire 250 day period and another 30 announcements which have missing data in the last 20 trading days. Our final sample for examining stock market reactions on TNPs consists of 434 announcements (65.3%).

After identifying the estimation period, there is also a need to determine the estimated model and calculate the normal or expected stock returns for the event period. The normal or expected returns are those returns that would be estimated if no event were to take place. In this study, we employed OLS market model to calculate the expected stock returns for the event period. In the literature, OLS market model is considered as a rigorous return-generating model and is also commonly used by other researchers. The other two models, the Mean-adjusted model and the Market-adjusted model are used for robustness testing of our results, which will be presented and discussed later. We collected all the stock return data as well as the market return data from CRSP database available from the University of Chicago. The OLS market model is a single index model which posits a linear relationship between the return of any given stock to the return on a market portfolio. This relationship is often mathematically written as:

$$r_{i,t} = \alpha_i + \beta_i r_{m,t} + \varepsilon_{i,t} \quad \text{where}$$

$r_{i,t}$ – the return of stock i on day t ;

$r_{m,t}$ – the return of the market portfolio on day t ;

α_i – alpha, the intercept of the relationship for stock i ;

β_i – beta, the slope of the relationship for stock *i,* and

$\varepsilon_{i,t}$ – the error term for stock i on day *t.*

After getting the estimates ($\hat{\alpha}_i, \hat{\beta}_i, \hat{s}^2_{\varepsilon_i}$), the normal or expected return for stock *i* for each day is calculated as:

$$NR_{i,t} = \hat{\alpha}_i + \hat{\beta}_i R_{m,t} \text{, where}$$

$NR_{i,t}$ − the normal or expected stock return for stock *i* on day *t* ;

$\hat{\alpha}_i$ − an estimate for α_i from OLS market model ;

$\hat{\beta}_i$ − an estimate for β_i from OLS market model ;

$R_{m,t}$ − the return on the CRSP equally weighted index for day *t*.

Then the abnormal return for stock *i* for each day is calculated as:

$$AR_{i,t} = R_{i,t} - NR_{i,t} \text{, where}$$

$R_{i,t}$ − the actual stock return for stock *i* on day *t* ;

$AR_{i,t}$ − the abnormal stock return for stock *i* on day *t*.

Finally, the test statistics need to be determined. Though daily excess returns are highly non-normal, Brown and Warner (1985) found evidence that the mean excess return in a cross-section of stocks converges to normality as the number of sample stock increases. Standard parametric tests, such as Student's *t*-test, for the significance of the mean abnormal return are well-specified as long as the sample size is larger than 50. Therefore, we followed

Brown and Warner (1985) and applied Student's *t*-test statistic to examine the significance of average daily abnormal returns during the event period. It is given by first aggregating the abnormal returns for all firms for a single event day to produce the average daily abnormal return, as shown below:

$$\overline{AR_t} = \frac{1}{N_t}\sum_{i=1}^{N_t} AR_{i,t} \text{ , where}$$

$\overline{AR_t}$ − the average abnormal return for day t ;

N_t − the number of stocks in the sample for day *t*.

Then the test statistic, TS_t , is defined as the ratio of the average daily abnormal return to its estimated standard deviation (Brown and Warner, 1985) and as shown below:

$$TS_t = \frac{\overline{AR_t}}{\hat{s}(\overline{AR_t})} \text{ , where}$$

$$\hat{s}(\overline{AR_t}) = \sqrt{\{\sum_{t=-244}^{t=-6}(\overline{AR_t} - \overline{\overline{AR_t}})\}/238} \text{ ,}$$

$$\overline{\overline{AR_t}} = \frac{1}{239}\sum_{t=-244}^{t=-6}\overline{AR_t}$$

While the above test statistic is adequate for testing daily abnormal stock returns, it may fail to detect trends which emerge over a series of days, i.e. the event period. In order to detect such trends, cumulative abnormal returns over time should be employed. The construction of test statistic, $TS_{t \in EvtP}$, for cumulative average abnormal return (*CAR*) is similar to that of daily returns in that the mean returns are divided by their estimated standard deviation to yield a test statistic. Using notations previously used, the test statistic for cumulative abnormal returns is given by:

$$TS_{t \in EvtP} = \frac{CAR}{\hat{S}(CAR)} \text{, where}$$

$$CAR = \sum_{t \in EvtP} \overline{AR}_t \text{ ,}$$

$$\hat{S}(CAR) = \sqrt{\sum_{t \in EvtP} \hat{S}^2 (\overline{AR}_t)}$$

$EvtP$ − the event period;

CAR − cumulative average abnormal returns.

4.2 Empirical Results and Discussions

4.2.1 Stock Reactions on Technologically New Products in All Industries

For the 434 announcements of TNPs, *Table 4.1* presents the average daily abnormal return ($\overline{AR}_t$) with its *t*-statistic (TS_t), and the cumulative average abnormal returns (*CAR*). *Table 4.2* provides more information and the statistics on the cumulative average abnormal return during the event period (day -1 to day 0).

Table 4.1 indicates that starting from 5 trading days before the announcements of TNPs to 5 trading days after the announcements (days -5 to 5), the firms in our sample gained an average of 2.01% of their market value. Over a smaller window starting from 2 trading days before the announcements to 2 trading days after (days -2 to 2), the average gain was 2.07%. While the average daily abnormal returns show slight positive drift before and after the announcement of a technologically new product announcement, the days in the event period (days -1 to 0) account for most of the gain in the market value. The day -1 average abnormal return is 0.59% and the day 0 average abnormal return is 1.71%. The *t*-statistics are 2.37 for day -1 and 6.91 for day 0, which are significantly different from zero at the 5% and 1% level, respectively.

Table 4. 1 Sample Firms in All Industries: Average Daily Abnormal Returns (in %) and Cumulative Average Daily Returns (In %) From 5 Days Before Through 5 Days After the TNPs Announcements (OLS Market Model-Equally Weighted)

Trading Day Relative to Announcement	Average Daily Abnormal Return (in %)	*T*-Statistics for the Average Daily Abnormal Return	Cumulative Average Daily Returns (in %)
-5	0.13	0.54	0.13
-4	-0.08	-0.34	0.05
-3	0.25	1.00	0.30
-2	-0.28	-1.12	0.02
-1	**0.59**	**2.37**	**0.61**
0	**1.71**	**6.91**	**2.32**
1	-0.13	-0.52	2.20
2	0.18	0.72	2.37
3	0.00	0.00	2.37
4	-0.15	-0.62	2.22
5	-0.21	-0.84	2.01

Although the *t*-test statistic is well specified for assessing daily abnormal returns (Brown and Warner, 1985; Dyckman *et al*, 1984), it is desirable to conduct additional tests using non-parametric statistics when examining abnormal returns over an event period. Such statistics are often used in conjunction with their parametric counterparts to check the robustness of findings (Campbell, Lo and MacKinlay, 1997). Although a number of different non-parametric statistics are available, we employed two non-parametric tests to assess the possible impact of outliers. The first is the Sign test. It is constructed on the basis of the efficient-market assumption that the sign of a sample firm's abnormal return would follow a binomial distribution, with the probability of its taking a positive sign being 0.5 (Brown and Warner, 1985). If announcements of TNPs have no significant effect on the returns of the introducing firms, the abnormal returns of the introducing firms during the event period would be normally distributed. That is, half the introducing firms would have positive abnormal returns and the other half would have negative abnormal returns. The other test used is the Wilcoxon signed-rank test, which takes into account the magnitude and sign of each introducing firm's abnormal return during the event period (Hollander and Wolfe, 1973).

Table 4.2 indicates that the event period (Day -1 to 0) mean abnormal return is 2.30%. A *t*-statistic of 4.76 for the event period indicates that this mean abnormal return is significantly different from zero at the 1% level. The median abnormal return is 0.94%. The *Z*-statistic of 4.88 for the Wilcoxon Signed-rank test indicates that the median abnormal return is significantly different from zero at the 1% level. The distribution of the event period abnormal returns presented in *Table 4.2* indicates that 252 out of 434 (58.1%) event period returns are positive. If for a given firm that the probability of observing a positive event period return equals 0.5, then the probability of observing 252 or more positive returns out of a sample of 434 is less than or equal to 0.001 (the *Z*-statistic of the Sign test is 3.31). It indicates the significantly positive abnormal returns are not caused by chance or any other unobserved random events.

Table 4. 2 Sample Firms in All Industries: Event Period (Day -1 and Day 0) Abnormal Returns for 434 Announcements of TNPs (OLS Market Model-Equally Weighted)

	Event Period (Day -1 to Day 0)	
Mean Abnormal Return (*T*-Statistics)	2.30%	(4.76)
Median Abnormal Return	0.94%	
Minimum Abnormal Return	-22.02%	
Maximum Abnormal Return	43.95%	
Percent Abnormal Returns Positive (*Z*-Statistics)	58.1%	(3.31)
Wilcoxon Signed-rank Test *Z*-Statistics	4.88	

Distribution of Event Period Average Abnormal Returns (R)	Number of Observations
R ≤ −10.0%	2
−10.0% < R ≤ −5.0%	15
−5.0% < R ≤ 0.0%	165
0.0% < R ≤ 5.0%	204
5.0% < R ≤ 10.0%	37
10.0% < R ≤ 25.0%	6
25.0% < R	5

The results presented in *Table 4.2* were consistent with our expectations. Investors favor the introduction of TNPs and anticipate higher cash inflows in the future. Stock market increased about 2.30% during a two-day (Day -1 to 0) event period following announcements of TNPs.

4.2.2 Stock Reactions on Technologically New Products in the Electrical and Electronics Related Industries

For 156 announcements of TNPs in the EEIs, *Table 4.3* presents the average daily abnormal return ($\overline{AR_t}$) with its *t*-statistic (TS_t), and the cumulative average abnormal returns (*CAR*). *Table 4.4* provides more information and the statistics on the cumulative average abnormal return during the event period (day -1 to day 0).

Table 4.3 indicates that starting from 5 trading days before the announcements of TNPs to 5 trading days after the announcements (days -5 to 5), the firms in the EEIs gained an average of 2.79% of their market value. Over a smaller window starting from 2 trading days before the announcements to 2 trading days after (days -2 to 2), the average gain was 2.63%. While the average daily abnormal returns show slight positive drift before and after the TNPs announcements, the days in the event period (days 0) account for most of the gain in the market value. The day 0 average abnormal return is 1.89%. The *t*-statistics are 4.76 for day 0, which is significantly different from zero at the 1% level.

Table 4. 3 Sample Firms in the EEIs: Average Daily Abnormal Returns (in %) and Cumulative Average Daily Returns (In %) From 5 Days Before Through 5 Days After the TNPs Announcements (OLS Market Model-Equally Weighted)

Trading Day Relative to Announcement	Average Daily Abnormal Return (in %)	*T*-Statistics for the Average Daily Abnormal Return	Cumulative Average Daily Returns (in %)
-5	0.44%	1.12	0.44%
-4	-0.63%	-1.59	-0.19%
-3	0.16%	0.39	-0.03%
-2	-0.26%	-0.66	-0.29%
-1	0.22%	0.56	-0.07%
0	**1.89%**	**4.76**	**1.82%**
1	0.55%	1.38	2.37%
2	0.23%	0.58	2.60%
3	0.43%	1.09	3.03%
4	-0.13%	-0.32	2.90%
5	-0.11%	-0.27	2.79%

Table 4.4 indicates that the event period (Day -1 to 0) mean abnormal return is 2.11%. A parametric *t*-statistic of 3.09 for the event period indicates that this mean abnormal return is significantly different from zero. The median mean abnormal return is 1.06%. The *Z*-statistic of 3.40 for the Wilcoxon Signed-rank test indicates that the median mean abnormal return is significantly different from zero at the 1% level. The distribution of the event period abnormal returns presented in *Table 4.4* indicates that 92 out of 156 (59.0%) event period returns are positive. If for a given firm that the probability of observing a positive event period return equals 0.5, then the probability of observing 92 or more positive returns out of a sample of 156 is less than or equal to 0.05 (the *Z*-statistic of the Sign test is 2.16). It indicates the significantly positive abnormal stock returns are not caused by chance or any other unobserved random events.

Table 4. 4 Sample Firms in the EEIs: Event Period (Day -1 and Day 0) Abnormal Returns for 156 Announcements of TNPs (OLS Market Model-Equally Weighted)

	Event Period (Day -1 to Day 0)	
Mean Abnormal Return (*T*-Statistics)	2.11%	(3.09)
Median Abnormal Return	1.06%	
Minimum Abnormal Return	-20.92%	
Maximum Abnormal Return	25.16%	
Percent Abnormal Returns Positive (*Z*-Statistics)	59.0%	(2.16)
Wilcoxon Signed-rank Test *Z*-Statistics	3.40	

Distribution of Event Period Average Abnormal Returns (R)	Number of Observations
R ≤ −10.0%	1
−10.0% < R ≤ −5.0%	4
−5.0% < R ≤ 0.0%	59
0.0% < R ≤ 5.0%	73
5.0% < R ≤ 10.0%	17
10.0% < R ≤ 25.0%	1
25.0% < R	1

4.2.3 Stock Reactions on Technologically New Products in the Pharmaceutical and Medical Devices Related Industries

For 181 announcements of TNPs in the PMIs, *Table 4.5* presents the average daily abnormal return ($\overline{AR_t}$) with its *t*-statistic (TS_t), and the cumulative average abnormal returns (*CAR*). *Table 4.6* provides more information and the statistics on the cumulative average abnormal return during the event period (day -1 to day 0).

Table 4.5 indicates that starting from 5 trading days before the announcements of TNPs to 5 trading days after the announcements (days -5 to 5), the firms in the PMIs gained an average of 2.12% of their market value. Over a smaller window starting from 2 trading days before the announcement to 2 trading days after (days -2 to 2), the average gain was 2.47%. While the average daily abnormal returns show slight positive drift before and after the announcements of TNPs introductions, the days in the event period (days -1 to 0) account for most of the gain in the market value. The day -1 average abnormal return is 1.09% and the day 0 average return is 2.30%. The *t*-statistics are 2.72 for day -1 and 5.77 for day 0, which are significantly different from zero at the 5% and 1% level, respectively.

Table 4. 5 Sample Firms in the PMIs: Average Daily Abnormal Returns (in %) and Cumulative Average Daily Returns (In %) From 5 Days Before Through 5 Days After the TNPs Announcements (OLS Market Model-Equally Weighted)

Trading Day Relative to Announcement	Average Daily Abnormal Return (in %)	*T*-Statistics for the Average Daily Abnormal Return	Cumulative Average Daily Returns (in %)
-5	0.20%	0.51	0.20%
-4	0.33%	0.83	0.53%
-3	0.24%	0.60	0.77%
-2	-0.38%	-0.96	0.39%
-1	**1.09%**	**2.72**	**1.48%**
0	**2.30%**	**5.77**	**3.78%**
1	-0.75%	-1.87	3.04%
2	0.21%	0.52	3.24%
3	-0.29%	-0.73	2.95%
4	-0.58%	-1.45	2.37%
5	-0.25%	-0.62	2.12%

Table 4.6 indicates that the mean abnormal return in the event period (day -1 to 0) is 3.39%. A *t*-statistic of 3.76 for the event period indicates that the mean abnormal return is significantly different from zero at the 1% level. The median abnormal return is 1.39%. The *Z*-statistic of 3.54 for the Wilcoxon Signed-rank test indicates that the median abnormal return is significantly different from zero at the 1% level. The distribution of the event period abnormal returns presented in *Table 4.6* indicates that 105 out of 181 (58.0%) event period returns are positive. If for a given firm that the probability of observing a positive event period return equals 0.5, then the probability of observing 105 or more positive returns out of a sample of 181 is less than or equal to 0.05 (the *Z*-statistic of the Sign test is 2.08). It indicates the significantly positive abnormal stock returns are not caused by chance or any other unobserved random events.

Table 4. 6 Sample Firms in the PMIs: Event Period (Day -1 and Day 0) Abnormal Returns for 181 Announcements of TNPs (OLS Market Model-Equally Weighted)

	Event Period (Day -1 to Day 0)	
Mean Abnormal Return (*T*-Statistics)	3.39%	(3.76)
Median Abnormal Return	1.39%	
Minimum Abnormal Return	-8.51%	
Maximum Abnormal Return	43.94%	
Percent Abnormal Returns Positive (*Z*-Statistics)	58.0%	(2.08)
Wilcoxon Signed-rank Test *Z*-Statistics	3.54	

Distribution of Event Period Average Abnormal Returns (R)	Number of Observations
R ≤ −10.0%	0
−10.0% < R ≤ −5.0%	8
−5.0% < R ≤ 0.0%	68
0.0% < R ≤ 5.0%	83
5.0% < R ≤ 10.0%	14
10.0% < R ≤ 25.0%	4
25.0% < R	4

In Hypothesis 5, we expect that the stock market reactions on TNPs introduced in the PMIs will be significantly higher than in the EEIs. From *Table 4.4* and *Table 4.6*, stock market increased about 3.39% during a two-day (Day -1 to 0) event period following an announcement of TNPs in the PMIs, while there is only an increase of 2.11% in stock returns in the EEIs. In order to examine whether there is significant difference in stock market reactions towards TNPs in the PMIs and the EEIs, we also conducted independent-samples t-test. From the test results, a *t*-statistic of 1.10 (*p*-value = 0.272) for the event period indicates that the stock market reactions on TNPs in the PMIs and the EEIs are not significantly different. The test results are not consistent with our expectations and do not support Hypothesis 5.

Investors seem to favor the introductions of TNPs in any industry.

4.3 Test of the Robustness of Results

4.3.1. Description of Robustness Testing Models

In additional to the OLS market model, we employed two other return-generating models to test the robustness of the findings. The simplest model is the Mean-adjusted model. This model assumes that the expected return for a given stock *i* is equal to a constant, which is the simple average of stock *i*'s daily returns in the estimation period (day -244 to -6 in this study), as the following equations show:

$$AR_{i,t} = R_{i,t} - \overline{R}_i \text{, where}$$

$$\overline{R}_i = \frac{1}{239} \sum_{t=-244}^{t=-6} R_{i,t}$$

The Market-adjusted model assumes that expected return is equal across stocks but not necessarily constant over time. As market portfolio is an average of all available stocks, the expected stock return in time *t* is the return from the market $R_{m,t}$, as the following equations show:

$$AR_{i,t} = R_{i,t} - R_{m,t},$$

where $R_{m,t}$ is the return on the CRSP equally weighted index for day *t*.

4.3.2 Robustness Testing Results

Table 4.7 to *Table 4.10* present the testing results based on the Mean-adjusted model and the Market-adjusted model. The results are very similar to the results based on the OLS market model. In *Table 4.7* and *Table 4.8*, starting from 5 trading days before the announcements of TNPs to 5 trading days after the announcements (days -5 to 5), the firms in our sample gained an average of 2.09% of their market value for the Mean-adjusted model and 2.44% for the Market-adjusted model, which are comparable to 2.10% for OLS market model. Over a smaller window starting from 2 trading days before the announcement to 2 trading days after (days -2 to 2), the average gain was 2.15% (based on the Mean-adjusted model) and 2.27% (based on the Market-adjusted model), which are also comparable to 2.07% (based on OLS market model). For all of the three models, the days in the event period (days -1 to 0) account for most of the gain in the market value. For the Mean-adjusted model, the day -1 average abnormal return is 0.65% ($p<0.05$) and the day 0 average return is 1.62% ($p<0.001$). Similarly, for the Market-adjusted model, the day -1 average abnormal return is 0.64% ($p<0.05$) and the day 0 average return is 1.68% ($p<0.001$). These results are also very close to the abnormal returns based on the OLS market model.

Table 4. 7 Sample Firms in All Industries: Average Daily Abnormal Returns (in %) and Cumulative Average Daily Returns (In %) From 5 Days Before Through 5 Days After the TNPs Announcements (Mean-adjusted Model)

Trading Day Relative to Announcement	Average Daily Abnormal Return (in %)	*T*-Statistics for the Average Daily Abnormal Return	Cumulative Average Daily Returns (in %)
-5	0.14%	0.55	0.14%
-4	-0.05%	-0.21	0.09%
-3	0.26%	1.02	0.35%
-2	-0.16%	-0.64	0.19%
-1	**0.65%**	**2.56**	**0.84%**
0	**1.62%**	**6.39**	**2.46%**
1	-0.11%	-0.42	2.35%
2	0.15%	0.60	2.50%
3	0.11%	0.44	2.61%
4	-0.20%	-0.80	2.41%
5	-0.32%	-1.26	2.09%

Table 4. 8 Sample Firms in All Industries: Average Daily Abnormal Returns (in %) and Cumulative Average Daily Returns (In %) From 5 Days Before Through 5 Days After the TNPs Announcements (Market-adjusted Model)

Trading Day Relative to Announcement	Average Daily Abnormal Return (in %)	*T*-Statistics for the Average Daily Abnormal Return	Cumulative Average Daily Returns (in %)
-5	0.12%	0.47	0.12%
-4	-0.03%	-0.11	0.09%
-3	0.31%	1.23	0.40%
-2	-0.18%	-0.74	0.22%
-1	**0.64%**	**2.57**	**0.86%**
0	**1.68%**	**6.76**	**2.54%**
1	-0.07%	-0.29	2.47%
2	0.20%	0.80	2.67%
3	0.11%	0.44	2.78%
4	-0.11%	-0.46	2.67%
5	-0.23%	-0.91	2.44%

Table 4.9 and *Table 4.10* indicate that mean abnormal return during the event period (day -1 to 0) is 2.27% (*p<0.001*) for the Mean-adjusted model and 2.32% (*p<0.001*) for the Market-adjusted model. The median abnormal return is 0.71% (based on the Mean-adjusted model) and 0.85% (based on the Market-adjusted model). The *Z*-statistics for these two models are both significantly different from zero at the 1% level. A total of 247 out of 434 (56.9%) event period abnormal returns are positive for the Mean-adjusted model, while 256 out of 434 (59.0%) are positive for the Market-adjusted model. All of these test statistics are very close to those based on OLS-market model.

Table 4. 9 Sample Firms in All Industries: Event Period (Day -1 and Day 0) Abnormal Returns for 434 Announcements of TNPs (Mean-adjusted Model)

	Event Period (Day -1 to Day 0)	
Mean Abnormal Return (*T*-Statistics)	2.27%	(4.50)
Median Abnormal Return	0.71%	
Minimum Abnormal Return	-23.52%	
Maximum Abnormal Return	43.01%	
Percent Abnormal Returns Positive (*Z*-Statistics)	56.9%	(2.93)
Wilcoxon Signed-rank Test *Z*-Statistics	4.10	

Distribution of Event Period Average Abnormal Returns (R)	Number of Observations
R ≦ −10.0%	3
−10.0% < R ≦ −5.0%	16
−5.0% < R ≦ 0.0%	168
0.0% < R ≦ 5.0%	195
5.0% < R ≦ 10.0%	34
10.0% < R ≦ 25.0%	13
25.0% < R	5

Table 4. 10 Sample Firms in All Industries: Event Period (Day -1 and Day 0) Abnormal Returns for 434 Announcements of TNPs (Market-adjusted Model)

	Event Period (Day -1 to Day 0)	
Mean Abnormal Return (*T*-Statistics)	2.32%	(4.80)
Median Abnormal Return	0.85%	
Minimum Abnormal Return	-22.42%	
Maximum Abnormal Return	43.71%	
Percent Abnormal Returns Positive (*Z*-Statistics)	59.0%	(3.50)
Wilcoxon Signed-rank Test *Z*-Statistics	4.92	

Distribution of Event Period Average Abnormal Returns (R)	Number of Observations
R ≦ −10.0%	2
−10.0% < R ≦ −5.0%	15
−5.0% < R ≦ 0.0%	161
0.0% < R ≦ 5.0%	210
5.0% < R ≦ 10.0%	32
10.0% < R ≦ 25.0%	10
25.0% < R	4

4.4 Discussions

In this research part, our findings provide insights on how investors estimated and reacted to the introductions of TNPs. We investigate the abnormal daily stock market returns after the introductions of TNPs by focusing on a two-day event window (Day -1 and Day 0). In our full sample, the abnormal daily stock return increases on average 2.30% during one day before (Day -1) and the day (Day 0) of a technologically new product introduction. The Day 0 accounts for 74% of the total stock return increase. We also find significant stock market returns one day before the announcements of TNPs. Our findings imply that investors generally favored such kind of product introductions and expected a higher cash inflow in future. They expected that TNPs could have the potential for generating positive long-term cash flows.

Introducing TNPs could be regarded as a strategic choice that introducing firms leverage their technology capabilities and gain competitive advantages over their rivals. Woolridge and Snow (1990) suggested that it is conceivable that relevant information about strategic decisions, such as introducing TNPs, is incorporated in the market value through information leakage before their commercialization (e.g. final product testing stage or customer trial stage). Therefore, it is possible that the stock market may ignore news about the later commercialization of TNPs. If this is true, we would expect to see some significant stock market reactions before the announcement dates. However, when we examine the preceding days before TNPs introductions, i.e. day -5 to day -2, we find that there is no significant results during this time period, which indicates that there might be no information leakage around the date of TNP introductions or the stock market only reacts to product development outcomes, i.e. TNPs introductions. Investors might regard developing TNPs as a risky process in which they cannot forecast the actual product development outcomes. It is conceivable that they only react to announcements of TNP introductions. Such announcements could increase investors' confidence in announcing firms' technology capabilities in developing TNPs and decrease the risk level perceived by investors. We also examined the following days after TNPs introductions (e.g. Day 2 and Day 3) to test the duration of significant effects on stock prices. There is no significant result, although some of the daily abnormal stock returns figures are positive. It indicates that the stock market appears to incorporate most information about the expected financial value that TNPs can add to the introducing firms within two days (Day -1 and Day 0) around the announcements dates.

Our findings in this chapter also provide some insights into the potential role of industry characteristics in influencing the abnormal daily stock returns of TNPs introductions. We split our samples into two industry sub-groups, which are the PMIs and the EEIs. We find that the stock returns increased about

3.39% during a two-day (Day -1 to 0) event period following announcements of TNPs in the PMIs, while 2.11% increase in stock returns in the EEIs. Although we find the introductions of TNPs in the PMIs appear to have higher abnormal returns (3.39% in the PMIs versus 2.11% in the EEIs), our further analysis through independent-samples t-test suggests that they are not significantly different. In other words, the industrial type (i.e., the PMIs versus the EEIs) does not significantly affect abnormal daily stock returns from TNPs announcements. Introducing TNPs in both industries could lead to higher stock returns since both types of products are expected to enhance the knowledge base of firms and strengthen competitive advantages according to the KBV.

Our findings in this chapter are in line with the results from some previous studies. Sorescu et al. (2003) found that technology breakthroughs in pharmaceutical industries lead to higher net present value of a firm. Similar results are also found in Eberhart et al. (2004) and Yew et al. (2005). They found that increases in R&D expenditures are positively related to stock returns of firms. Although increase in R&D expenditure is different from the introduction of TNPs, both are regarded as a signal that a firm is committed to increase their technology capabilities which are expected to generate more profits in the future.

4.5 Conclusion of Research Part One

In this chapter, we examined the stock market reactions towards the introductions of TNPs. We found that in general investors favor this kind of product introductions and expect a higher cash inflow in future. The stock return increases by 2.30% on average during one day before (Day -1) and the day (Day 0) of TNPs introductions. The Day 0 accounts for 74% of the total stock return increases. Therefore, Hypothesis 1 is supported.

In order to examine the impact of industry characteristics on stock market returns after TNPs introductions, we focused specifically on two major industrial sectors that are under rapid technology development in the past decades – the pharmaceutical and medical devices related industries (PMIs) and the electrical and electronics related industries (EEIs). We found that the stock market returns upon the introductions of TNPs in the PMIs are higher than those in the EEIs. The stock prices increase by 3.39% during a two-day (Day -1 to 0) event period following an announcement of TNPs in the PMIs, while there is only an increase of 2.11% in the EEIs. However, based on the results of independent-samples t-tests, we found they (3.39% in the PMIs versus 2.11% in the EEIs) are not significantly different. Therefore, Hypothesis 5 is not supported.

We also employed two other return-generating models to examine the robustness of our results and found that the results are very consistent across three models, which are the OLS market model, the Mean-adjusted model and the Market-adjusted model. The robustness of our results is confirmed.

Chapter 5 Research Part Two – Technologically New Products and Long-term Operating Performance Changes

In Chapter 4, we examined the short-term stock market reactions to TNPs. Short-term event studies are based on the assumption that the stock market operates efficiently and rationally in terms of reflecting current information and expectations. The abnormal stock market returns reflect investors' perceived or expected value of future cash inflows which attributed to the release of new information about a firm. However, several limitations are associated with short-term event studies based on stock market reactions. Some researchers argued that these studies might only capture the lower-bound economic estimate or partial economic impact of a firm-specific event (e.g. Hendricks and Singhal, 1997; Koh and Venkatraman, 1991). Furthermore, a body of evidence on stock market has presented a direct challenge to the traditional view of stock market efficiency and rationality (Daniel et al., 1998). Research studies have documented the investors' over-reaction and under-reaction related to economic events (e.g., Barberis, et al., 1998; Hong and Stein, 1998). The increase or decrease in stock price could also be due to stock market inefficiency and irrationality. Accordingly, it appears that we are not able to capture the full picture of the economic implications of TNPs introductions by simply examining abnormal stock market returns. Academic researchers and practitioners need to make judgment on the success or failure of their product development effort by comparing actual financial performance against investors' prior expectations. Therefore, in this chapter, we supplement the findings on stock market returns on the TNPs introductions with the investigation on their impacts long-term operating performance. We will provide empirical evidence based on objective accounting data on the six hypotheses we developed in Chapter 2:

Hypothesis 2. Technologically new products will lead to higher ROA.

Hypothesis 3. Technologically new products will lead to higher ROS.

Hypothesis 4. Technologically new products will lead to higher SOA.

Hypothesis 6. Technologically new products will lead to higher ROA in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

Hypothesis 7. Technologically new products will lead to higher ROS in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

Hypothesis 8. Technologically new products will lead to higher SOA in the pharmaceutical and medical devices related industries compared to the electrical and electronics related industries.

5.1 Long-term Event Study on Operating Performance Changes

Research studies generally use long-term event study to assess the changes in operating performance following major corporate events. In this study, we employ this methodology to examine the effects of TNPs announcements on accounting-based measures of operating performance.

Barber and Lyon (1996) identified several key choices in designing an event study based on accounting data, which are summarized below:

1) *Event definition.* The initial task of conducting an event study is to define the event of interest and identify the period over which the performance measures (e.g., ROA, ROS etc) of the firms involved in the event will be examined - the *event window.* In this study the event of interest was the announcements of TNPs by a sample firm. We defined our event period as the year in which a technologically new product was announced (year *t*). We investigated the abnormal financial impact of TNPs over a four-year period after their introduction (i.e., the event window is from year *t+1* to year *t+4*),

which is a rough estimate of the product life cycle. In Deng et al.'s (1999) studies, they found the technology cycle time is industry specific. Technology cycle time is as short as 3-4 years in rapidly changing industries, such as electronics, and as long as 8-9 years in drugs and medicine. Terwiesch et al. (1998) also found comparable product life cycles, where on average 3.4 years for the EEIs and 7.4 years for the PMIs. Therefore, in order to set a common measurement period for inter-industry comparison, we use 4 years as a rough estimate of the product life cycle. By choosing a four-year period, we attempt to strike a balance such that the period is not too short that we miss out on many of the performance changes that can be attributed to TNPs, nor is it so long that we only measure noise that can increase the variance of performance changes and reduce the power of the statistical tests.

2) *Performance Measures.* We focused on operating income, which is sales less the cost of goods sold (COGS), and selling, general and administrative expenses (SGA) to assess the financial impacts of TNPs. Operating income is considered to be a clearer measure of performance since it is not obscured by other factors, e.g., special items and tax considerations (Barber and Lyon, 1996; Hendricks and Singhal, 2008). Three performance measures based on operating income are adopted in this research, which are ROA, ROS and SOA.

ROA is an overall profitability indicator commonly used to measure how effective the management is in using its assets to generate profits, as shown below:

$$ROA = \frac{Sales - COGS - SGA}{Total\_Assets}$$

ROS is a ratio widely used to evaluate a firm's operating profit margin that provides insights into how much profit is being produced per dollar of sales. A higher ROS indicates a firm is growing more rapidly and financial healthy, as shown below:

$$ROS = \frac{Sales - COGS - SGA}{Sales}$$

SOA is borrowed from Hendricks and Singhal (2008), indicates how efficient a firm is in using its assets to generate revenue, a primary source of profit, as show below:

$$SOA = \frac{Sales}{Total\_Assets}$$

3) *Selection criteria.* After identifying the event of interest, it is necessary to determine the selection criteria for the inclusion of sample and/or control firms in the study. The criteria in our study for the sample firm were that it

should have announced TNPs and have sufficient related accounting data in the Compustat (North America) database. We started with 884 firms with announcements of TNPs. We deleted 168 firms which did not have sufficient accounting data in the base year *t-1* in the Compustat database. *Table 5.1* reports the descriptive statistics of the sample firms.

Table 5. 1 Summary Statistics of Sample Firms

	N	Mean	Median	S.D.	Max.	Min.
Total Assets[a]	716	4345.923	104.483	14114.27	167662	0.02
Sales[a]	716	3975.546	85.906	13003.44	142897	0
ROA[b]	716	-14.2409	7.925885	95.51465	69.71407	-1640.78
ROS[b]	716	-57.7101	9.883845	213.4043	53.06027	-1611.57
SOA[b]	716	86.1946	85.0985	59.2132	500.396	0

[a] Total Assets and Sales are expressed in millions of US dollars.

[b] ROA, ROS, and SOA are expressed in percentages.

We selected control firms that have similar total assets, ROA (ROS or SOA), and is of the same 2-digit SIC code. The control firms' ROA (ROS or SOA) must lay between 90% and 110% of that of the sample firm and their total assets must lay between 33% and 300% of those of the corresponding sample firm in the base year (year *t*-1). There are no theoretical or empirical guidelines on the appropriate base year to select control firms. The focus of our study is to measure the commercial outcomes of TNPs after their introductions to the market. We considered it to be logical and appropriate to select control firms based on year *t*-1 since there should be no economic values created before a product is introduced to the market. We selected control firms using 2-digit SIC code because it represents most of the differences and characteristics among industries. There are higher proportions of discrepancies in 3-digit and 4-digit SIC codes (Guenther and Rosman, 1994). Our sample would diminish rapidly if we selected control firms using 3-digit or 4-digit SIC codes. All the control firms that met the selection criteria for a sample firm constituted its control group. Following Barber and Lyon (1996), we trimmed the data by eliminating the data at the 2.5% level in each tail. After trimming, in base year *t-1*, our sample consisted of 524, 485, and 541 pairs of sample firms and their corresponding control groups selected on the basis of ROA, ROS and SOA, respectively.

4) *Normal and abnormal performance.* The abnormal return is the actual post-event financial performance of a sample firm over the event window minus its estimated normal financial performance over the same time period. The estimated normal performance is defined as the return that would be expected if the event were not happening. In our study this was represented by the median post-event performance of the control group of a sample firm, which is mathematically expressed as follows:

$$AP_{i,T,d} = P_{i,T+d} - [P_{i,T} + Med(C_{i,T+d}) - Med(C_{i,T})],$$

$AP_{i,T,d}$ - the abnormal performance in ROA (ROS or SOA) of sample firm *i* from year T to $T+d$, where year T represents the base year;

$P_{i,T+d}$ - the actual post-event performance in ROA (ROS or SOA) of sample firm *i* (the control group of firm *i*) during the year $T+d$;

$C_{i,T+d}$ - the actual post-event performance in ROA (ROS or SOA) of the control group of sample firm *i* during the year $T+d$;

$P_{i,\,T}$ - the actual performance in ROA (ROS or SOA) of sample firm *i* during the base year T;

$C_{i,\,T}$ – the actual performance in ROA (ROS or SOA) of the control group of sample firm *i* during the base year T.

The estimated normal performance in ROA (ROS or SOA) of sample firm *i* without the event during the year $T+d$ is represented by $[P_{i,T} + Med(C_{i,\,T+d}) - Med(C_{i,T})]$, where Med is the median of the actual performance of the control group during year $T+d$ and year T, respectively.

A simple example is helpful to demonstrate the calculation. Suppose that in the base year T the sample firm *i* had an ROA of 10% (i.e., $P_{i,T}$ = 10%), while the group of control firms had a median ROA of 9% (i.e., $Med(C_{i,T})$ = 9%).

Assume that over the next four years (d = 4) the median ROA of this control group changed from 9% to 12% for a net change of 3% (i.e., Med($C_{i,T+4}$) – Med($C_{i,T}$) = 3%). Then, if there was no TNPs introduced, we estimate the sample firm's expected performance as 13% (i.e., the base year performance of 10% plus the 3% change in the median of the performance of the control group). If the sample firm's actual performance four years after the base period was 14%, then we estimate its abnormal performance as 1% (14% - 13%).

5) *An appropriate statistical test.* Since the choice of a test statistic depends on the distribution of abnormal performance, non-parametric tests are found to be more powerful than parametric tests (Barber and Lyon, 1996). They attributed this finding to the existence of extreme observations in the distribution of the accounting-based performance measures analyzed. When the distribution of abnormal performance is symmetric, we used the Wilcoxon Signed-rank test; in other cases, if the distribution is highly skewed, we used the less powerful sign test. For completeness, we reported all three statistics, i.e., t-test, Wilcoxon Signed-rank test and Sign test.

5.2 Empirical Results and Discussion

5.2.1 Results for Abnormal Operating Performance in All Industries

Since there is no universal agreement in the literature on how long it will take to develop and commercialize TNPs, it is necessary to test whether the sample firms had already performed better than their control groups. Firms with better financial performance may be in a better position to develop technological innovations than firms with poorer financial performance (Ali, 1994). This pre-event bias, should it exist, would undermine our analysis and findings. In order to detect the possible existence of pre-event performance bias, we obtained the abnormal performance in ROA, ROS and SOA from year *t*-2 to year *t*-1, respectively. From *Table 5.2*, the abnormal performance in ROA, ROS and SOA from year *t*-2 to year *t*-1, respectively, was positive but not significant. Therefore, we have reasons to believe that the sample firms and the selected control firms had similar pre-event performance before the announcement of TNPs.

Table 5.2 shows the statistical results of abnormal operating performance for the full sample over the four-year period (from year *t+1* to year *t+4*). The results are partly positive and statistically significant. The rows "*t*-1 to *t*+1", "*t*-1 to *t*+2", "*t*-1 to *t*+3", and "*t*-1 to *t*+4" show the results of abnormal operating performance accumulation when the product had been introduced to the market for about one year, two years, three years, and four years, respectively. More specifically, there were significant increases in ROA over the periods "*t*-1 to *t*+1" to "*t*-1 to *t*+4", with an increase from 1.25% ($p < 0.05$) to 1.44% ($p < 0.01$). However, these significant results are indicated by sign-test, which is weaker than Student's t-test and WSR test. The magnitude of abnormal performance increase is also very limited, only a 0.19% increase in ROA during the four-year period. Similar patterns are found in the abnormal performance changes in ROS. Though we could find positively significant increase in abnormal performance in SOA during period "t-1 to t+1" across three statistical tests, these positive significances are not long lasting. Therefore, we conclude that *H1(a)* is weakly supported.

In Chapter 4, we found that the short-term stock market reactions on TNPs are positively significant. Investors seem to favor the introductions of TNPs and expect higher future financial gains. However, when we examined the long-term operating performance changes, we found that the financial gains created by the TNPs were not as much as what indicated by short-term stock market reactions. This interesting finding provides some empirical evidence that investors might over react or expect too much from TNPs.

Table 5. 2 Sample Firms in All Industries: Abnormal Operating Performance in Full Sample (Performance-Size-SIC-2-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	510	0.03	0.42	0.632	0.965	0.540
t to t+1	477	0.21	-0.81	0.600	0.647	0.299
t+1 to t+2	420	-0.16	-1.54	0.339	0.733	0.073*
t+2 to t+3	374	0.28	0.51	0.481	0.278	0.526
t+3 to t+4	330	0.14	-0.30	0.916	0.783	0.723
t-1 to t+1	479	1.25	-0.77	0.314	0.022**	0.394
t-1 to t+2	422	1.02	-2.11	0.760	0.036**	0.049**
t-1 to t+3	374	1.35	-0.11	0.131	0.070*	0.924
t-1 to t+4	334	1.44	0.47	0.154	0.014**	0.688

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	470	0.11	5.02	0.243	0.489	0.215
t to t+1	436	0.35	7.69	0.688	0.114	0.026**
t+1 to t+2	387	0.00	-6.16	0.491	1.000	0.049**
t+2 to t+3	346	-0.01	-12.77	0.345	0.957	0.001***
t+3 to t+4	298	0.32	-7.54	0.608	0.685	0.068*
t-1 to t+1	439	0.68	11.18	0.313	0.105	0.001***
t-1 to t+2	386	0.59	9.95	0.263	0.140	0.018**
t-1 to t+3	345	0.49	3.80	0.713	0.451	0.491
t-1 to t+4	301	0.57	-3.44	0.813	0.420	0.573

Table 5.2 Sample Firms in All Industries: Abnormal Operating Performance in Full Sample (Performance-Size-SIC-2-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	533	0.53	0.20	0.322	0.488	0.833
t to t+1	492	1.79	2.35	0.036**	0.053*	0.022**
t+1 to t+2	435	1.00	0.48	0.209	0.292	0.625
t+2 to t+3	395	0.75	-0.08	0.723	0.687	0.929
t+3 to t+4	347	0.27	1.08	0.283	0.747	0.337
t-1 to t+1	493	2.24	2.78	0.043**	0.072*	0.018**
t-1 to t+2	437	2.31	2.26	0.128	0.180	0.101
t-1 to t+3	394	1.26	1.96	0.429	0.513	0.199
t-1 to t+4	350	1.04	1.20	0.599	0.423	0.513

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

5.2.2 Results for Abnormal Operating Performance in the Electrical and Electronics Related Industries

Table 5.3 presents the abnormal operating performance over the four-year period (from year *t+1* to year *t+4*) for the sample firms in the EEIs. Similar to the analysis in the full sample, we tested the pre-event bias from year *t*-2 to year *t*-1. From *Table 5.3*, we see that the abnormal performances between sample and control firms in the EEIs from year *t*-2 to year *t*-1 are not significant. Therefore, we have reason to believe that the sample firms and the selected control firms had similar pre-event performance before the announcements of TNPs. Over the four-year period, most of the results are strongly negative and statistically significant. More specifically, there were significant decreases in ROA in the periods "*t*-1 to *t*+1", "*t*-1 to *t*+2", "*t*-1 to *t*+3" and "*t*-1 to *t*+4", with -3.08% ($p < 0.001$), -2.34% ($p < 0.001$), -1.85% ($p < 0.05$) and -2.61% ($p < 0.001$), respectively. The results are similar when abnormal performances in ROS were tested. Though there is no negatively significant result found in SOA, the median changes are negative for most time periods.

In Chapter 4, we found that the short-term stock market reactions on TNPs are positively significant in the EEIs. However, when we examined the long-term operating performance changes in the EEIs, we found that firms in these industries suffered financial loss after introducing TNPs. This is in conflict with what stock market reactions indicate. This interesting finding also provides some empirical evidence to investors' over-reaction to good news, such as introductionsof TNPs.

Table 5. 3 Samples Firms in the EEIs: Abnormal Operating Performance (Performance-Size-SIC-2-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	181	0.12	1.72	0.331	0.766	0.161
t to t+1	173	-1.09	-1.20	0.031**	0.094*	0.180
t+1 to t+2	152	-0.17	-2.17	0.560	0.935	0.091*
t+2 to t+3	133	0.12	0.92	0.797	0.729	0.514
t+3 to t+4	115	-0.23	-2.89	0.125	1.000	0.010**
t-1 to t+1	173	-3.08	-4.47	0.000***	0.023**	0.000***
t-1 to t+2	152	-2.34	-5.25	0.002***	0.089*	0.000***
t-1 to t+3	132	-1.85	-2.99	0.025**	0.192	0.023**
t-1 to t+4	114	-2.61	-4.57	0.006***	0.075*	0.001***

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	164	0.12	1.81	0.168	0.585	0.127
t to t+1	161	-0.58	-0.18	0.132	0.753	0.864
t+1 to t+2	141	0.04	-2.54	0.629	1.000	0.085*
t+2 to t+3	126	0.80	-0.52	0.512	0.327	0.730
t+3 to t+4	106	0.60	-0.58	0.744	0.497	0.574
t-1 to t+1	161	-1.58	-1.76	0.010**	0.040**	0.270
t-1 to t+2	142	-1.12	-5.15	0.024**	0.208	0.001***
t-1 to t+3	124	-0.68	-6.02	0.036**	0.419	0.001***
t-1 to t+4	108	-1.45	-4.85	0.125	0.386	0.015**

Table 5.3 Samples Firms in the EEIs: Abnormal Operating Performance (Performance-Size-SIC-2-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	187	1.02	0.31	0.542	0.661	0.878
t to t+1	185	0.92	3.29	0.204	0.659	0.062*
t+1 to t+2	163	0.99	2.31	0.098*	0.531	0.184
t+2 to t+3	146	1.47	1.36	0.607	0.363	0.663
t+3 to t+4	128	-0.26	-0.28	0.991	0.930	0.892
t-1 to t+1	186	-1.32	-0.58	0.611	0.714	0.782
t-1 to t+2	163	1.19	-1.19	0.717	0.876	0.628
t-1 to t+3	146	-1.58	-0.32	0.900	0.934	0.914
t-1 to t+4	129	-0.31	-3.13	0.296	0.725	0.348

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

5.2.3 Results for Abnormal Operating Performance in the Pharmaceutical and Medical Devices Related Industries

Table 5.4 presents the abnormal operating performance over the four-year period (from year *t+1* to year *t+4*) for the sample firms in the PMIs. Similar to the analysis in the full sample, we tested the pre-event bias from year *t*-2 to year *t*-1. From *Table 5.4*, we see that the abnormal performances in sample firms in the PMIs from year *t*-2 to year *t*-1 are not significant. Therefore, we have reason to believe that the sample firms and the selected control firms had similar pre-event performance before the announcement of TNPs. Over the four-year period, the results are strongly positive and statistically significant. More specifically, there were significant increase in ROA in the periods "*t*-1 to *t*+1", "*t*-1 to *t*+2", "*t*-1 to *t*+3" and "*t*-1 to *t*+4", with 4.47% ($p < 0.001$), 5.39% ($p < 0.05$), 5.41% ($p < 0.001$) and 6.54% ($p < 0.001$), respectively. The results are similar when abnormal performances in ROS (SOA) were tested.

Table 5. 4 Sample Firms in the PMIs: Abnormal Operating Performance (Performance-Size-SIC-2-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	236	0.27	0.99	0.703	0.745	0.397
t to t+1	218	0.55	-0.03	0.518	0.310	0.984
t+1 to t+2	191	0.83	0.02	0.579	0.385	0.990
t+2 to t+3	170	0.84	1.71	0.282	0.319	0.317
t+3 to t+4	155	0.92	2.69	0.143	0.335	0.184
t-1 to t+1	222	4.47	0.15	0.004***	0.000***	0.941
t-1 to t+2	191	5.39	-0.70	0.019**	0.000***	0.752
t-1 to t+3	169	5.41	2.66	0.001***	0.000***	0.257
t-1 to t+4	156	6.54	5.65	0.000***	0.000***	0.021**

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	205	0.05	18.30	0.940	1.000	0.219
t to t+1	185	1.06	22.17	0.112	0.056*	0.113
t+1 to t+2	159	0.16	-6.62	0.959	0.751	0.573
t+2 to t+3	140	-1.32	-67.64	0.027**	0.272	0.009***
t+3 to t+4	119	0.29	-24.59	0.414	1.000	0.320
t-1 to t+1	185	2.82	50.58	0.002***	0.000***	0.004***
t-1 to t+2	161	3.16	49.44	0.000***	0.000***	0.030**
t-1 to t+3	140	3.45	7.29	0.008***	0.014**	0.803
t-1 to t+4	121	4.59	-1.57	0.043**	0.006***	0.961

Table 5.4 Sample Firms in the PMIs: Abnormal Operating Performance (Performance-Size-SIC-2-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	233	0.19	-0.93	0.949	1.000	0.491
t to t+1	202	2.86	3.35	0.024**	0.020**	0.048**
t+1 to t+2	174	0.66	-0.65	0.950	0.705	0.655
t+2 to t+3	157	-1.38	-1.84	0.808	0.425	0.288
t+3 to t+4	141	1.49	1.98	0.151	0.312	0.230
t-1 to t+1	202	5.83	7.58	0.000***	0.002***	0.000***
t-1 to t+2	175	3.77	7.53	0.005***	0.096*	0.001***
t-1 to t+3	156	3.60	5.06	0.070*	0.093*	0.035**
t-1 to t+4	143	7.55	7.33	0.018**	0.045**	0.011**

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5.5 summarizes the significance levels in abnormal performance in ROA among the sample firms in all industries, sample firms in the PMIs and sample firms in the EEIs. Comparing the overall patterns of abnormal performance changes in ROA shown in *Table 5.5*, there is a sharp and apparent difference between firms in the EEIs and firms in the PMIs. The performance improvement in ROA after the introductions of TNPs is stronger in the PMIs. Firms in the EEIs in fact suffered from a decrease in ROA after introducing a TNP. Therefore, *H6* is supported. We found that the introduction of TNPs in the PMIs leads to stronger positive abnormal performance in ROA than that in the EEIs.

Table 5. 5 Summary of Significance in Abnormal Performance in ROA among Three Groups of Sample Firms

	All Industries				EEIs				PMIs			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	510				181				236			
t to t+1	477				173	(**)	(*)		218			
t+1 to t+2	420			(*)	152			(*)	191			
t+2 to t+3	374				133				170			
t+3 to t+4	330				115			(**)	155			
t-1 to t+1	479		**		173	(***)	(**)	(***)	222	***	***	
t-1 to t+2	422		**	(**)	152	(***)	(*)	(***)	191	**	***	
t-1 to t+3	374		*		132	(**)		(**)	169	***	***	
t-1 to t+4	334		**		114	(***)	(*)	(***)	156	***	***	**

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5.6 summarizes the significance levels in abnormal performance in ROS among the sample firms in all industries, sample firms in the PMIs and sample firms in the EEIs. Comparing the overall patterns of abnormal performance changes in ROS shown in *Table 5.6*, there is a clear difference between firms in the EEIs and firms in the PMIs. The performance improvement in ROS after the introductions of TNPs is strongly positive in the PMIs. In contrast, firms in the EEIs suffered from a decrease in ROS after the introductions of TNPs. Therefore, the *H7* is supported. We found that TNPs introduced in the PMIs are associated with greater improvement in ROS than those introduced in the EEIs.

Table 5. 6 Summary of Significance in Abnormal Performance in ROS among Three Groups of Sample Firms

	All Industries				EEIs				PMIs			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	470				164				205			
t to t+1	436			**	161				185		*	
t+1 to t+2	387			(**)	141			(*)	159			
t+2 to t+3	346			(***)	126				140	(**)		(***)
t+3 to t+4	298			(*)	106				119			
t-1 to t+1	439			***	161	(**)	(**)		185	***	***	***
t-1 to t+2	386			**	142	(**)		(***)	161	***	***	**
t-1 to t+3	345				124	(**)		(***)	140	***	**	
t-1 to t+4	301				108			(**)	121	**	***	

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5.7 summarizes the levels of significance in abnormal performance in SOA among the sample firms in all industries, sample firms in the PMIs and sample firms in the EEIs. As shown in *Table 5.7*, comparing the overall patterns of abnormal performance changes in SOA in the EEIs to those in the PMIs, there a clear difference. The performance improvement in SOA after the introduction of TNPs is strongly positive in the PMIs, but not in the EEIs. Therefore, the *H8* is supported. We found that TNPs introduced in the PMIs are associated with higher SOA than those introduced in the EEIs.

Table 5. 7 Summary of Significance in Abnormal Performance in SOA among Three Groups of Sample Firms

	All Industries				EEIs				PMIs			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	533				187				233			
t to t+1	492	**	*	**	185			*	202	**	**	**
t+1 to t+2	435				163	*			174			
t+2 to t+3	395				146				157			
t+3 to t+4	347				128				141			
t-1 to t+1	493	**	*	**	186				202	***	***	***
t-1 to t+2	437				163				175	***	*	***
t-1 to t+3	394				146				156	*	*	**
t-1 to t+4	350				129				143	**	**	**

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

5.3 Cross-Sectional Regression Analysis of Abnormal Operating Performance

This section presents some analyses of the other variables that might explain the abnormal operating performance associated with the introductions of TNPs. The market would need some time to evaluate and accept the TNPs. Two years after product introductions seems to be a reasonable time period since it is neither too short for organizations to fully capture the market nor too long that TNPs might enter the decline stage of their product life cycle. Therefore, we develop several multiple-regression models, examining how firm-level and industry-level variables influence the abnormal ROA over the three-year period (from year -1 to year 2). Each sample firm's industry is defined as all firms that have the same three-digit SIC code as that of the sample firm. We consider the following variables.

- *Firm Size*: The abnormal ROA of a firm with TNPs introductions will be more positive for larger firms. Larger firms could have more resources to develop better marketing programs for promoting the TNP. They might dedicate more resources (e.g., sales force) to facilitate the product commercialization. Firm size is measured as the natural logarithm of sales in year *t-1* (the base year).

- *Industry Size and Industry ROA*: Although there are many industry variables that can influence firm abnormal performance, we focus on analyzing the effect of industry financial attractiveness on abnormal ROA. We predict that the more profitable or larger the industry, the more positive will be the impact of TNPs introductions on abnormal ROA. Firms operating in industries which are more profitable have more to gain from introducing TNPs. We use two variables to measure an industry's financial attractiveness, which are industry size and industry ROA. Industry size is measured as the natural log of sales at year t-1 in an industry and industry ROA is measured as the median ROA in year t-1.

We also include the following control variables.

- Industry concentration: We use the Herfindahl index (HI) to measure industry concentration. In a highly concentrated industry (high HI) where competition among firms is low, firms could focus on more incremental product improvements to gain profits. However, firms need to develop TNPs to help them gain competitive advantages in a highly competitive industry (low HI). Firms might achieve higher abnormal performance in ROA by introducing TNPs in industries with low HI (i.e., highly competitive industries).
- *Prior industry sales growth*: measured as the percentage change in industry sales from year -2 to year -1.
- *Firm and Industry R&D Intensity*: We estimate each *firm's R&D intensity* as the difference between the R&D/Sales of the sample firm and the median R&D/Sales of its industry at year t-1. *Industry R&D Intensity* is measured as the median R&D/Sales in year t-1.

- *Industry Groups*: To control the inter-industry difference in appropriating returns from TNPs, we create two indicator variables to represent two industry groups: 1) EEIs=1, PMIs=2 and 0 otherwise.

Table 5.8 reports the cross-sectional regression results. Our dependent variable in the model is abnormal ROA from year -1 to year 2 obtained based on the performance-industry-size-matched method. Overall, *F*-values are greater than 3.75 for all models, an indication that the models are significant at the 1% level or better. Adjusted R^2 values ranges from 7.1% to 11.40%, which are comparable to those observed in previous studies on cross-sectional regression models that attempt to explain abnormal performance (e.g., Hendricks and Singhal, 2008).

As predicted, the coefficient of firm size is positive and statistically significant at the 1% level, based on a two-tailed test. Therefore, larger firms gain more abnormal ROA by introducing TNPs as compared to smaller firms. These results are consistent across five models.

Contradictory to our prediction, we observe that an industry's financial attractiveness is negatively correlated to abnormal ROA. Both of the coefficients of *industry size* and *Industry ROA* are negative and statistically significant. This indicates firms operating in less profitable industries gain more abnormal ROA by introducing TNPs when compared with firms operating in more profitable industries. It implies that introducing TNPs is a more important strategy for firms in less profitable industries to perform better;

they can leverage the opportunities by introducing TNPs.

The results also indicate that *prior industry sales growth* and *industry concentration* do not have a significant effect on abnormal ROA. Similar results could also be found in *Industry and Firm R&D Intensity*.

Model 4 and Model 5 gives the regression results that include industry group as a control variable. In Model 4, the coefficient of the EEIs is negative and statistically significant. It implies that firms operating in these industries gain lower abnormal ROA from introducing TNPs compared to their peers. However, in Model 5, the coefficient of the PMIs is positive and statistically significant. It indicates that firms operating in these industries gain higher abnormal ROA from introducing TNPs compared to their industry peers. These findings also confirm our main testing results from event study.

Table 5. 8 Estimated Coefficents (t-Statistics in Parentheses) from Regressions of Abnormal ROA Change from Year -1 to Year 2 (Performance-Size-SIC-2-digit)

Independent Variables		**Model 1**			**Model 2**			**Model 3**			**Model 4**			**Model 5**	
Intercept	20.489	(1.882)	*	24.789	(2.158)	**	23.680	(1.935)	*	11.505	(0.893)		-9.388	(-0.625)	
Size and Performance															
Firm size +	1.514	(3.924)	***	1.645	(4.161)	***	1.890	(4.296)	***	1.767	(4.030)	***	1.890	(4.322)	***
Industry size -	-2.436	(-2.515)	**	-2.824	(-2.813)	***	-2.833	(-2.562)	**	-1.446	(-1.202)		-0.531	(-0.427)	
Industry ROA -	-0.505	(-5.199)	***	-0.503	(-4.995)	***	-0.518	(-2.481)	**	-0.368	(-1.720)	*	0.130	(0.459)	
Industry Sales Characteristics															
Industry concentration (Herfindahl index)				-13.250	(-1.091)		-13.558	(-1.074)		-8.162	(-0.645)		4.278	(-0.328)	
Industry sales growth				9.271	(0.881)		10.691	(0.931)		6.200	(0.539)		-3.947	(0.319)	
R&D intensity															
Industry R&D intensity							2.189	(0.214)		3.682	(0.363)		-5.501	(-0.517)	
Firms' R&D intensity							-2.018	(-0.198)		-3.547	(-0.351)		5.603	(0.528)	
Industry Groups															
Electrical and Electronics										-7.543	(-2.791)	***	-2.824	(-0.878)	
Medical and Pharmaceutical													13.640	(2.653)	***
Number of observations		408			408			385			385			385	
Model F value		10.387	***		6.692	***		4.588	***		5.061	***		5.353	***
R squared (%)		7.10			7.70			7.80			9.70			11.40	
Adjusted R squared (%)		6.50			6.50			6.10			7.80			9.20	

Note: Significance levels (two-tailed tests) of independent variables: p<0.1*; p<0.05<**;p<0.01***

5.4 Test of The Robustness of Results

5.4.1 Description of Robustness Testing Models

Besides selecting control portfolio for each sample firm based on prior performance (90% to 110% of sample firm's ROA, ROS or SOA), firm size (33% to 300% of the sample firm's total assets) and industry (2-digit SIC code) (i.e., the "Performance-Size-SIC-2-digit" model), we also employed two other two models of portfolio selection to test the robustness of the findings.

We labeled the first model in robustness testing as the "Performance-Size-SIC-3-digit" model. The only difference between this model and the "Performance-Size-SIC-2-digit" model is that we put a stricter constraint on industry matching. In the "Performance-Size-SIC-3-digit" model, we selected a control portfolio for each sample firm based on prior performance (90% to 110% of sample firm's ROA, ROS or SOA), firm size (33% to 300% of the sample firm's total assets) and industry (3-digit SIC code). This model has tighter requirements when selecting control portfolio for each sample firm.

The second model in robustness testing is the "Performance-SIC-2-digit" model. The difference between this model and the "Performance-Size-SIC-2-digit" model is that we relaxed the matching constraint on firm size. In the "Performance-SIC-2-digit" model, we selected a control portfolio for each sample firm based on prior performance (90% to 110% of sample firm's ROA, ROS or SOA) and industry (2-digit SIC code), but not on firm size. Accordingly, this model has looser requirements when selecting control portfolio for each sample firm.

5.4.2 Robustness Testing Results

Table 5.9 presents the summary of significance levels in abnormal performance in ROA among "Performance-Size-SIC-2-digit" model, "Performance-Size-SIC-3-digit" model and "Performance-SIC-2-digit" model for the sample firms in all industries. Similarly, *Table 5.10* and *5.11* present the summary of significance levels in abnormal performance in ROS and SOA, respectively, among the three models. For detailed testing results, please refer to *Appendix A.* From *Table 5.9,* we could find that the patterns of significance levels are similar across three models. The two models for robustness testing also indicate that TNPs could lead to higher ROA. From *Table 5.10* and *Table 5.11*, we could find that the patterns of significance levels are also similar across the three models. The two models for robustness testing indicate that TNPs could lead to higher ROS and SOA; however, these higher ROS and SOA could not last long.

Table 5. 9 Summary of Significance in Abnormal Performance in ROA among Three Models for Sample Firms in All Industries

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC-2-digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	510				385				601			
t to t+1	477				356				568			
t+1 to t+2	420			*	304				507		**	
t+2 to t+3	374				271		*		462			
t+3 to t+4	330				231				416			
t-1 to t+1	479		**		357	*	***		572	**	***	
t-1 to t+2	422		**	(**)	305				509	*	***	
t-1 to t+3	374		*		272	*	**		463	***	***	
t-1 to t+4	334		**		232	**	***		416	***	***	**

**p* < 0.1; ***p* < 0.05; ****p* < 0.01

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5. 10 Summary of Significance in Abnormal Performance in ROS among the Three Models for Sample Firms in All Industries

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC-2-digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	470				357				578			
t to t+1	436			**	323			**	543	**	***	**
t+1 to t+2	387			(**)	281			(*)	480		*	(**)
t+2 to t+3	346			(***)	243	(***)	(*)	(***)	436			(***)
t+3 to t+4	298			(*)	207				383			(***)
t-1 to t+1	439			***	323			***	540	*		***
t-1 to t+2	386			**	282			**	483			
t-1 to t+3	345				245				432			
t-1 to t+4	301				209				385			

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5. 11 Summary of Significance in Abnormal Performance in SOA among Three Models for Sample Firms in All Industries

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC-2-digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	533				438				599			
t to t+1	492	**	*	**	395	*		**	561			
t+1 to t+2	435				345				502			
t+2 to t+3	395				301				456			
t+3 to t+4	347				260				409			
t-1 to t+1	493	**	*	**	396	*		**	563	*		**
t-1 to t+2	437				344				504			
t-1 to t+3	394				299				456			
t-1 to t+4	350				262				411			

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The p-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's t-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5.12 presents the summary of significance levels in abnormal performance in ROA among "Performance-Size-SIC-2-digit" model, "Performance-Size-SIC-3-digit" model and "Performance-SIC-2-digit" model for samples firms in the EEIs. Similarly, *Table 5.13* and *5.14* present the summary of significance levels in abnormal performance in ROS and SOA, respectively, among the three models. For detailed testing results, please refer to *Appendix B.* From *Table 5.12,* we could find that similar patterns of significance levels across three models. The two models for robustness testing also indicate that TNPs lead to lower ROA in the EEIs. From *Table 5.13* and *Table 5.14*, we could find that the patterns of significance levels are also similar across the three models. The two models for robustness testing indicate that TNPs lead to lower ROS and no improvement in SOA in the EEIs.

Table 5. 12 Summary of Significance in Abnormal Performance in ROA among Three Models for Sample Firms in the EEIs

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC-2-digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	181				108				203			
t to t+1	173	(**)	(*)		100	(**)	(***)		203			
t+1 to t+2	152			(*)	87				178			
t+2 to t+3	133				77				161			
t+3 to t+4	115			(**)	61				144			
t-1 to t+1	173	(***)	(**)	(***)	101			(*)	204	(**)		(**)
t-1 to t+2	152	(***)	(*)	(***)	87	(**)		(**)	178	(*)		(**)
t-1 to t+3	132	(**)		(**)	78				162			(**)
t-1 to t+4	114	(***)	(*)	(***)	61	(*)		(*)	144	(*)		(**)

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5. 13 Summary of Significance in Abnormal Performance in ROS among Three Models for Sample Firms in the EEIs

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC 2 digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	164				110				200			
t to t+1	161				102				197			
t+1 to t+2	141			(*)	93				172			
t+2 to t+3	126				77				156			
t+3 to t+4	106				63				136			
t-1 to t+1	161	(**)	(**)		104				198	(**)		
t-1 to t+2	142	(**)		(***)	94	(**)			171			(***)
t-1 to t+3	124	(**)		(***)	77	(**)			156			(**)
t-1 to t+4	108			(**)	63				134			(**)

**p* < 0.1; ***p* < 0.05; ****p* < 0.01

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5. 14 Summary of Significance in Abnormal Performance in SOA among Three Models for Sample Firms in the EEIs

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC 2 digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	187				132				212			
t to t+1	185			*	127				207			
t+1 to t+2	163	*			112				179			
t+2 to t+3	146				93				162			
t+3 to t+4	128				78				143			
t-1 to t+1	186				128				208			
t-1 to t+2	163				112				179			
t-1 to t+3	146				94				162			
t-1 to t+4	129				79				143			

*p < 0.1; **p < 0.05; ***p < 0.01

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5.15 presents the summary of significance levels in abnormal performance in ROA among the "Performance-Size-SIC-2-digit" model, the "Performance-Size-SIC-3-digit" model and the "Performance-SIC-2-digit" model for samples firms in the PMIs. Similarly, *Table 5.16* and *5.17* present the summary of significance levels in abnormal performance in ROS and SOA, respectively, among the three models. For detailed testing results, please refer to *Appendix C.* From *Table 5.15,* we find that similar patterns of significance levels across three models. The two models for robustness testing also indicate that TNPs lead to higher ROA in the PMIs. From *Table 5.16* and *Table 5.17*, we find that the patterns of significance levels are also similar across the three models. The two models for robustness testing indicate that TNPs lead to higher ROS and SOA in the PMIs.

Table 5. 15 Summary of Significance in Abnormal Performance in ROA among the Three Models for Sample Firms in the PMIs

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC 2 digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	236				210				256			
t to t+1	218				196				243			
t+1 to t+2	191				164				212		**	
t+2 to t+3	170				142				190			
t+3 to t+4	155				127				174			
t-1 to t+1	222	***	***		196	***	***		243	***	***	
t-1 to t+2	191	**	***		164		***		212	***	***	
t-1 to t+3	169	***	***		142	**	***		191	***	***	
t-1 to t+4	156	***	***	**	128	***	***	**	175	***	***	***

**p* < 0.1; ***p* < 0.05; ****p* < 0.01

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5. 16 Summary of Significance in Abnormal Performance in ROS among the Three Models for Sample Firms in the PMIs

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC 2 digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	205				173				240			
t to t+1	185		*		154				223	**	**	
t+1 to t+2	159				127				195		**	
t+2 to t+3	140	(**)		(***)	109	(***)	(**)	(***)	170	(***)	(*)	(***)
t+3 to t+4	119				95				155			**
t-1 to t+1	185	***	***	***	154	***	**	***	223	***	***	***
t-1 to t+2	161	***	***	**	127	***	**	*	195	***	***	*
t-1 to t+3	140	***	**		111	**	*		171	***	***	
t-1 to t+4	121	**	***		95				156	***	***	

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Table 5. 17 Summary of Significance in Abnormal Performance in SOA among the Three Models for Sample Firms in the PMIs

	Performance-Size-SIC-2-digit				Performance-Size-SIC-3-digit				Performance-SIC 2 digit			
Time Period	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]	N [a]	WSR [b]	Sign [b]	t-Test [b]
t-2 to t-1	233				214				253			
t to t+1	202	**	**	**	182	***	**	***	226	***	***	**
t+1 to t+2	174				154				200			
t+2 to t+3	157				140				179			
t+3 to t+4	141				123				166			
t-1 to t+1	202	***	***	***	182	***	**	***	227	***	***	***
t-1 to t+2	175	***	*	***	155	***	**	***	201	***	*	***
t-1 to t+3	156	*	*	**	140	**	*	***	180	*		**
t-1 to t+4	143	**	**	**	124	***	***	***	167			*

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

5.5 Discussions

In this research part, we examine the long-term operating performance changes (in terms of ROA, ROS and SOA) associated with TNPs to obtain a full picture regarding the financial impacts of TNPs. We started by examining the overall financial impacts associated with TNPs (regardless of the industrial types). We matched the sample firms to a portfolio of control firms with similar firm size, firm performance and the same 2-digit SIC code. In our full sample, we found that long-term financial gains associated with TNPs are rather limited. ROA, which indicates how effective a firm uses its assets, only increases from 1.25% to 1.44% during a four-year period after the introduction of TNPs. The other two performance indicators, ROS and SOA, are not much improved. This implies that TNPs do not necessarily enhance the competitive advantage of a firm to a large extent.

This finding is contradictory to the largely held faith that the financial performance of firms improves when they have introduced TNPs. Instead, our research echoes some findings of other previous studies that developing technology innovations or introductions of TNPs often go with a high failure rate due to several types of risks and uncertainties. TNPs thus do not guarantee positive financial returns. For example, Asplund and Sandin (1999) and Cozijnse *et al.* (2000) find that only one out of every five new product development projects would be successful. Studies also find that developing TNPs is not the only strategic choice that a firm could choose to enhance competitive advantages.

Strong operating firms that cleverly use existing products and product lines with a minimum of investment could potentially outperform truly innovating firms (Chaney *et al.* 1991).

Our finding pose some challenges to the knowledge-based view (KBV) that we find that technological innovations (TNPs in this study), as a valuable resource to firms, do not seem to guarantee competitive advantages. Drawing upon the contingency theory, we argue that there might be some exogenous factors (industry characteristics in this study) that moderate the impact of TNPs on firm performance. We tested a contingent factor by specifically focusing on two major industrial sectors that are under rapid technology development in the past decades – the PMIs and the EEIs. As discussed in our theoretical development (Chapter 2), we argue that TNPs in the PMIs is generally demand-triggered and knowledge-facilitated. TNPs in the EEIs, on the other hand, are generally pushed by advances in scientific and technological knowledge (Adner and Levinthal, 2001; Ende and Dolfsma, 2005; Workman, 1993). The empirical evidence presented in this chapter provides support to the above argument and suggests a contingent role played by industry characteristics. We found that TNPs in the PMIs greatly enhance the financial performance of the introducing firms (i.e., a jump of 5.39% in ROA in the first two years after introducing TNPs). However, TNPs in the EEIs are negatively related to financial performance of the introducing firms (i.e., a drop of 2.34% in ROA in the first two years after introducing TNPs). We suggest that the argument that valuable knowledge (e.g. technological innovations) leads to superior financial implications is not generic to all firms but holds true only under certain conditions - industry characteristics is an important moderating factor.

Another interesting finding is that we found some inconsistency between the stock market reactions to TNPs introductions and their impacts on operating performance. According to traditional theory on stock market efficiency, securities are rationally priced to reflect all publicly available information (cf. Fama, 1991). However, in recent years a body of evidence has presented a sharp challenge to this traditional theory. Some studies conclude that the market under-reacts to information (e.g. Womack, 1996; Michaely et al., 1995), while others find evidence of overreaction (e.g. Chopra, *et al.*, 1992; Cornett, *et al.*, 1998).

If the argument on stock market efficiency holds true, we would expect to see improved financial performance when the TNPs are introduced to the market. However, when we further examined the later operating performance changes, it seems that there is a conflict between the reactions of the stock market and the actual long-term financial impact. In particular, this is particularly the case in the EEIs – while the stock market reactions are positive and significant, the long-term operating performance after the introduction of TNPs is negative and significant. This empirical finding, like some other studies in the finance literature, also challenges to the argument on stock market efficiency.

In fact, previous research highlights that the stock market is sometimes governed by social dynamics that sometimes compromise market efficiency (Zajac and Westphal, 2004). Studies of trader markets have shown that investors often make investment decisions based on collectively believed evaluation rather than individual assessment of a firm's economic performance (Abolafia, 1996; Cetina & Bruegger, 2002). Technological innovations are widely believed to be a major source of competitive advantages among investors, while their actual financial impact to individual firms is not widely known (or cannot be accurately evaluated by investors). Under this circumstances, the signaling effect of technological innovations for competitive advantages, rather than actual gains in competitive advantages (e.g., real financial gains), appear to have a more important to investors.

5.6 Conclusion of Research Part Two

In this chapter, we examined the long term operating performance changes after the introductions of TNPs. By selecting a portfolio of control firms for each sample firm with similar firm performance and firm size, we compared the performance changes between sample firms and their corresponding control portfolios. We found that TNPs do not necessarily lead to higher abnormal financial gains – while TNPs lead to an abnormal ROA of 5.39% in the PMIs in the first two years of their introductions, they lead to a drop in ROA of -2.34% in the EEIs during the same period of time. Cross-sectional analysis further confirms this interesting finding and further indicates that firm size moderates the impact of TNPs on abnormal operating performance. Larger firms could gain more from introducing TNPs compared to smaller ones. It might be due to the reasons that larger firms could have more resources for developing such a technologically new product, designing better marketing programs to promote products, dedicating more manpower (R&D personnel, sales force) to facilitate the product commercialization.

Another interesting finding from this chapter is the existence of some inconsistency between the stock market reactions on TNPs introductions and the later impacts on operating performance. We argue that this finding provides empirical evidence on the argument of stock market inefficiency.

We also employed two other control models to examine the robustness of our findings and found that the results are very similar across the Performance-Size-SIC-2-digit model, the Performance-Size-SIC-3-digit model and the Performance-SIC 2 digit model. Our results appear to be rather robust.

Chapter 6 Conclusions

6.1 Summary of Major Findings

This study examined the financial implications (in terms of stock market reactions, ROA, ROS and SOA) of TNPs which were introduced to the markets between 1985 and 2008. We further investigated the role of industry characteristics in moderating the financial impacts associated with TNPs. In Research Part One, we examined the short-term stock market reactions to the introduction of TNPs. The estimation was based on the OLS-market model, which compares the actual stock returns to the stock returns that would be expected without the introduction of TNPs. We found that stock market reactions on TNPs announcements are generally positive and significant. Investors favored the introduction of TNPs and expected a higher financial performance in the future. The stock return increases by 2.30% on average during a two-day period (day -1 to 0), while Day 0 accounts for 74% of the total increase. We further compared the stock market reactions on the introductions of TNPs in two major types of industries with high technological developments in the past decades – the PMIs and the EEIs. We found that stock market reactions on the introductions of TNPs are generally positive and significant in both industries.

In Research Part Two, we considered the potential limitations of short-term stock market reactions and examined the long-term operating performance changes (in terms of ROA, ROS and SOA) associated with TNPs. We compared the sample firms with TNPs introductions to a portfolio of control firms with similar firm size, firm performance and in the same 2-digit SIC code but without TNPs introductions. We found that TNPs do not necessarily bring higher abnormal operating performance – while TNPs lead to an abnormal ROA of 5.39% in the PMIs in the first two years of their introductions, they result in a drop of 2.34% in ROA in the EEIs during the same period of time. While stock market reacts positively to TNPs in the EEIs, they do not necessarily lead to higher abnormal operating performance in the long-run. This finding provides some empirical support to the argument that the stock market is not necessarily efficient.

6.2 Limitations of This Study

In this research we examined the financial consequences of TNPs in the EEIs over a four year period. One might argue that for products in the EEIs, their product life cycle (PLC) could be very short (e.g., less than a year for some products). An investigation over a four year period might be too long that includes some noises in the final results. We argue that this short PLC might be applicable to new products in the EEIs in which the core technologies are already very mature. In our study, the focus is on new products which incorporates advanced or breakthrough technologies. Studies find that technology cycle time is as short as 3-4 years in rapidly changing industries, such as electronics, and as long as 8-9 years in drugs and medicine (Deng et al., 1999; Terwiesch et al., 1998). By choosing a four-year period, we attempted to strike a balance.

6.3 Suggestions on Future Study

In this research, we collected the financial data at the firm-level. Firms may be diversified into different product markets and have different business lines. Therefore, it would be worthwhile to replicate this study if there is possibility to identify the business lines that TNPs belong to and estimate the corresponding financial data in the business lines.

A boarder examination of the relationship between technology innovations and firm performance may be a promising area of research. It will be useful to link TNPs to other measures of firm performance, such as sales growth rate. It might also be interesting to examine the relationship between TNPs and senior executive compensation in the introducing firms. Developing advanced or breakthrough technologies and commercializing them is a risky process and the whole process needs support from senior management. For example, will senior executives in the introducing firms of TNPs be rewarded with higher compensation upon the introduction of TNPs in both the PMIs and the EEIs? An answer to this type of questions would provide valuable sights into the impacts of TNPs in introducing firms.

It is also worthwhile investigating the performance differences between firms with TNPs and firms with only general new product introductions (e.g. product updates, incremental product improvements), using objective data. Future studies on this aspect would provide further empirical evidence on the financial values of

TNPs.

6.4 Implications for Academics and Practitioners

This study contributes to several areas of management literature. This is the first study which directly examines the financial consequences of TNPs with objective financial and using event-study methodologies. We found that TNPs do not necessarily lead to higher financial performance. In particular, previous studies did not examine the contingent factors like the industry characteristics. We found that industry characteristics play a significant role in moderating the financial impacts of TNPs.

We examined the stock market reactions as well as the long-term operating performance after the introduction of TNPs. It is interesting to find although stock market reacts positively to TNPs in the EEIs, they do not necessarily lead to higher profits in long-term. Therefore, we provided some empirical evidence that the stock market is not necessarily efficient. Technological innovations are widely believed to be a major source of competitive advantages among investors, while their actual financial impact to individual firms may not be positive. This finding also provides some practical implications to practitioners in the EEIs – the introduction of TNPs does not guarantee positive financial returns.

Appendix A

Appendix A (1) Sample Firms in All Industries: Abnormal Operating Performance (Performance-SIC-2-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	601	-0.20	0.79	0.751	0.253	0.186
t to t+1	566	0.19	-0.97	0.856	0.475	0.147
t+1 to t+2	507	0.64	-0.24	0.420	0.013**	0.734
t+2 to t+3	462	0.08	-0.47	0.773	0.816	0.505
t+3 to t+4	416	0.10	0.87	0.589	0.659	0.325
t-1 to t+1	572	1.63	-0.29	0.039**	0.001***	0.706
t-1 to t+2	509	1.78	-0.66	0.069*	0.005***	0.464
t-1 to t+3	463	2.56	0.18	0.004***	0.000***	0.858
t-1 to t+4	416	2.75	2.19	0.001***	0.000***	0.022**

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	578	-0.45	0.81	0.152	0.180	0.774
t to t+1	543	0.76	9.01	0.029**	0.005***	0.012**
t+1 to t+2	480	0.28	-5.57	0.842	0.061*	0.026**
t+2 to t+3	436	0.01	-14.32	0.125	0.962	0.001***
t+3 to t+4	383	0.11	-10.45	0.541	0.838	0.003***
t-1 to t+1	540	0.84	7.27	0.053*	0.107	0.002***
t-1 to t+2	483	0.48	1.23	0.122	0.379	0.752
t-1 to t+3	432	1.42	0.91	0.150	0.110	0.729
t-1 to t+4	385	1.64	-3.43	0.189	0.190	0.476

Appendix A (1) Sample Firms in All Industries: Abnormal Operating Performance (Performance-SIC-2-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	599	0.31	-0.50	0.958	0.624	0.549
t to t+1	561	0.72	1.09	0.264	0.554	0.208
t+1 to t+2	502	-0.01	0.00	0.662	1.000	0.982
t+2 to t+3	456	0.39	-0.68	0.691	0.743	0.410
t+3 to t+4	409	0.61	0.68	0.452	0.373	0.474
t-1 to t+1	563	0.86	1.57	0.071*	0.500	0.020**
t-1 to t+2	504	-0.58	1.10	0.488	0.755	0.381
t-1 to t+3	456	-0.90	-0.17	0.627	0.606	0.902
t-1 to t+4	411	-1.42	-1.19	0.299	0.324	0.454

**p* < 0.1; ***p* < 0.05; ****p* < 0.01

[a] *"N"* indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Appendix A (2) Sample Firms in All Industries: Abnormal Operating Performance (Performance-Size-SIC-3-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	385	0.26	1.24	0.162	0.210	0.262
t to t+1	356	-0.16	-0.46	0.537	0.491	0.677
t+1 to t+2	304	-0.25	-1.66	0.435	0.606	0.145
t+2 to t+3	271	0.90	1.01	0.196	0.089	0.372
t+3 to t+4	231	1.13	1.75	0.225	0.114	0.197
t-1 to t+1	357	2.03	0.18	0.061*	0.006***	0.890
t-1 to t+2	305	0.93	-2.11	0.944	0.252	0.132
t-1 to t+3	272	2.41	0.25	0.052*	0.025**	0.876
t-1 to t+4	232	2.72	2.32	0.042**	0.007***	0.124

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	357	0.00	9.36	0.278	1.000	0.141
t to t+1	323	0.55	12.17	0.361	0.182	0.036**
t+1 to t+2	281	0.04	-7.91	0.815	0.905	0.091*
t+2 to t+3	243	-0.94	-23.69	0.005***	0.072*	0.002***
t+3 to t+4	207	-0.13	2.45	0.774	0.889	0.888
t-1 to t+1	323	0.50	16.97	0.290	0.182	0.002***
t-1 to t+2	282	0.03	15.13	0.275	0.953	0.015**
t-1 to t+3	245	0.72	-1.26	0.637	0.701	0.884
t-1 to t+4	209	0.34	12.55	0.675	0.678	0.510

Appendix A (2) Sample Firms in All Industries: Abnormal Operating Performance (Performance-Size-SIC-3-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	438	-0.43	-0.83	0.586	0.599	0.473
t to t+1	395	2.72	2.77	0.054*	0.107	0.030**
t+1 to t+2	345	-0.48	-0.08	0.710	0.914	0.948
t+2 to t+3	301	0.76	0.39	0.540	0.489	0.761
t+3 to t+4	260	-0.13	0.19	0.571	0.951	0.894
t-1 to t+1	396	1.25	3.50	0.076*	0.291	0.015**
t-1 to t+2	344	1.77	1.13	0.418	0.359	0.463
t-1 to t+3	299	0.30	1.30	0.361	0.908	0.453
t-1 to t+4	262	2.57	2.11	0.276	0.294	0.344

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Appendix B

Appendix B (1) Sample Firms in the EEIs: Abnormal Operating Performance (Performance-SIC-2-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	203	-0.70	0.71	0.811	0.326	0.463
t to t+1	203	-0.52	-1.95	0.299	0.483	0.114
t+1 to t+2	178	0.68	-0.93	0.775	0.410	0.391
t+2 to t+3	161	-0.24	-1.54	0.442	0.875	0.199
t+3 to t+4	144	-0.32	-1.27	0.362	0.803	0.347
t-1 to t+1	204	-1.21	-2.59	0.033**	0.234	0.011**
t-1 to t+2	178	-0.92	-3.26	0.074*	0.261	0.013**
t-1 to t+3	162	-1.69	-3.18	0.102	0.480	0.028**
t-1 to t+4	144	-0.98	-3.08	0.059*	0.359	0.017**

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	200	-0.43	0.83	0.511	0.437	0.401
t to t+1	197	0.33	0.93	0.934	0.476	0.437
t+1 to t+2	172	0.19	-3.32	0.911	0.703	0.114
t+2 to t+3	156	0.31	-2.20	0.968	0.575	0.188
t+3 to t+4	136	0.60	1.06	0.662	0.265	0.367
t-1 to t+1	198	-0.74	-2.19	0.041**	0.286	0.141
t-1 to t+2	171	-0.05	-6.85	0.108	1.000	0.002***
t-1 to t+3	156	0.41	-3.85	0.454	0.378	0.025**
t-1 to t+4	134	-0.04	-5.02	0.418	1.000	0.013**

Appendix B (1) Sample Firms in the EEIs: Abnormal Operating Performance (Performance-SIC-2-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	212	2.01	-0.28	0.543	0.192	0.874
t to t+1	207	-0.60	1.31	0.696	0.781	0.440
t+1 to t+2	179	1.33	1.27	0.152	0.765	0.411
t+2 to t+3	162	0.18	-0.12	0.898	1.000	0.935
t+3 to t+4	143	-0.26	0.61	0.700	1.000	0.746
t-1 to t+1	208	-2.49	-1.57	0.278	0.188	0.435
t-1 to t+2	179	-3.67	-2.67	0.235	0.232	0.237
t-1 to t+3	160	-3.80	-1.55	0.248	0.133	0.546
t-1 to t+4	140	-3.18	-2.78	0.112	0.151	0.326

$*p < 0.1$; $**p < 0.05$; $***p < 0.01$

[a] *"N"* indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Appendix B (2) Sample Firms in the EEIs: Abnormal Operating Performance (Performance-Size-SIC-3-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	108	0.17	1.89	0.207	0.923	0.212
t to t+1	100	-2.77	-1.18	0.042**	0.007***	0.287
t+1 to t+2	87	0.17	-1.93	0.748	0.830	0.312
t+2 to t+3	77	0.80	1.34	0.686	0.494	0.486
t+3 to t+4	61	1.14	-0.61	0.917	0.442	0.687
t-1 to t+1	101	-0.83	-2.58	0.128	0.426	0.058*
t-1 to t+2	87	-2.30	-4.64	0.027**	0.284	0.013**
t-1 to t+3	78	-1.76	-1.65	0.413	0.428	0.451
t-1 to t+4	61	-3.83	-3.96	0.072*	0.306	0.062*

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	108	1.66	2.27	0.159	0.590	0.290
t to t+1	102	0.89	0.79	0.530	0.678	0.373
t+1 to t+2	93	0.04	1.87	0.378	0.606	1.000
t+2 to t+3	77	-0.31	-2.30	0.174	0.346	0.649
t+3 to t+4	63	0.46	0.78	0.612	0.676	0.801
t-1 to t+1	104	-0.61	-1.61	0.273	0.427	0.492
t-1 to t+2	94	-0.88	-3.41	0.011**	0.319	0.606
t-1 to t+3	77	-0.78	-5.71	0.028**	0.213	0.820
t-1 to t+4	63	-0.34	-3.89	0.174	0.529	1.000

Appendix B (2) Sample Firms in the EEIs: Abnormal Operating Performance (Performance-Size-SIC-3-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	132	-0.84	-0.29	0.913	0.542	0.918
t to t+1	127	0.02	0.79	0.847	1.000	0.768
t+1 to t+2	112	2.29	2.04	0.186	0.508	0.428
t+2 to t+3	93	-1.23	3.34	0.620	0.836	0.257
t+3 to t+4	78	-1.50	-2.39	0.737	0.571	0.484
t-1 to t+1	128	-2.94	-3.93	0.207	0.426	0.203
t-1 to t+2	112	-2.21	-4.11	0.341	0.777	0.214
t-1 to t+3	94	-0.95	-1.85	0.956	0.353	0.643
t-1 to t+4	79	-5.51	-4.21	0.328	0.368	0.394

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] "*N*" indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Appendix C

Appendix C (1) Sample Firms in the PMIs: Abnormal Operating Performance (Performance-SIC-2-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	256	0.01	0.78	0.956	1.000	0.393
t to t+1	241	0.49	-1.68	0.748	0.303	0.221
t+1 to t+2	212	0.95	-0.02	0.320	0.023**	0.986
t+2 to t+3	190	0.03	1.09	0.947	1.000	0.468
t+3 to t+4	174	0.54	1.84	0.181	0.255	0.342
t-1 to t+1	243	5.06	0.85	0.000***	0.000***	0.643
t-1 to t+2	212	5.42	0.48	0.003***	0.000***	0.803
t-1 to t+3	191	6.28	1.72	0.000***	0.000***	0.440
t-1 to t+4	175	6.81	7.09	0.000***	0.000***	0.001***

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	240	-0.79	11.57	0.407	0.330	0.343
t to t+1	223	1.81	16.58	0.028**	0.011**	0.278
t+1 to t+2	195	0.70	-6.34	0.845	0.032**	0.645
t+2 to t+3	170	-1.61	-63.15	0.006***	0.078*	0.002***
t+3 to t+4	155	-0.15	-81.47	0.340	0.748	0.016**
t-1 to t+1	223	3.39	38.79	0.000***	0.000***	0.000***
t-1 to t+2	195	3.59	37.19	0.002***	0.001***	0.076*
t-1 to t+3	171	4.17	9.12	0.000***	0.000***	0.640
t-1 to t+4	156	5.33	-9.79	0.003***	0.000***	0.770

Appendix C (1) Sample Firms in the PMIs: Abnormal Operating Performance (Performance-SIC-2-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	253	-0.07	-0.60	0.773	0.900	0.623
t to t+1	226	2.30	3.44	0.005***	0.004***	0.015**
t+1 to t+2	200	-1.14	-0.43	0.539	0.525	0.740
t+2 to t+3	179	1.43	-0.92	1.000	0.295	0.515
t+3 to t+4	166	1.01	0.49	0.608	0.244	0.726
t-1 to t+1	227	3.78	6.69	0.000***	0.000***	0.000***
t-1 to t+2	201	4.16	6.03	0.006***	0.067*	0.003***
t-1 to t+3	180	1.62	4.56	0.054*	0.118	0.038**
t-1 to t+4	167	2.29	4.35	0.127	0.279	0.087*

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] *"N"* indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

Appendix C (2) Sample Firms in the PMIs: Abnormal Operating Performance (Performance-Size-SIC-3-Digit)

Time Period	ROA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	210	0.51	1.78	0.577	0.190	0.212
t to t+1	196	0.55	-2.38	0.992	0.721	0.266
t+1 to t+2	164	0.03	-2.62	0.858	0.815	0.276
t+2 to t+3	142	0.71	1.02	0.472	0.557	0.612
t+3 to t+4	127	2.09	3.58	0.185	0.110	0.191
t-1 to t+1	196	5.36	1.55	0.003***	0.000***	0.501
t-1 to t+2	164	4.01	-1.55	0.108	0.001***	0.570
t-1 to t+3	142	6.39	0.95	0.011**	0.000***	0.337
t-1 to t+4	128	6.37	7.26	0.001***	0.000***	0.014**

Time Period	ROS					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	173	-0.90	9.72	0.484	0.128	0.619
t to t+1	154	0.60	18.15	0.287	0.468	0.352
t+1 to t+2	127	0.53	-13.79	0.990	0.594	0.498
t+2 to t+3	109	-3.69	-92.92	0.001***	0.035**	0.005***
t+3 to t+4	95	-0.67	61.97	0.616	0.538	0.666
t-1 to t+1	154	1.90	76.40	0.021***	0.019**	0.005***
t-1 to t+2	127	3.65	59.71	0.003***	0.021**	0.059*
t-1 to t+3	111	2.24	-14.52	0.048**	0.088*	0.724
t-1 to t+4	95	1.41	50.56	0.149	0.218	0.527

Appendix C (2) Sample Firms in the PMIs: Abnormal Operating Performance (Performance-Size-SIC-3-Digit) (Continued)

Time Period	SOA					
	N [a]	Median [b]	Mean [b]	WSR [c]	Sign [c]	t-Test [c]
t-2 to t-1	214	-0.47	-2.14	0.196	0.538	0.134
t to t+1	182	4.08	5.19	0.002***	0.014**	0.003***
t+1 to t+2	154	-0.59	0.20	0.880	0.809	0.912
t+2 to t+3	140	1.14	0.73	0.313	0.353	0.691
t+3 to t+4	123	1.73	2.46	0.167	0.718	0.221
t-1 to t+1	182	3.71	8.62	0.001***	0.014**	0.000***
t-1 to t+2	155	4.07	7.55	0.007***	0.037**	0.001***
t-1 to t+3	140	4.31	6.87	0.013**	0.076*	0.009***
t-1 to t+4	124	11.96	12.85	0.000***	0.000***	0.000***

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

[a] *"N"* indicates the total number of pairs of sample firms and control groups in the respective time period.

[b] Mean and Median are the mean and median abnormal operating performance (presented in percentage), respectively.

[c] The *p*-values shown are those for the two-tailed test of the null hypothesis of no abnormal performance using the Student's *t*-test, Wilcoxon signed ranks test, and the sign test, respectively.

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