The Influence of Product Design on Switching Decisions for Capital-intensive Technologies: The Case of MRI Purchasing in Research Facilities

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

This research investigates the role of product design on technology switching in the context of a capital-intensive product. I focus on switching rather than on new sales because switching is the primary means of changing market share in nearly mature markets. Further, the dominant logic – is that, because of switching costs and the related consequences, incumbents have a strong advantage when upgrading or replacing equipment. However, the literature on lead users suggests that those users at the cutting-edge are willing to meet the costs of changing technology because they have the capabilities needed to leverage significant advantages from the new technology. The extant literature on switching focuses primarily on consumers in highly competitive markets. There is little understanding of the antecedents of switching in business markets, especially in markets for capital-intensive technology-based products. This research investigates the influence of product design on switching behavior for capital-intensive high technology products, where buyers are faced with numerous implications and significant costs at each step of the process. The switching behavior for capital-intensive products has not been studied previously; because of this deficiency, we do not know the consequences for theory, that is, how different theoretical assumptions will contribute to the final decision to switch, or for managerial practice, that is, the kind of strategies managers should follow to retain existing buyers under such conditions.

Previous literature did not explore explicitly the concept of product design as an influence on switching, because satisfaction and switching cost were widely used as determinants of switching decisions in competitive markets. This gap in knowledge is due to the difficulty in identifying a method that would allow one to differentiate among the products' performance and how the difference would impact consumers' objectives. It is also difficult for researchers to define the characteristics of high technology products that make certain products more attractive on the market than others, without substantial assistance from experts in particular products. These conditions create a barrier to investigating switching behavior for high technology products.

This research is positioned in the overlapping area between product design and switching behavior. The linkage between these two bodies of literature has never been explored. The research answers two important questions: (1) what are the antecedents of technology switching in a context where there are considerable costs?, and (2) does product design encourage technology switching behavior?

Dynamic capabilities theory is used to explain this research, because the decision to switch an old technology for a new one in rapidly changing technology markets is about renewing resources and capabilities to maintain competitive advantages. This research is conducted in the context of the Magnetic Resonance Imaging (MRI) industry as a case study. Considerable switching has occurred in this industry over the last decade, resulting in this industry offering a good opportunity to investigate the reasons why. The market is divided into different segments based on the region and the health care system. I selected the university hospitals segment, MRI research centers, to conduct this research study, because it is feasible to track the technology switching process for this segment over time and because this segment's market is nearly mature. Data were collected from multiple sources including personal interviews, online surveys, annual conference database, product technical reports, and patent data.

In this study, the independent variable is product design and other variables related to switching costs and marketing strategies. The dependent variable is switching behavior, which has two values: (1) "switched," defined as purchasing a new technology from a different supplier, and (2) "not switched," defined as repurchasing from the same supplier. After collecting surveys from decision makers who purchased MRI technology, I use logistic regression analysis to test the hypothesis that the product design has a direct impact on the switching decision of capital-intensive products.

Research findings have shown that buyers are willing to switch to a different technology in spite of high associated costs, particularly when they are faced with a product that restricts their capabilities. Product design represents the most influential factor underpinning switching, because it provides more capabilities that motivate switching. Notwithstanding the fact that moving to a new supplier imposes significant challenges, including technology and relationship incompatibility, findings confirm that this distinction in product capabilities has induced some MRI buyers to move to a new supplier in order to maintain a competitive market position. The findings also confirm that support during the transition process can be achieved through marketing strategies.

The findings of this research clarify our understanding of the switching behavior of capital-intensive products where successful product design is expected to play a significant role. This behavior is expected to be different from the behavior identified in previous research, because the previous research was conducted using mainly competitive markets with frequently purchased products. For lead users faced with products that restrict their capabilities, switching is an expected option despite high switching costs. Those early switchers, having capitalized on the real value of the new product, serve to encourage other users to pursue the same behavior later. The outcomes from this MRI study – as one example of a high technology device – could be applied to the different industries that share the same characteristics in terms of high rates of technological change and high switching costs, for example, military devices, aircrafts, and advanced medical and industrial devices.

Acknowledgements

I would like to take this opportunity to express my sincere appreciation to those who have helped me in completing this research. First and foremost I would like to acknowledge the efforts of my supervisor, Dr. Rod B. McNaughton, whose research experience and guidance have made my years worthwhile. His sincere help and encouragement enabled me to accomplish this work with strong confidence. I greatly appreciate the investment of time and the valuable feedback provided by my supervisory committee members, Dr. Brian Cozzarin, Dr. Bon Koo, and Dr. Mikko Packalen. I am also grateful to Dr. Joseph C. Paradi, external examiner, for his thoughtful review of my thesis and his many valuable comments and suggestions. I gratefully acknowledge the financial support I received from NSERC and OGS, which allowed me to focus on my research.

Dedication

I would like to dedicate this thesis to my wife Rana, whose love, care and commitment played a crucial role during the last four years. Her faith in me helped me overcome all the challenges in completing this thesis.

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Chapter 1
Introduction

1.1 General Review

The literature shows that the long-term success of suppliers depends on retaining consumer satisfaction (Anderson and Sullivan, 1993), because a satisfied customer repurchases from the same firm. However, ensuring customer satisfaction requires continuous improvement in product features to meet changing consumers' preferences, especially for high technology products where consumers prefer to own advanced technology to secure a competitive position. The product itself could cause consumer switching, if the features that are important to consumers are slow in embracing new technology. Because it shrinks the market share of certain suppliers and imposes significant costs to get consumers back, customer churn is a serious issue (Zins, 2001). Existing literature refers to consumers as individuals and to buyers as organizations/firms; both terms are used interchangeably in this study.

While the literature reports considerable research that investigates switching behavior, most of it is focused on competitive market products. Variables that are used to explain this behavior can be classified under three major categories: marketplace characteristics, interpersonal relationships, and consumer characteristics. However, the influence of product design on consumer switching behavior is rarely discussed. Furthermore, evaluating switching behavior for capital-intensive technology products at the organizational level is almost undocumented in the literature. These products are characterized by: (1) rapid pace of technological changes that require intensive market research to evaluate a buyer's demands (Kreig, 2004), (2) substantial levels of technology heterogeneity (lacking a standard design among competitors) (Anderson and Tushman, 1990), and (3) products that can be significantly differentiated through the integrated technology. These characteristics reflect the fact that these products tend to be information intensive and impose a high uncertainty during the purchasing process (Glazer, 1991), perhaps forcing buyers to engage in extensive search efforts to act on information before it becomes outdated (Glazer and Weiss, 1991).

This condition makes switching behavior complicated and costly from the evaluation stage to the final decision to resume operations under the new product set-up (Weiss, 1993).

The management of technology literature demonstrates that retaining current consumers requires the provision of product design that reflects the right preferences of consumers (Pae, 2006; Danneels, 2002). For capital-intensive products, where the rate of technological change is high and technology standards are hard to define, Bhattacharya et al. (1998) found that integrating the optimum buyers' preferences into the product design is a challenging task, because each consumer's preference represents a unique product feature that might achieve different objectives. Therefore, to be successful these products should have the "right" features that fit consumer demands in different market segments (Barbiroli and Focacci, 2005; Krishnan and Bhattacharya, 2002). Failing to do this objective will result in buyers switching to other more attractive products.

The product design concept is used widely in product innovation and marketing literature. Product innovation literature emphasizes the importance of product design features to achieve high market performance (Chang and Hsu, 2005); and the user-oriented product design for optimal combination of product features (Lai et al., 2006). Marketing literature explains the need to take consumer preferences into consideration to create a successful product design (Srinivasan at al., 1997), and the influence of product design on consumer choice (Bloch, 1995; Fuente and Guillen, 2005). In previous studies, product design has been used to refer to product features, characteristics, and functionalities.

This research explores a gap in knowledge about the influence of product design on buyer switching behavior for capital-intensive product. Previous literature on buyer switching focuses almost exclusively on competitive market products. This study demonstrates that buyers of capital-intensive products who are already committed to a certain product, constantly evaluate their relationship with a supplier and whether they are satisfied with the overall product performance. At this stage, good product design plays an important role in encouraging the switching behavior, because it helps buyers achieving their goals effectively. Buyers switching can be a measure of product attractiveness and success in the market. The key contributions of the proposed research is to find answers to two important questions in the business-to-business relationship context: (1) What are the antecedents of technology switching in a context where there are considerable costs?, and (2) does product design encourage technology switching behavior?

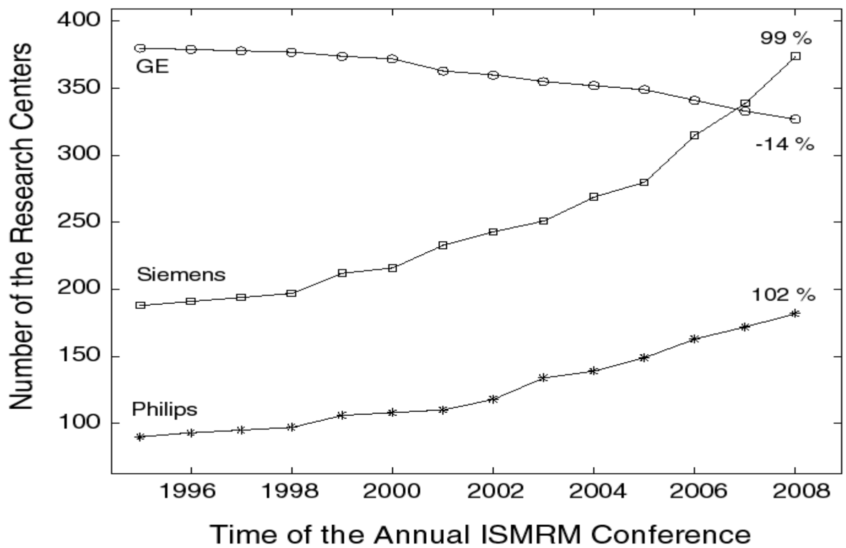
The resource based view of the firm (RBV) argues that firms possess resources that are heterogeneously distributed across firms (Wernerfelt, 1984), and that these resource differences persist over time (Amit and Schoemaker, 1993; Mahoney and Pandian, 1992; Barney, 1991). These resources are valuable and unique for each firm and lead to the creation of competitive advantage, which can be sustained over longer periods by implementing new strategies that are hard for rivals to duplicate (Conner and Prahalad, 1996; Nelson, 1991). However, RBV does not adequately explain how firms achieve competitive advantage in conditions of rapid and unpredictable change. Therefore, dynamic capabilities theory has emerged to explain how firms respond to highly dynamic environments to maintain competitive advantages (Teece et al., 1997).

Previous research on dynamic capabilities shows that timely responsiveness and flexible product innovation, coupled with management capability, are essential to coordinate and redeploy internal and external competences effectively and to deliver marketable products that successfully meet buyers' demands (Eisenhardt and Martin, 2000). Dynamic capabilities theory explains how suppliers use their capabilities to design products that outperform competing products by offering distinctive advantages that reflect consumers' preferences in highly dynamic environments.

If the previously adopted technology in an organization becomes slow in meeting its strategy to secure a competitive advantage, the organization will try to acquire a new technology that helps it achieve its objectives efficiently and effectively. Hogan and Armstrong (2001) show that technology switching to a different supplier means replacing the old resource with a more valuable one to achieve a competitive advantage. Wang and Ahmed (2007) indicate that maintaining a competitive advantage requires renewing and reconfiguring resources and capabilities in response to technological changes in the external environment. This argument shows that switching to a better technology to renew the internal capabilities and preserve high organizational performance can be explained by dynamic capabilities theory.

The research is conducted in the context of the Magnetic Resonance Imaging (MRI) industry, which has a high rate of technological change and a wide range of applications. Three suppliers -GE, Siemens and Philips- share 75% of the world market which implies an oligopolistic market. The market is divided into different segments. I selected the university hospitals segment (or MRI research centers) to conduct my research, for the following reasons: (1) They perform regular clinical operations in addition to conducting advanced medical research, which requires continuous adoption of the state-of-the-art technology (lead users, who can gain competitive advantage through early adoption); (2) this segment is spread world-wide and is located mainly in North America, Europe, and Japan, providing a global market prospective for this research; (3) there is the feasibility of tracking the technology switching process from available conference database; (4) the associated switching costs are high; and (5) considerable technology switching was taking place in this market, as shown in Figure 1. In 1995, 380 research centers utilized GE-MRI technology compared with 188 and 90 centers utilized Siemens and Philips technologies respectively. Over time, the number of centers that use Siemens-MRI technology increased steadily, to reach 374 centers in 2008, achieving 99% increase compare with 1995 results. The number of Philips-MRI technology users increased to 182 centers, achieving 102% increase over the 1995 number. However, the number of centers that operate GE-MRI technology declined over time to 327 centers, which corresponds to 14% decrease from the 1995 number.

Figure 1. Technology switching impact on MRI market share



The percentage at the end of each curve represents the change in value reported at 1995 (ISMRM, 2007).

1.2 MRI Industry

The magnetic resonance phenomenon was discovered in the early 1940s, but it was not until 1977 that the first human whole-body scan was performed. Since that time, there have been many ongoing significant improvements in its features and performance to generate high image quality (Iezzoni et al., 1985). MRI plays a significant role in making the invisible visible, because internal body parts can be imaged non-invasively with high quality. Since patients can be treated after they are diagnosed, MRI technology enables health care professionals to improve their abilities to detect and define the nature of a disease so as to implement better treatment and quality of life. Today, MRI is an integral part of modern health care, clearly demonstrated by the fact that in 2001 over 75 million MRI procedures were performed worldwide (Amersham Company, 2001).

Since the commercial introduction of MRI in 1980, GE has dominated the MRI sales market, followed by Siemens and Philips. These companies are known to have large medical departments and solid R&D foundation, helping to maintain a strong market share for each one.

Investigating new diseases is the driving forces behind developing new features and capabilities for the next MRI product, and that investigation generates strong competition between MRI companies to introduce MRI technology that meets expectations. This behavior can be characterized by monitoring the number of patents filed each year. Since GE was the incumbent of the established imaging industry in the US (CT scanner) (Frost and Sullivan, 1975), and has an integrated structure of development, distribution, and service procedures, it was able to dominate the MRI market in US. The US has the largest MRI market in the world, followed by Europe and Japan (Frost and Sullivan, 1975).

In the US, two major events significantly affected the demand for advanced medical technologies. The first was the establishment of publicly financed medical programs in the late 1960s; the second was the introduction of medical cost containment in the 1980s (Oh et al., 2005). These events made hospitals more tolerant of the high costs of adopting medical technologies. With the US market comprising almost half of the MRI world market, many foreign companies entered the US market. In the US, existing medical companies reacted to the high demand by expanding, and new companies were established (Teplensky et al., 1993).

In the early 1980s, a few entrants found an opportunity in the MRI market, but they quickly dropped out. These failures were due to lack of access to an integrated structure of intense development, complicated manufacturing, strong distribution channels, and reliable service programs – all needed in order to stay successful. New companies in the MRI market were at a disadvantage because they could not establish themselves as reliable providers of rapidly changing technology. Most of the entrant companies either ended in bankruptcy or were acquired by other, large established companies.

1.2.1 MRI Market Growth

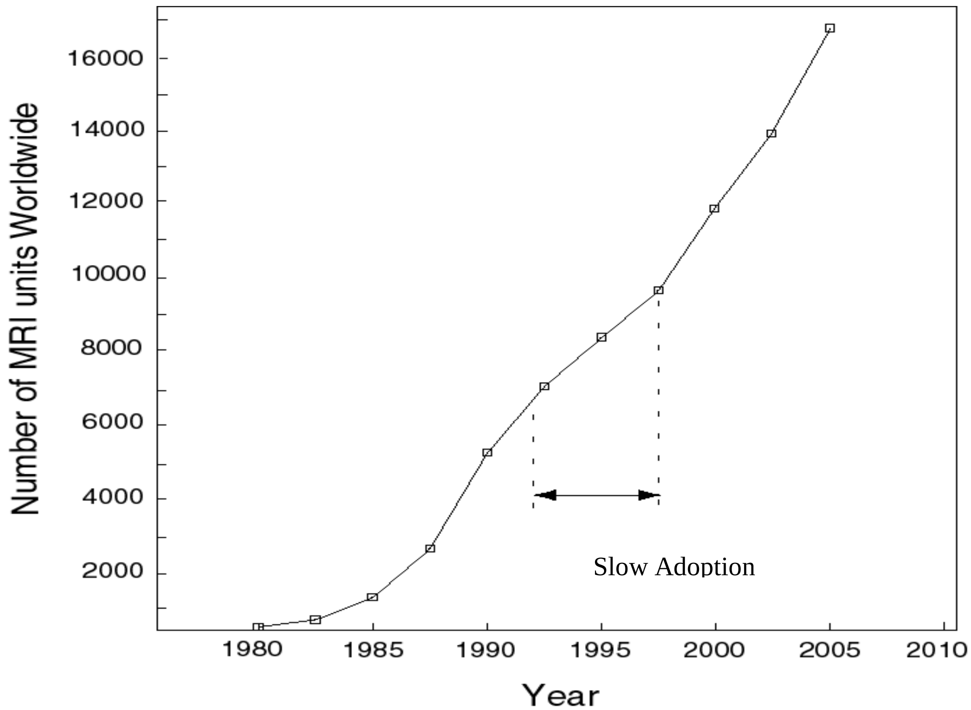
Developments in clinical applications plus MRI technology advances are the driving forces to high market demand (Wilson et al., 1999). In response, companies attempt to expand their market share by launching more capabilities with new MRI products. Based on 1994 estimates, the industry produces about 1600 MRI units per year, with worldwide installation about 8100 units. In 1994, the US had approximately 4000 MRI units in operation (Appleby, 1995), of which 700 were mobile (Technology on Wheels, 1987). In 2006, the US held 7225 units, for an average increase of 7% over 12 years (IMV, 2007). The number of MRI examinations was increasing steadily by an average of 5% per year, with brain, spine and vascular diseases among the biggest areas of examination growth.

Figure 2, showing MRI market growth since 1980, reveals a slight slow-down in MRI adoption between 1993 and 1997 (Baker and Atlas, 2004), which was due to introducing managed care activities in the US. These activities represent health care plans undertaken to reduce the high level of spending that attached to unfettered fee-for-service medicine (Baker, 2001). These plans resulted in financial constraints associated with managed care, an environment that has led to creating restrict policies to control technology spending, causing a temporary slow-down in the adoption rate of new technologies like MRI.

Later studies comparing the benefits of medical technology adoption and the overall cost of diseases have shown that technological change is economically worthwhile (Cutler and McClellan, 2001; Newhouse, 1992). Such studies have reduced the pressure on health care spending, especially when reports on the economics of different diseases started to show alarming signals in the industrial countries. Table 1, based on 2000 statistics, presents the economic cost of different diseases in the US alone.

Figure 3 shows the economic impact of different diseases on the Canadian economy in 1998, revealing the tremendous resources spent each year to ensure that health care requirements are met. Cardiovascular diseases are the leading cause of death, followed by brain diseases – that is mental disorders, nervous system diseases, and brain tumors.

Figure 2. MRI market growth since 1980



Sources: (Appleby, 1995; IMV, 2007; Passariello, 1997)

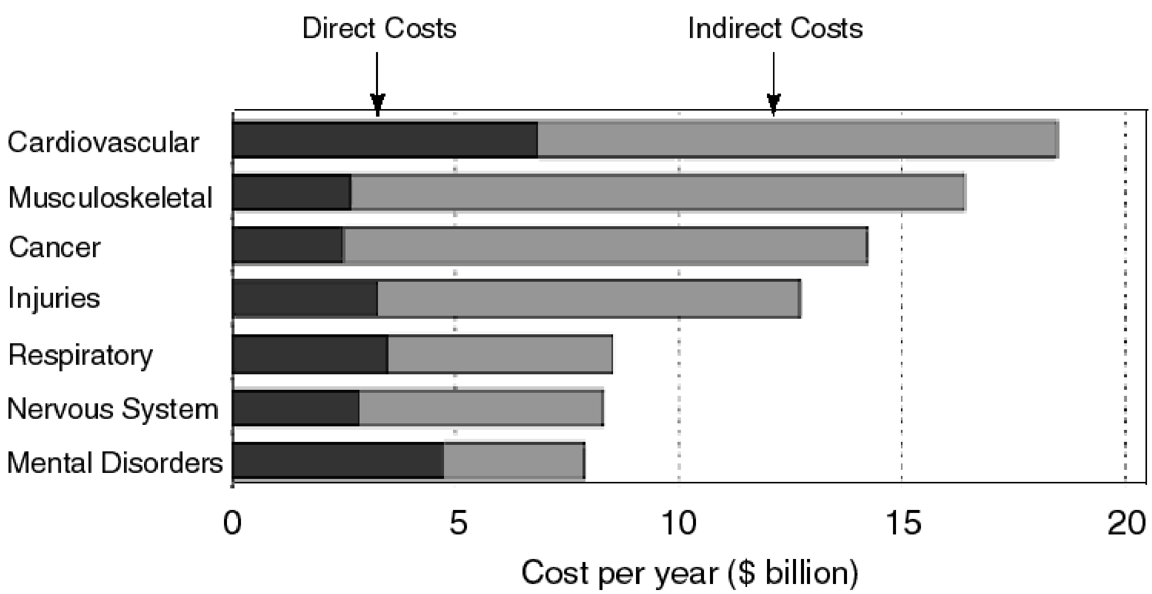
Table 1 and Figure 3 demonstrate that the most frequently used clinical applications in MRI market. Also, the large economic impact of different diseases on the economy has induced the industrial countries to increase health care spending and health care research, putting more focus on diseases that have higher impact on society. This shift increased market demand for medical technologies, in particular MRI technology, which can diagnose numerous diseases. In 2007, market research reports were expecting a steady increase in MRI technology demand by an average of 8% per year over the next five years (IMV, 2007), in order to improve the quality of health care and reduce the economic impact of different diseases. Currently, MRI unit sales represent one of the strongest markets in the medical imaging industry in the US (TriMark, 2007); its 2010 market is expected to be $7 billion.

Table 1. Annual economic cost of different diseases in US

Disease Category	Annual Cost ($US Billions)
Cardiovascular disease	$148
Cancer	$107
Neurological disease	$196
Alzheimer's disease	$100
Depression	$44
Stroke	$43

Sources: (Pharmaceutical Research and Manufacturers of America, 2000)

Figure 3. Economic cost of different diseases on Canadian economy



The direct costs represent the hospital expenses, whereas indirect costs are an estimate for the future loss, including disability cost and loss of income. (Sources: Health Canada, Economic Burden of illness in Canada, 1998).

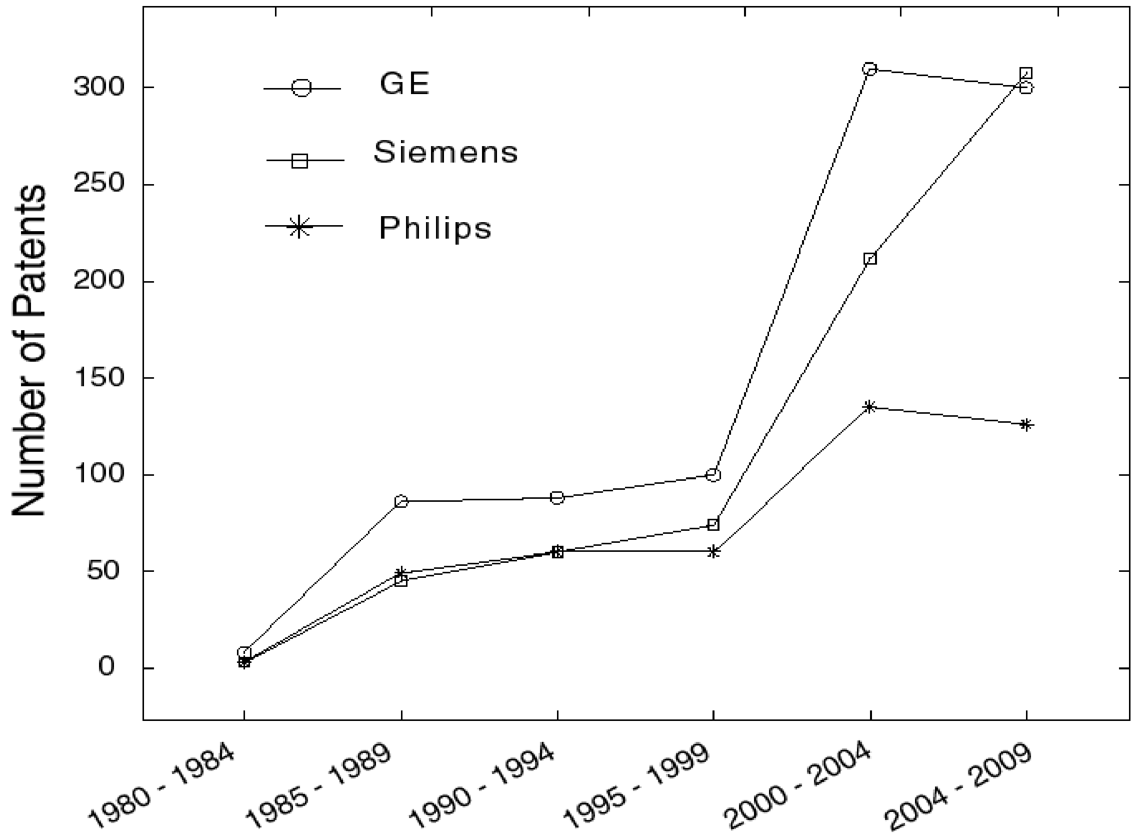
1.2.2 Innovation Capacity of the Major MRI Suppliers

From the US online patent office (Online-Patent, 2005), I obtained the number of patents (innovations) registered for GE, Siemens and Philips for each year from 1980 to 2009. The patent issue date is considered in the search process, which means that the patent is accepted officially as a new innovation. These patents are related directly to MRI development process, which includes technical and software features. Monitoring the number of patents over time can provide useful information about a company's strategy to empower its product with advanced features, in order to make it more attractive in the marketplace. This is why I thought that patent data can be useful in this study.

The number of patents per year was determined as a function of time to monitor the innovation process of each company over time. Results were plotted as the number of innovations taken as a sum over five year segments, as shown in Figure 4. For example, patents from 1980 to 1984 were considered as the first segment, resulting in six segments of time to reach 2009. This process is practical to remove the fluctuation in data over time, because the number of issued patents in this year might be less (or more) than those from previous year. This is due to the patent registration process, which takes longer time for some patents.

Figure 4 demonstrates the innovation capacity of each supplier. It shows that GE achieved a strong patent portfolio from 1980 to 1994, which enhanced its MRI technology features and positioned it as a market share leader. During the same period, both Siemens and Philips achieved similar progress pattern to GE, but at lower level. After 1994, Siemens started to enrich its patent portfolio by producing more innovations to secure a strong position; however, GE remains ahead of other suppliers. This dramatic change requires a substantial investment in R&D operations to advance Siemens technology over other competitors. Philips' innovation progress remained comparable to GE, but at lower level.

Figure 4. Accumulative number of MRI patents over 30 years



1.2.3 MRI Technology Development

MRI technology is produced at different field strengths, namely <0.5T, 0.5-0.9T, 1T, 1.5T, 3T, >3T. While higher fields generate better image quality and more capability to diagnose different diseases, the price increases with field strength. Technology selection depends on the clinical application requirement (Marti-Bonmati and Kormano, 1997). For example, 3T can be used for a wide range of medical examinations and has the ability to produce the highest image quality, although its global market is growing slowly because it is the most expensive MRI technology. Currently, 1.5T is widely used in the global market and has impressive capabilities. Figure 5 shows a picture of 1.5T and 3T MRI technology.

Figure 5. Two types of MRI technology at different field strength

1.5T MRI   3T MRI

Source: Siemens online technical reports for 1.5T and 3T -2008.

The development cycle of MRI technology entails close collaboration between universities, including educational hospitals, and MRI companies. This collaboration is essential for testing and improving the performance of new applications on patients. Radiologists, professors, engineers, and other experts have played a significant role in creating and evaluating new MRI innovations (Lettl et al., 2006). Each MRI development needs an FDA approval before being launched to market, to ensure its safety on human subjects, a condition that has stimulated a strong collaboration between MRI companies and universities to enhance the innovation cycle of MRI technology.

Generally, new applications are integrated into the same MRI technology as standard features, if these applications are used in regular clinical operations. On the other hand, if these applications target specific diagnosis, they are sold as extra features based on demand. In the early 2000s, there was an increased interest in having dedicated MRI technology for certain diseases, such as cardiovascular and head-related diseases. Such technology contains a wide range of applications and protocols designed for specific purposes. In this regard, Siemens successfully designed the first Cardiac MRI and a dedicated head MRI technology. The high demand for specialized MRI technology was stimulated by the urgent need to investigate and diagnose the diseases that are the leading cause of death in the world, namely cardiovascular and brain diseases.

Each MRI company uses a different platform to design its final product. The main structure of an MRI product is the same across companies, but the controlling system (software and hardware) is different. This difference prevented the MRI industry from having a standard platform that facilitates sharing new applications developed by various companies. This condition has forced MRI users to buy the entire MRI technology from a single company. If they wish to utilize specific applications produced by a different company, then they have to purchase a second MRI technology (Rycroft and Kash, 2002).

1.2.4 MRI Market Segments

The MRI market is divided into different segments based on various measures. It can be split based on region (North America, Europe, Asia, Japan, etc); hospital size (large, medium, small, free-standing center); MRI technology (field strength or fixed/mobile); and operation activities (research, clinical, or both). Table 2 shows different MRI market segments in the US based on hospital size.

Table 2. MRI market segments in the US based on hospital size

Hospital Size (Market Segment)	Percent of Market
Large Hospital	8%
Medium Hospital	16%
Small Hospital	38%
Free-standing Center	37%

Source: (IMV, 2001).

1.2.5 Technology Evaluation Process

The decision making process to either purchase a new MRI scanner or switch to another supplier is complex (Kreig, 2004). It begins by establishing a special committee that includes different members of the health care system, including chief radiologist, radiologist, cardiologist, administrators, technologists, and engineers. The committee starts by gathering extensive information about the current status and potential development of the existing MRI product and competing products. The collected information undergoes comprehensive investigation and analysis to match the committee's objectives and financial constraints. During this process, different hospitals that use prospective technologies may be consulted for their experience. Finally, a decision is made either to continue with the same supplier or to switch to a new one.

If the purchaser decides to buy a new MRI scanner from a new supplier, the committee members try to manage the transition period as smoothly as possible to resume the clinical operations under the new set-up. In addition to the high costs of replacing the old MRI scanner, hospitals could face various challenging procedures to complete the switching process successfully. The challenges include the following: (1) MRI technologists, or operators, need to undergo training to operate the new product efficiently; (2) engineers and programmers (an important element in the research process at the university hospitals) need to master the new programming language and the way different hardware components are communicating, so that they can implement new research ideas; (3) clinical operations downtime during the switching process must be considered, which requires transferring critical patients to other hospitals; and (4) the building configurations must be adjusted to fit the specifications of the new technology. On the other hand, the upgrading process from the same supplier is easier and cheaper than switching; it includes installing new hardware components every few years or purchasing new clinical software packages every few months as needed.

1.3 Thesis Contribution

This research advances the theoretical understanding of switching behavior for capital-intensive products in highly dynamic environments, where the pace of technological change and switching costs make the switching decision more complicated than those in consumer markets (Moriarty and Kosnik, 1989). The present findings emphasize the influence of product design on switching decisions for capital-intensive products, whereas previous studies put more emphasis on factors such as marketplace characteristics, switching costs, and marketing strategies as the main antecedents of buyer switching.

The literature demonstrates that there is no standard model to predict buyer switching behavior. This is why previous studies adapted different models to explain this behavior based on the product under examination. Most of these studies were conducted in a competitive market with frequently purchased products. This research contributes by generating a new model to explain this behavior for capital-intensive markets; the model reflects the special characteristics of such markets, where both users' preferences and the rate of technology change vary constantly.

This research also contributes to marketing literature by demonstrating how an effective product design can undermine different switching barriers and provide buyers with strong incentives to switch, by providing them with advanced capabilities that lever significant advantages from switching. It demonstrates that some marketing strategies can be valuable to reduce the negative impact of switching costs and offer smooth transition for buyers. These marketing strategies have to be identified accurately for different type of industries, in order to select the most efficient approach that helps users to switch from one product to another.

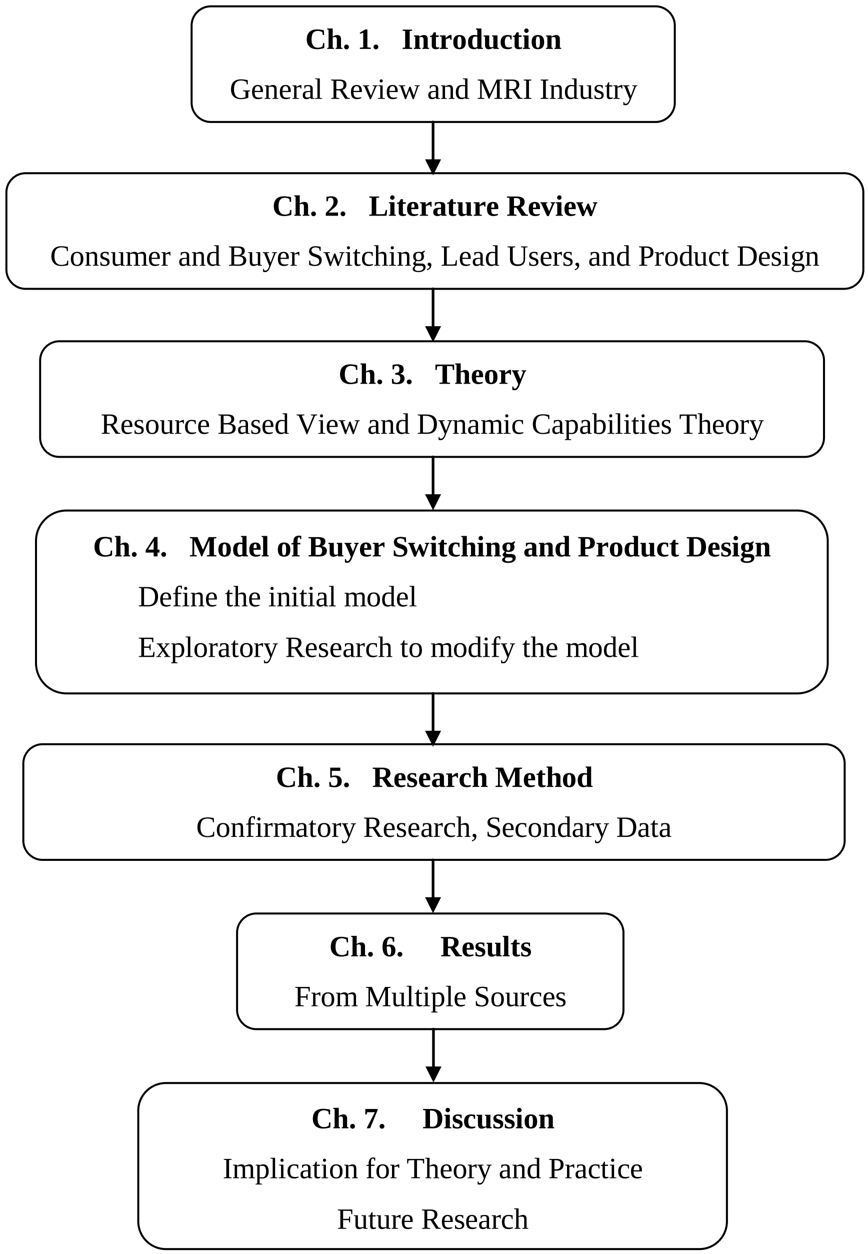
Switching from one product to another after a long commitment indicates that certain suppliers have the dynamic capabilities to produce a successful product design that meets buyers' preferences effectively in rapidly changing technology settings. In this regard, product development mangers should continuously identify certain buyers, or lead users, for the following purposes: use them as a trusted source of innovative product ideas, as a reliable source of market research, and as an encouragement for others to adopt the same technology. Those buyers, being advanced adopters relative to others, can be approached to determine the optimum product features and generate new products based on their advanced application status.

For marketing managers, this research will emphasize the importance of observing the factors behind technology switching in the market place. They need to find a reliable strategy to assess antecedents behind switching behavior for their industry. They should not rely on their expectation to predict those antecedents, because previous research shows that buyers and suppliers claim different perceptions of the determinants of switching. Determining the main factors behind switching is a critical matter to define the appropriate strategy that keeps market share from eroding.

1.4 Thesis Organization

Figure 6 describes the structure of the research proposal. After the introduction in Chapter 1, Chapter 2 reviews the literature, which is divided into four parts. The first part analyses the literature on consumer switching behavior, including barriers and antecedents of switching. The second part expands the analysis into buyer switching behavior in organizational settings. The third part reviews the literature about lead users and their incentives to adopt advanced technologies continuously. The fourth part demonstrates the concept of product design as the main influencer on switching to more attractive products, especially for lead users of capital-intensive products. In Chapter 3, I review different theories to explain switching behavior and select dynamic capabilities as the central one to explain this behavior. In Chapter 4, I introduce the proposed model to predict buyer switching behavior for capital-intensive technology products, where the product design is expected to be the major factor. This model is modified based on an exploratory research. In Chapter 5, I describe different approaches to collecting data, along with data analysis methods to test the research hypotheses. In Chapter 6, results from multiple data sources are presented. In Chapter 7, I discuss study findings, their implication for theory and practice, research limitation, and future research directions.

Figure 6. General structure of the research proposal



Chapter 2
Literature Review

Switching from one product (or technology) to another is an important consideration, because it indicates that certain products do not meet consumer expectations whereas others are more attractive. The negative side of switching behavior is reflected in a reduction in the firm's consumer base, driving the firm to rely on a more unpredictable consumer mix, thus diminishing the firm's reputation (Levesque and McDougall, 1996). Market statistics show that, on average, many US firms lose half their consumers over five years and that consumer switching at this rate diminishes firm performance (Reichheld, 1996). This issue becomes serious in markets that are close to maturity, where the only way to expand market share is through encouraging consumers to switch from competitor firms. Consumer switching leads to a decline in sales volume and increased marketing activities to attract new consumers (Zins, 2001). Eventually, the switching erodes profits, because relative costs of retention of consumers are significantly less than those for acquiring new ones (Fornell and Wernerfelt, 1987). Thus, understanding the factors behind switching behavior is important to reduce costs and to promote long-term consumer relationships. Once those factors have been identified, firms can act upon them to develop strategies that discourage existing consumers from switching (Anderson and Sullivan, 1993; Rust and Zahorik, 1993). On the other hand, competitive firms could use these factors as a tool to attract prospective switchers and enhance their market share (Colgate and Lang, 2001).

The existing literature studies switching behavior in two contexts: business-to-consumer (B2C) marketing and business-to-business (B2B) marketing or organizational buying. In the business-to-consumer case (or consumer switching) the consumer takes full control over the switching process, from evaluating different alternatives to making a final decision. In the business-to-business case (or buyer switching), the switching process becomes more complicated, because organizational buying behavior involves complex environmental influences and different individuals' involvement in the decision making process (Sheth, 1973; Barclay, 1991). Research in business marketing indicates that consumer concepts may be successfully applied to the organizational buyers (Durvasula et al., 1999; Cooper and Jackson, 1988); nonetheless, more additional barriers would face the organizational buyers and not all factors identified in consumer switching literature would be applicable in the buyer case.

The literature refers to switching behavior using different expressions: brand switching, product switching, and technology switching. Brand switching (counterpart of brand loyalty) is used in consumer switching studies mainly to indicate the influence of marketing and advertising strategies on switching behavior, for example, promotions, brand image and brand awareness (Sun et al., 2003; Clarke, 2001; Fudenberg and Tirole, 2000; Mazursky et al., 1987; Raju, 1984). Product switching on the other hand emphasizes product differentiation, complexity and applications (Gehrig and Stenbacka, 2004; Burnham et al., 2003; Shy, 2002, Bayus, 1991). Technology switching is used narrowly in the literature, focusing on high technology products to stress the importance of integrated technologies on users' capability, productivity, and performance (Pae and Hyun, 2006); Jovanovic and Nyarko, 1996; Heide and Weiss, 1995). Various studies refer to the previous expressions of switching by using these terms: "consumer switching," "buyer switching," and "switching behavior."

This chapter is divided into four sections: The first two sections review the literature on consumer and buyer switching behavior, barriers that prevent such behavior, factors that stand behind switching, and the required stages to complete the switching process. The third section reviews the literature on lead users as a special group of general users, who have a strong incentive in the early adoption of the most advanced technologies despite high switching costs. The fourth section explores the role of product design and its advanced features in inducing lead users to reject the old product and move toward a more attractive alternative, which provides more capabilities.

2.1 Consumer Switching Behavior

The marketing literature shows that significant research has been done to investigate consumer switching behavior, which is conceptualized as terminating the relationship with the current supplier and moving toward a more attractive alternative (Ping, 1993); usually, the switching comes after the first purchase decision of a certain product class. In general, research has shown that switching behavior could take place when a consumer: (1) is not satisfied with the overall product performance (Heide and Weiss, 1995), (2) finds that improving the product performance can not be anticipated in the near future (Bansal et al., 2005), and (3) knows that the capacity to move to another more satisfying product is available (Weiss and Heide, 1993). Most of the existing literature on consumer switching examines differentiated competitive markets and focuses on frequently purchased consumer products such as software programs (Pae and Hyun, 2006), financial services (Bell et al., 2005; Ganesh et al., 2000; Colgate and Lang, 2001; Kim et al., 2003), hairstyling and banking (Jones et al., 2000), auto repairs and hairstyling (Bansal et al., 2005), mobile phones (Ranganathan et al., 2006), airlines (Klemperer, 1987), automobiles (Bayus, 1991), on-line services (Keaveney and Parthasarathy, 2001), retailing (Seiders et al., 2005), service industry (Burnham et al., 2003; Ruyter et al., 1998; Sharma and Patterson, 2000), TV-entertainment (Lemon et al., 2002), house-hold products (Van Trijp et al., 1996; Raju, 1984), and insurance (Crosby and Stephens, 1987).

2.1.1 Barriers to Consumer Switching Behavior

A body of literature investigates consumers' switching intentions and the reasons consumers choose to stay with the current supplier despite incomplete satisfaction. This behavior is found to be a result of different factors that perform switching barriers, such as technology compatibility and switching cost (Pae and Hyun, 2006); service quality, consumer expertise and switching cost (Bell et al., 2005); service quality, switching cost and loyalty (Ruyter et al., 1998); availability of attractive alternatives and switching cost (Sharma and Patterson, 2000); interpersonal relationships, switching cost and attractiveness of alternatives (Jones et al., 2000), long-term relationships that provide high benefits and special treatment (Gwinner et al., 1998), inertia (Bawa, 1990), and switching cost (Gronhaug and Gilly, 1991). The wide differences among these factors could be due to the nature of products under investigation and how consumers perceive the value of each product. Meanwhile, switching cost remains the common factor that prevents consumers from switching. Based on that fact, Colgate and Lang (2001) found that in the banking industry more than 22% of consumers who decided to switch were ended up not switching.

Panther and Farquhar (2004) explain the intention to stay with the existing product by specific factors that reflect a real life scenario of consumers: (1) hassle to change, (2) not having enough time to evaluate alternatives and change, (3) the perception that all suppliers are almost the same, (4) the complexity of changing, and (5) the long relationship with current supplier. It is important to mention that consumer perception of the switching costs acts as a force to deter the consumer from switching to another improved or more satisfying product. These switching costs are determined not only by the financial penalties but also by many negative aspects, including psychological impacts of losing the relationship and building new ones (Burnham et al., 2003), time and efforts spent finding a better and more satisfying alternative (Kim et al., 2003; Sengupta et al., 1997), downtime and disruption of operations before resuming them effectively under the new product set-up (Smith et al., 1999). To distinguish among different switching costs, Jones et al. (2002, 442) proposed a comprehensive measure to evaluate the perceived switching costs using the following six dimensions:

1. Lost performance costs: Perceptions of the benefits and privileges lost by switching.
2. Uncertainty costs: Perceptions of the likelihood of lower performance when switching.

3. Pre-switching search and evaluation costs: Perceptions of the time and effort of gathering and evaluating information prior to switching.
4. Post-switching behavioral and cognitive costs: Perceptions of the time and effort of learning a new service routine subsequent to switching.
5. Set-up costs: Perceptions of the time, effort, and expense of relaying needs and information to provider subsequent to switching.
6. Sunk costs: Perceptions of investments and costs already incurred in establishing and maintaining relationship.

Jones found that all switching cost dimensions were significantly associated with the intention to repurchase from the same supplier; lost performance costs were the most influential dimension. He also found that the mean level of perceptions across switching cost dimensions is different for various products, like hairstyling and banking, leading to different evaluations of switching costs for various products. To calculate the switching costs numerically, Shy (2002) developed a model that estimates costs when switching from one product to another, one that could be used in a variety of industries. However, as technology continues to develop, products will become more complex, and the magnitude of the associated switching costs will rise, leading to more difficulties in estimating the actual costs that would impel consumers to act.

Based on the nature of the products used in conducting the previous research, much of the intention to stay with the current supplier could be explained by the fact that product performance is not severely limiting consumers' capabilities; still, consumers are unsatisfied simply because better alternatives are available in market. The remaining motivation to stay is the negative consequences of switching. However, Ganesh et al. (2000) showed that consumers could switch products when switching costs are affordable and the impact of the transition process is tolerable, whereas Burnham et al. (2003) demonstrated that unsatisfied consumers stick with the existing product and try to manage its pitfalls, because the related switching costs are high and the recovery from the transition process is expensive.

2.1.2 Antecedents of Consumer Switching Behavior

Reviewing the literature to discover the common factors behind consumer switching behavior would generate contradicting arguments, simply because factors underpinning switching behavior follow different trends based on the product under investigation and the way researches set up their studies. This section, explores different factors that are used in the literature to explain consumer switching behavior, while demonstrating studies' findings and their limitations. Table 3 presents a short summary of these studies, listing the main factors behind consumer switching.

In the early 1980, Raju (1984) explained the exploratory product switching as an intrinsic desire for a change or variety, which takes place regularly in market, especially for food and house-hold products like shampoo, laundry bleach, shower soap, and blue jeans. He designed a model based on four factors: individual difference variable, product awareness, product switching cost, and product class. He showed that product awareness, including advertisement, has a significant impact on exploratory switching, and a monetary deal could counter that switching. The influence of individual difference variable is relatively small and inconsistent for different products. In the marketing literature, variety seeking as a consumer motive to switch has generated considerable attention (Roehm and Roehm, 2005; Kahn and Isen, 1993; Feinberg et al., 1992; Bawa, 1990; Mazursky et al., 1987; McAlister and Pessemier, 1982; McAlister, 1982).

Later, Van Trijp et al. (1996) found that the variety seeking model can not be explained just by individual difference characteristic; therefore, they added product category factors such as need for variety, hedonic features, strength of preference, perceived differences between brands, and involvement with the model to determine situations in which variety seeking is more likely to happen compared with repeated purchasing. The model demonstrates that the consumer variety seeking does not occur for all products like beer, coffee, tobacco, and cigarettes to the same extent, where product category factors influence the degree of that behavior. This study has tested only a small subset of many product categories that moderate

Table 3. Selected studies of consumer switching behavior

Study	Theory	Product	Dependent Variable	Independent Variables
Raju (1984)	Consumer behavior	Shampoo, laundry bleach, shower soap, and blue jeans	Exploratory brand switching	1- Individual difference variable 2- Brand awareness 3- Switching cost 4- Product class
Van Trijp et al. (1996)	Variety seeking behavior	Beer, coffee, tobacco, and cigarettes	Variety seeking	Product category factors: 1- Need for variety 2- Hedonic features 3- Strength of preference 4- Perceived differences between brands 5- Involvement
Bayus (1991)	Replacement behavior	Automobile	Switching behavior	Demographic characteristics: 1- Income 2- Education 3- Age 4- Occupation 5- Married 6- Working spouse 7- Other cars owned 8- Residence location Product perception: 9- Value 10- Size 11- Styling 12- Cost 13- Brand image Search activities: 14- Number of dealers visited 15- Number of information sources 16- Considering other automobiles 17- Time to gather information 18- Time to visit dealers 19- Time and effort into the final decision
Ranganathan et al. (2006)	Relationship investment	Mobile cell phone	Switching behavior	Relational investment: 1- Service usage 2- Service bundling 3- Relationship duration Demographics factors: 4- Age 5- Gender

Table 3. Selected studies of consumer switching behavior ('continued')

Study	Theory	Product	Dependent Variable	Independent Variables
Keaveney & Parthasarathy (2001)	Consumer behavior	Online services	Switching behavior	Behavioral factors: 1- Information that consumers used to make the decision 2- Level of service usage Attitudinal factors: 3- Risk-taking tendency 4- Satisfaction 5- Involvement Demographic factors: 6- Education 7- Income
Lemon et al. (2002)	Decision making	TV-entertainment service	Keep/Drop decision	1- Future expectations of usage 2- Anticipated regret 3- Satisfaction
Bansal et al. (2005)	Migration	Hairstyling, Auto-repair	Switching behavior	Push effects: 1- Low quality 2- Low satisfaction 3- Low value 4- Low trust 5- Low commitment 6- High price perceptions Mooring effects: 7- Unfavorable attitude toward switching 8- Unfavorable subjective norms 9- High switching costs 10- Infrequent prior switching 11- Low variety seeking Pull effect: 12- Alternative attractiveness
Mittal and Kamakura (2001)	Consumer satisfaction	Automotive	Purchasing behavior	Consumer characteristics: 1- Gender 2- Educational level 3- Marital status 4- Age 5- Number of children in household 6- Area of residence Consumer Satisfaction: 7- Satisfaction
Seiders et al. (2005)	Consumer resource allocation	Retail industry	Purchasing behavior	Marketplace characteristics: 1- Convenience of offering 2- Competitive intensity Relational characteristics: 3- Relationship age 4- Relationship program participation Consumer characteristics: 5- Household income 6- Involvement

the relationship between the need for variety and actual variety seeking behavior. The selection of these particular products may reflect the addictive nature during variety seeking behavior. The authors also identify that, given the survey design, differentiation between true variety switching and derived switching may not be clearly understood by participants, which implies that the level of variety seeking in this study is not representative for other products, because it would depend on other factors that influence consumers' perception, such as mood (Kahn and Isen, 1993) and product display format (Simonson and Winer, 1992).

Motivated by consumer demographic characteristics, Bayus (1991) conducted a study to understand the timing of consumer switching in the automobile industry, and relates a behavior to demographic characteristics (income, education, age, occupation, married, working spouse, other cars owned, and residence location); product perception (value, size, styling, cost, and brand image); and search activities (number of dealers visited, number of information sources, considering other automobiles, time to gather information, time to visit dealers, time and effort into the final decision). He found that early switchers are more concerned with styling and fashion and less worried about the cost than are late switchers, who pursue more detailed search activities to find a good deal. These findings were associated with the higher income and lower education of most early switchers than most late switchers. This study reflects the importance of considering the demographic factors for this product, which is expensive and requires extensive search efforts. Nonetheless, findings from one product category are difficult to generalize to other product categories, until the model is verified using different products.

Ranganathan et al. (2006) studied the impact of relational investment, or switching costs, and demographics on switching behavior of mobile users. They found that increasing service usage and bundling of services have a significant impact on switching suppliers. Also, a strong association was found between age and gender on mobile user switching, with young users being more likely to switch and male users being the main switchers. Other studies evaluated various marketing strategies adapted by suppliers that encourage consumer switching by introducing special discounts and promotions (Fudenberg and Tirole, 2000; Gehrig and Stenbacka, 2004; Sharpe, 1997; Sun et al., 2003). These studies reflect how different marketing approaches could increase the incentives to switch by giving more perceived value to the products and reducing switching costs.

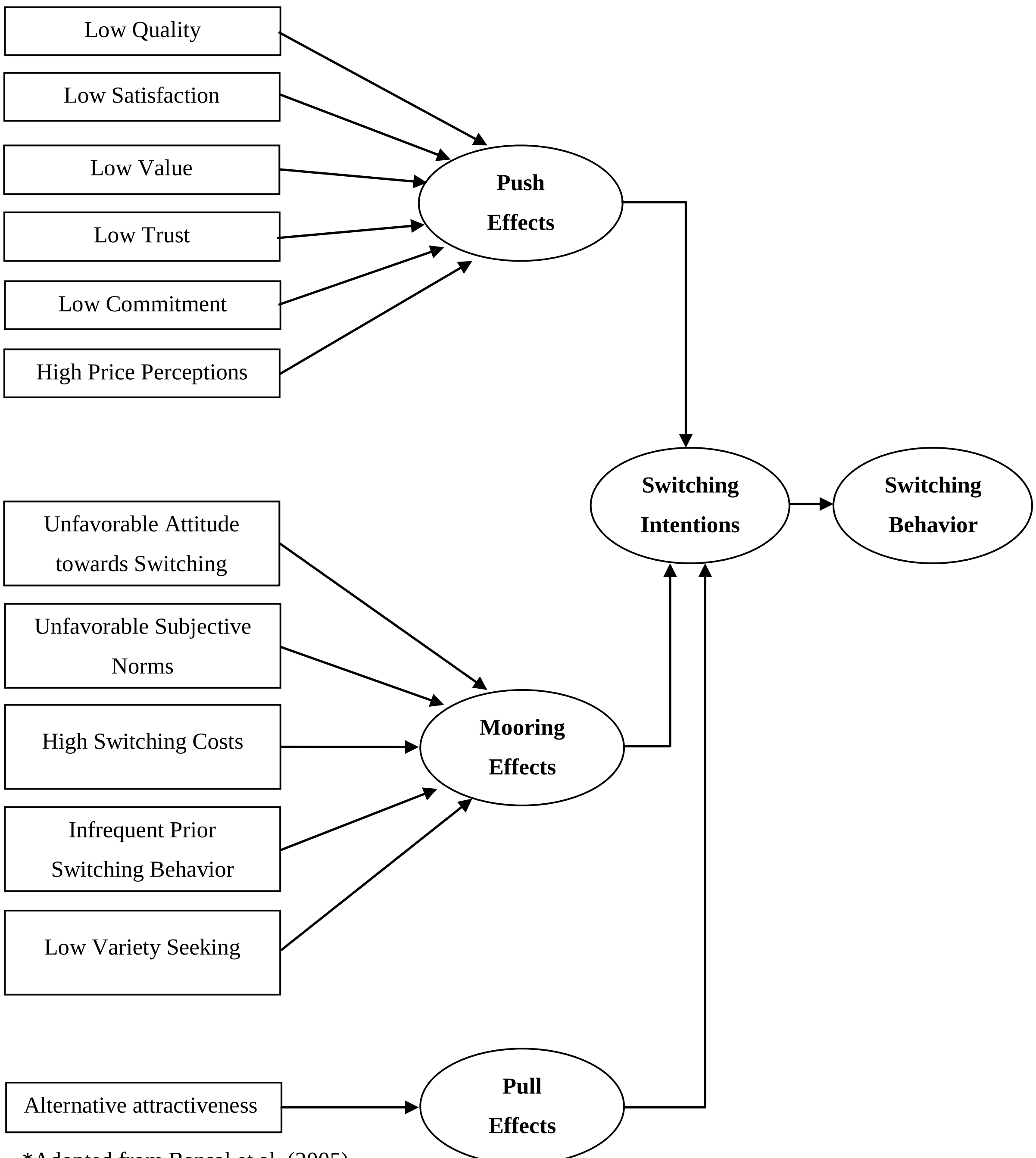
Different studies have tried to establish the relationship between satisfaction and product quality on the one hand and consumer switching on the other (Dabholkar and Walls 1999; McDougall and Levesque, 2000; Crosby and Stephens, 1987; Bansal et al., 1999; Bolton and Bronkhorst, 1995; Keaveney, 1995); however, these studies suggest that dissatisfaction explains only some of the consumer switching behavior. Therefore, Keaveney and Parthasarathy (2001) tried to include factors other than satisfaction to study the switching behavior in online services (MSN, AOL, and CompuServe); those factors were behavioral (information that consumers used to make the decision and level of service usage), attitudinal (risk-taking tendency, satisfaction, and involvement), and demographic (education and income). They found that switchers have the following profile: an individual who subscribed to the online service without thorough search activity or previous experience; who used the service less frequently; who was less satisfied; who had a lower income and education; and who was less willing to take risks. In summary, the overall satisfaction entailed both product satisfaction and related information satisfaction. Although this model is useful and predictive for certain services, the marketing literature suggested that consumers perceive the selection of services to be riskier and more complicated than that of goods (Murray, 1991; Murray and Schlacter, 1990); therefore, applying the Keaveny and Parthasarathy model on other products may reflect a different weighting of the attitudinal and demographic factors.

Alternatively, Lemon et al. (2002) took the consumer decision to either keep or drop a TV-entertainment service in another direction, arguing that the consumer’s future expectations of usage and anticipated regret have a significant influence on consumer decision, in addition to satisfaction. This study suggests that consumers will follow an adaptive approach to update their future expectations based on current usage experience. But in reality, not all users are capable of making a good judgment and evaluation about their existing experience of the service, or on how to generate reasonable expectations regarding future benefits that reflect the actual pace of technology change. Therefore, this study could be relevant for knowledgeable users with high expertise. For rapidly changing technological products, the expected future use is difficult to assess, and reaching a decision based on that is even more difficult.

To account for different aspects of switching, Bansal et al. (2005) did a comprehensive study to include most of the previous factors in their model, adding new ones to understand how different variables might influence the switching behavior in new service providers (auto repair and hairstyling). They divided these variables into three categories: (1) push effects (low quality, low satisfaction, low value, low trust, low commitment, and high price perceptions); (2) mooring effects (unfavorable attitude toward switching, unfavorable subjective norms, high switching costs, infrequent prior switching behavior, and low variety seeking); and (3) pull effect (alternative attractiveness). This comprehensive model allows the assessment of the relative influence of different categories, as shown in Figure 7. An important result of this study is that the push effects, which include some of the most important switching predictors that dominate extant switching models, appear to be the weakest of these three categories, whereas the mooring effects are the strongest drivers of switching behavior, especially when the switching cost is low. The pull factor was characterized by a single variable, "alternative attractiveness," which may not explain the whole case for this category. Adding more variables related to marketing strategy or product design itself might identify what factors make other products highly attractive. In addition, future studies could incorporate additional categories to this model, such as demographic and attitudinal, to give more explanatory power to switching behavior for different product types, because product type could moderate the relationships found in this model.

Nonetheless, Bansal’s model is unique, because it represents a real-life scenario, where consumers undergo a sequence of events during the switching process. Initially, different

Figure 7. Bansal model of consumer switching behavior*



*Adopted from Bansal et al. (2005)

factors create an overall state of product dissatisfaction, which add into a final force that creates the push effects. On the other hand, there should be alternative options (or products) that are attractive enough to pull consumers; otherwise, consumers can not conveniently switch. It is rational that consumers switch to better alternatives to increase their economic return or overall value. Meanwhile, mooring effects stand as strong barriers that inhibit switching; based on the magnitude of these negative forces, a final decision is made to switch or not to switch. Without these switching barriers, consumers can move freely to try any product at any time, an option not available in real life.

Using 100,000 automotive consumers, Mittal and Kamakura (2001) demonstrated that measuring consumer satisfaction using a typical consumer satisfaction survey as described in previous literature does not reflect well the true consumer satisfaction, because few of the studies take into account the consumer's characteristics (such as gender, educational level, marital status, age, number of children in household, and area of residence). Their findings showed that consumers with different characteristics have progressively different thresholds and different response biases, to the extent that their satisfaction level could translate into repurchasing or switching behavior that varies steadily. Interestingly, they found the relationship between satisfaction and repurchasing behavior is highly non-linear. This study finding represents a milestone on the way researchers can conduct and interpret consumer satisfaction surveys.

Findings from Mittal and Kamakura encouraged Seiders and his colleagues (2005) to investigate the relationship between satisfaction and repurchasing/switching behavior using more moderating factors such as marketplace characteristics (convenience of offering and competitive intensity), relational characteristics (relationship age and relationship program participation), and consumer characteristics (household income and involvement). The study was conducted in the context of the retailing industry (home furnishing), with 99% female participation. The empirical findings from their study emphasize that consumer and marketplace characteristics play important moderating roles; consumer satisfaction has a strong effect on repurchase intentions but has no direct effect on repurchase behavior, whereas relational characteristics have a positive direct impact on repurchase behavior. Therefore, satisfaction scores may not predict repurchase/switching behavior accurately and may create a false impression if suppliers assume that higher satisfaction scores necessarily lead to stronger repurchase behavior (Oliver, 1999). This study tries to include a wider range of moderating factors, but some important ones are not included, such as switching barriers, attractiveness of alternatives, gender, and marital status.

2.1.3 Stages of Consumer Switching Behavior

The consumer switching process undergoes a series of stages until a final decision is implemented. Generally, it can be summarized as three major stages. First stage, the consumer conducts different search activities to collect sufficient information about potential alternative products; second stage, establishing the consideration set (Roberts and Lattin, 1991), where a detailed evaluation of the available alternatives is made to reduce them into limited options; third stage, taking the final decision to select the optimal choice that fits consumer needs and financial constraints.

For high technology products associated with rapid changes and intensive information (Glazer, 1991), consumers might find more difficulties in evaluating different alternatives, especially information that could be time-sensitive and impose high uncertainty if the decision is not made at the right time (Glazer and Weiss, 1993). Under this condition, consumers could spend more time to obtain sufficient information, delaying the switching process, or could ignore it completely because of the high involvement risk. Burnham et al. (2003) found that perceived product complexity increases the evaluation process period, forming another switching barrier. Strebel et al. (2004) found that a decision making for high technology products requires the processing of complex and dynamic information, creating frustration that reduces the probability of taking a decision to commit to a new product.

In the competitive market, it is believed that the consumer spends significant time sorting out different products based on quality, performance and price because this market contains a wide variety of alternative options, whereas less time is spent on the final decision.

2.1.4 Conclusion about Consumer Switching Behavior

Limitations evident in previous research suggest new areas for exploration. The previous assessment of extant literature demonstrates that there is no single or comprehensive model to fully explain or predict consumer switching behavior, which is due to the complexity of this behavior and the related factors. For future studies, it is important that we consider a broader model that accounts for different factors, such as the model adopted by Seiders and his colleagues (2005). However, more variables could be added to this model based on the product under investigation; these variables could be divided into three categories: marketplace characteristics (satisfaction with competitor, financial switching costs, competitive intensity, convenience of offering, and attractiveness of alternatives), interpersonal relationships (length of experience, loyalty, relationship age, and relationship program participation), and consumer characteristics (variety seeking, heavy user, income, gender, age, apathetic shopping orientation, education, marital status, number of children in household, purchase volume, and area of residence). The weighting of different variables in the potential model would vary based on the selected product, because consumers perceive different products in different ways (Oliver, 1999).

Another serious finding is how to establish a special tool to measure consumer satisfaction/dissatisfaction toward certain products (Piercy, 1996), given that previous research shows that the relationship between dissatisfaction and switching behavior is contingent on the moderating effects of marketplace characteristics, relational characteristics and consumer characteristics. This is why Reichheld (1996) found that satisfaction measures have accounted for up to 40% of the variance in models of consumer retention, and showed that satisfaction scores could sometimes echo untrue picture of consumer behavior. Also, Anderson and Sullivan (1993) found that t-values for satisfaction-repurchase intention varies significantly, indicating that staying with the current supplier could be due to different switching barriers rather than the actual satisfaction.

Consumer prior experience (or expertise) plays a significant role in the decision to switch suppliers, because it could provide many advantages: (1) deep understanding of the limitation of the current product, (2) adequate evaluation of different product values and their potentials, (3) accurate assessment of switching costs, and (4) rational action on reliable information. This expertise on how a product should function and the effective way of using it is developed over time (Sharma and Patterson, 1999). Surprisingly, the role of prior experience was not mentioned in consumer switching literature, except in the Bell et al. (2005) study, when researchers investigated its positive effect in evaluating the value of different products and selecting the one associated with high return.

By reviewing consumer switching behavior for competitive market products, some important insights could be concluded about this behavior in this particular market. First, these products are widely available and have relatively affordable cost for the average consumer, who can switch back and forth since the cost is controllable to some extent. In other words, switching behavior is not locking in the consumer most of the time. Second, the tendency to stay with the same supplier despite incomplete satisfaction could be due in part to the perceived switching costs; or perhaps the consumer’s objectives are not badly affected. Third, improving the product performance requires limited consumer involvement (filling out a complaint or talking with the manager) and can be managed promptly by the supplier to maintain consumer satisfaction. Fourth, the switching process is relatively manageable but the perception of its negative consequences may prevent consumers from adopting it.

Despite the significant variations in evaluating consumer perception and reaction toward different products and the factors behind consumer switching behavior, previous research provides important insights about consumer behavior in the market domain (Bitner et al., 1990), information that could be used by firms to modify and enhance the product performance, and thus, manage and limit consumers' switching by addressing their needs effectively (Su et al., 2006; Hsieh and Chen, 2005).

2.2 Buyer Switching Behavior

As consumers exhibit switching behavior organizations (buyers) demonstrate the same action under certain circumstances. But switching behavior at this level is more complicated than otherwise because of greater complexity of buyers' needs and the long-term relationships with suppliers (Jackson and Cooper, 1988). Also, products used by buyers are more specialized to meet certain needs and are more technology-intense because of the complexity of organizational requirements. Usually, buyers are more likely to focus on long-term relationships and engage in cooperative activities that result in greater benefits for both partners (Dabholkar et al., 1994), which further complicates the switching process.

Since research in business marketing indicates that consumer concepts may be successfully applied to the organizational buyers (Durvasula et al., 1999), different studies have evaluated buyer switching by using similar variables adapted in the consumer switching research and through monitoring different products: courier service provider (Lam et al., 2004), service provider (Yanamandram and White, 2006), computer workstation (Heide and Weiss, 1995), banking (Wathne et al., 2001), financial industry (Liu et al., 2005), insurance and advertising (Money, 2004), telecommunication services (Low and Johnston, 2006), and hardware retailers (Ping, 1997). The amount of research that has studied the switching behavior of buyers is less than that for consumer switching, perhaps because of the difficulty of conducting such studies and getting reliable information at the organizational level.

2.2.1 Barriers to Buyer Switching Behavior

A body of research examined why dissatisfied buyers would stay with current suppliers because of different factors that present switching barriers. The reasons include switching costs and overall relationship satisfaction (Ping, 1997), buyer value and switching costs (Liu et al., 2005), buyer value, satisfaction and switching costs (Lam et al., 2004), service recovery programs (Durvasula et al., 2000), service quality and switching costs (Lee and Cunningham, 2001), attractiveness of alternatives, switching costs, and interpersonal relationships (Yanamandram and White, 2006). It is clear that the common factor among switching barriers is the switching costs, which are expected to be higher in organizational settings compared with those at the consumer level (Claycomb and Frankwick, 2005). If switching costs were behind buyers' intention to stay, they would create a situation in which buyers felt locked into that supplier (Klemperer, 1995).

The previous paragraph noted that Liu et al. (2005) defined the buyer value as a benefits-costs comparison of a current supplier based on the relationship investment model (Rusbult, 1980; Barksdale et al., 1997). If this value is greater than other available alternatives, then a buyer is more likely to stay with the same supplier (Sweeney et al., 1997). This value is reassessed periodically at the organizational level to become more accurate and descriptive over time (Flint et al., 2002); it is used frequently in purchasing decisions as relationships continue to improve. Durvasula et al. (2000) defined service recovery programs as claims handling, problem handling and complaint handling, which are associated with the level of satisfaction. In general, firms try to act quickly to remedy any complaint regarding a perceived service failure; by doing so, they ensure that buyers do not have a reason to switch to other suppliers (Bolton and Bronkhorst, 1995).

An industrial marketing study by Nielson (1996) offered two dimension typologies to describe switching costs. The first dimension, called hard assets, is loaded with items representing fixed asset investments (such as dedicated plant facilities), modification to the product, and supply agreement terms. The second dimension, called soft assets, is related to the quantity and quality of the individual-level working relationships between both organizations, and personal relationships that develop over time between supplier and buyer. He found that switching behavior is significantly influenced by the hard assets, which can be measured to some degree of accuracy compared with the soft assets. The non-tangible nature of the soft assets (such as personal relationship and long-term commitment) makes them unquantifiable for financial evaluation, slightly undermining their actual impact. He also found that trust and cooperation have indirect influences over switching decision, with both acting as switching barriers. A major limitation in this study was the selection of supplier side to investigate the proposed model, and assuming it is equally applicable in the buyer side. This limitation could undermine the importance of some factors, especially given that buyers and suppliers have different perceptions of the determinants of switching costs (Wathne et al., 2001).

2.2.2 Antecedents of Buyer Switching Behavior

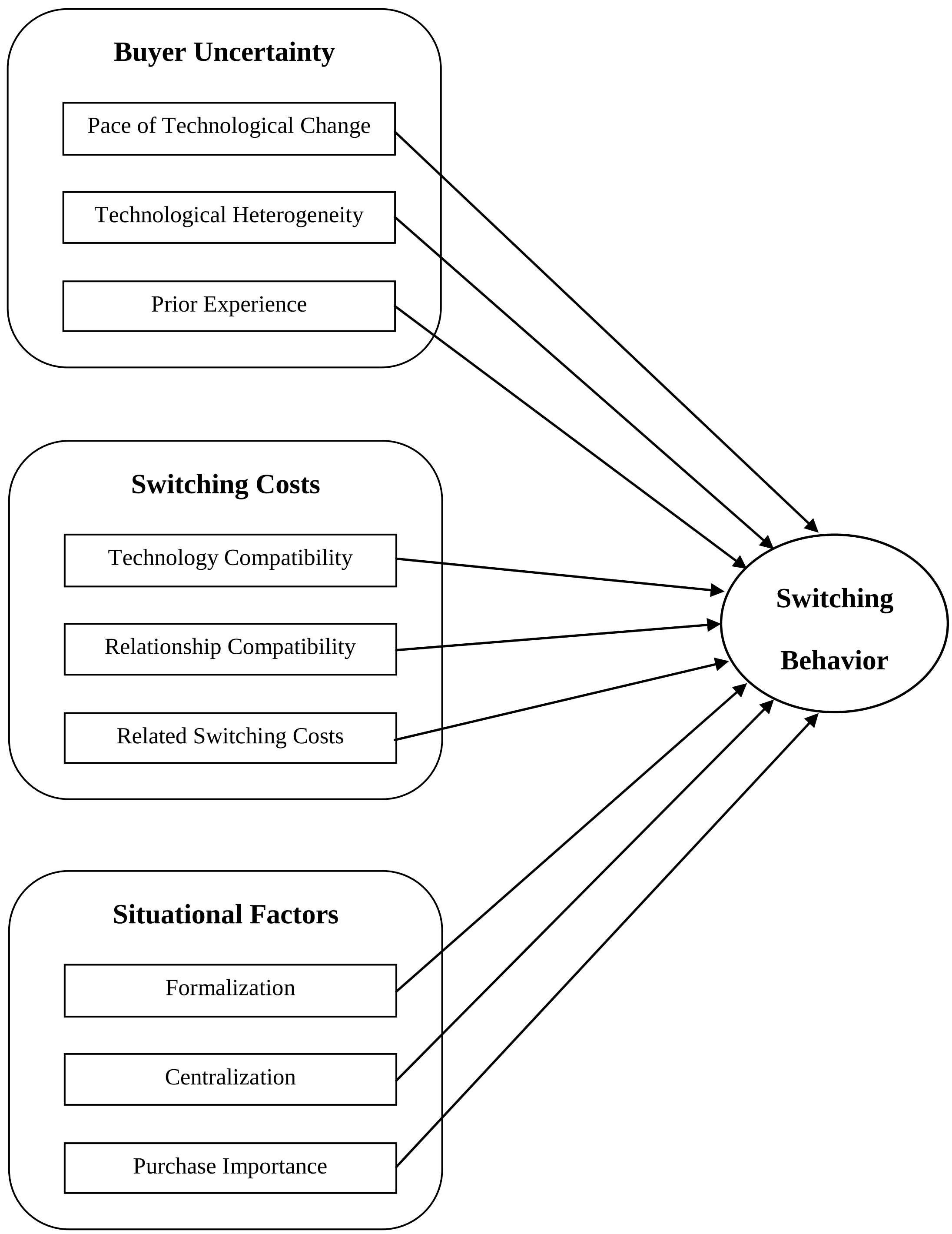
To understand the factors behind buyer switching behavior, the literature on the topic tries to establish different models from those adopted in consumer switching. It is expected that the selected product validating each model will generate some contradicting arguments, because factors behind switching behavior are weighted differently based on the product under investigation and the model design. In this section, a detailed explanation of different factors used in the literature to explain buyer switching behavior will be demonstrated, along with studies' findings and limitations. Table 4 presents a short summary of these studies, including the main factors behind switching.

To find the factors that influence buyers' consideration of new suppliers, during the early stage of decision making, and a final-choice decision, Heide and Weiss (1995) suggested a model that focuses on three categories of factors: (1) buyer uncertainty (pace of technological change, technological heterogeneity, and prior experience), (2) switching costs (compatibility problems and related switching costs), and (3) situational factors (buying process formalization and centralization, and purchase importance). This model is shown in Figure 8. The importance of the buyer uncertainty category appears from the product nature that is selected for this study, computer workstation. The technological heterogeneity represents a

Table 4. Selected studies of buyer switching behavior

Study	Theory	Product	Dependent Variable	Independent Variables
Heide & Weiss (1995)	Organizational learning	Computer workstation	Supplier consideration and switching behavior	Buyer uncertainty: 1- Pace of technological change 2- Technological heterogeneity 3- Prior experience Switching costs: 4- Technology compatibility 5- Relationship compatibility 6- Related switching costs Situational factors: 7- Formalization 8- Centralization 9- Purchase importance
Wathne et al. (2001)	Social capital-organizational investment	Banking industry	Supplier choice during switching behavior	1- Interpersonal relationships 2- Switching costs Marketing strategies: 3- Product price 4- Product breadth (bundling)
Money (2004)	Social network	Appliances, food, banking, and insurance	Purchase/switching behavior	1- Number of WOM consulted sources 2- Tie strength to WOM source 3- Centrality of WOM source Moderators: 4- Culture 5- Location
Low & Johnston (2006)	Equity theory	Telecommunication	Switching behavior	Relationship equity: (characterized by manager skills) 1- Customer orientation 2- Communication/presentation 3- Ability to deliver promises 4- Conflict resolution skills 5- Buyer's trust in manager 6- Buyer's affective commitment Switching costs: 7- Technological compatibility 8- Relationship compatibility 9- Calculative commitment Moderators: External factors 10- Intensity of market competition 11- Technological uncertainty Internal buying firm factors 12- Different rewards comparison

Figure 8. Heide and Weiss model of buyer switching behavior*



*Adopted from Heide and Weiss (1995)

lack of a common technology standard between suppliers (Tushman and Anderson, 1986), whereas rapid pace of technological change reflects the uncertainty, because of time sensitivity of information (Glazer and Weiss, 1993). Formalization and centralization reveal the organizational buyer structure, which may impact the way in which information is processed to reach a final decision. A high degree of formalization leads to information processing according to fixed procedures, which constrain information acquisition and handling (Bunn, 1993). In centralization, however, the decision making authority is concentrated within a small group of people at high-level management (McCabe, 1987). Study findings indicate that rapid pace of technological change and technological heterogeneity intensify the search activities efforts to get more information about different products, but that they increase the probability to stay with the current supplier, while limited prior experience increases the likelihood to switch to a new supplier. High switching costs reduce incentives to consider new suppliers and increase the tendency to stay with the current one. For situational factors, purchase importance has a significant impact when considering new suppliers, but has no effect on switching behavior. Formalization limits buyers' ability on consideration and switching stages, but centralization has no effect on the stages.

A comparison of the Heide and Wiess model with the Bansal model of consumer switching behavior leads to some interesting findings. In the Bansal model, different variables are divided into three categories: push, mooring, and pull effects, to evaluate their influence on consumer behavior; their impact varies toward encouraging switching (push and pull effects) or inhibiting that action (mooring effects). However, in the Heide and Wiess model, different variables are divided into three categories: buyer uncertainty (or market characteristics), switching costs, and situational factors. All the variables act relatively as mooring effects, making the model incomplete for reflecting the switching behavior. The push effects could be impeded in buyer dissatisfaction and not included in the model, but the pull effects (or alternative attractiveness) should at least be included in the model because it has an important influence on switching. In other words, buyers will switch to something that motivates them to do so.

Using the banking industry, Wathne et al. (2001) studied the determinants of supplier choice in the situation where a buyer already has an existing supplier, but with another attractive competitor in the market. They investigated the influence of interpersonal relationships, switching costs, and marketing strategies (price and product breadth "as bundling") on switching behavior. Data were collected from both buyers and suppliers to determine any differences between both sides regarding the importance of various variables. Generally, social interaction between buyers and account managers develops strong interpersonal relationships that act as switching barriers over time; the literature has acknowledged the importance of such relationships in maintaining loyal buyers in a variety of industries (Crosby and Stephens, 1987; Murry and Heide, 1998). Wathne and colleagues found that buyers perceived marketing variables as the main factors underpinning switching, with price dominating all other factors; and the importance weight of both marketing variables went above the total weight of interpersonal relationships and switching costs. This outcome undermines the frequently mentioned role of interpersonal relationships and switching costs as a shield against price and product strategy. Another interesting result is that both buyers and suppliers claim different perceptions of the determinants of switching: Buyers believe that switching costs are the most important factor in deciding to continue with an incumbent, whereas the incumbent perceives interpersonal relationships as the main switching barrier.

The influence of word-of-mouth (WOM), or consultation, on buyer switching behavior was studied for the first time by Money (2004), when he examined whether buyers use referrals to find a better service supplier (appliances, food, banking, and insurance). The study was designed in a cross-national context to evaluate the effect of culture, Japanese and American, and geographic location, foreign and domestic. He proposed a three-components model, which reflects the referral activities to explain the outcome of switching. These components are: (1) number of WOM consulted sources, (2) tie strength (duration, frequency, social importance, business importance, attractiveness, trust, and perceived expertise), which represents different dimensions of a referral source and buyer relationship, and (3) centrality.

Generally, centrality is defined as the strategic position of an individual within a firm. For example, a person with high centrality in a service firm would be an expert in the network resources and could influence the buyers' decision. Two important findings emerge from this study. First, buyers who conducted referrals to explore their potential service supplier switched less frequently than those who did not; in addition, buyers working in foreign countries (as agents) switched more than those working domestically, perhaps because domestic buyers are more familiar with their market and because finding a long-term provider is uncomplicated. Second, for Japanese buyers operating in Japan, attractiveness, business importance, and perceived expertise have a significant influence on switching; whereas for American buyers operating in the US, the business importance has a significant impact on switching. A major limitation in this study is the lack of control for switching costs, which is known to have a strong effect on buyers' behavior. In addition, data collection was made from buyers during their firms' start up stage only, which is a crucial and unstable stage, especially for the foreign companies.

Low and Johnston (2006) proposed the effect of relationship equity (fair treatment) on switching behavior. They presented a model that links key dimensions of relationship equity in the process of adopting a new telecommunication services. The model was examined by interviewing some managers, but it was not tested empirically. The model considers that relationship equity is a result of a buyer's perception of key account manager practices (customer orientation, communication skills, ability to deliver promises, conflict resolution skills, buyer's trust, and buyer's affective commitment). These practices are moderated by external factors (intensity of market competition and technological uncertainty) and internal buying firm factors (different rewards comparison). The study suggests that once a buyer perceives the relationship to be inequitable, he or she will switch to a new supplier after evaluating switching costs (technological compatibility, relationship compatibility, and calculative commitment). Despite lacking the empirical support, this study represents a dynamic model to assess antecedents behind switching behavior for the service industry, where managers could play an important role to build and manage strong buyer relationships.

The study also recommends that managers could implement some segmentation for different buyers by addressing some issues deemed important for each segment; this in turn would help managers to focus their time and effort to develop stronger relationships with each segment.

2.2.3 Stages of Buyer Switching Behavior

Similar to the concepts in the consumer switching process, the buyer switching process undergoes a series of stages until a final decision is implemented, but the process is more complicated because of the organizational structure and the different individuals participating in the decision making process. Sheth (1973) described an integrative model of organizational buying behavior, which is a part of switching behavior. The model was complicated, reflecting the reality whereby significant information has to be collected and processed by different departments (mainly purchasing, quality control, and manufacturing) to reach a final decision. During that interdepartmental efforts, conflicts start to appear (Barclay, 1991), pushing different parties to adopt some conflict-resolution techniques to reach a satisfactory outcomes. The nature of the organization, the product, and the individuals involved determine the complexity of this process.

Bunn (1993) investigated how different organizations pursue this buying behavior, including manufacturing, services, transportation and construction. Four distinguished buying activities are used: information search, use of analysis technique, proactive focusing, and reliance on procedural control. He generated six buying decision approaches, ranked from casual to strategic. Each approach is different, based on the weighting of these buying activities for various industries. For example, one buying decision approach could rely directly on established procedures, whereas another could require a high level of search and much analysis. Then he found that the use of a specific buying decision approach depends on four situational factors: importance of purchase, uncertainty, extensiveness of choice set, and perceived buyer power. For the casual buying decision, these situational factors are presented as: minor importance, little uncertainty, many choices, and little or no buyer power. This study has an important value in segmenting buyers in terms of the adopted buying approach for each level of the organization, so suppliers can develop adaptive marketing strategies that fit the needs of each segment.

As discussed, the buyer switching process is a complicated procedure; therefore, I adopted three main stages to characterize this process: search, consideration, and choice (Patterson and Dawes, 1999). These stages were utilized in the literature of switching behavior, where the implications of each stage were evaluated in depth. Weiss and Heide (1993) investigated buyers' search stage in high technology markets (computer workstation) to evaluate the influence of different factors on this stage. The study revealed four important findings. First, rapid pace of technology change tends to increase the search activities to get more information, which is time-sensitive and imposes high uncertainty (Glazer, 1991; Glazer and Weiss, 1993). Second, high switching costs tend to decrease the efforts of search activities. Third, buyers with less experience tend to conduct more search efforts. And fourth, suppliers share information about new technologies with active buyers (such as lead users) who try to test or enhance the performance of new applications (Von Hippel, 1986).

Later, Heide and Weiss (1995) investigated buyer switching behavior during the consideration and choice stages in high technology markets using a computer workstation. They found that various factors affect each stage differently, presenting five important outcomes. First, both rapid technological change and technological heterogeneity increases the tendency to include more suppliers in the consideration stage, but they increase the likelihood of staying with the same supplier in the choice stage. Second, prior experience has no significant impact on the consideration decision, whereas limited prior experience tends to decrease the probability of selecting the existing supplier, which reflects less commitment by this group of users (March, 1991). Third, high switching costs decrease the tendency to consider new suppliers and the desire to switch to new ones. Fourth, importance of the purchase tends to push the search for more suppliers, but it has no effect on the final decision. Fifth, organizational procedures may impact the complexity of each stage, especially when different departments are involved in the decision making process.

2.2.4 Conclusion about Buyer Switching Behavior

The previous review of extant literature shows that there is no distinctive model to describe or predict buyer switching behavior, with each study adapting different independent variables to explain this behavior. Therefore, it is recommended that a comprehensive model be used that accounts for the majority of factors mentioned in previous studies; such a model could include the independent variables under three categories: marketplace characteristics (intensity of market competition, pace of technological change, technological heterogeneity, and prior experience), switching costs (technology compatibility, relationship compatibility, and financial costs), and marketing strategies (product price and product breadth). Some extra factors can be included in the model if deemed important, such as internal buying firm factors, purchase importance, culture, and location. The weighting of different variables in the potential model would vary based on the selected product, because the same buyer would pursue different switching behaviors for different products.

By evaluating buyers' switching behavior described in previous studies, important insights about the behavior can be summarized. First, most of the selected products are available on the market from multiple suppliers (competitive market), but significant information has to be collected and processed among different departments to reach a final decision. Second, the tendency to stay with the same supplier is mainly due to the perceived high switching costs. Third, for complete satisfaction, high technology products should be highly customized to fit the specific needs of each buyer. However, future improvement of these products is a complicated task, requiring buyers' involvement and feedback (Parkinson, 1985). Fourth, the switching process is complex, and it takes a long time to analyze information and solve interdepartmental conflicts. Fifth, Wathne et al. (2001) showed that both buyers and suppliers have contradicting perceptions about the influence of marketing and relationship variables on the switching process, perceptions that impose significant implications on theory and practice.

In high technology markets, the rapid pace of technological change and lack of a dominant design could make the buyer's switching behavior even more complicated because decision makers encounter high uncertainty (Heide and Weiss, 1995). On the other hand, studying this behavior at the organizational level is a difficult task and requires contacting the "right" people, who are in charge of the decision making to obtain reliable information. Because of these challenges, little research has been written on switching behavior for high technology products in the business-to-business context. Until now, literature and empirical studies have lacked an in-depth consideration of a comprehensive model that characterizes this behavior for high technology products. A detailed investigation of such behavior is important so as to enrich the theoretical understanding and reflect managerial implications.

While evaluating the switching behavior for capital-intensive high technology products is largely undocumented, such products can be significantly differentiated through integrated technologies (or product features). These products tend to be information-intensive and reflect high uncertainty (Glazer, 1991), forcing buyers, perhaps, to engage in extensive search efforts and act on collected information before they become outdated (Glazer and Weiss, 1991). This condition makes the switching behavior complicated and expensive at each step of the process. The switching behavior model for these products is expected to be influenced largely by the product design and what it can offer to maintain and enhance buyers' objective. For these products, not every buyer is willing to take the risks associated with switching — unless the potential outcomes will generate significant advantages to overcome the negative effects of switching. Eventually, a special category of buyers called "lead users" is more motivated than others to stay connected with the cutting-edge technology so as to maintain a distinctive market position compared with other buyers. The following section describes this group of users and their incentives to adopt the most advanced technologies.

2.3 Lead Users

Market users, as consumers and buyers, of any type of product are divided across different market segments based on their collective preferences. However, market lead users are identified as being the early adaptors and as having a high incentive to innovate (Morrison et al., 2004). Therefore, identifying those users has a significant impact on suppliers' innovative capacity, because they represent a valuable asset. Morrison et al. (2004) suggested a construct to identify lead users based on organization innovativeness and time of adoption. His results demonstrate a substantial value of lead users as a trusted source of new product ideas, a reliable source of market research, and an influence on others to adopt the same technology, thus increasing the diffusion rate. The contribution of lead users in different industrial organizations is well documented; for example, Cisco Company, the worldwide leader in Internet networking, depends on external sources to get the required technologies and innovations to develop its products.

2.3.1 Lead Users Demand of Advanced Technology

The literature on lead users suggests that cutting-edge users are willing to meet the high costs of adopting state-of-the-art-technology, because they have capabilities that enable them to leverage significant advantage from new technology. Von Hippel (1978) defined the lead users on the basis of two elements; the recognition of benefits from early adoption of innovation (or technology) and the potential for accruing large benefits from using it. He also suggested that users with those characteristics have a strong tendency to innovate in order to solve their problems and produce new applications (Urban and Von Hippel, 1988). Lead users, unlike other users, strongly demand advanced technologies to achieve their objectives and maintain their competitive position (Teplensky et al., 1993). However, being early adopters of new technologies imposes a high risk, because future potentials of such technologies are uncertain (Greatorex et al., 1992).

2.3.2 Lead Users as a Source of Developing Innovative Products

Since lead users' importance is well-defined, Von Hippel (1986) suggested a method to identify those users and integrate them into industrial and consumer marketing research analyses of rapid changing technologies, because these users have the ability to provide reliable information about market trends and demands, whereas most potential users lack real-world experience that reflects market characteristics. He found that such users can serve as a technology forecasting tool for market research and provide new concepts to improve the product design features. Additional studies have shown a strong influence of lead users on the innovation-development process of various products (Johnson et al., 2006; Bonner and Walker, 2004; Lilien et al., 2002; Olson and Bakke, 2001; Urban and Von Hippel, 1988, Von Hippel, 1989). These users, being advanced adopters relative to other users, can be approached for forecasting purposes and generate new products based on their advanced application status (Lilien et al., 2002). Also, Morrison et al., (2004) explored the value of lead users to utilize and test different applications, ensuring a faster adoption process by general users who wait to verify the authentication of each application.

Recognizing the role of lead users as a tremendous source of innovation, Gassmann (2006) reviewed the importance of adopting an open innovation concept, especially for high technology products, where users are given full access to the internal product system. This privilege encouraged users to extend product design capabilities even further so as to generate new applications. Lettl et al. (2006) demonstrated that highly motivated users and an open innovation research are important to the early innovations phases of the medical equipment industry, especially when those users come from diverse competencies and are integrated in a supportive environment (Shaw, 1985). Recently, Franke et al. (2006) conducted an empirical study on kite-surfing equipment to advance the understanding of lead user theory; they found two components that contribute independently to determine attractive products developed by users: First, high expected benefits explain the high probability of innovation. Second, securing advanced positions explains the innovation attractiveness and probability of innovation.

2.3.3 Lead Users and Technology Switching

Since lead users are more likely to push for advanced features to ensure they are ahead of the trend, they have a strong motivation to adopt new technologies consistently (Teplensky et al., 1993). If the current supplier is not able to meet their demands, switching to another alternative becomes a valid substitute to protect their goals. Logically, lead users have more incentives to switch if their goals are badly affected by slow rate of technological innovation of the current supplier. This eventually implies that the product design and its associated features play a big role in the switching to more attractive brands, those containing unique features that provide buyers with certain capabilities not anticipated in the replaced product. This suggests that an investigation into the product design is an essential step to understand its influence on buyers' decisions to switch, despite high associated costs.

2.4 Product Design

Product design is an engineering concept used widely in the literature (Muffatto and Roveda, 2000; Pullman et al., 2002; Wind, 1997; Cooper and Kleinschmidt, 1995) to describe the process of product design and study the effects of different factors on the design process. The value of the product design does not come from its robustness and reduced assembly costs only (Wu and Chyu, 2004), but also from its capabilities to influence current supplier competencies to create new market segments and enhance the position of the existing ones (Yang and Jiang, 2006; Danneels, 2002). The design concept is also used in product innovation and marketing literature. In product innovation literature, it was used to emphasize the importance of product design features in achieving high market performance (Chang and Hsu, 2005), and the value of user-oriented product design for optimal combination of product features (Lai et al., 2006). In marketing literature, it explains the need to take consumer preferences into account to create a successful product design (Srinivasan at al., 1997), and the influence of product design on consumer choice (Bloch, 1995; Fuente and Guillen, 2005).

This research focuses mainly on the final product design that is launched to market domain, upon which buyers can make a final decision. Since this research is concerned mainly with studying organizational buyer switching behavior, I will use “buyers” from now on to refer to lead users. Those buyers represent the selected market segment to conduct this research, that is, MRI research centers or medical centers involved in research activities. I will use “consumers” to refer to specific examples that represent purchasing behavior at the individual level.

The concept of product design in this research comes from the fact that buyers during the purchasing-switching process are confronted usually by: (1) a wide range of products from the same or multiple suppliers, and (2) many features associated with each product, which are linked to certain performances. These two important aspects reflect the ultimate value of the overall product design and influence buyers’ final decision. In the marketplace, buyers can see and judge only the final products and their features; nonetheless, the product design itself is the driving force behind launching these attractive products and their associated features. If the overall product design does not reflect buyers’ demands effectively, then this design is not able to capture continuously market dynamics and intense buyers’ demands (John et al., 1999).

A good example demonstrating this concept is the automobile market in North America, where interested consumers are faced with a wide range of selections from both the same supplier and multiple suppliers. For most automobile brands, the main features are standard among all suppliers, so consumers intend to focus more on the quality and performance of these features as a long-term investment. Surprisingly, consumer statistics shows that the overall product satisfaction is shifting more toward Japanese cars over American ones (ACSI, 2006), leading to significant consumer switching despite the higher prices of comparable Japanese cars. This shift in consumer preferences is not a result of a unique product launched at a certain time to dominate the market; it is a direct result of product design capabilities to integrate consumers' needs consistently (such as fuel consumption, low maintenance cost, etc.), and it creates more attractive features that could address consumers' potential demands.

For capital-intensive high technology products, with technology rapidly changing and with buyers' requirements diverse and hard to define (Krieg, 2004), the importance of good product design becomes critical. Previous research demonstrated that selecting inappropriate product design could lock the development efforts in certain directions that create subsequent failures to the supplier (Krishnan and Saurabh, 2001; Ramdas and Sawhney, 2001); changing the initial product design could be difficult and expensive, leading the supplier to lose its market domination over time and force the introduction of new innovative products to regain its position (Martin and Will, 1998). Studies have shown that in these cases, buyers (as lead users) could assist in identifying buyers' preferences and enhance the process of successful product design through their innovative contributions (Von Hippel, 1986, Von Hippel, 1995; Thomke and Von Hippel, 2002). Therefore, suppliers should recognize those groups of buyers and establish strong relationships with them to increase innovative capacity and the market value of products. Building such a relationship can be an effective strategy to fuel the supplier's products with well-tested features (Franke et al., 2006).

In summary, a successful product design can be characterized by three dimensions: (1) a large number of derivative products that can be launched from that design to meet various requirements and needs of different buyers (ability for market segmentation), (2) a large number of features linked with each product and associated with high performance, and (3) timely launching of products and their features. Such products would be able to maintain the existing buyers and encourage new ones to switch from other less satisfactory brands. The following section highlights the use of the product design concept as an antecedent of switching behavior in the extant literature; subsequent sections present a detailed explanation of successful product design dimensions.

2.4.1 Product Design and Switching Behavior

By reviewing the literature of consumer switching behavior, it is evident that this action is due to various variables that are separated under three main categories: marketplace characteristics, relational characteristics, and consumer characteristics. The weighting of different variables in these categories would depend on the selected products and how consumers perceive these products. Most of the time the overall dissatisfaction with product performance drives this behavior to better alternatives, but little information was offered on how the overall product design could influence this switching, except for a few studies that considered "alternative attractiveness" (Bansal et al., 2005), "perceived differences between brands" (Van Trijp et al., 1996), and "product value" (Bayus, 1991). The disregard in previous studies for the impact of product design could be related to placing more emphasis on the overall value of the new product rather than focusing on product features and product performance.

The existing literature on buyer switching behavior has adopted slightly different models, putting more emphasis on three categories: marketplace characteristics, interpersonal relationships, and marketing strategies. Interestingly, buyer characteristics were rarely mentioned in any study, indicating that buyer switching decisions are more rational than consumer efforts to reflect the organizational objectives. When organizational buyers are confronted by high technology products, then, after detailed investigation and analysis, a final decision is made to evaluate the potential value of different alternatives in order to select the one that maximizes the buyers' benefits. At this point, buyers do not switch for variety seeking or personal preferences; they do so because the new product design provides much advanced capabilities and features that compensate for and exceed the related switching costs.

Surprisingly, most of the literature on buyer switching behavior puts considrable emphasis on marketplace characteristics and interpersonal relationships as the antecedents of switching behavior. A notable exception is a study by Wathne et al. (2001), who showed that products with a broader range of features (as bundling) have a strong effect on the tendency to switch to a new supplier; they included this variable as a marketing strategy for banking services. Although the final switching is logically motivated by the attractive product features and the overall capabilities of the selected product, there is no evidence in the literature that favors adopting the product features as the main factor behind switching. Those attractive features will weaken the value of the old product and decrease the magnitude of various switching barriers to the point where the switching behavior is a reality. The lack of interest in the product design as an important factor behind switching behavior could be due to the difficulties in setting up surveys to collect specific data about product features, which motivate buyers to switch. For capital-intensive high technology products, preparing such surveys becomes a challenging task and requires direct involvement of individuals from the buying organizations or suppliers. This missing link in knowledge between product design and switching behavior motivated this research to investigate this shortage in knowledge and its implications for theory and practice.

2.4.2 Successful Product Design Dimensions

A successful product design reflects three interrelated dimensions: (1) creating a wide range of market segments to meet the specific requirements of different buyer groups, (2) providing a large number of features for each product associated with high performance, and (3) launching of these products and their features in a timely manner.

2.4.2.1 Creating Different Market Segments

Management of technology literature demonstrates that retaining current buyers requires providing product design that reflects the optimum preferences (Danneels, 2002; Kekre and Srinivasan, 1990). But Meyer and Lehnerd (1997) have shown that with buyers' demands spread over different market segments, integrating mass technological demands into a single product would increase the design complexity, leading to significant implications in upgrading the product into the next generation or adding extra features. This condition creates the need for launching derivative products into various market segments (Ramdas, 2003; Ramdas and Sawhney 2001; Sawhney, 1998; MacDuffie et al., 1996). These products share a common design with different subcomponents that reflect certain buyers' demands (Gupta and Krishnan, 1998; Meyer and DeTore, 2001). To be successful in the market, each product should be empowered with the optimum technologies that fit the demands of each market segment (Barbiroli and Focacci, 2005; Krishnan and Bhattacharya, 2002). Failing to do so will result in buyer switching to other attractive products.

On the other hand, the marketing literature also emphasizes the importance of segmenting the market domain to get a better understanding of buyers' needs and manage them efficiently to maintain satisfaction (Athanassopoulos, 2000; Jeffrey and Franco, 1996; Blattberg and Deighton, 1996). Otherwise, unsatisfied buyers will consider moving to more attractive alternatives (Keaveney and Parthasarathy, 2001; Bansal et al., 2005; Bayus, 1991). Using data from American Customer Satisfaction Index, Fornell et al. (1996) showed that product customization is more important than reliability in deciding consumer satisfaction.

In high technology markets, where technology uncertainty is hard to define (Krieg, 2004), product design customization becomes a challenging task because the environment is highly dynamic and buyers' preferences are changing (Bhattacharya et al., 1998). In such cases, it is difficult to translate buyers' demands into product specifications or define certain applications that fit the needs of a specific market segment (Bacon et al., 1994). Therefore, buyer knowledge integration plays an important part in creating successful products (Zha and Sriram, 2006; Chen and Su, 2006; Su et al., 2006). Many studies have emphasized the importance of involving buyer knowledge in the product innovation process to create a product that reflects precisely the buyers' needs and reduces market risks (Enkel et al., 2005; Kreig, 2004), an objective accomplished by propagating buyers' information throughout the functional areas of suppliers and interpreting this information into favorable and marketable product features (Stump et al., 2002; Chen et al., 2004).

The role of modularity and flexibility become important in developing high technology products so as to minimize the impact of technology uncertainty and analyze the available technologies that can leverage the product across different market segments with minimum cost (Krishnan and Bhattacharya, 2002; Worren et al., 2002; Thomke, 1997).

2.4.2.2 Large Number of Features with High Performance

The concept of product features has been used widely in product innovation and marketing literature (Chang and Hsu, 2005; Thompson, et al., 2005; Tholke et al., 2001; Sen, 1996; Bayus, 1994). Studies have demonstrated that firms must differentiate their product offerings from competitors to preserve and grow their market share, when launching new product features is considered the most significant activity that firms utilize to maintain survival (Tholke et al., 2001). Cooper (1979) found that the most important dimension in new product success is product uniqueness and superiority, which represent incorporating unique features that reflect customer demands better than competing products. Literature information shows that the product feature represents each identifiable product characteristic that can be recognized by customers as a new and useful feature (Chang and Hsu, 2005; Tholke et al., 2001; Nicholas, 1992).

Successful products are those that provide buyers with the optimum features for their essential needs. The more useful the features attached to products the better is their market position (Krieg, 2004). Each feature is coupled with specific quality performance that varies among suppliers. The performance of the features is an important aspect to determine the overall product value. Since these features provide buyers with certain capabilities, suppliers try to induce buyers to switch by differentiating the performance of their features from those of other suppliers. However, this strategy is not the dominant factor behind the switching behavior in competitive market products, because product core is reaching the commodity level, where it is hard to clearly differentiate between products (Ovans, 1997). On the other hand, improving product features in a competitive market is not a difficult task, requiring limited buyer involvement.

Capital-intensive high technology markets are characterized by significant turbulences, because of the rapid pace of technology change, changing buyers’ preferences, and competitive moves. From a supplier standpoint, these factors make it a complex problem to determine the right features to be developed and integrated in the final product (Bhattacharya et al., 1998). Without knowing the right product features, the product will be under constant threat from competitors and may be failing to extract the maximum market value. Therefore, the buyers’ knowledge and feedback is an important matter in selecting the product features in this market (Griffin and Hauser, 1993; Zha and Sriram, 2006), because it fills the gap between what suppliers think buyers want and will buy and what buyers really want and will go to the competitors for.

Although many companies have knowledge of their buyers or keep tracking the information by conducting a comprehensive market research analysis, in reality, this is in a fragmented form and difficult to analyze and it is often incomplete, or not integrated efficiently in the product design, leading to produce inferior product features (Henard and Szymanski, 2001). However, different studies have demonstrated that lead users could enhance the process of product design through their innovative contributions (Von Hippel, 1995; Thomke and Von Hippel, 2002), which imply advanced features. In such cases, those groups of buyers can increase the innovative capacity of suppliers (Franke et al., 2006).

2.4.2.3 Timely Launching of Products and their Features

Products with rapid pace of technology change tend to increase the importance of the timely launching of products to different market segments, to maintain the competitive position of new products (Meyer and Utterback, 1995). In high technology markets, some features could be crucial to implement or to solve some problems, and desperate buyers need for these to appear to protect their interests. In this market, buyers often rely on product preannouncement by suppliers to make the purchase-switching decisions, which could be announced well in advance of the actual launching. If a supplier builds a strong reputation in delivering promises (Choi et al., 2005), he or she would reduce the buyer's decision uncertainty and encourage switching.

Since buyers' preferences are broad and are difficult to accommodate at once, suppliers need to evaluate these preferences and rate their importance based on the buyers' expectations, so that suppliers would prioritize the process of launching the most promising features in a timely manner (Chen et al., 2004). This implies that buyers have to be heavily involved in the innovation and development process, taking into account market characteristics and competitor strategies (Carbonell and Rodriguez, 2006). In addition, suppliers with strong distribution channels can deliver their products and services worldwide in a timely manner.

2.5 Conclusion

This chapter reviews empirical knowledge on consumer and buyer switching. It demonstrates that there is no distinctive model to describe or predict switching behavior. Each study adapted different independent variables to explain this behavior, based on the industry under investigation. Previous studies rarely mentioned the influence of product design on buyer switching behavior; but rather put emphasis on other factors such as marketplace characteristics, switching costs, and marketing strategies as the main antecedents to buyer switching.

Most of the existing literature on switching behavior examines competitive markets and focus on frequently purchased consumer products. The literature demonstrates a tendency to stay with the current supplier (despite incomplete satisfaction) because of many factors, the most important being switching costs. In previous literature, the concept of product design was not considered explicitly as an influence on switching, because more emphasis is placed on satisfaction and switching costs as the main determinants of switching decisions in competitive markets.

In competitive markets, it is difficult to differentiate products based explicitly on the integrated features. However, in high technology markets, products can be differentiated based on their features and the impact of these features on users' capabilities. This could explain the reluctance to use product design as a factor behind switching in competitive markets. A literature review shows that switching behavior for capital-intensive markets has never been studied, the reason being the complexity of setting up an approach to differentiate among the products' features and how that would impact consumers' objectives. As well, researchers need substantial assistance from experts in particular products to identify the characteristics of high technology products that make certain products more attractive. These conditions create a challenging obstacle to investigating switching behavior for high technology products.

The literature review enabled me to identify a gap in our knowledge about the influence of product design on switching decisions for capital-intensive technology products. The linkage between these two bodies of literature, which motivated this research, has not been explored previously. Given the gap in previous literature, the next chapter reviews general theories that can help to generalize expectations to the unique context of capital-intensive technologies and the likely role of product design in switching.

Chapter 3
Theory behind Switching Behavior

3.1 Introduction

Previous literature tries to explain the technology switching behavior of consumers and buyers using different theories including consumer behavior (Raju, 1984), consumer satisfaction (Mittal and Kamakura, 2001), organizational learning (Heide and Weiss, 1995), social network (Money, 2004), social exchange (Liu et al., 2005), and equity theory (Low and Johnston, 2006). These theories are considered successful in establishing a concrete ground to explain switching behavior based on the perspective they take into account. For example, if switching behavior is considered a change in relationship between buyers and suppliers to obtain a higher payback, it is best explained by using social exchange theory. Table 3 and Table 4 (in the previous chapter) list various theories utilized to explain consumer and buyer switching behavior.

However, Hogan and Armstrong (2001) suggest that switching to a different supplier means more than just business exchange relationships to get a better deal. They propose a new theoretical perspective in business-to-business marketing based on resource based theory. They extend this theory by looking at business relationships as a valuable asset of the buying organization to achieve a competitive advantage. In this case, the organization will try to build a business relationship that secures a long-term competitive advantage and maximizes shareholder value.

The theoretical foundation of this research is established in the resource based view (RBV) including related arguments of capabilities approach and dynamic capabilities. In RBV, strategic decisions are made as continuous activities to increase rent (Mahoney and Pandian, 1992), which can be made by exploiting the existing resources and capabilities in organizations. Changes in technology can emerge as changes in organization capabilities

(Helfat, 2000), which would impact the behavior and overall performance of the organization. This condition imposes significant pressure on an organization to adopt more advanced product design to maintain its competitive advantage, because this product contains special features that provide unique capabilities for the organization.

At the organizational level, the decision to change a technology (or a product) requires a detailed evaluation of the capabilities of the existing product and the new one, in order to identify if the new product design would enhance the internal resources and capabilities of the organization. The final decision to switch is made by a group of individuals to select a product that contains the best features and provides the utmost capabilities and enhances the organization's competitive position. This implies that the switching process is rational, and focuses on achieving organizational objectives. This argument explains why RBV and dynamic capabilities are particularly useful in helping us to understand buyer behavior in the context of capital-intensive markets.

Competitive advantage is a relative concept; it represents the advantage that one organization has over competitors in a given industry (Kay, 1993). An organization can have many advantages over other competitors – such as distinctive customer service, low cost production, and high quality product – but the most important advantages are those that lead to customer value-creation (Coyne, 1986). In this research, the competitive advantage in MRI research centers represents generating an advanced medical research (innovations), reputable publications, and scientific achievement, all of which can help an organization raise research funding from different agencies.

The following sections describe the RBV and its limitations, which lead to the emergence of capability and dynamic capabilities approaches. Both capability perspectives arise from the RBV, but offer a more dynamic explanation mechanism, especially when the technology in the external environment is changing rapidly. This chapter ends by utilizing dynamic capabilities to explain technology switching in MRI centers and the impact of technology switching on suppliers.

3.2 Resource Based View

Penrose (1959), then Wernerfelt (1984) put forward the initial insights of the resource based view of the organization, and Barney (1991) later made it popular. This theory considers organizations as unique bundles of resources that can create sustainable competitive advantage (Barney, 1991), which is characterized by acquiring economic rent by implementing value-creation (Nelson, 1991). RBV is based on two assumptions in analyzing sources of competitive advantage. First, organizations possess resources that are heterogeneously distributed across organizations (Wernerfelt, 1984). Second, these resources may not be perfectly mobile across firms, and thus, resource differences can persist for a long time (Amit and Schoemaker, 1993; Mahoney and Pandian, 1992; Barney, 1991). By these assumptions, the RBV explains how organizations try to enhance their performance from the resources they currently have or can obtain. It also describes how certain organizations can sustain superior performance relative to other organizations in the same industry, and reflects outstanding performance in acquiring and exploiting exceptional resources in the organization.

Since any organization may own many resources, it should act effectively on those that represent a source of competitive advantage in order to achieve maximum performance. Barney (1991) states four conditions when considering a resource as a foundation of sustainable competitive advantage: valuable, rare, inimitable, and nonsubstitutable (VRIN):

I- Valuable: An organization resource can be valuable if it has a strategic value and helps to improve efficiency and effectiveness, by exploiting opportunities or neutralizing threats in the organization’s environments (Barney, 1991; Amit and Shoemaker, 1993). Typically, organizations can possess multiple valuable resources at the same time. In MRI research centers, valuable resources may include MRI scanners, scientific knowledge, and technical experience.

II- Rare: Typically, valuable resources can be possessed by many organizations; therefore, to be a source of sustained competitive advantage, they must be unique or rare among the current or potential competitors of the organization (Dierickx and Cool, 1989; Barney, 1991). For example, a unique resource required in an MRI research center to maintain a competitive advantage is scientific knowledge or technical experience, which can differentiate different scientists and their achievements. If these particular resources are not rare, then the majority of MRI research centers will generate the same outcome when they use the same MRI technology.

III- Imperfectly Imitable: To consider a resource as a source of sustainable competitive advantage, it should be impossible for one of the following reasons to copy it by current or potential competitors: (1) It is difficult to acquire because of path dependency, (2) the link between the resource and the achieved competitive advantage is ambiguous, and (3) the resource is socially complex in nature, so it is difficult to codify. The concept of path dependency relies on unique historical events as determinant of subsequent achievements. For example, when the scientists are appointed and equipped with advanced technology to investigate advanced applications, they may acquire an imperfectly imitable resource through the nature of historical path of the scientist's expertise (Winter, 1988).

IV- Non-substitutability: Non-substitutability is the last condition for a resource to be a source of sustained competitive advantage. This condition could collapse if competitors can substitute a resource by using an alternative resource to reach the same outcomes. For example, it is not possible for another organization to duplicate the high-quality top management team to achieve the same competitive advantage, simply because the cultural setting of each organization can not be identical (different individuals, different experience, and different practices) (Barney, 1991; Dierickx and Cool, 1989). On the other hand, organizations can work on creating a unique top management team that fits its position and make it a source of competitive advantage.

3.2.1 Type of Resources in the Resource Based View

The need to classify internal resources appears to be crucial, so organizations can act only on those that would achieve competitive advantage. Based on this argument, resources are defined as tangible and intangible assets that are attached to an organization (Grant, 1991). Tangible assets refer to the current assets that have a long-term capacity, such as equipment, land, goods and plant (Wernerflet, 1989). They are relatively easy to measure and determine value based on accounting mechanisms (Hall, 1989), so they are fairly simple to imitate and substitute by competitors (Grant, 1991). On the other hand, intangible assets are more knowledge-based, including patents, trademarks, networks, and reputation (Hall, 1992). These assets have reasonably wide application because organizations can utilize their value internally and externally, by licensing or selling (Wernerfelt 1989). Intangible assets are complex resources, reflecting the difficulty in transferring them from one organization to another. In other words, the inherent complexity and specificity of accumulation of assets precludes competitors from imitating and substituting them in the short-term, making them a source of competitive advantage (Hall, 1992).

Another method of resource classification has attempted to categorize resources into more specific groups. Barney (1991) suggests that resources can be sorted into physical, human, and capital. Grant (1991) extends the debate to explain different resources as financial, technological, and reputational. The importance of reputation comes from the fact that it represents a strong customer trust in the organization built over time, and it therefore represents a substantial competitive advantage (Grant, 1991). Wernerfelt (1995) separates resources into physical assets (equipment and land), human assets (knowledge, experience, and intelligence) (Becker, 1964), and organizational assets (internal planning routines, coordination systems, and external communication) (Tomer, 1987). Regardless of the method used in resources classification, competitors can easily imitate physical (or tangible) resources, so they are seldom a source of competitive advantage. In contrast, human and organizational skills are the more likely source of competitive advantage because they are complex intangible resources (Prahalad and Hamel, 1990). It is debatable whether any one of the resource classifications is more reliable than another, because it depends on the industry and the organization. Some resources may fall under different categories, leading to the belief that the classification process, rather than being perfect, is complementary to studying the significance of resources of each organization.

3.2.2 Main Approaches within Resource Based View

The RBV continues to maintain a strong position in strategic management literature by focusing mainly on the internal resources (Wernerfelt, 1984). This internal focus positions RBV as a static posture away from the external environmental factors, leading to difficulties in including dynamic changes of the environment around the organization (Eisenhardt and Martin, 2000). This condition encouraged new segments to diverge into different schools of thought. Currently, RBV has two approaches: the structural approach and the process approach (Shulze, 1994). Table 5 describes the differences between these approaches.

The primary difference between these approaches lies in the types of acquired rents. In the structural approach, the main focus is on land and Ricardian rents during the emphasis on market processes as economic activities (whose parameters of behavior are assumed to be known). This approach presumes that sustained competitive advantage is possible only when resources are valuable, rare, immobile and non-substitutable (Barney, 1991); subsequently, the scope of organizational means that are rated as strategic is fairly limited to certain resources. To implement value-creating strategies that can not be imitated by competing organizations, management should focus the investment on these types of resources only (Wernerfelt, 1984; Nelson, 1991). It is assumed that management skills have little influence on this approach and that they are comparable among competitors. To reach the same

Table 5. The main differences between the structural and process approaches

Assumptions	Structural Approach	Process Approach
Dominant Process	Market processes	Organizational processes
Activity Focus	On rare, inimitable, immobile, unique resources	On the details of the "common processes"
Type of rent	Ricardian and land	Quasi rents
Representative authors	Barney (1991) Wernerfelt (1984)	Grant (1991) Teece et al., (1997)

Quasi rents: return from the difference between the first and second best use of resources. Ricardian rents: return on physical assets (Mahoney and Pandian, 1992).

productive outcomes by different organizations, similar resources must be owned by both, implying that there is only one best procedure.

In contrast, the process approach stresses the significance of quasi rents, available to organizations by exploiting the common resources. These resources are found in special processes that include institutional routines, organizational procedures, and management insights (Teece et al., 1997). This approach emphasizes the importance of managerial processes in combining different resources to generate competitiveness; these processes include organizational-learning, culture, and skills. Since these processes are developed and accumulated inside the organization, they become distinctive and a potential source of competitive advantage (Fiol, 1991). Examples of these processes are innovation, knowledge transfer, and tacit knowledge. In this approach, interactions between human (intangible) assets and physical (tangible) assets are considered important sources of heterogeneity in achieving competitive advantage (Grant, 1991). Occasionally, different resources can help an organization reach similar productive outcomes by using different paths.

The structural and process approaches arise from the same concept, which is focusing on the organization's internal resources as the basis of competitive advantage. But they try to describe different aspects of organizational phenomena. The structural approach focuses on the existing resources for rent-generation, and identifies how these resources can be a source of competitive advantage. The process approach, on the other hand, puts more emphasis on resources that are not easily manageable to those ones that are totally controlled, and analyzes how these resources can be developed to maintain a competitive position.

The RBV adds essential elements to understand the organizational performance based on key resources. It is complementary to other leading theories in strategic management (evolutionary economics and institutional theory) in explaining how organizations can achieve superior performance in the market. Nevertheless, the validity of the RBV has been criticized in several key aspects (Conner, 1991; Eisenhardt and Martin, 2000; Priem and Butler, 2001a). The following section describes the limitations of the RBV based on the structural approach.

3.2.3 Limitations of Resource Based View

Different studies have linked several key weaknesses to RBV. First, there is the lack of operational practicality in managerial settings (Priem and Butler, 2001b). The RBV has failed to recognize the importance of management insights in the process by which resources lead to sustainable competitive advantage. It assumes that managers always make optimal decisions to get a maximum performance for their organization, while economic motives drive these decisions. However, this assumption contradicts the fact that managers have different personal skills and judge the same information in different ways (Teece et al., 1997).

Second, the RBV proposes that driving organizational growth depends on developing valuable, rare, inimitable, and non-substitutable resources. This can be implemented by identifying and categorizing the organization's resources, then comparing their VRIN's characteristics with the competitors' resources to find the rent-generation potential. Finally, the best strategy that exploits these resources relative to external opportunities is selected (Barney, 1991). In spite of its simplicity, the previous steps are difficult to implement in managerial practice because it is also difficult to determine the value of each resource and whether competitors have the capacity to imitate or substitute it. In addition, the value of different resources is determined by market demand, which is external to the organization and could change constantly.

Third, the RBV has been criticized for being a static model (lack of adaptability), where sustained competitive advantage can not be explained in dynamic markets (Eisenhardt and Martin, 2000). RBV provides information about the source of heterogeneity among organizations, but it presents little explanation about the activities that cause a distinctive resource to evolve (D'Aveni, 1994). Thus, the RBV was unsuccessful in addressing the influence of market dynamics and firm evolution over time.

Fourth, the RBV has failed to identify mechanisms that describe the process of transforming resources into a competitive advantage in high velocity markets (Williamson, 1999), where short-term unpredictable advantages are highly anticipated (Brown and Eisenhardt, 1998). In such markets, such as telecommunications and software, the high rate of technological changes could turn unique resources into limited value in a short-time.

Despite the previous weaknesses of the structural approach in the RBV, it still provides a limited explanation of this research. It demonstrates how combining and exploiting organizational resources in an efficient manner is the source of attaining competitive advantage over other competitors. It also acknowledges the difference between different resources and the fact that their degree of complexity makes it difficult for competitors to imitate them. However, the ability of the RBV to explain the formation of competitive advantage in dynamic markets seems to be weak (Teece et al., 1997), because as the external environment changes, the value of internal resources may also change. In this market, organizations achieve a competitive advantage by considering capabilities. The following sections explain the organizational capabilities and dynamic capabilities approaches; both can be classified under the process approach of the RBV, which has already been explained.

3.3 Organizational Capabilities Approach

For the purpose of this research, one of the limitations in the RBV is its lack of operational practicality and the assumption that managers make decisions rationally (Eisenhardt and Martin, 2000). In addition, the RBV was not able to explain the mechanisms of transferring resources into competitive advantage. The organizational capabilities approach has emerged as an important stream to provide a better explanation for the competitive advantage of organizations. Capabilities have been defined in the literature in different ways. Amit and Schoemaker (1993) identify capabilities as moderators that convert resources into strategic assets, which are a set of unique and specialized resources and capabilities. Wang and Ahmed (2007) see capabilities as the organization's ability to exploit resources by using both specific routines and tacit knowledge embedded in the routines. They suggest that capabilities evolve over time through socially complex interactions among the organization's resources; thus, core capabilities can be a group of resources and capabilities that are strategically unique to maintain a sustainable competitive advantage.

Since capabilities are embedded in intangible routines (Kogut and Zander, 1992), they are firm-specific and difficult to imitate, so they become a source of competitive advantage (Grant, 1991). Different studies have analyzed the importance of organization capabilities (Raff, 2000; Fujimoto, 2000; Tripsas and Gavetti, 2000). Fujimoto (2000) describes three levels of organization capabilities: (1) static capability that impacts the levels of performance and is a static routine in nature, (2) improvement capability that impacts the pace of performance improvement and is fairly dynamic, and (3) evolutionary capability that permits changes in capabilities themselves and is highly dynamic. The last two capabilities are related to organization change; both are considered complex and difficult to imitate; hence, they are a source of competitive advantage.

The difficulty in imitating capabilities is related to their being knowledge-based, with organizational knowledge socially assembled. They are represented in the organization's human resources and their interaction in keeping with explicit and implicit knowledge (Kogut and Zander, 1992). Two important aspects that prevent the mobility of knowledge are codifiability and complexity of knowledge. Complex knowledge is difficult to imitate because it is difficult to codify; this kind of knowledge is referred to as tacit knowledge (Nonaka, 1991). Sometimes intellectual property rights can deter the knowledge imitation process as well.

The organizational capabilities approach is concerned with capabilities that lead to organizational development. The approach describes how an organization maintains competitive advantage by modifying its capabilities in the operative mode (Dosi et al., 2000). This approach enhances the RBV position to interpret capability formation and change. Wang and Ahmed (2007) refer to resources as the "zero-order" element in the hierarchical order; they represent a source of competitive advantage when showing VRIN characteristics. On the other hand, a dynamic market environment requires more than VRIN resources — it needs capabilities to create improved performance or "first-order" element. Core capabilities, which represent an integration of resources and capabilities to create competitive advantage in certain strategic paths, are considered "second-order" (Wang and Ahmed, 2007). However, dynamic capabilities, explained in the next section, are considered the "third-order."

3.4 Dynamic Capabilities Approach

One of the weaknesses in the RBV is the difficulty in explaining the source of competitive advantage in a rapidly changing technology environment. To overcome this limitation, the dynamic capabilities approach was developed, focusing on special capabilities that are close to Fujimoto's evolutionary capabilities (2000). This approach associates rapid changes in the external environment with distinctive processes, called dynamic capabilities, inside the organization to enable mangers to redirect the internal resources (Itami and Roehl, 1987). According to Teece et al. (1997, 509), the "dynamic capabilities framework analyses the sources and methods of wealth creation and captures the private enterprise firms operating in environments of rapid change."

Eisenhardt and Marten (2000, 1107) describe dynamic capabilities as "the antecedent organizational and strategic routines by which managers alter their resource base to generate new value-creating strategies. As such, they are drivers behind the creation, evolution and recombination of other resources into new sources of competitive advantage." More recently, Wang and Ahmed (2007, 35) defined dynamic capabilities as a "firm's behavioral orientation constantly to integrate, reconfigure, renew and recreate resources and capabilities and, most importantly, upgrade and reconstruct its core capabilities in response to the changing environment to attain and sustain competitive advantage." Based on this definition, it is obvious that dynamic capabilities are not processes, but rather routines embedded in processes, while processes are defined by Wang and Ahmed (2007, 35) as "explicit or codifiable structuring and combination of resources and thus can be transferred more easily within the firm or across firms." In this research, the definition of dynamic capabilities proposed by Wang and Ahmed is considered more descriptive, and suitable to explain my findings. Especially, it focuses on the concept of renewing and upgrading the core capabilities of the organization to maintain competitive advantage in response to technological changes in the external environment.

Collis (1994) demonstrates that dynamic capabilities control the rate of change of capabilities. Given this conclusion, Wang and Ahmed (2007, 36) argue that "dynamic capabilities are the ultimate organizational capabilities that are conducive to long-term performance." Eisenhardt and Marten (2000) suggest that dynamic capabilities must be applied sooner and more effectively than the competitors', to create resource configurations that can be a source of competitive advantage, because they are identifiable and can be imitated by others.

Teece et al. (1997) have identified different forms of dynamic capabilities, which include: (1) integration of resources, that is, product development and decision making; (2) reconfiguration of resources, that is, resource allocation and collaboration; and (3) exchange resources, that is, strategic alliance and knowledge creation. The nature of previous capabilities varies with market dynamics. If the market is stable, these capabilities may appear as traditional routines with anticipated results. In this case, best practices are known in the industry with codified knowledge. However, in highly dynamic markets, such as in the MRI market, dynamic capabilities are more experimental and include complex processes to generate new knowledge and practices. Multiple paths can be used to reach the same dynamic capabilities, where successful organizations apply similar approaches to obtain these capabilities (Teece et al., 2000).

Since dynamic capabilities are drivers of organization development, Adner and Helfat (2003) propose the concept of dynamic managerial capabilities, in which managers build, combine, and reconfigure different resources and capabilities to maximize the operational decisions that increase their competitive advantage. Knowing that dynamic capabilities evolve as the external environment changes, organizational learning should develop to match the external changes, doing so through systematic modifications of capabilities that maintain effectiveness and high performance (Zollo and Winter, 2002). This concept is reflected directly in this research, with managers of MRI research centers, or the chief radiologist, acting diligently to reconfigure the internal resources that maximize efficiency and effectiveness, by finding the most favorable product that contains advanced features with unique capabilities that enhance the organization's competitive position.

Despite their special contributions, capabilities and dynamic capabilities approaches have been criticized for the lack of empirical research that consolidate theoretical predictions. This is referred in part to the ambiguous definition of capability terms. On the other hand, the capability prospective adopts the bounded rationality of managers, creating a wide argument for individual interpretation. Also, these approaches can not determine the best capabilities for specific organizations in certain environments (Williamson, 1999). However, since capabilities and dynamic capabilities approaches focus mainly on change and development, they are found to be a suitable framework for this research, including the decision to switch to better technology; but the RBV offers limited explanation because it is a static model. Dynamic capabilities demonstrate that knowledge-based capabilities, which are the source of competitive advantage in MRI centers, are difficult to imitate.

3.5 Dynamic Capabilities and Technology Switching

Previously adopted technology could fail to meet the organization's strategy to secure a competitive advantage, for example, as a result of a slow rate of technological changes associated with an old technology. In this situation, the organization is in a critical position to continue using the old technology and lose its competitive position in the industry, or try to acquire new technology that helps it achieve its objectives efficiently and effectively. Hogan and Armstrong (2001) show that technology switching to a different supplier is about replacing the old resource with a more valuable one to achieve a competitive advantage. Wang and Ahmed (2007) indicate that maintaining a competitive advantage requires renewing and reconfiguring resources and capabilities in response to technological changes in the external environment, implying that switching to better technology could be essential in order to renew resources that preserve high organizational performance.

Knowledge-base, especially researchers' knowledge, in MRI research centers is evolving and is enriching the external environment, while technology is also advancing. This progression imposes significant challenge to improve internal capabilities, including physical technologies, to respond effectively to the external dynamic environment. The decision to switch MRI technology is an attempt to renew and reconfigure part of these capabilities to attain a strong position in the medical research community. This strategic decision starts by gathering extensive information about the current resources, that is, existing MRI technology, and other competing technologies. Collected information undergoes comprehensive evaluation and analysis to match the organization’s objectives with technology capabilities. Finally, a switching decision is reached if the new technology can create sufficiently more capabilities than the old one. The successful acquisition process of external resource is characterized by: (1) pre-acquisition practices that carefully evaluate the importance and suitability of this acquisition (Larrson and Finkelstein, 1999), and (2) post-acquisition activities to resume regular operations after redeploying the new resources (Capron et al., 1998).

Once the new technology is proven to be effective in providing advanced features with unique capabilities, the trend of technology switching increases in the market over time, because more buyers are motivated to obtain the advanced features that achieve organizational objectives. However, technology, as a physical asset, is by itself a valuable source for an organization; but it is not rare or imperfectly imitable (Barney, 1991), because if one organization can buy it, then others should be able to acquire it at some point regardless of the cost (Wernerfelt, 1984). Thus, the technology standing by itself can not be a source of sustainable competitive advantage. However, organizations operate the technology using a combination of socially complex resources, such as technical training, internal routines, scientific expertise, and managerial talent (Wernerfelt, 1984).

If all MRI research centers are creating the same capabilities by utilizing and exploiting the same MRI technology, then the research outcomes (in terms of publications and innovations) will be the same for most research centers worldwide, an unrealistic outcome. Still, some individuals could reach the same research findings by following the same scientific approach. Hence, it is the combination of resource and resource configuration that will determine whether other competitors can imitate the organization setting (Eisenhardt and Marten, 2000). MRI research centers will renew and optimize their resources and capabilities in response to the rapidly changing environment to create a competitive advantage constantly (Wang and Ahmed, 2007).

3.6 Technology Switching Impact on Suppliers

Organizations are increasingly seeking to extend their innovative capacity through strategic partnerships with lead users to leverage their value-creating knowledge and innovation capabilities (Franke et al., 2006). Some have suggested that business relationships are an organizational response to increasing market turbulence and globalization (Doz, 1996). Others find that the real assets of “asset-intense” organizations are coming from their relationships and not from their physical assets (Sawhney and Zabin, 2002). Building and managing these relationships with consumers, partners, and suppliers would create competitive advantage for these organizations (Sawhney and Zabin, 2002). The importance of these relationships has encouraged Jarratt (2004) to develop a theoretical representation of a relationship management capability, recognizing that building a competitive advantage is dependent on the effectiveness of these relationships to build capabilities, which leverage consumer assets, the value-creating knowledge, and innovation assets.

MRI lead users, who switch to a new supplier, were looking to build a new relationship to obtain cutting-edge technology that leverages significant capabilities to achieve competitive advantage. Morrison et al. (2004) recognize lead users as a valuable asset that suppliers, as organizations, need to identify and build a strong relationship with in order to increase their innovative capacity. This requires significant efforts from the supplier to design a technology that offers new capabilities to encourage users to switch.

When lead users start to switch to a new supplier, a mutual relationship value creation starts to develop, in which the supplier gets unique advantages on different fronts (Von Hippel, 1986), by being able to: (1) produce a group of users to serve as a technology forecasting tool for market research, (2) get new concepts to improve the product design features, (3) increase the innovative process of new products, and (4) influence others to adopt the same technology. In this research, the switching process creates a distinctive relationship that empowers both parties with special capabilities. For the supplier, this relationship is a source to increase its dynamic capabilities for improving and developing attractive technologies or products, through the influence of the previous advantages. Morgan (2000) emphasizes the significance of managing such relationships as a source of competitive advantage.

3.7 Conclusion

This chapter reviews the literature to define the appropriate theory behind switching behavior. It demonstrates that there is no typical theory to explain or predict switching behavior. Each study adopted a different theory to explain this behavior. Each theory is considered successful in establishing a concrete ground to explain the switching behavior based on the perspective taken into account.

Resource based view theory is examined as a theoretical foundation of this research, where organizational decisions are made as continuous activities to increase rent. These decisions can be made by exploiting the existing resources and capabilities in organizations or acquiring new resources. Because RBV was not able to explain the source of competitive advantage in a rapidly changing technology environment, the dynamic capabilities theory was selected to compensate. This theory associates rapid changes in the external environment with distinctive processes inside the organization to redirect the internal resources.

For capital-intensive products, the decision to switch is made by a group of individuals at the organizational level after a detailed evaluation of both the existing product and the new products on the market. This evaluation determines the exact capabilities of each product and how the product could enhance organizational resources and capabilities to sustain a competitive advantage. The product design that offers great capabilities that are critical to achieve organizational objectives would be very attractive and could influence the switching decision to replace the old product. Since organizational decision making is focused mainly on improving the organization's resources and capabilities to sustain a competitive advantage, the dynamic capabilities theory represents a strong theoretical foundation to explain the source of competitive advantage in a rapidly changing technology environment. In this environment, product capabilities are constantly changing and organizations are under pressure to evaluate these capabilities to select a product that helps them achieve their objectives.

This chapter establishes the theoretical foundation of this research to help explain the switching behavior in capital-intensive markets as a strategic decision to maintain a competitive advantage in a rapidly changing technology environment. The next chapter will present the research model and the different hypotheses which flow from dynamic capabilities theory.

Chapter 4
Model of Buyer Switching and Product Design

4.1 Introduction

A review of the literature on buyer switching behavior shows that the influence of product design was rarely researched; rather the emphasis was placed on other factors such as marketplace characteristics, switching costs, and marketing strategies as the main antecedents of buyer switching. The selection of these factors to explain the buyers' decisions can be due to the product nature and competitive market conditions. For capital-intensive technology products, the product design is expected to have a strong influence on the final purchasing decision, because these products are coupled with features that provide distinctive capabilities that do not exist in the current product. This condition will give buyers unique competences to pursue their operations under advanced settings, promoting a strong market position. In MRI research centers, these competences represent the performance of various clinical tests and conducting advanced research operations, all of which would attract more government and private funds as well as high scientific reputation. In capital-intensive markets switching behavior is expected to be influenced mainly by the overall product design, in addition to some impact from other factors such as marketplace characteristics, switching costs, marketing strategies, and situational factors.

The market has many examples of cases that support the importance of product design on switching behavior. For instance, in the commercial aviation industry, Boeing dominated the market until recently, when Airbus introduced the most advanced design airplane, A380, which provides huge capacity, unique interior design for passenger satisfaction, various advanced features, and fuel efficiency, exactly what buyers want. The plane's elegant design has led many airline companies to place large number of purchase orders for the product to secure competitive positions in the aviation industry. Total orders for the A380 stand at 166 airplanes, priced at US$ 296--316 million (Airbus, 2007), with between 400 and 880 sales anticipated by 2025 (Babka, 2006). Another example can be drawn from Boeing Company who lost many military contracts to other competitors that had provided superior designs of military devices (Wayne, 2007).

To emphasize the importance of product design on market performance, Henard and Szymanski (2001) developed a taxonomy to define the most significant factors underpinning a successful product; they ranked these factors into four categories: product (customized features, price, and superior performance), strategy (marketing, timing product entry, and R&D resources), process (integration of buyer input, fast product development, and market analysis), and marketplace characteristics (intensity of competition, market potential, and competitive response). The first three categories reflect supplier competencies, while the last one is dominated by market activities.

A considerable part of the literature on innovative product design has focused on the value of integrating advanced technologies to make products more attractive (Su et al., 2006; Danneels, 2002; Henard and Szymanski, 2001; Cooper and Kleinschmidt, 1995), but little was mentioned about this value in switching behavior literature, a fact that motivated this research to fill this gap in knowledge.

In this chapter, dynamic capabilities theory informs the selected hypotheses, with each hypothesis representing a factor that influences organizational internal resources and capabilities to achieve its objectives. Some of the selected hypotheses are not explicitly identified from RBV/dynamic capabilities, but they have a direct impact on the ability to renew the internal resources of an organization, and the rationale for their inclusion being supported by empirical studies on switching behavior. The dynamic capabilities theory also emphasizes the decision to switch to a technology in a rapidly changing technology environment, representing a strategic decision to upgrade the internal resources and capabilities to sustain a competitive advantage.

A literature review on switching behavior, detailed in Chapter 2, shows that there is no distinctive model to describe or predict switching behavior. Each study starts by adapting different hypotheses that are related to the industry or product, then conducting further research to determine the significant variables that explain this behavior. It was also demonstrated that the extant literature has no model characterizing this behavior for capital-intensive high technology products, which is the focus of this research.

To ensure therefore that all relevant hypotheses are included in the research model, I used the deductive and partially inductive approach to generate my hypothesis (Haider and Sue, 1999). The initial model developed in this chapter is based on the dynamic capabilities theory, and contains all possible hypotheses that could explain the switching behavior of capital-intensive technologies. This model is modified later based on qualitative research (in-depth interviews) to sustain the most influential hypothesis in the model and identify unanticipated factors. The final qualitative research (online survey) is conducted on the modified model. This strategy is deemed essential because of lack of information on evaluating and purchasing capital-intensive high technology products. In-depth interviews provide an important opportunity to discover factors that had not been considered when the research began, yet they are relevant to the research question. The following sections explain the rationale behind this strategy.

The deductive approach begins with a general idea (theory or principles), based on which specific hypotheses are formed for further testing in order to support the general idea by concrete empirical evidence (Neuman 1997). On the other hand, the inductive approach begins with specific events (observations of individual), and based on the accumulation of such observations a general idea can be built (Henwood and Pidgeon, 1993). Social research often prefers the deductive approach over the inductive, although the literature contains both types (Reger and Huff, 1993; Ketchen at al., 1993). David et al., (1997) found that inductive research of organizational configurations reports a stronger relationship with performance than studies conducted using deductively derived configurations. This finding indicates the importance of inductive research in gaining a deeper understanding of certain situations.

Occasionally the literature lacks a solid foundation to explain and support a certain situation, where it would be appropriate to incorporate an inductive approach into the model design (Haider and Birley, 1999). The limitation of the deductive approach is that it enables testing of the validity of the hypotheses or to which extent a relationship exists, but it does not allow identifying if other unanticipated factors exist (Neuman 1997). This limitation could reduce the richness of data, leading to unreliable findings and limit the value of the research towards understanding a specific situation. Integrating the inductive approach (through in-depth interviews or observations) can overcome this limitation and reshape the initial model design so as to build one that truly reflects the real phenomena (Eisenhardt, 1989).

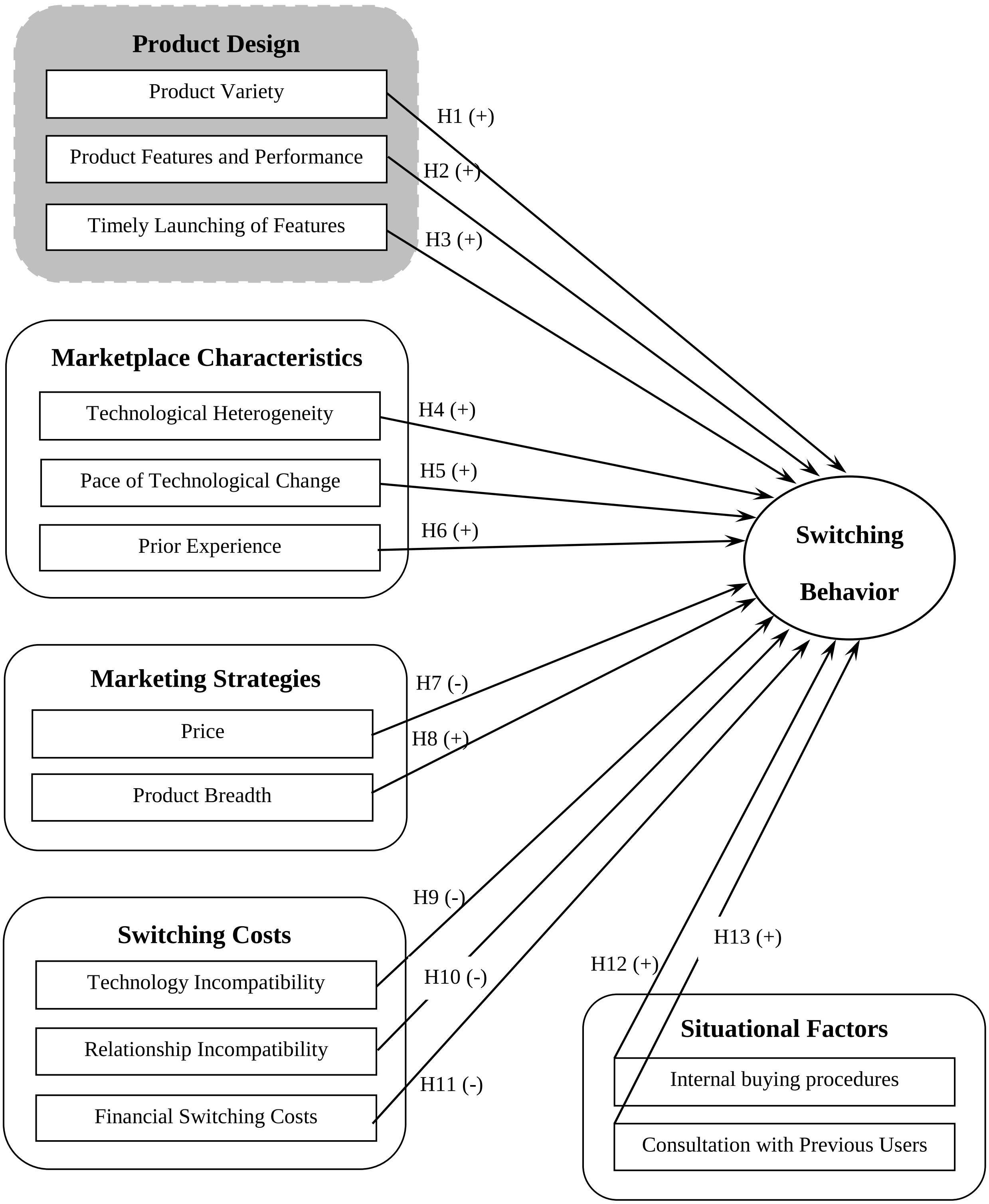
Many studies in social research use the inductive concept indirectly to get a deeper understanding of the phenomena (after developing the hypotheses), but the concept is mentioned as an initial exploratory phase to verify the importance of some factors and include others that relate to a specific situation (Patterson and Dawes, 1999; Patterson et al., 1997). In this phase, potential participants are approached to investigate the relevance of the selected variables to explain the real context.

The following sections demonstrate the process of building a research model and how it is modified based on the initial exploratory phase, in order to reach the final model that truly reflects this research context.

4.2 Research Model and Hypotheses

Figure 9 shows a graph of the initial proposed model, which consists of five main categories that are expected to influence buyers' switching behavior: product design, marketplace characteristics, marketing strategies, switching costs, and situational factors. This model was

Figure 9. The proposed model of buyer switching behavior



assembled after conducting an intense review of the related studies and to reflect the unique characteristics of purchasing a capital-intensive technology product — in this study an MRI technology. These characteristics can be described as follows: (1) purchasing an MRI scanner represents a complex process that requires an intensive evaluation to find the appropriate product; (2) MRI technology is characterized by high rate of technological change (Day et al., 2000); (3) associated switching costs are very high, a fact that imposes considerable switching barriers; and (4) buyers have a strong incentive to obtain advanced technological features.

In this model and in parallel to findings from buyer switching literature, switching costs are expected to act as switching barriers to delay or prevent switching (Yanamandram and White, 2006; Liu et al., 2005; Lam et al., 2004; Durvasula et al., 2000; Lee and Cunningham, 2001; Ping, 1997), whereas the other categories would operate as pulling effects that encourage switching to better alternatives. This model considers the important findings from literature on consumer and buyer switching behavior, where the relevant factors are adapted from previous studies and new ones are added (related to product design) to support the research objectives.

This model does not explicitly mention buyer's satisfaction as an focal factor, it being assumed at this stage that buyers are already dissatisfied with the current product because of different variables such as low quality, low value, and low trust, while the attractive options on the market magnify this disappointment to the point where switching becomes an attractive option. This concept of buyer dissatisfaction is discussed in the literature (Low and Johnston, 2006; Liu et al., 2005; Wathne et al., 2001; Heide and Weiss, 1995). While these variables act as a pushing effect toward the new product, they are not included in the model because the product design variables reflects (measures) these variables in an indirect way.

Table 6 lists the five main categories in the proposed model and the corresponding independent variables, adopted from previous studies. The dependent variable, switching

Table 6. The proposed constructs in the model and study adapted from

Category	Construct	Study Adapted from
Product Design	*Product Variety*: measuring the buyer's perception of supplier product variety in market.	MacDuffie et al. (1996) Meyer and DeTore (2001)
	Product Features and Performance: measuring the buyer's perception of diverse product features and applications.	Von Hippel (1986, 1989) Henard and Szymanski (2001) Homburg and Rudolph (2001)
	Timely Launching of Features: measuring the buyer's perception of supplier commitment to deliver on promises of new feature releases.	Gao et al. (2005) Pae and Hyun (2006)
Marketplace Characteristics	*Technological Heterogeneity*: measuring the buyer's perception of the degree of similarity/dissimilarity among different MRI technologies.	Heide and Weiss (1995)
	Pace of Technological Change: measuring the buyer's perception of MRI technology changing rate over time, including different components such as hardware parts and software packages.	Low and Johnston (2006) Heide and Weiss (1995)
	Prior Experience: measuring the buyer's experience with MRI technology and its applications.	Heide and Weiss (1995)
Marketing Strategies	*Price*: measuring how much difference in price is offered by the new supplier, as a percentage value.	Wathne et al. (2001)
	Product Breadth: measuring how many additional services or components are bundled to encourage switching.	Wathne et al. (2001) Ranganathan et al. (2006)
Switching Costs	*Technology Compatibility*: measuring the buyer's perception of the involved costs as a result of MRI technology incompatibility.	Heide and Weiss (1995) Low and Johnston (2006)
	Relationship Compatibility: measuring the buyer's perception of the involved costs due to reestablishing new relationships after switching.	Heide and Weiss (1995) Low and Johnston (2006) Wathne et al. (2001)
	Financial Switching Costs: measuring the buyer's total expected costs including learning costs, setup costs, and monetary costs.	Low and Johnston (2006) Heide and Weiss (1995) Bansal et al. (2005) Wathne et al. (2001)
Situational Factors	*Internal buying procedures*: measuring the extent to which top management personnel are involved in the decision making process and formalization process.	Heide and Weiss (1995)
	Consultation with Previous Users: measuring the extent to which consulting other users would impact the switching decision.	Money (2004)

behavior, has two values: “switched” and “not switched.” The effect of this variable on MRI market share of different suppliers was demonstrated in Chapter 1 (Figure 1). The following sections provide more details on these categories, the hypotheses that represent each variable, the linkage between hypothesis and dynamic capabilities theory, and its expected influence on buyer switching behavior for capital-intensive products.

4.2.1 Product Design

The product design category is expected to have the largest influence on buyer switching behavior, determining the level of product attractiveness that induces buyers to switch despite high associated switching costs. Three constructs, never before used under this category to explain switching behavior, are proposed in this category to reflect the characteristics of the capital-intensive high technology market.

4.2.1.1 Product Variety

Studies have shown that long-term success of suppliers can not rely on improving a single product design at a time (Kahn, 1998; Cottrell, 2004; Carbonell and Rodriguez, 2006), because empowering it with mass buyers’ demands to meet the requirements of the different market segments would increase the design sophistication (Meyer and Lehnerd, 1997). This condition emphasizes the need for market segmentation by introducing product variety to meet effectively the preferences of different segments (Ramdas, 2003; Sawhney, 2001). Market segmentation can guarantee wider market domination and higher profit, but it should be associated with the introduction of persistent innovative products into existing and emerging market segments.

From a buyer’s point of view, having a wide range of products with distinctive functionality would increase the incentive to move into a new segment that provides more competitive advantages than just switching to a new product from the same segment. The unique advantages derived from each product segment are due to the associated functionalities, which provide exceptional capabilities that distinguish buyers from others in the market. Since the high technology market is changing rapidly, high technology buyers evaluate existing technology and its value-creation in order to decide whether they should alter or recombine resources to become more competitive. This changing environment puts continued pressure on buyers to obtain a product that helps them renew the core capabilities of the organization in response to the technological changes in the external environment to maintain a competitive advantage.

For example, when Airbus Company introduced its A380 aircraft under a new segment called superjumbo, it encouraged many airline companies to upgrade part of their fleets to the level of this segment, which offers many competitive advantages. These advantages are derived from integrating distinctive capabilities with the new product, including a doubling of capacity size, outstanding interior design for customer comfort, and high fuel efficiency. Product variety is expected therefore to be an effective strategy for meeting wider preferences while increasing buyers' incentives to switch to improve their market position.

H1: Product variety increases the probability of switching.

4.2.1.2 Product Features and Performance

Product features are expected to be the most important factors in the product design category and the major stimulus behind buyers switching, undermining the value of the old product and encouraging buyers to replace it. In rapidly changing markets where product features turn trivial in a short-time, buyers continuously evaluate existing features and their role in creating a competitive position. This assessment determines whether more features should be added or the product is reaching its utmost capacity, where switching to a new product with new features would be the only solution to sustaining a competitive advantage. In a rapidly changing environment, it is critical that users upgrade product features constantly because doing so helps renew the core capabilities of the organization in response to the external technological changes to sustain a competitive position.

Product features provide unique capabilities that make buyers bear the switching costs and their consequences, granting higher pay offs. Certain product features become attractive only when they are associated with high performance to differentiate them from other products on the market (Thompson et al., 2005); however, determined what are the attractive features in capital-intensive technology products is a challenging task for suppliers (Krieg, 2004; John et al., 1999), because technology is changing rapidly and buyers' needs are difficult to predict. Some suppliers are, therefore, continuously investigating the buyers' current needs and potential applications to decide on integrating the optimum features to meet buyers' expectations (Krieg, 2004; Tholke et al., 2001). One component of these features is providing buyers with full access to the internal software to improve it and add more applications such as in the case of lead users in this study (Von Hippel, 1995; Thomke and Von Hippel, 2002), who can modify the internal programs to create different clinical applications and enhance the performance of existing ones.

Although suppliers find it difficult to identify the right features, buyers have another problem in evaluating the performance of these features and their suitability for certain needs. Sometimes specific features have a complex functionality that makes buyers unable to critically evaluate their performance, so they seek advice form other users or external sources. Buyers who are technically well skilled and experienced can do this assessment effectively. In this study, MRI buyers have the expertise to conduct a self-evaluation of different product features and check their performance. The product design that incorporates a wider range of features associated with high performance is expected to increase buyers' incentives to switch.

H2: Wider product features linked to high performance increase the probability of switching.

4.2.1.3 Timely Launching of Features

Effective integration and testing of different product features are crucial to ensure that the product and its features come to market on time, as promised by the supplier (Choi et al., 2005). For a high technology product, the development cycle might take longer than anticipated, especially for medical technology products that require detailed testing and Food and Drug Administration (FDA) approval, before entering the market. Some buyers put significant emphases on certain features when deciding to switch or purchase a new product, when such features are essential for implementing certain applications or solving problems, and buyers could need them urgently to maintain a certain level of performance and market position. Recent news from the aviation industry has shown that a few airline companies, including FedEx, have decided to cancel their orders for the Airbus A380, because of the continuous delay in launching the product.

In high technology markets, suppliers often announce products or features before they come on market, sometimes when they are in the early stages of development or testing. This action would influence buyer's decision to purchase a new product by two ways. First, ignore other products that are inferior to the announced product. Second, delay the purchasing process until the anticipated product is on market. However, suppliers should build a strong reputation in delivering promises (Choi et al., 2005; Gao et al., 2005); otherwise, buyers might not take their promises into consideration. To meet the buyers' demands effectively, suppliers rank the importance of buyers' preferences to prioritize the process of launching features into the market (Krieg, 2004; Chen et al., 2004).

Buyers in rapidly changing technology markets are aware that valuable product features soon become insignificant because of technology's short life cycle. The dramatic change in the features' value requires frequent assessment of existing features and those under launch, in order to select the potential product that contains the required features to achieve a strong position relative to competitors. Therefore, I expect that timely launching of the features, as promised by suppliers, would encourage buyers to switch.

H3: Timely launching of features increases the probability of switching.

4.2.2 Marketplace Characteristics

Here three external uncertainty constructs are identified to measure the effect of the marketplace on buyers' switching decisions: technological heterogeneity, pace of technological change, and prior experience. These constructs are the most fundamental characteristics of the marketplace because they reflect the influence of technology and buyers' uncertainty (Li and Calantone, 1998). Several studies have investigated the impact of these constructs on buyer switching behavior using different products in a competitive market (Low and Johnston, 2006; Heide and Weiss, 1995). In this study, an attempt is made to examine the potential impact of constructs for capital-intensive technology products, where market is characterized by rapid technology changes.

4.2.2.1 Technological Heterogeneity

Technological heterogeneity refers to a lack of standard design among suppliers due to pursuing exclusive product designs that fit suppliers' strategies (Tushman and Anderson, 1986). This condition is common in high technology markets (Teece, 1986), where a product and its features undergo enormous changes because of the fast rate of technological innovation. In this case, coordinating between suppliers to set certain product standards is an impossible task, because each supplier is trying to dominate the market by massive integration of advanced features.

Heide and Weiss (1995) used this construct as an indicator of buyer uncertainty during decision making to switch suppliers. This uncertainty is a psychological condition resulting from incomplete knowledge about the final consequences of such action, which motivates buyers to conduct more search activities to collect detailed information about the value of each product and how it is differentiated in overall value (Dawes et al., 1993). They found that this construct increases the probability of staying with the current supplier to avoid the negative consequences associated with technology heterogeneity. This decision was based on buyer's inability to act upon limited information related to lack of a standard design.

Research shows that technological heterogeneity diminishes the buyers' capability to utilize certain principles to guide the decision process (Pfeffer et al., 1976). However, lead users in this study, who are expert in utilizing the product and its functionalities, are able to analyze and assess other products' capabilities and differentiate those that could achieve competitive advantages. Therefore, the lack of a common design does not limit the desire to switch; on the contrary, it provides more incentive to replace the old design with a new one once it is proved to be more valuable.

H4: Technological heterogeneity increases the probability of switching.

4.2.2.2 Pace of Technological Change

The rapid pace of technological change in high technology products creates another dimension in buyer uncertainty, just as the technological heterogeneity does (Heide and Weiss, 1995). A high level of technological changes increases the possibility that a product or certain components may become outdated at any time (Stump and Joshi, 1998). Heide and Weiss (1995) used this construct as a pointer to represent buyer uncertainty, where it deliberately encourages buyers to acquire updated information about the latest applications and technologies of each available product. This information is time-sensitive, hence, processing it for effective decision making imposes considerable pressure and uncertainty on buyers (Glazer, 1991; Glazer and Weiss, 1993).

Based on their level of expertise and experience, buyers respond to the rapid pace of technological change in different ways. If buyers lack the requisite knowledge (Wagner et al., 2003), the risks associated with uncertainty would increase, enhancing the likelihood of staying with a current supplier to avoid unanticipated outcomes. Sometimes buyers seek guidance from external sources such as suppliers or consultants to differentiate the value of different alternatives in the market. However, lead users can depend on their expertise to evaluate the value and validity of new applications, leading to better decision outcomes. For this reason, lead users are anticipated to have strong incentives to switch to suppliers that provide rapid pace of valuable technological changes, as features, enhancing the core capabilities of the organization to maintain competitive advantages.

H5: Rapid pace of technology change increases the probability of switching.

4.2.2.3 Prior Experience

The rapid pace of technological changes makes the buyers' experience soon outdated, hindering their ability to fully appreciate the value of new technologies and make adequate decisions. This would force inexperienced buyers to constantly increase their information acquisition regarding new technologies so as to stay updated about technology trends and its implications on switching decisions. While some buyers' experience is often outdated in high technology markets (Von Hippel, 1986), experienced buyers meet less uncertainty in handling information about new technologies and can rely on their expertise to make good decisions.

Prior research shows that inexperienced buyers are more likely to switch to a new supplier, whereas the experienced tend to stay with the same supplier (Heide and Weiss, 1995; Anderson et al., 1994). In contrast, Bell et al. (2005) found that prior experience has a positive effect on evaluating the value of different products and switching to the one associated with high returns. In this study, lead users (as experienced buyers) are anticipated to have more incentive to switch, because their expertise is able to differentiate the strategic value of competing technologies in the market, and select a technology that improves the organization's capabilities to be in a competitive position.

H6: Prior experience increases the probability of switching.

4.2.3 Marketing Strategies

Marketing strategies should be targeted toward reducing the negative consequences of switching costs on buyers' decision so that they act as a pulling effect to encourage buyers to switch. Two important marketing variables, outcome price and product breadth, could have a strong impact on the final decision to switch. Both were used in the literature to explain switching beahvior (Wathne et al., 2001).

4.2.3.1 Price

Product price perceived by buyers reflects an important variable in the switching equation because it represents an important dimension in the total switching costs (Jones et al., 2002). Suppliers have full control over this variable; by lowering the price buyers can appreciate the economic value of switching (Kranton, 1996), especially when it is associated with extra marketing packages that provide continuous training support to resume full operations under the new product set-up. In rapidly changing technology markets, lower prices are an effective strategy to encourage new buyers to renew their internal resources and capabilities to become more competitive.

Sometimes suppliers can spread the price over a certain period, giving some relief from bearing the large costs all at one time. Monroe and Dodds (1988) found that low price could represent a low quality, whereas Schmalensee (1977) suggested that high quality produces more sales, leading the supplier to drop prices in the long run to induce more switching and higher profits. Wathne et al. (2001) found that price dominated all other factors behind switching behavior (in the banking industry), because it directly impacts the total switching costs. In this study, lower prices are anticipated to encourage buyers to switch.

H7: Lower prices increase the probability of switching.

4.2.3.2 Product Breadth

Product breadth or bundling is an effective marketing strategy to attract more buyers, because it offers buyers wider options and services than those provided by the current product. For certain products, bundling could come as extra services or components to be used with the same product or as separate supporting devices that enhance overall product capabilities. Generally, buyers are interested in such offers to augment their internal resources and capabilities to achieve competitive advantages.

In the MRI case, success could come through adding more software packages for lower price or providing external units for image storage or processing. As mentioned before, each feature allows buyers certain capabilities; therefore, bundling the features would make the product more attractive. These additional features may offer greater performance causing them to be of significant value during the switching process, especially for high technology products. Wathne et al. (2001) found that product breadth has a significant effect on the decision to switch. In this study, bundling product features is expected to be an effective marketing strategy to increase incentives to switch.

H8: Wider product breadth increases the probability of switching.

4.2.4 Switching Costs

Nielson (1996) has established two types of switching costs in an industrial organization: hard assets (fixed asset investments, product modification, and supply agreement terms), and soft assets (personal relationships that develop over time, and a communication system that prompt these relationships). Hard assets can be estimated to a higher degree of accuracy than the soft assets, and they have more influence on switching behavior. Studies have proposed various constructs to measure the switching costs, where the selection of these constructs is based on the nature of the product and its usage (Low and Johnston, 2006; Heide and Weiss, 1995; Wathne et al., 2001). In this study, I adapt technology compatibility, relationship compatibility proposed by Low and Johnston (2006), and financial switching costs suggested by Jones et al. (2002).

4.2.4.1 Technology Incompatibility

Previous studies have shown that buyers frequently repurchase their technological products and added features from existing suppliers who had provided the initial version of the product (Rosenthal, 1984). The main reason behind this repeated purchasing is technology compatibility, in which a buyer's prior investment with a particular supplier causes continuous commitment to get all related upgrades from that source, particularly for products that lack a standard design (Teece, 1986). In such cases, it is not possible to request attractive features or applications from other suppliers, unless the entire product is ordered.

This incompatibility is considered by different studies as the main barrier to move to attractive products, in particular for high technology products, where larger capital costs are coupled with the replacement process (Low and Johnston, 2006; Heide and Weiss, 1995). In this study, costs associated with overcoming technology incompatibility of capital-intensive technology products are exceptionally high, and this cost could inhibit buyers' intention to renew internal resources and capabilities with more attractive ones, on which the competitive market position can be maintained. However, if buyers are able to meet the actual costs of replacing the product, then technology incompatibility does not represent a switching barrier.

H9: Technology incompatibility decreases the probability of switching.

4.2.4.2 Relationship Incompatibility

Over time, the supplier-buyer relationship becomes more intimate and personal, leading to profitable outcome for both, because the understanding of each other's demands generates effective routines to handle the different issues. If this relationship is deemed to change, buyers have to develop new practices and procedures to fit the new relationship requirements with a potential supplier (Heide and John, 1990; Heide and John, 1992). Occasionally, the entire set of working and personal-interorganizational relationships need to be rebuilt with the new supplier to make the new environment more efficient and productive; that would include a special rearrangement of technical support personnel and application specialists (Weiss and Heide, 1993). Establishing such new relationships with new suppliers requires intense engagement to understand the needs of each side and guide them to greater benefits for both partners (Dabholkar et al., 1994). Research in marketing shows that a long relationship imposes strong pressure to stay with the same supplier to maintain the accumulative value of this relationship (Wathne et al., 2001; Price and Arnould, 1999; Beatty et al., 1996).

In reality, buyers appreciate the value of such long-term relationships as being profitable (Turnball and Wilson, 1989), with suppliers able to deliver these values efficiently and promptly to solve any obstacles. This relationship helps buyers to utilize their internal resources effectively to sustain a competitive position. In this situation, switching to a new supplier would create a major disruption of regular operations, during which significant efforts are needed to re-establish new relationships and resume the operations effectively under the new procedures (Low and Johnston, 2006). Therefore, established relationships are expected to create a strong barrier to switching.

H10: Relationship incompatibility decreases the probability of switching.

4.2.4.3 Financial Switching Costs

Financial switching costs refer to the perception of time, activities, and money associated with switching from one supplier to another, from the initial stages of consideration to the final behavior; those costs can be spread over different dimensions so as to understand their impact on the total costs. Jones et al. (2002) did a remarkable job in establishing and analyzing six dimensions of switching costs, as shown in Appendix A. Interestingly, these costs represent the total cost starting from the initial stage of gathering information about different suppliers to the last stage of actual switching. In reality, evaluating and measuring these costs for each study is a difficult task because it depends on the product under investigation and how participants are able to interpret or predict the real impact of each cost dimension, reflecting exactly what Jones and colleagues found. Therefore, in this study I will focus on a few dimensions only (monetary costs, set up costs, and learning costs), which are believed to reflect the most important costs associated with switching suppliers for the MRI case.

High technology markets are known to have high switching costs, which could outweigh switching benefits and reduce buyers' intention to look for changes in their internal resources. Different studies of such markets investigated buyers' reactions toward switching costs (Low and Johnston, 2006; Heide and Weiss, 1995), emphasizing the strong tendency to stay with the current supplier to avoid expensive consequences. For capital-intensive technology products, the same tendency to stay with the current supplier is expected to prevail.

H11: Financial switching costs decrease the probability of switching.

4.2.5 Situational Factors

4.2.5.1 Internal Buying Procedures

As mentioned earlier, the decision making process at the organizational buying level is more complicated than that at the consumer level, because of the organizational structure and different individuals' involvement in the decision making process (Bunn, 1993; Sheth, 1973). In general, different buyers adopt various policies to reach decisions based on different factors: importance of purchase, uncertainty, extensiveness of choice set, and perceived buyer power (Bunn, 1993). Heide and Weiss (1995) found that formalization has limited buyers' ability to switch, because the bonding procedures and routines make the process of acquiring information and analyzing them tedious. On the other hand, they found that centralization has no influence on switching behavior, because higher management prefer to make a switching only if it is vital to the organization competitive position.

For capital-intensive technology products, different departments would be involved with different degrees of authority, imposing significant challenges to accommodate the needs of all parties and leading to delay or abandonment of the final decision. In this study, the internal buying procedure could have an effect based on the structure of the organization. For example, if the MRI center were able to attract larger financial support from external funding agencies (public or private source that supports research) to finance the purchasing process, then the decision would undergo less formalization and centralization routines. In this case; MRI personnel would be in more control of the final decision, where they can select a supplier that helps in renewing and upgrading internal capabilities to meet specific objectives. However, when the required funding is allocated from the same buying organization (hospital budget), more individuals from different departments participate in the final decision, leading to some compromising activities to select a certain supplier. Based on the previous discussion, flexible organizational procedures are anticipated to facilitate the switching process.

H12: Flexible internal buying procedures increase the probability of switching.

4.2.5.2 Consultation with Previous Buyers/Switchers

The difficulty in processing the technical information of capital-intensive products could lead to some complexity in the decision making process (Glazer, 1991; Glazer and Weiss, 1993), especially with the involvement of many individuals with different interests. In such cases, buyers might need assistance to establish a clear interpretation of the collected information, and how it will impact their internal capabilities to achieve their competitive position. Therefore, they could seek an external consultation from different sources to get a better understanding of the value of different alternatives and differentiate the one with high advantages (Money, 2004). In the MRI case, visiting other hospital sites can be a common practice to validate the technical information and get practical verification of their significance, especially when they are applied on patients. Contacting others during conferences is also a common way to exchange information about certain products. If buyers are provided with positive feedback about certain product performance and capabilities, especially from previous switchers, they could more easily decide about switching.

H13: The positive consultation from prior users increases the probability of switching.

4.3 Exploratory Research

In this phase, in-depth interviews were conducted with individuals who were involved in the purchasing process. Interviews like these confirm the relevance of the major variables in the proposed model before constructing the initial survey items. Eventually, this step is essential to avoid developing a long survey and then verifying its validity with a small sample of participants who would be reluctant to spend a long time to complete it. Based on the outcome of these interviews, the initial survey was modified; its validity was verified in a later stage.

4.3.1 In-depth Interviews

4.3.1.1 Overview

Nineteen individuals from different MRI research centers were contacted by email to explain the purpose of this research, and get more information about different factors that drive the purchasing processing of MRI technology. Thirteen responded positively to the email, all of them, department heads or research scientists who had been on the purchasing committee to select a new MRI technology. Then, four visits were scheduled to meet a few radiologists and scientists who were involved in the decision making in the purchasing of MRI technology in Ontario. The outcome from this stage was useful to better understand the evaluation process of different MRI technologies and generate a list of important questions that would guide subsequent interviews. In Appendix B is a copy of the interview protocol. The questions represent various variables related to the purchasing process of MRI technology. Most questions require a "Yes" or "No" type of answer, while others are open-ended. The open-ended questions were used to collect detailed information about the purchasing process of MRI technology, and the measurement items that reflect each independent variable. Personal interviews with a large number of individuals (around sixty) would accomplish the following objectives:

1- Confirm the relevance of the variables in the proposed model.
2- Understand the purchasing process and develop the measurement items.
3- Identify key informants that are familiar with the purchasing process to participate in the final online survey.

It is important to mention that the decision making process to buy MRI scanner usually involves many individuals in the buying organization, but the focus is at an individual level. In this study, I need to identify a distinct individual (key informant) who was involved in the buying process or familiar with it, who would participate in the final survey and provide reliable information about the purchasing process of MRI technology. Such an individual could be the head of a department, a radiologist, a scientist, an engineer, or a technologist. He or she should be from the same department and be knowledgeable about the process of purchasing MRI technology. Generally, the head of a department is considered the most knowledgeable person on the purchasing process and has a strong impact on the final decision. However, other senior individuals in the department could become familiar with the process, even if they have not been directly involved, by sharing information.

This sharing of information is facilitated by regular interaction among different individuals who use the same technology consistently. On the other hand, the purchasing of an MRI technology takes about one year to finalize, during which most senior individuals in the department witness different factors that lead to the final selection of a specific technology. Seniority is based on years of experience and the position held in the department. Although this argument indicates that I have multiple key informants from the same MRI department, it is important to verify that different key informants in the same department are able to provide the same information when they are asked the same questions about the purchasing process (Patterson and Dawes, 1999). The verification is made by comparing the frequency of the same answer, ‘Yes” or “No,” to the same questions. For example, if two key informants from the same department answer the same questions with a high degree of similarity, it means both of them are familiar with the purchasing process of MRI technology.

4.3.1.2 Conducting Interviews

The International Society for Magnetic Resonance in Medicine conference (ISMRM, 2007) in Berlin was an optimal location to conduct in-depth interviews, because this annual meeting is attended by many individuals who work in MRI research, in addition to industry experts and marketing mangers. This conference has a technical exhibition to demonstrate MRI stat-of-the-art technologies developed by different companies. The ISMRM database of conference attendees was used to identify potential interviewees. Selected candidates were contacted by email and provided a description of the study purpose and importance.

Initial screening was made by asking potential candidates if they had been involved in the purchasing process of MRI technology or were familiar with it. Those who agreed to participate in personal interviews were asked to select a suitable 30- to 45- minute time slot during the conference period. In total, 55 individuals agreed to meet during the ISMRM conference; however, 6 individuals found they could not attend the interview because of other commitments, resulting in 49 final interviews. Table 7 shows the academic position of participants interviewed during the ISMRM conference.

Table 7. Sample characteristics of interviewees

Academic Position of Participants	Number (%)
Department Chair (DC)	10 (20.4)
Scientist (Snt)	15 (30.6)
Medical Doctor (MD)	12 (24.5)
Physicist / Engineer (P/E)	7 (14.3)
Technologist (Tech)	5 (10.2)
Total	49 (100)

The final group was created with the intention that it contains different key informants from the same MRI research centers, but the different colleagues were not informed that each individual would be interviewed separately. Table 8 shows the distribution of 49 participants from 28 centers. By correlating responses to certain questions related to purchasing MRI technology, this process helped to confirm that those individuals were familiar with the purchasing process at their department.

Table 8. Distribution of interviewees based on MRI research center

Number of MRI Research Center	Number of Interviewees per center	Academic Position*
1	3	DC, MD, Tech
2	4	DC, P/E, P/E, Tech
3	3	MD, P/E, Tech
4	4	DC, MD, P/E, Snt
5	2	MD, Snt
6	3	DC, MD, Tech
7	4	MD, MD, P/E, Snt
8	3	MD, Snt, Snt
9	4	P/E, P/E, Snt, Tech
10-15	1	DC
16-19	1	MD
20-28	1	Snt
Total 28 centers	Total 49 interviewees	

***** The abbreviation of academic position is taken from the previous table.

During the ISMRM meeting, each interview was conducted in a semi-structured format guided by questions in Appendix B**,** a format that allowed collecting the important information in an effective manner. The interview started by thanking the interviewee for participating in the study and he or she was encouraged to stop the conversation at any point to clarify any vague questions. Then I started collecting the information by asking the prepared questions. “Yes” and “No” answers were recorded, in addition to comments related to each question. These comments and open-ended questions are used to develop the initial measurement items of each variable.

Although the interview period was projected to last 30 to 45 minutes, some interviewees spent over 2 hours explaining their experience during the purchasing of a new MRI technology. The interviews generated a comprehensive understanding of the process of evaluating and verifying capabilities of different MRI technologies, before the final decision is reached.

4.3.2 Interviews Analysis

Appendix B contains a list of questions that require a “Yes” or “No” type of answer, representing various variables related to the purchasing process of MRI technology. The collected responses were gathered and analyzed to determine the most influential variables in the process. The variable that weighs significantly with “Yes” is considered an influential variable, whereas a variable that scores high-ranking with “No” is deemed to be trivial. A few variables in the original proposed model demonstrated a low impact during the process, so these were dropped from the model, including timely launching of features, technological heterogeneity, pace of technological change, prior experience, and consultation with previous users. Table 9 shows the analysis of interviewees’ response, revealing the significant variables during the purchasing of a new MRI technology. The following section explains why some hypotheses were excluded from the initial model and others included.

4.3.3 Modifying the Initial Model

Low and Johnston (2006) recommend in-depth interviews for exploratory research, in which the most influential hypothesis in the model can be determined. Findings from interviews revealed that some of the hypotheses in the initial model (Figure 9) are not significant, including technological heterogeneity, pace of technological change, prior experience, consulting previous users, and timely launching of product features. The other hypotheses in the model are shown to be significant during the switching process.

Marketplace characteristics variables (technological heterogeneity, pace of technological change, and prior experience) are not significant during the MRI switching process – in contrast to a previous study that placed a large emphasis on marketplace characteristics as the antecedents of switching behavior (e.g., Heide and Weiss, 1995), which was conducted using high technology products in a competitive market (computer workstations).

Table 9. Analysis of interviewees' responses

Category	**Independent Variable**	**Yes** number (percent)	**No** number (percent)	**NA** number (percent)
Product Design	Product Variety	42 (85.7%)	7 (14.3%)	
	Product Features and Performance	46 (93.9%)	3 (6.1%)	
	Timely Launching of Features	<u>4 (8.2%)</u>	44 (89.8%)	1 (2.0%)
Marketplace Characteristics	Technological Heterogeneity	<u>3 (6.1%)</u>	45 (91.8%)	1 (2.0%)
	Pace of Technological Change	<u>3 (6.1%)</u>	43 (87.8%)	3 (6.1%)
	Prior Experience	<u>2 (4.1%)</u>	46 (93.9%)	1 (2.0%)
Marketing Strategies	Price	35 (71.4%)	14 (28.6%)	
	Product Breadth	15 (30.6%)	34 (69.4%)	
	Research Collaboration*	41 (83.7%)	8 (16.3%)	
	Product Service*	39 (79.6%)	10 (20.4%)	
Switching Costs	Technology Incompatibility	44 (89.8%)	5 (10.2%)	
	Relationship Incompatibility	43 (87.8%)	6 (12.2%)	
	Cost of Learning Technology	40 (81.6%)	9 (18.4%)	
	Cost of Verifying Technology	23 (46.9%)	26 (67.3%)	
Situational Factors	Internal buying procedures 1- Support of top management	16 (32.7%)	33 (67.3%)	
	Consultation with others: 1- ask experts	<u>2 (4.1%)</u>	47 (95.9%)	
	2- ask previous users	<u>3 (6.1%)</u>	44 (89.8%)	2 (4.1%)

Underlined values represent variables with non-significance influence at $p < 0.05$ (t-test)
* New variables presented based on interview findings

In this study, interviewees expressed little concern about technological heterogeneity among suppliers and the rate of technological change, for the following reasons. First, since the establishment of MRI technology, it has been produced by few suppliers, based on different platforms. Those suppliers are large companies with major market share and intense development capabilities, so there is no concern that a dominant platform will eventually emerge, turning other platforms obsolete. Second, MRI technology, since its early launching, is improving rapidly and becoming a powerful tool, with the major suppliers competing to integrate the state-of-the-art features as they become available. The rate of technological change of the MRI industry will continue to increase (Kreig, 2004). Therefore, MRI buyers believe that the rate of MRI technological change will continue to be high, reflected in continuous launching of advanced features by major suppliers. The influence of these two variables can be recognized by this statement from one interviewee: "… widely used MRIs in the market have been introduced by major companies that support different platforms, it is hard to get them to agree on a single platform because the fast innovation cycle would make it impossible to coordinate development activities based on a common platform structure. I believe that each company made a large investment in this path and will continue to maintain its distinctive platform."

Interviewees also showed no relationship between their prior experience and the probability of switching to a new technology. Previous research found contradicting outcomes for the impact of prior experience on switching. Given some studies, inexperienced buyers are more likely to switch to a new supplier (e.g., Heide and Weiss, 1995; Anderson et al., 1994), while given other studies, prior experience has a positive effect on evaluating the value of different products and switching to the one associated with high returns (e.g., Bell et al., 2005), this work was done on the financial services industry. In this study, individuals involved in the decision making (as lead users) appear to have comparable technical expertise in MRI technology, and to be able to differentiate the strategic value of competing MRI technologies and their impact on their internal capabilities to maintain competitive position.

Money (2004) shows that the consulting with others has a significant impact on selecting specific products, especially for frequently purchased products (e.g. appliances, food, banking, and insurance). In this study, however, the process of consulting previous buyers and switchers was considered by interviewees as part of the technology verification process because it is common practice to validate the technical information and get practical insights from others, especially when they are applied to practical settings (e.g. on patients). However, because interviewees placed little emphasis on its importance (as a key variable) in the process of purchasing a new MRI technology, it was removed from the initial model.

Timely launching of product features, as the supplier promised (Choi et al., 2005), was originally thought to have a strong influence on one switching decision, because it demonstrates a strong commitment in meeting buyers' needs and a strong reputation in delivering promises (Gao et al., 2005). However, interviewees expressed that the purchasing decision from any supplier is based on what they have currently available in the market, because the development cycle of any potential capabilities might take longer than anticipated; especially if it needs detailed testing for Food and Drug Administration (FDA) approval. Therefore, little focus is placed on future promises to integrate advanced features, although doing so would be advantageous. The influence of the variable is realized by this remark from one interviewee: "The purchasing committee makes the decision based on collected information, which is verified for accuracy. It is hard to decide on features that are expected to arrive soon, because they might not arrive for one year or later."

Interviewees emphasized the importance of two new variables that play a significant role in this process: "research collaboration" and "product service." The first variable is central to overcoming any research-related challenges and utilizing the technology to test new clinical applications, especially when the new technology contains many complicated capabilities. This becomes an important issue for implementing various research projects more effectively and generating reputable research. The significance of this variable can be emphasized by two comments from interviewees: "...MRI technology is very sophisticated; help is always needed to figure out the best way to integrate our research projects," and "…research agreement with the MRI provider is a key aspect to get access to the internal software and network with other users through the online networking community."

Accessing the internal software development tool is an essential part of conducting research using user customized MRI protocols in which researchers manipulate the internal software routines to investigate new settings to generate better clinical information. This open source access is a special capability granted by MRI suppliers to certain users who sign a research agreement. If the internal development tool is flexible (easy to use and modify), it will be a very attractive feature for MRI buyers, enhancing the ability to integrate new research ideas and generating reputable research. A statement by an interviewee stresses this point: "Our main focus is conducting research activities by altering the internal routines and software to get better image quality. I found the Siemens platform is more flexible than GE's to accommodate new adjustments… our research agreement with Siemens was there to support us with any obstacles."

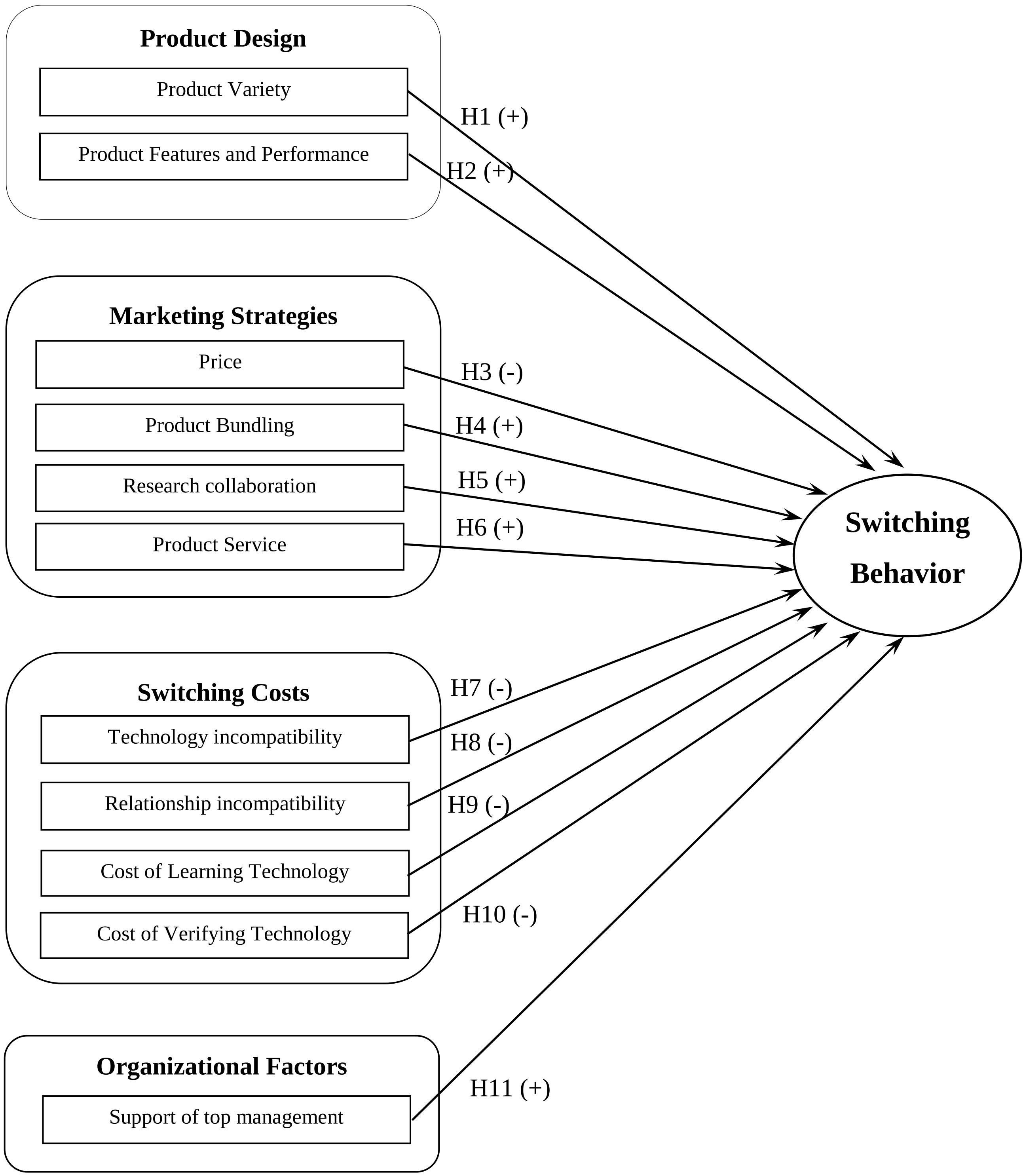
The second new variable "product service," is vital to ensure that MRI technology will run constantly without interruption. If there is an interruption, it will be resolved efficiently, otherwise the downtime and shifting schedules will be extremely expensive. Since MRI technology contains multiple advanced features, it is considered a very sensitive technology, requiring a specialized engineer to fix it and calibrate the system after each service. Many MRI users expressed deep concern about the delay in getting the engineer from the supplier's main office and the time needed to fix a sudden break, and most of them prefer to use a nearby service center that can provide quick on-site service support. The importance of this variable is stressed by a note from an interviewee: "…downtime cost is very expensive and only one company can fix all sorts of problems…if the problem is not solved hastily, everything has to be rescheduled based on priority, and our department needs a contract service that reduces this conflict."

These new variables represent new hypotheses that were not considered in the initial model, and the literature on switching behavior did not identify them as valuable factors. Nonetheless, these variables are part of the internal capabilities that an MRI research center will obtain as part of the switching process, because research collaboration and good product service are essential factors for exploring and using the new technology in an effective manner to generate a competitive advantage. Without research collaboration the value of the technology can be limited and absence of product service can paralyze functioning at a competing level. Both factors, if not utilized effectively, could limit the internal capabilities of an organization to sustain a competitive advantage.

The new variables are included in the marketing strategies category because the MRI supplier uses them as part of its marketing strategy to make the product more attractive. As a result, the proposed model is adjusted to eliminate non-significant variables and add the new ones to reach a new model, as shown in Table 10. Interestingly, variables in the marketplace characteristics category (technological heterogeneity, pace of technological change, and prior experience) did not influence the current research context.

Interviewees' responses from the same MRI research center were correlated for signs of similarity in answers to the same questions. If key informants from the same center reply to the same questions using the same answers "Yes" or "No," then they have a perfect degree of familiarity with the purchasing process of MRI technology (inter-rater reliability test). The analysis among individuals' responses from the same center indicates that correlation is significant at the 0.01 level. This result suggests that I have multiple key informants in the same department who are familiar with the purchasing process, and could be considered a reliable source of information to collect data in the final survey (Kumar et al., 1993). This evaluation, to assess informants' knowledge of the purchasing process, is important to provide confidence about the informants' credibility (Seidler, 1974). The interviewing process makes it clear how the purchasing process took place to evaluate different MRI

Figure 10. The modified model based on interview findings



Note that hypothesis number has changed in this model compared with the initial model in Figure 9.

technologies (from different suppliers) and reach the final decision. Appendix C shows the generally adopted procedure, which could change slightly based on the internal policy of each MRI research center, especially at the final stage of decision making.

4.4 Conclusion

By integrating the expected hypotheses underpinning switching behavior, I obtain the initial proposed model illustrated on Figure 9. The selected hypotheses are expected to affect the switching intention and, subsequently, the actual switching behavior. Exploratory research is conducted to verify the relevance of the major hypotheses in the proposed model before constructing the confirmatory research, leading to modifying of the initial model to reflect the real context of this research. The development of the appropriate hypotheses with the dependent variable, as switching behavior, allows me to make a reliable and testable model. A detailed plan for conducting the empirical evaluation of this model is explained in the next chapter, "Research Method."

Chapter 5
Research Method

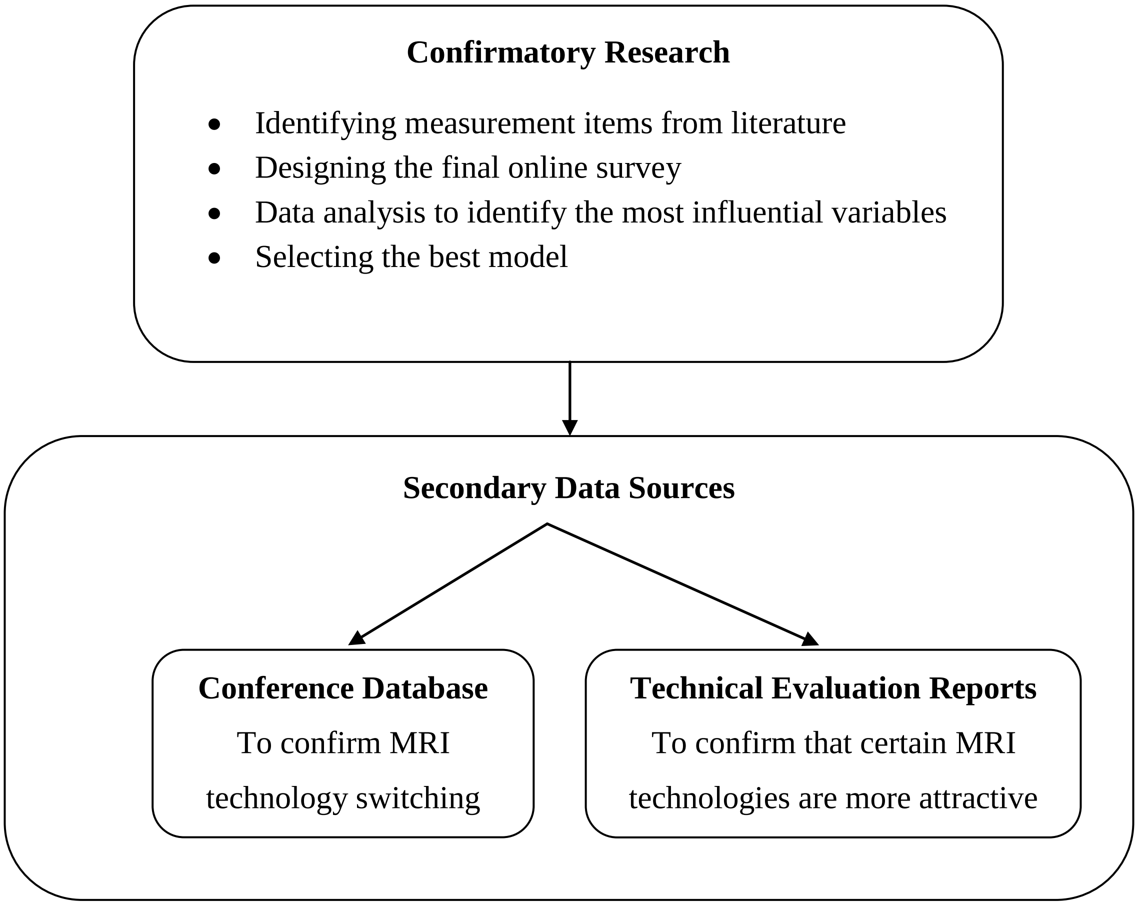
5.1 Introduction

I used the MRI industry as a case study to conduct this research. As explained in Chapter 1, the MRI industry market is divided into different segments, and the university hospitals segment, or research centers, is selected because this represents the lead users of this market. This research is performed at different stages using multiple data sources, as shown in Figure 11. This chapter maps the multiple steps of the research and discusses why those steps are necessary to gather data to test the hypotheses developed in the previous chapter.

In the first stage, the literature is reviewed to identify the measurement items used to measure the main variables defined from in-depth interviews (from the previous chapter). This stage leads to the creation of the initial survey, which was verified by industry experts, academic researchers, and individuals involved in the purchasing process. A confirmatory research is carried out by implementing an online survey and transferring it to different MRI research centers world-wide. The collected data undergoes different analysis steps to test for variable validity and collinearity. Logistic regression is used to define the most influential variables and select the optimal model.

In the second stage, secondary data sources are investigated to support and explain research findings. First, I used MRI conference database, over fourteen years, to confirm that MRI technology switching was taking place in the market. Second, I used technical evaluation reports to confirm that certain MRI technologies are especially attractive, because they have more features and capabilities.

Figure 11. Different stages in conducting this research



5.2 Industry Case

The MRI industry is selected as a case study to conduct this research, where considerable switching has occurred in this industry over the last decade. This industry is the fastest growing in the medical imaging industry (IMV, 2007). Developments in clinical applications plus MRI technology advances are the driving forces to high market demand (Wilson et al., 1999). In addition, there are high barriers to technology switching in this industry. These aspects make the MRI industry a good opportunity to investigate the main factors underpinning switching.

Most of the existing studies on switching behavior focus on a single industry or use similar industries (Low and Johnston, 2006; Bansal et al., 2005; Seiders et al., 2005; Money, 2004; Lemon et al., 2002), because the selected model in each study differs based on the chosen industry. This trend was fully demonstrated in Chapter 2, which describes different models to explain switching behavior based on the industry under investigation.

Selecting a single industry brings the issue of generalizability to other industries, an issue is expected to arise if research findings are used to explain switching behavior across different industries. However, research findings can be generalized to industries that have similar characteristics. The outcomes from the MRI study (as an example of high technology device) could be applied to different industries that share the same characteristics in terms of high rate of technological change and high switching costs, such as industrial equipment, advanced medical devices, airlines, and military devices.

The buying process in business is often dynamic and complex across different organizations and industries, and there is no single model to cope with the complexities of this situation. The literature contains different models to study business buying behavior (Bunn, 1993), where numerous sets of independent variables are used to evaluate various products and industries. Chapter 4 proposed a new model to examine switching behavior for capital-intensive products. I followed an approach recommended by Churchill (1979) to develop different measurement items for the model's independent variables. Existing items are used if they are available; if not, new items are developed based on reviewing the literature and validating through insights drawn from a pilot pool of potential participants.

5.2.1 Identifying Measurement Items for the Initial Survey

Previous interviews helped to identify the key independent variables for the model, as well as to recognize a set of items that reflect and explain each variable. These items are sorted based on frequency of occurrence, an approach deemed necessary to reduce data quantity while still maintaining essential data characteristics (Yin, 1994). These items are used to refine measurement items found in the literature. Table 10 lists the initial measurement items of each independent variable (construct) obtained from the literature. The wording of these items is slightly adjusted to reflect the current research context and findings from previous interviewees. Table 10 shows composite measures of variables created by combining two or more reflective measurement items into a single measure. The response for each item is measured using the seven point Likert-scale. Measurement items of each variable are added, and divided by the number of items, assuming that each item contributes equally to the total score (Madhu, 2005).

Most of these measurement items were used in the consumer and buyer switching context; therefore, I need to conduct an extra investigation to ensure their appropriateness to measure the key variables in the proposed model within the MRI context.

Hardesty and Bearden (2004) conducted a study that confirms the importance of selecting expert judges in enhancing scale reliability and validity, especially if the research is using new and modified measurement items. This approach increases the face validity (the degree to which measurement items reflect what they are intended to measure), because these experts are familiar with the behavior under investigation. Therefore, the initial survey was created based on Table 10, which contains measurement items of independent variables. This survey was administered to three marketing mangers and two consultants in the MRI industry. Because of their comments, some items were added, others are adjusted or deleted. This process took a few iterations to ensure that all measurement items reflect the study context.

A second test of the measurement items was performed to consider the opinion of academic researchers. The items were shared with three researchers asking their feedback on the appropriateness of items – asking them to provide open-ended comments to explain why an item needed modification. The feedback was carefully considered and implemented into the survey.

Table 10. Construct measurement items from the literature

Construct	Construct Measurement Items	Adapted from
Product Variety	- The selected supplier offers a wider range of products for different applications, which provides us with more options to choose from. - The selected supplier's product meets our needs more precisely than other suppliers' products.	MacDuffie et al. (1996) Meyer and DeTore (2001)
Product Features and Performance	- The product provides more capabilities to conduct advanced research applications. - The overall product features (clinical applications) are more advanced in the new product. - The overall product performance is higher in the new product than in the old. - The new product contains new features that do not exist in other products.	Von Hippel (1986, 1989) Henard and Szymanski (2001) Homburg and Rudolph (2001) Henard and Szymanski (2001)
Price	- The overall price of the new supplier was the lowest on the market. - The selected supplier provides best value for money.	Wathne et al. (2001) Liu et al. (2005)
Product Breadth	- The new supplier offers additional products or components as part of the final deal to switch. - The new supplier offers a free upgrade for some components as part of the final deal to switch.	Wathne et al. (2001) Wathne et al. (2001)
Research Collaboration	- We worked consistently with the customers to solve their problems. - We helped the new buyers to integrate MRI technology into their research activities effectively. - We sponsor user group meetings for collaboration.	Athaide et al. (1996) Athaide et al. (1996) Athaide et al. (1996)
Product Service	- We provided on-site service support. - We respond immediately to customer problems.	Athaide et al. (1996) Athaide et al. (1996)

Table 10. Construct measurement items from the literature ('continued')

Construct	Construct Measurement Items	Adapted from
Technology Compatibility	- Most of the internal components of the old MRI system will not work with a product from a different supplier. - The peripherals such as image display computers and film development have to be replaced if a new product is bought from a different supplier. - My department/organization was concerned about the technology compatibility issue if we should switched to a new supplier. - When we were considering switching to a new supplier, compatibility with the existing system was an issue.	Pae and Hyun (2006) Pae and Hyun (2006) Heide and Weiss (1995) Heide and Weiss (1995)
Relationship Compatibility	- We have already established relationships with the current Supplier, making switching difficult. - Our personnel became accustomed to working with this supplier, so switching would be difficult. - Developing a working relationship with new supplier would be a time consuming process. - Developing new procedures to deal effectively with a new supplier would take a lot of time and efforts.	Nielson (1996) Nielson (1996) Liu et al. (2005) Liu et al. (2005)
Cost of Learning Technology	- The use of the new product requires major learning for technologist/operator. - It will take time and efforts to work efficiently with the new product. - Learning to use all the features (including image analysis tools for radiologist) will take a long time.	Jones et al. (2002) Pae and Hyun (2006) Burnham et al. (2003)
Cost of Verifying Technology	- It takes time to go through the steps of switching to new supplier (including evaluating MRI scanner) - It costs a lot of time and efforts to install and calibrate the new product.	Burnham et al. (2003) Lam et al. (2004)
Support of Top Management	- The radiology department was in full control of this process more than high level management were. - The switching process was handled to a large extent by the standard procedures. - To a large extent, the outcome of the switching process was determined by higher-level management.	Heide and Weiss (1995) Heide and Weiss (1995) Heide and Weiss (1995)

In the last stage, the modified survey was administered to 28 individuals from different MRI research centers (8 Department Chairs, 7 Medical Doctors, 9 Scientists, and 4 Technologists) to review items for clarity and face validity. The feedback was valuable to draft the final survey in a complete manner (in terms of vocabulary and wording used in the MRI community). Every effort was made to include the most relevant measurement items to reflect the diverse perception of individuals at different research centers around the world, and keep the length of the survey at an acceptable level. Appendix D shows the final measurement items of each independent variable. The dependent variable "MRI technology switching" is measured by inserting two questions in the final survey. The first question determines whether an MRI research center owns multiple MRI technologies from the same supplier, or different suppliers; the second question specifies the name of suppliers that provide these technologies. Both questions are listed in Appendix D, "Question 10 and 11."

In this research, technology switching has two components; it could be a *complete switching*, characterized by replacing the existing MRI technology with a new one from a new supplier, or it could be *partial switching*, described as adding another MRI technology (to the exiting one) from a different supplier. In Appendix D, "Question 7" is inserted to differentiate between the two types of switching. Differentiation between *complete switching* and *partial switching* is made for comparison; however, the final data analysis treats switching behavior as one component.

5.3 Confirmatory Research

5.3.1 Designing the Final Survey

The final survey is designed to include the measurement items of key variables and some demographic information. This study is conducted at an international level to target all MRI research centers. English is used as the main communication language in the study, which usually is well understood by all key participants, because they have been regularly attending the ISMRM conferences that are presented each year in English regardless of the location.

A Web-based survey is appropriate to satisfy private matters; suppliers' names are mentioned in this survey, which might cause some discomfort to some participants in case the survey is distributed on paper. Also, the Web-based survey is convenient in terms of low cost, wider distribution (internationally in this study), and faster turnaround times (Roztocki and Morgan, 2002). Previous studies adopted this approach for its consistency in getting fewer missing values than paper surveys and generating similar covariance structure (Stanton, 1998).

The Web-based survey was created using online software, starting with demographic information in the first section, followed by subsequent sections that include measurement items of different independent variables. To maintain participants' focus and to avoid confusion, a limited number of questions was displayed on each computer screen and an indicator was given to mark the number of remaining pages. A short description was provided before each set of questions to clarify the general meaning of the variable and help participants focus their answers. For reliability of data entry, each question that requires entering a value within a certain range by participants is subjected to real-time checking by the online software, where a warning message shows "out of range value." For example, if a participant enters a character instead of a numerical value for a certain question, the online software provides a message asking to correct the entered value. All questions that require entering values by hand are provided by internal check-up. Measurement items are presented with a scale ranging from "strongly disagree" to "strongly agree" (seven point Likert-scale). Appendix D includes the final survey.

In the final survey, several questions were included to ensure that participants are knowledgeable and qualified to provide information. To increase the reliability and validity of the collected data and assess the appropriateness of participants, two screening questions were added: (1) Was there personal involvement in the process of purchasing MRI technology (Yes or No), and (2) What was the degree of familiarity with the purchasing process (Not at all familiar, A little familiar, Somewhat familiar, or Very Familiar). These questions are important to ensure that only key informants are included in the final data analysis, those who are knowledgeable about the internal activities in their department. In the survey, if a participant specified that he or she was "Not involved" in the process, but was "Very Familiar" with the process, then he or she is included in the final data set.

5.3.1.1 Data Collection

In an effort to increase the response rate, a personalized invitation letter was emailed to each participant highlighting the objectives of this study and its benefits, as shown in Appendix E. To encourage a wide involvement, each participant was offered an executive summary of research results at the end of the study. The final survey was administered online following this protocol:

1- Personal email to all key participants asking for their contribution, including the URL link of Web-based survey.
2- Reminder letter after three weeks.
3- Final email to show appreciation for those who contributed their time and efforts.

Data collected from Web-based survey was monitored closely to ensure an acceptable level of participation and adequate technical functionality. Collected data were saved in a secured location for further analysis.

5.3.1.2 Sample for Survey

The contact information, email addresses, of potential participants were identified from ISMRM database (ISMRM, 2007). Since the response rate is expected to be low for such kinds of study, I decided to include multiple participants from each MRI research center to increase the chance of getting at least one response from each MRI center. However, only one response was entered in the final data analysis from each MRI center. The screening criteria were applied to keep only key informants in the final data set, which include: (1) the participant was involved in the purchasing process, or (2) he or she was not involved, but was "Very Familiar" with the process.

From the ISMRM database, it was possible to identify 1217 MRI research centers worldwide. These centers conduct various kinds of research activities, ranging from basic development to advanced clinical trials. The online survey was sent out to 5831 participants and it was administered as previously described. As a result, 967 respondents completed the online survey for a 17% response rate. To account for multiple informants from the same MRI research center, 231 responses were removed. However, before removing them, the inter-rater reliability was applied on survey data to check whether different participants (from the same MRI research center) were being consistent in their reporting of purchasing MRI technology. This reliability assesses the degree to which different participants give consistent responses to the same questions. This test was made by calculating the correlation between responses of participants from the same MRI research center. Three questions were used in this test "rank the importance of different variables that lead to buy MRI technology," "estimate the time to buy MRI technology" and "estimate the percentage time of research operation." These questions are listed in Appendix D as 18, 19 and 20, respectively. Results show significant correlation ($p < 0.05$) between participants from the same center.

If two responses or more are received from the same MRI center, one that satisfies one of these criteria is kept: (1) the participant was involved in the purchasing process, or (2) the participant was "Very Familiar" with the process. If all participants were involved or very familiar with the process, then the one with the higher position is selected (based on Table 7 order). If both have the same position, the one with more years of experience is kept in the data. Then another 77 were removed to account for the screening criteria, while another 24 were discarded because of missing data. Thus, final data analysis was implemented on a sample of 635 responses, representing 52% of the MRI research centers worldwide.

Academic Position of Participants and their Location

Table 11 shows subgroups of participants in the final survey and years of experience of each group. The largest group is "Scientist" and the smallest is "Department Chair," an expected result, because in reality, the number of department chairs is limited and equal to the number of MRI research centers. The number of other subgroups is expected to be higher, because any center will contain, at least, a few individuals from each group. Years of experience of each group are reflective of the level of seniority in the department. For example, years of experience of "Department Chair" are higher than for all other individuals in the department. The same pattern is seen for "Chief Technologist" and ordinary "Technologist."

Table 11. Distribution of participants based on position and years of experience

Academic Position of Participants	**Number (%)**	**Years of Experience** Mean (S.D.)
Department Chair	28 (4.4)	19.6 (8.1)
Medical Doctor	150 (23.6)	12.8 (4.1)
Physicist / Engineer	134 (21.1)	10.9 (3.5)
Scientist	216 (34.0)	13.9 (4.3)
Chief Technologist	33 (5.2)	14.0 (3.6)
Technologist	74 (11.7)	9.7 (2.8)
Total	635 (100)	

Table 12 shows the geographic distribution of participants and the switching behavior in each region. It is clear that the majority of participants come from North America, and also the majority of switchers are from North America (38.7% of the total sample). In contrast, the majority of non-switchers are from Europe, based on the percentage of the original number in that location. The reason for the large number of participants from North America and Europe is that most MRI research centers are located in the industrial countries, where medical research requires considerable financial support that other countries can not afford.

Table 12. Distribution of participants based on location

Location of Participants	Number (%)	Switchers (%)	Non-switchers (%)
North America	402 (63.3)	246 (38.7)	156 (24.6)
Europe	150 (23.6)	53 (8.3)	97 (15.2)
Asia	60 (9.5)	46 (7.2)	14 (2.2)
Japan	18 (2.8)	11 (1.7)	7 (1.1)
South America	5 (0.8)	4 (0.6)	1 (0.2)
Total	635 (100)	360 (56.7)	275 (43.3)

Table 13 shows the geographic distribution of participants in the online survey and the target population, based on ISMRM database. It is apparent that the survey sample represents the target population in terms of the relative geographic distribution of each region, where the majority is located in North America and Europe. The large number of participants from North America compared with the target population could reflect the fact that the majority of switchers are in North America. Perhaps those participants were more interested to participate in this study and check its outcome, since each participant is offered an executive summary of research findings.

Table 13. Geographic distribution of participants and the target population

Location	Participants in Online Survey Number (%)	Target Population (ISMRM database) Number (%)
North America	402 (63.3)	591 (48.1)
Europe	150 (23.6)	381 (31.3)
Asia	60 (9.5)	150 (12.3)
Japan	18 (2.8)	89 (7)
South America	5 (0.8)	16 (1.3)
Total	635 (100)	1217 (100)

It was not feasible to identify the academic positions of the target population from ISMRM database, because the professional titles are not cited on conference abstracts; therefore, distinguishing the following individuals was not feasible: department chair, medical doctor, scientist, engineer, physicist, and technologist. However, since the response rate is 52%, the survey sample is a reliable representation of the target population. In addition, the relative geographic distribution of each region is comparable in both groups.

5.3.2 Data Analysis

5.3.2.1 Non-response Bias

One way of testing for non-response bias is to compare the mean response of the first and last quartile of respondents (Armstrong and Overton, 1977). This approach assumes that the late respondents are more likely to share characteristics with non-respondents. This issue was a concern for this study; therefore, the date of completing each online survey was recorded by the software tool. Doing this allows evaluating non-response bias by comparing early respondents (25% of the sample) with late respondents (25% of the sample). A comparison of the two groups demonstrates no significant differences on demographic variables, such as years of experience, location, and position, and no significant differences emerged between these two groups across the variables included in the model, mitigating any concerns about non-response bias (Lambert and Harrington, 1990).

5.3.2.2 Variable (Construct) Validity

A good variable has a theoretical basis that is translated through clear operational definitions involving measurable items. Appendix D shows the final measurement items of each independent variable, where composite measures of variables are created by combining several reflective measurement items into a single measure. Measurement items of each variable are added, and divided by the number of items (Madhu, 2005).

To ensure the validity of study variables, I checked two types of variable validity: convergent and discriminant. The convergent validity estimates the degree to which measurement items are related to each other, and was assessed by the correlation among measurement items, which make up each variable, internal consistency validity. In general, moderate correlations could demonstrate external validity. The discriminant validity shows that measurement items for different variables are not so highly correlated as to lead one to conclude that they measure the same thing. This could occur if there were a definitional overlap between variables. Discriminant validity analysis refers to testing statistically whether two variables differ (as opposed to testing convergent validity by measuring the internal consistency within one variable). Correlation was used to check that measurement items that should not be related are, in reality, not related.

The reliability analysis of measurement items for all independent variables reveals a good level of internal consistency, convergent validity, as shown in Table 14. Correlations of all pairs of measurement items of each variable were calculated. A careful inspection of the inter-item correlation matrix demonstrates that all correlations have moderate magnitude (r^2 in the 0.2 to 0.5 range); all are positive in direction, indicating that an increase in frequency of one measurement item is associated with an increase in another measurement item (Streiner, 2003). In discriminant validity analysis, correlation between measurement items for different variables showed low correlation ($r^2 < 0.2$), confirming that measurement items for different independent variables are not correlated in problematic matter.

5.3.2.3 Factor Analysis

To confirm the previous findings of convergent and discriminant validity, a factor analysis of the thirty four measurement items, reported in Table 14, was conducted (Bollen, 1989). Eleven factors were extracted, which represent the eleven independent variables in the proposed model, as shown in Table 15, where values greater than 0.60 are shaded by gray so

Table 14. Reliability analysis of measurement items

Independent Variables and Measurement Items	Cronbach's Alpha	Corrected Item-Total Correlation	Cronbach's Alpha if item deleted
Product Variety	.781		
product_variety_1		.643	.680
product_variety_2		.669	.647
product_variety_3		.666	.765
Product Features	.844		
product_features_1		.673	.805
product_features_2		.761	.775
product_features_3		.689	.799
product_features_4		.697	.831
Price	.830		
price_1		.677	.776
price_2		.644	.808
price_3		.746	.705
Product Breadth	.824		
product_breadth_1		.705	n/a
product_breadth_2		.705	n/a
Research Collaboration	.865		
research_collaboration_1		.724	.823
research_collaboration_2		.748	.814
research_collaboration_3		.728	.849
research_collaboration_4		.659	.822
Product Service	.836		
product_service_1		.714	.756
product_service_2		.670	.799
product_service_3		.714	.756
Technology Incompatibility	.869		
technology_incompatibility_1		.747	.818
technology_incompatibility_2		.760	.806
technology_incompatibility_3		.743	.823

Table 14. Reliability analysis of measurement items ('continued')

Independent Variables and Measurement Items	Cronbach's Alpha	Corrected Item-Total Correlation	Cronbach's Alpha if item deleted
Relationship Incompatibility	.870		
relationship-incompatibility_1		.759	.809
relationship-incompatibility_2		.744	.823
relationship-incompatibility_3		.750	.817
Cost of Learning Technology	.853		
cost_of_learning_technology_1		.727	.794
cost_of_learning_technology_2		.724	.795
cost_of_learning_technology_3		.723	.798
Cost of Verifying Technology	.826		
cost_of_verifying_technology_1		.677	.766
cost_of_verifying_technology_2		.718	.730
cost_of_verifying_technology_3		.660	.788
Support of top management	.769		
support_of_top_management_1		.575	.720
support_of_top_management_2		.600	.692
support_of_top_management_3		.633	.655

as to highlight the factor loadings of each group of measurement items (Bagozzi and Yi, 1988; Kim and Mueller, 1978). The high loading of measurement items (related to the same variable) to a specific factor indicates high convergent validity. These eleven factors explain 74.9% of the variance in the data. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.803, indicating that the data yields distinct and reliable factors. Likewise, Barlett's Test of Sphericity ($\chi2 = 9983.540$; DF = 561; p = 0.000) is highly significant ($p < 0.001$), so factor analysis is warranted (Field, 2005).

The discriminant validity is tested by running the factor analysis with oblique rotation to obtain the correlation between factors. When the correlation between factors is not high (>0.5), it indicates the two factors have not overlapped conceptually (Bagozzi et al., 1991). Table 16 shows a factor correlation matrix that demonstrates high discriminant validity.

5.3.2.4 Logistic Regression

The main empirical test of the proposed model is based on the final survey. Since the dependent variable "switching behavior" is a binary variable, the logistic regression model is applied (Bishop et al., 1975; Stock and Watson, 2006). This model is selected because it does not require normality distributed variables and has sufficient statistics associated with the independent variables (Press and Wilson, 1978). The sufficient statistic for a model is a statistic that captures all information relevant to statistical inference within the context of the model. Logistic regression estimates the coefficients of a probabilistic model of independent variables that best predict the dependent variable. This model estimates the probability that an event (switching behavior in this study) will happen, and expresses this probability as an odds ratio. The odds of an event happening is equal to the ratio of the probability of the event happening (p) to the probability it will not (1-p), and can be expressed as (p)/(1-p). Logistic regression allows the examination of the influence of many variables at once. In other words, the impact of one variable can be assessed while controlling for the effect of all other variables in the model.

The logistic model can be expressed as $Ln[(p)/(1-p)] = b_0 + b_1.X_1 + b_2.X_2 + \ . \ . \ . \ + b_i X_i$, where b_0 is a constant, $b_1...b_i$ are the estimated coefficients, i is the number of independent variables, and $X_1 ... X_i$ are values of the independent variables. This model predicts the log odds of switching behavior, which in turn, can be translated into an easier format such as the probability of switching. The constant b_0 estimates the log odds of switching when independent variables are not included in the model (baseline value). The coefficients b_i symbolize the log odds ratio to measure any increase (or decrease) in odds of switching, in response to a one unit increase in the value of the independent variable (Pampel, 2000).

Table 15. Factor analysis - rotated factor matrix

	Factor										
Measurement Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
product_variety_1	.149	.203	-.051	-.154	-.105	-.119	.073	-.037	**.673**	-.043	-.033
product_variety_2	.091	.150	-.047	-.058	-.080	-.117	.037	-.057	**.784**	-.080	.019
product_variety_3	.080	.162	-.064	-.099	-.040	-.039	.068	.011	**.615**	-.019	-.018
product_features_1	.088	**.628**	-.119	-.135	-.171	-.209	.127	.001	.156	-.101	-.031
product_features_2	.061	**.807**	-.140	-.099	-.118	-.183	.107	.019	.179	-.013	-.032
product_features_3	.113	**.638**	-.115	-.140	-.220	-.226	.114	.004	.172	-.073	-.006
product_features_4	.103	**.601**	-.109	-.105	-.102	-.099	.093	-.040	.176	-.131	-.030
price_1	-.097	-.167	.067	.093	.065	**.712**	-.119	-.010	-.097	.049	.020
price_2	-.038	-.187	.082	.141	.145	**.658**	-.103	-.003	-.077	.031	-.044
price_3	-.076	-.189	.077	.077	.056	**.836**	-.091	.063	-.103	.055	-.014
product_breadth_1	.005	-.027	-.017	.017	-.020	.009	-.008	-.026	-.017	-.017	**.832**
product_breadth_2	.006	-.039	.003	-.054	-.033	-.038	.018	.038	-.010	-.009	**.847**
research_collaboration_1	**.777**	.122	-.071	-.053	-.042	-.061	.038	.003	.072	-.067	.024
research_collaboration_2	**.820**	.046	-.039	-.058	.025	-.024	.039	-.026	.062	.024	.006
research_collaboration_3	**.803**	.061	.002	.003	-.034	-.065	.026	-.024	.057	.044	-.057
research_collaboration_4	**.699**	.045	-.066	-.060	-.048	-.052	.055	.014	.110	-.027	.032

Extraction Method: Principal Axis Factoring. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 6 iterations.

Table 15. Factor analysis - rotated factor matrix ('continued')

Measurement Items	Factor										
	1	2	3	4	5	6	7	8	9	10	11
product_service_1	.028	.145	-.100	-.059	-.114	-.076	**.841**	-.037	.033	-.088	.007
product_service_2	.085	.111	-.066	-.080	-.044	-.111	**.827**	-.027	.009	-.031	-.033
product_service_3	.033	.070	-.050	-.043	-.089	-.086	**.858**	-.013	.123	-.020	.037
technology_incompatibility_1	-.053	-.122	.061	**.864**	.056	.033	-.061	.017	-.144	.029	-.032
technology_incompatibility_2	-.074	-.130	.092	**.862**	.097	.089	-.071	.056	-.066	.009	.028
technology_incompatibility_3	-.038	-.118	.069	**.851**	.064	.172	-.057	.036	-.075	.028	-.034
relationship-incompatibility_1	-.057	-.125	**.869**	.089	.027	.064	-.065	.016	-.086	.045	.042
relationship-incompatibility_2	-.071	-.122	**.861**	.092	.039	.068	-.074	.037	-.025	.039	-.033
relationship-incompatibility_3	-.037	-.107	**.876**	.034	-.015	.071	-.076	.029	-.045	.031	-.023
cost_of_learning_technology_1	-.024	-.121	.051	.087	**.860**	.041	-.056	.000	-.050	.038	-.036
cost_of_learning_technology_2	-.064	-.153	.020	.073	**.843**	.157	-.097	.046	-.056	-.007	-.015
cost_of_learning_technology_3	-.006	-.154	-.023	.050	**.853**	.044	-.096	.020	-.092	.061	-.003
cost_of_verifying_technology_1	.013	.055	.078	.000	-.007	.010	.003	**.860**	.022	.010	.041
cost_of_verifying_technology_2	-.020	-.052	.007	.015	.036	.005	-.043	**.881**	-.012	.029	-.010
cost_of_verifying_technology_3	-.021	-.024	-.008	.081	.029	.023	-.030	**.841**	-.070	-.003	-.021
support_of_top_management_1	-.008	-.072	.096	.079	.070	.051	-.082	.016	-.037	**.789**	.021
support_of_top_management_2	.024	-.068	.044	-.034	.017	.022	-.024	.010	-.034	**.822**	-.009
support_of_top_management_3	-.038	-.060	-.035	.015	-.001	.031	-.020	.008	-.035	**.847**	-.034

Table 16. Factor analysis - factor correlation matrix

Factor	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	.206	1.000									
3	-.036	-.028	1.000								
4	-.281	-.121	.062	1.000							
5	.181	.029	-.034	-.099	1.000						
6	.282	.122	-.059	-.188	.115	1.000					
7	.045	0.08	-.010	.009	-.027	-.008	1.000				
8	.305	.135	-.075	-.191	.067	.182	-.032	1.000			
9	.402	.156	-.040	-.188	.098	.247	-.022	.254	1.000		
10	.389	.206	-.052	-.151	.106	.172	.015	.248	.230	1.000	
11	-.336	-.085	.047	.080	-.087	-.215	.045	-.200	-.230	-.189	1.000

Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

The odds of switching are given by the exponentiation of the log odds (Odds Ratio (OR) = exp(b_i)). The probability of switching is given by: Pr = OR/(1+ OR). The Wald statistic and -2 log-likeihood are frequently used to assess the significance of the estimated coefficients. The Wald statistic is a test commonly used to test the significance of individual logistic regression coefficients for each independent variable (test the null hypothesis in logistic regression that a particular logit coefficient is zero). The Wald statistic is the squared ratio of the unstandardized logistic coefficient to its standard error (Hosmer and Lemeshow, 2000). In linear regression, R-square (coefficient of determination) represents the proportion of variance in the dependent variable associated with the independent variables, where larger values indicate that more variation is explained by the model. For regression models with a binary dependent variable, it is not possible to calculate a single R-square statistic that has the same characteristics of R-square in the linear regression model. However, some approximations have been computed to estimate the coefficient of determination, such as Cox & Snell R-square and Nagelkerke R-square. In this study, the model chi-square corresponds to an increase in predictability of likelihood of the switching when independent variables are included. Hosmer and Lemeshow (H-L) is also a widely used goodness-of-fit test to examine the overall model fit (Hosmer and Lemeshow, 2000).

5.3.2.5 Model Diagnosis

The literature has listed several methods to diagnose logistic regression models to determine the one that reasonably approximates the behavior of data. In addition to using the previously mentioned statistics (such as H-L, model chi-square, and Nagelkerke R-square), c-statistic is used as an additional diagnostic measure to determine the overall fit of the model. The c-statistic is a measure of the predictive power of the logistic equation. It varies from 0.5 (the model's predictions are no better than chance) to 1.0 (the model always assigns higher probabilities to correct cases than to incorrect cases). In other words, it measures the proportion of times the model assigned a higher probability of the outcome occurring when it actually did occur versus not occurring (Norusis, 1997). A c-statistic less than 0.5 indicates that the logistic mode1 is not effective in accurately recognizing those cases in which the outcome occurred beyond what would be expected by chance alone. The closer this value is to 1.0, the higher is the predictive power of the model.

5.4 Secondary Data Sources

Multiple secondary data sources were used to support this research: (1) conference database from 1995 to 2008, and (2) technical evaluations reports of different MRI products.

5.4.1 Conference Database

Conference books and CD’s of the ISMRM meetings were collected from colleagues and by attending this conference. This conference is held annually, attended by about 6500 participants and generating some 3000 abstracts. The abstracts cover a wide range of MRI applications. Initially, CD’s of ISMRM conferences from 1998 to 2008 are obtained. Later, books for conferences held from 1995 to 1997 were collected from colleagues (in this period CD's were not available). From each abstract, it is possible to obtain the following information: (1) name of the MRI research center, (2) name of contact people, and (3) type of MRI technology (or supplier), as shown in Appendix F.

Conference database abstracts provide information about particular MRI buyers that conduct various research activities; these buyers are considered the lead users in this study. This secondary source of information is considered reliable and can be used to track switching behavior over time.

5.4.1.1 Tracking the Dependent Variable from Conference Database

The dependent variable is defined as technology switching, which means buying a new MRI technology from a new supplier, when the old technology can be fully replaced or kept functioning. This section explains the process to track the dependent variable "switching behavior" and how it has been evaluated, as a confirmatory stage of conducting this research.

Starting with the 1995 abstracts, each abstract of the ISMRM conference was scanned individually to identify the research center it originated from and the type of MRI scanner used. Every effort is made to avoid any duplication in this process, since many abstracts could be generated from the same research center under slightly different names, due to collaboration with different departments in the same university. For example, an abstract from the department of radiology at a certain university (usually the main source of abstracts) can be found at another department from the same university, such as the department of computer science that submitted another abstract related to improving image processing quality. In this case, only one research center should be counted because both departments are using the same MRI scanner.

At the end of this process, 658 research centers are identified, which are distributed in different countries. For those centers, the type of MRI technology used is recognized, whether from GE, Siemens or Philips; then the process of either complete switching or partial switching to another technology is tracked from 1995 to 2008. For some centers, it was not possible to identify MRI technology, because its name was not mentioned explicitly in the conference abstract. In addition, the technology switching process for some suppliers (Bruker BioSpin, Hitachi, Toshiba, and Varian) was not tracked in this study, because they have limited market share compared with the major three suppliers. This outcome explains why it was possible to track technology switching for only 658 research centers, whereas the number of research centers identified for the survey is larger at “1217”.

If a research center uses one MRI technology, for example MRI Philips, that center would be counted as one even if it owns two scanners from Philips. However, if the research center operates two different MRI technologies, for example GE and Philips, that center would be counted twice. The main focus in this study is to identify who is using a certain technology and the reasons behind switching to another technology over time rather than counting the number of MRI’s in research centers.

5.4.2 Technical Evaluation Reports

Evaluating product features and their performance is a complicated process for capital-intensive products, imposing significant challenges to those involved in the evaluation process to find the optimal choice. Technical reports regarding product features and their performance could be obtained directly from each supplier, but they would not represent a reliable source of information without an independent and objective verification from an autonomous agency. The reason behind that reality is that technical information can be presented in various formats to magnify performance of certain features and ignore others. Therefore, technical reports for various products are collected from a non-profit agency allied with the Centre for Evidence-based Purchasing in UK (MagNET, 2007). This agency has accumulated more than thirteen years of experience in evaluating and comparing MRI devices from different suppliers (Wilde et al., 2002). Results from these evaluation reports have been used in the UK National Health Service primarily during purchasing and installation of new MRI systems.

Reports issued by MagNET agency have a special value because the process of comparing different MRI products is based on well-established protocols (Och et al., 1992). MagNET completes this comparison through a long process. Initially, it conducts some visits to different factory sites with full cooperation of suppliers; sometimes an evaluation may be carried out at hospital sites and then data from different suppliers analyzed and presented in a form that can be easily understood by the MRI community and other interested personnel. Finally, the data are officially published after consultation with suppliers, with related comments included in the appendix of the final report. These reports are updated whenever a new product is launched to market; they include the important hardware components and a complete list of the available clinical software packages for each product.

The previous description indicates that these reports are a reliable and valuable source for this study. Features of different products and their performance can be evaluated; then the overall value of each product can be determined in terms of the number of features (hardware and software) and their quality performance. MagNET reports are used to produce a separate measure of product design (based on non-perceptual measurement) to determine the overall product value based on the integrated features and product performance. This measurement is based on counting the number of associated features and ranking the performance of each product. This approach would support the findings of the final survey and provide a better explanation for the factors behind switching to certain products.

5.4.2.1 Identifying Product Features and Performance from Technical Reports

In this study, the independent variable (product features) was identified from MagNET report at two stages, to select the most competent MRI technology. In the first stage, the performance of different hardware components of the three MRI technologies are compared, and ranked in ascending fashion: “1” refers to MRI technology with the highest performance, “3” refers to the lowest performance, and “2” indicates an intermediate performance. This ranking is based on three criteria: image resolution, radio frequency coils with parallel imaging capabilities, and image quality. Generally, these criteria represent the overall hardware capabilities and can be used when evaluating different MRI technologies. In the second stage, the number of different software packages for each clinical application is counted and listed for each MRI technology. The actual performance of software packages is not listed because it depends on the hardware performance, which is utilized when running each software package.

In this research, it was not possible to obtain the individual annual MagNET reports that cover the period 1995 to 2008, during which technology switching was monitored in this study. However, the selected report in this study represents accumulative product features that have been integrated over time (2006 annual report). Hence, it is a good indication of MRI technology features (capabilities) over time.

5.5 Conclusion

To achieve the research objectives and check the accuracy of the self-reported switching data (survey), I compared the rate of switching reported in the survey with that observed from conference proceedings. Survey findings suggest that certain MRI technologies are superior to others in the market, where participants were asked to rank different MRI technologies based on various clinical applications. Technical evaluation reports are used to confirm survey ranking of the lead technology for each clinical application. These reports demonstrate independently the most attractive MRI technology on the market that encourages switching.

Since product features are an important factor in making a technology attractive for buyers, patent data is associated with introducing more product features by each supplier (including clinical software applications). Comparing results from different data sources is an important requirement so as to avoid the problem resulting from 'common method bias' (Doty and Glick, 1998).

Chapter 6
Results

6.1 Introduction

This chapter demonstrates research findings generated at different stages of data analysis, with results presented in four sections. The first section presents different analysis steps to check reliability of measurement items and logistic regression. The second section shows data from secondary sources to support previous findings, including data from MRI conference database, and product technical reports. The third section compares findings from survey data and conference database, where significant correlation is found between both data sources. The final section correlates survey data with results from technical reports, to demonstrate that product features of certain suppliers are superior and play a key role in encouraging technology switching.

6.2 Confirmatory Research

Confirmatory research is based on analyzing data from the online survey.

6.2.1 Description of the Dependent Variable and the Institutional Context

This section provides the descriptive statistic of the dependent variable as a function of institutional context, in which switching occurs. It offers a comprehensive understanding of the conditions in which switching behavior was taking place, and under what circumstances it might escalate.

6.2.1.1 Complete and Partial Switching of MRI Technology

When defining the impact of technology switching on each supplier, an in-depth tracking of the switching behavior is required in order to monitor the number of technology buyers over time.

Table 17 shows the number of technology buyers for each MRI technology on the market (as first MRI purchase) and outlines how each group undergoes the process of switching to another technology, whether it is complete or partial. The table identifies the main market suppliers by their names and it groups the remaining companies under one category called "Other" MRI technology. By tracking the percentage number of complete and partial switchers of each MRI technology, it appears that GE technology buyers are the most frequent switchers in both cases, whereas Siemens technology buyers are the least frequent switchers in both cases. Non-switchers are those who repurchase MRI technology from the same supplier.

Table 17. Distribution of participants based on MRI technology

MRI Technology	Number	Complete Switchers (%)*	Partial Switchers (%)	Non-switchers (%)
GE	294	49 (16.7)	138 (46.9)	107 (36.4)
Philips	75	9 (12.0)	30 (40.0)	36 (48.0)
Siemens	131	3 (2.3)	32 (24.2)	96 (73.3)
Other**	135	26 (19.3)	58 (43.0)	51 (37.7)
	635	87 (13.7)	273 (43.0)	275 (43.3)

* All percentage values are in reference to the number reported in the second column and not the total sample.
** Includes different MRI suppliers such as Toshiba, Hitachi, Varian, Bruker, etc.

Table 18 reveals how switching behavior has affected the market share of each MRI technology. In this table, the numbers reported in "After Switching" include the added (or subtracted) numbers resulting from complete and partial switching among different MRI technologies. It appears that switching behavior has significantly increased the market share of both Siemens and Philips, increasing by 104% and 89%, respectively. In contrast, this behavior has negatively influenced GE market share causing it to lose 10%. The market share of other technologies also has declined to 20%.

Table 18. Distribution of MRI technology buyers before and after switching

MRI Technology	Before Switching	After Switching	Change (%)
GE	294	263	-10%
Philips	75	142	+89%
Siemens	131	268	+105%
Other	135	108	-20.0%

6.2.1.2 Influence of New Technology on Research Activities

Since the new technology is expected to offer more capabilities than the old, such as advanced imaging protocols and better potential to diagnose different diseases, it seems that more time is consumed in conducting research activities on the new technology. In this context, the new technology can come from the same or a different supplier. Table 19 compares the percentages of research activity time spent on the old and new MRI technologies, that is, the time spent on research operation based on the total time. For example, 35% of total time is devoted for research. It is noticeable that more research activities are spent using the new technology, which provides more advanced applications and features.

Table 19. Relationship between technology and percent of research activities

MRI Research Center	% of Research Activities on the Old Technology Mean (S.D.)	% of Research Activities on the New Technology Mean (S.D.)
Small Hospital	1.1 (0.9)	2.0 (0.9)
Medium Hospital	1.6 (1.3)	2.3 (1.1)
Large Hospital	2.0 (1.8)	3.8 (1.3)
University	76.5 (16.7)	89.7 (11.0)
Educational Hospital	13.1 (10.2)	20.5 (17.9)

6.2.1.3 Characteristics of MRI Research Centers

MRI research centers are distributed into different types as shown in Table 20. Most of the sample is dominated by participants from educational hospitals and universities, which are heavily involved in research activities. Based on the percentage value of each group, universities are ranked first, as the most switching group, followed closely by educational and large hospitals. This ranking could be due to high demand for advanced technologies by universities, which conduct intense research activities, leading to higher incentive to buy the capable technology even from different suppliers. For example, 63% (or 119 out of 189) of participated universities had purchased an MRI technology from a different supplier. This incentive to change a technology decreases slightly as the center's research activities decline. Nonetheless, it is still significant for medium and small hospitals, 45% and 28%, respectively.

Table 20. Distribution of participants based on MRI research centers

MRI Research Center (type)	**Number (%)***	**Switchers (%)**	**Non-switchers (%)**	**Switchers Ranking****	**% of Research Activities***** Mean (S.D.)
Small Hosp.	14 (2.2)	4 (0.6)	10 (1.6)	5	1.6 (0.8)
Medium Hosp.	20 (3.1)	9 (1.4)	11 (1.7)	4	1.9 (1.1)
Large Hosp.	42 (6.6)	23 (3.6)	19 (3.0)	3	2.9 (1.4)
University	189 (29.8)	119 (18.8)	70 (11.0)	1	83.1 (10.1)
Educational Hosp.	370 (58.3)	205 (32.3)	165 (26.0)	2	16.8 (12.6)
Total	635 (100)	360 (56.7)	275 (43.3)		

* Percentage values in reference to the total number of 635.
** 1 represents the most switchers group, whereas 5 for the least switchers.
*** Percentage of research activities using both technologies (old and new).

Table 21 shows multiple relationships among MRI research centers. The number of scientists per MRI research center increases relative to its size (small, medium, etc.). The educational hospitals contain the most scientists, followed by university centers, while small hospitals contain very few individuals who conduct research activities. On the other hand, the percentage of research activities takes a similar function to the number of scientists, one exception being educational hospitals, behind universities, which are devoted largely to research activities. The reason for this shift, educational hospitals are committed essentially to regular clinical operations, which is supported by certain research activities.

In utilizing different clinical applications, educational hospitals take the first rank, followed by universities. The average years of experience of participants are comparable across different types of centers. The time required to complete the purchasing process increases with the diversity of clinical applications utilized in the center, an indication of the complexity of evaluating different MRI technologies to find the one that meets the diverse requirements. Taking a long time to decide on a particular technology would suggest there is a conflict among decision makers, requiring more rounds of discussions to reach the final decision that meets the interests of all individuals.

Table 21. Relationship between MRI research centers and number of scientists

MRI Research Center	**Number of Scientists** Mean (S.D.)	**Applications Diversity** (ranking)**	**Average Years of Experience** Mean (S.D.)	**Purchasing Time** (month) Mean (S.D.)
Small Hosp.	1.8 (0.9)	1	10.6 (3.3)	8.1 (1.4)
Medium Hosp.	2.9 (1.6)	2	11.7 (4.4)	10.0 (3.1)
Large Hosp.	3.9 (1.3)	3	11.6 (3.8)	11.2 (2.7)
University	9.6 (4.3)	4	13.6 (5.0)	11.4 (2.9)
Educational Hosp.	12.4 (6.2)	5	12.6 (4.5)	11.6 (3.2)

* Percentage of research activities in the MRI research center using both technologies.
** 5 indicates using more diverse clinical application and 1 indicates using less.

Usually, small and medium size hospitals do not perform research activities, because they are focused on delivering clinical services. Therefore, a further investigation was made to find out how the names of these groups of hospitals ends up in the conferences database, from which I obtained the contact information of participants. Personal communication with some industry experts and marketers revealed the following: Some physicians, physicists, and technologists are required to achieve a minimum number of professional development hours per year to maintain credibility for their license, or as a regular policy for many institutions to stay updated with new technologies and clinical procedures. These hours can be spent at scientific conferences or development workshops.

Sometimes, those individuals attend a conference and present a clinical research study that is based on regular clinical operations, or a modified clinical protocol that optimizes the time and performance to diagnose a disease. This is the reason why the sample contains a set of small and medium size hospitals. Since participants from these hospitals participate in some research activities, they are kept in the sample, because the main scope of this research is to evaluate technology switching behavior at MRI research centers, which are involved in research activities regardless of its size.

6.2.1.4 Switchers' Research Activities on the New Technology

As proposed, technology switchers are seeking a new technology that provides more capabilities than the old one. It becomes visible that such advanced technology is boosting their research activities and the percentage of time used to conduct such activities. Table 22 shows the percentage of research activities of switchers and non-switchers using a new technology, from a new or the same supplier, respectively. Although the increase in such activities is not as large as the previous one, between the old and new technology, the finding gives some indication that switchers are utilizing the new technology to a larger extent to achieve some advantages, which were not possible with the old technology. Note that the increase in research activities is more appreciable at educational hospitals and universities.

Table 22. Relationship between research activities and technology switchers

MRI Research Center	% of Research Activities for Non-switchers, Mean (S.D.)	% of Research Activities for Switchers, Mean (S.D.)
Small Hospital	2.0 (1.0)	2.0 (0.8)
Medium Hospital	2.2 (0.9)	2.3 (1.3)
Large Hospital	3.2 (0.9)	4.3 (1.4)
University	85.5 (9.9)	92.2 (10.9)
Educational Hospital	17.6 (16.4)	22.9 (18.9)

6.2.1.5 Participants' Ranking of Different MRI Technologies

To examine how participants distinguish technological capabilities of different suppliers, they were given in the final survey a list of various clinical applications and asked to write the name of the supplier that offers the best MRI features for each application. Table 23 shows the outcome of this procedure: it appears that participants had given a high score for Siemens as the best provider for most of the clinical applications, suggesting that there is a general agreement among MRI technology buyers that Siemens is offering advanced capabilities for different clinical applications. Such agreement essentially implies that Siemens technology is perceived on the market as highly competitive, with advanced capabilities that meet customer expectations.

Table 23. Participants' ranking of different MRI technologies

Clinical Application	First Rank	Second Rank	Third Rank
Angiography and Cardiac Imaging	Siemens	Philips	GE
Breast MRI	GE	Siemens	Philips
Functional MRI (fMRI)	Siemens	Philips	GE
Molecular Imaging	Siemens	GE	Philips
Neuro-imaging	Siemens	Philips	GE
Spectroscopy	Siemens	GE	Philips

6.2.2 Logistic Regression Analysis

The primary goal of this research is to test the hypothesis developed in Chapter 4 that predict switching behavior. The dependent variable represents technology switching (both partial and complete switching). The logistic regression was conducted using 635 cases. The values listed in Table 24 represent criteria for assessing the fit of the final model. The -2 Log Likelihood of the final model was 113.436, which was reduced from 600.294 for the initial model, which contains only the constant. This likelihood value measures the success and believability (credibility) of the model. A good model will predict a high probability of switching for those who had switched and a low probability of switching for those who had not.

The model chi-square was 489.338, which is statistically significant, confirming that the included variables allow for better prediction of the switching behavior than if they were not included (Menard, 1995). The Nagelkerke R-Square (coefficient of determination estimate) was 0.90, suggesting that the final model can explain 90% of variability. The Hosmer & Lemeshow Goodness of Fit test gave a chi-Square of 2.564 and a p-value of 0.959, indicating a strong fit between the model and the data. Further, the classification table demonstrated a high overall percent correct prediction rate of 94.3%, indicating strong model validity in predicting the switching behavior. The c-statistic was 0.987, indicating that the model has high predictive power to identify those cases in which the outcome occurred beyond what would be expected by chance alone.

Table 24. Goodness of Fit measures

-2 Log Likelihood (constant)	-2 Log Likelihood (final model)	Model chi-Square	Model P-value	Hosmer & Lemeshow Goodness of Fit	Classification Table (overall)
600.294	113.436	486.858	0.000	p = 0.959	94.3%

Table 25 shows the classification table, which can be used to evaluate the predictive accuracy of the logistic regression model (Pampel, 2000). In this table, the observed values for the dependent outcome and the predicted values (at a cut-off value of p = 0.50) are cross-classified. In this case, the model correctly predicts 94.3% of the cases, where both categories of the dependent variables contribute equally to the percentage of correctly predicted cases.

Table 25. Classification table

Observed		Predicted		
		Switch		Percentage Correct
		No	Yes	
Switch	**No**	260	15	94.5
	Yes	21	339	94.2
Overall Percentage				94.3

The cut value is 0.50

Wald statistics in Table 26 shows that eight variables were significant, whereas three were non-significant (marked in gray and bold). The non-significant variables include product breadth, cost of verifying technology, and support of top management. Since the meaning of a logistic regression coefficient b is not as straightforward as that of a linear regression coefficient, Exp(b) is generally used to interpret findings in terms of effect size. Each of the variables that are significantly associated with switching behavior can be interpreted as having an impact on that behavior independent of all other variables. For example, after controlling for the effect of all other variables, the odds of switching is 3.521 times for one new product feature in the new technology, and the corresponding probability of switching is 3.521 / (1+3.521) = 0.78. On the other hand, after controlling for the effect of all other variables, the odds of switching is 0.231 times for a one challenge in technology incompatibility (or one failure to integrate a new research idea), and the corresponding probability of switching is 0.231 / (1+0.231) = 0.19. Usually Exp(b) values above 1 increase the probability of switching (positive influence), whereas values below 1 decrease this probability (negative influence). Figure 12 illustrates the final model that explains switching behavior of capital-intensive technology.

Table 26. Estimated coefficients of logistic regression analysis

Variable	b	S.E.	Wald	Sig.	Odds Ratio Exp(b)	Lower 95% CI Exp(b)	Upper 95% CI Exp(b)
Product Variety	1.125	.273	16.920	.000	3.080	1.802	5.264
Product Features	1.259	.220	32.708	.000	3.521	2.287	5.421
Price	-1.547	.284	29.567	.000	.213	.122	.372
Product Breadth	.190	.325	**.340**	**.560**	1.209	.639	2.285
Research collaboration	.956	.251	14.505	.000	2.603	1.591	4.258
Product Service	.571	.240	5.683	.017	1.771	1.107	2.833
Technology Incompatibility	-1.465	.287	25.974	.000	.231	.132	.406
Relationship Incompatibility	-1.156	.251	21.166	.000	.315	.192	.515
Cost of Learning Technology	-1.087	.307	12.546	.000	.337	.185	.615
Cost of Verifying Technology	-.457	.352	**1.683**	**.195**	.633	.318	1.263
Support of Top Management	.241	.309	**.609**	**.435**	1.272	.695	2.329

6.2.3 Ranking the Importance of Independent Variables

One of the main objectives of this study is to determine key independent variables that influence switching behavior. However, identifying the most influential variables underpinning this behavior is also an important objective. Therefore, I intentionally included a question in the final survey asking participants to rank the importance of certain factors in the purchasing decision. This step was implemented to confirm that the effect size provided by the logistic regression analysis is a true indicator for ranking the relative importance of different variables. Table 27 shows the ranking of different variables by switchers and non-switchers, where 1 represents the most important factor (variable) and 5 is the least important factor.

Figure 12. The final model with significant variables

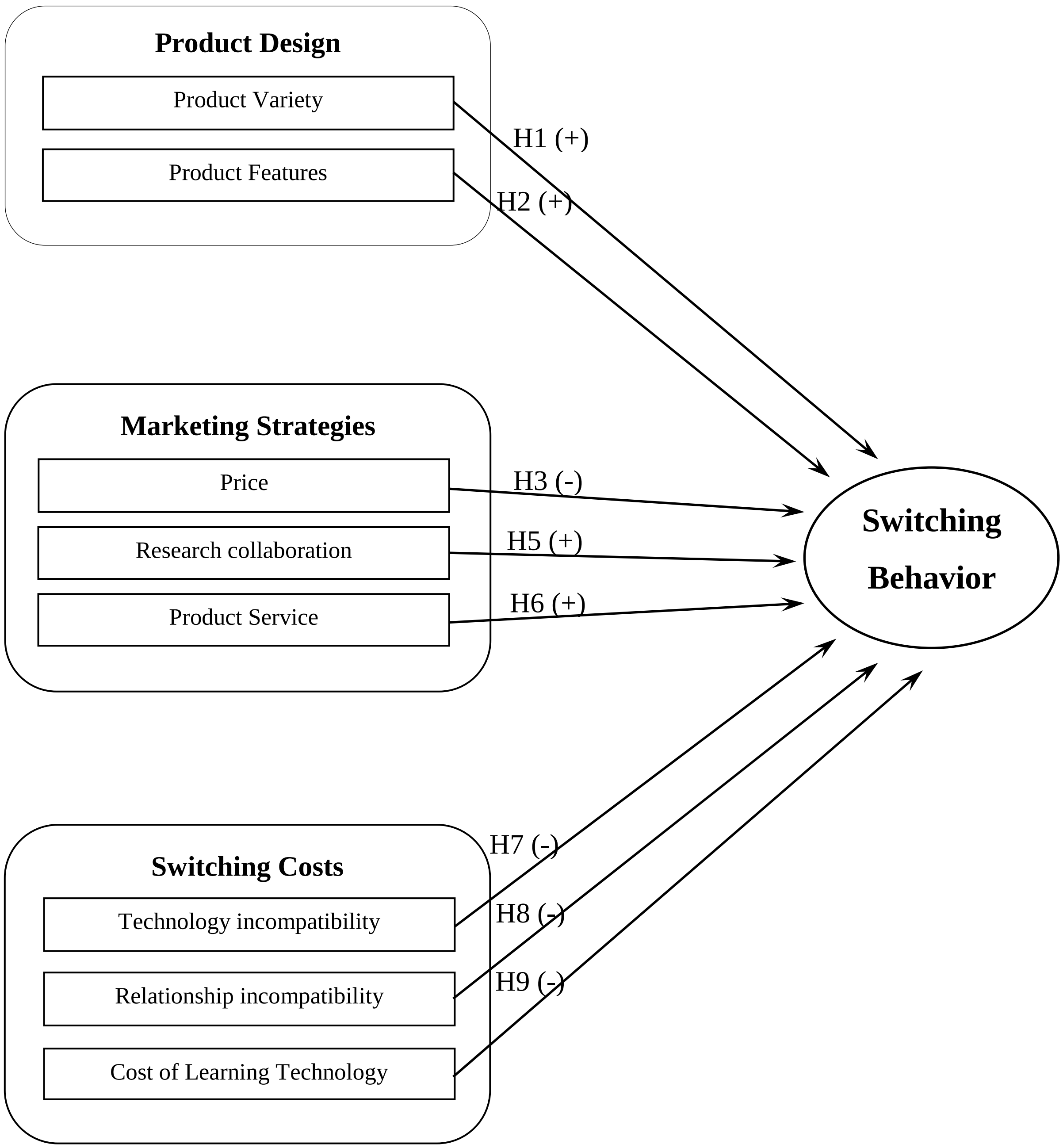


Table 27. Ranking the importance of different variables

Ranking	Switchers		Non-switchers	
	Percent*	**Variable**	**Percent***	**Variable**
1	85.3%	Product Features	52.4%	Product Features
2	58.3%	Research Collaboration	45.1%	Price
3	54.2%	Product Service	46.5%	Product Service
4	42.5%	Price	55.3%	Research Collaboration
5	83.3%	Product Breadth	76.7%	Product Breadth

* Percent column is the percent of respondents identifying the variable as the first, second, etc. rank.

Table 27 demonstrates that product features are the most influential factor in the decision making to switch to new technology from a new supplier, with 85.3% of switchers placing it in the first rank. Since these features represent new capabilities and applications to advance a wide range of research activities, research collaboration was placed in the second rank, because technology buyers would like to receive research support to use these capabilities effectively. On the other side, non-switchers have placed product features in the first rank in their decision to buy a new technology from the same supplier, but with a smaller percent of voters, 52.4%. It seems that non-switchers have selected the first four factors with comparable voting percentages, which raises several issues. First, the current technology is not limiting their capabilities to some extent, so they are in less need to switch suppliers. Second, technology total cost is an essential component, and could be a limiting factor in switching, because of limited financial resources. Third, low ranking of research collaboration may be due to less difficulty in using the same technology from the same supplier. Interestingly, bundling was ranked the last in the purchasing process for both groups with high percentage, because more focus is placed on other factors that achieve a competitive position for technology buyers.

To measure and compare technology buyers' satisfaction with the new technology, whether it came from a new or the same supplier, the final survey lists a few questions to assess the degree of satisfaction. These questions are related to the impact of product capabilities (features) in generating reputable research and investigating new clinical applications that were not possible with the old technology. Also, some questions were included to evaluate suppliers' reliability in providing good product service and facilitating research collaboration, as originally promised in the purchase contract. Table 28 lists responses from switchers and non-switchers to these questions. In general, switchers were more satisfied with product capabilities of the new technology, and suppliers' commitment to provide constant product service and research collaboration.

Table 28. Satisfaction with the new technology

Switchers		Non-switchers	
Product Capabilities	**Product Service/ Research Collaboration**	**Product Capabilities**	**Product Service/ Research Collaboration**
6.16 (0.73)*	5.61 (0.56)	4.96 (0.71)	4.87 (0.76)

* Mean and S.D. values for seven points Likert-scale

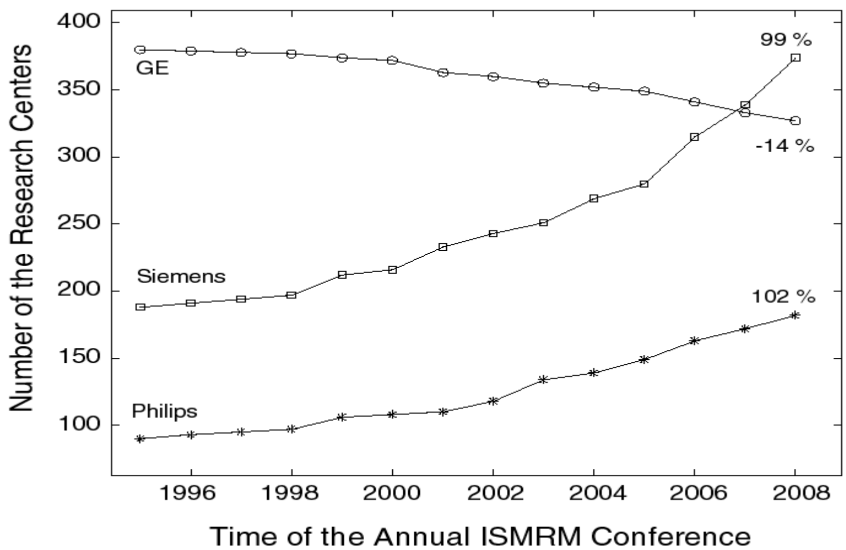
6.3 Secondary Data Sources

6.3.1 Tracking the Dependent Variable from Conference Database

Figure 13 demonstrates MRI technology switching that occurred from 1995 to 2008. In 1995, 380 research centers operated GE-MRI technology compared with 188 and 90 centers operated Siemens and Philips technologies, respectively. Over time, more research centers started expanding their research operations by upgrading or by buying new MRI technology. During this stage, research centers that use Siemens-MRI technology increased steadily, to reach 374 centers in 2008, achieving 99% increase over 1995. On the other hand, Philips-MRI technology buyers also increased to 182 centers, achieving 102% increase over 1995. However, centers that operate GE-MRI technology kept declining over time, ending at 327 centers, corresponding to 14% decrease in the number of research centers reported in 1995.

This shift in market share of different firms indicates that some technologies were more attractive in encouraging MRI research centers to buy them. This confirmatory research indicates clearly that switching behavior is taking place within MRI research centers around the world.

Figure 13. MRI technology switching over 14 years



The percentage at the end of each curve represents the change in value reported at 1995.

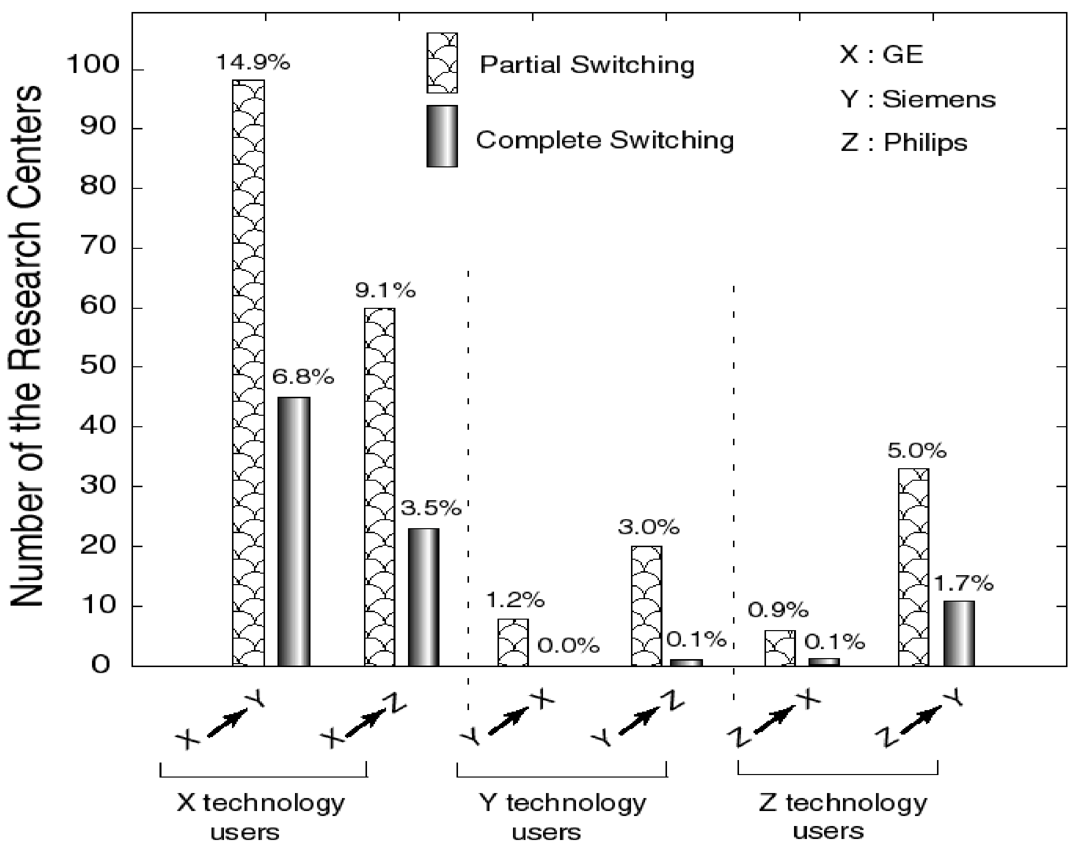
Figure 14 shows the same results as in Figure 13, but in different representation so as to recognize MRI research centers that did partial switching from those who changed to complete switching. This helps to identify the switching directions toward the most attractive MRI technologies.

Figure 14 is divided into three components based on the old technology buyers on 1995 (horizontal axis). This figure represents the accumulative technology switching over fourteen years. It is evident that research centers operating GE-MRI technology have strong incentives to switch or to add another technology from Siemens or Philips, with more emphasis on

Siemens technology. In contrast, Siemens-MRI technology buyers have the least desire to implement partial switching; and when they did implement, they selected Philips-MRI technology over GE. Note that Siemens-MRI technology buyers did not implement complete switching to GE-MRI technology at any time over the fourteen-year period. On the other hand, when Philips-MRI technology buyers decided to add a new technology, they chose Siemens; and if they switch completely, they preferred Siemens over GE-technology.

Figure 14 indicates that Siemens and Philips technology buyers have little incentive to switch completely to GE-MRI technology, denoting the lower attractiveness of GE-MRI technology.

Figure 14. Partial and complete switching over 14 years



The percent value above each bar represents a portion of the total number of research centers (658).

6.3.2 Identifying Product Features and Performance from Technical Reports

Table 29 shows hardware performance ranking for three MRI technologies, reflecting the hardware's capability to produce high quality images. This ranking is based on the performance of different hardware components reported in technical reports (Chapter 5, section 5.4.2.1): "1" refers to MRI technology with the highest performance, "2" indicates an intermediate performance, and "3" refers to the lowest performance. Unlike the case of software packages, this case makes it possible to accumulate the performance of different hardware components, because all of them work simultaneously to generate the final image. The overall performance of all hardware components is ranked first for Siemens, second for Philips, and third for GE.

Table 29. Hardware performance of three MRI technologies

Hardware Performance	GE	Siemens	Philips
Image resolution: 1- Two dimensional image 2- Three dimensional image	 2 2	 1 1	 2 1
Radio frequency coils with parallel imaging capabilities	3	1	2
Image quality	3	1	2
Overall performance	3	1	2

Table 30 shows the number of software options in each package for different clinical applications provided by the three firms; the options are used to diagnose a variety of diseases. The first group of packages (Standard Options) is usually sold as part of each MRI technology for general clinical applications. However, the remaining packages are dedicated to advanced clinical imaging and can be sold separately based on the requirements of each MRI research center. For example, if a research center is focusing on studying brain imaging, it will buy more software packages for this particular application, ensuring that it can conduct advanced research by utilizing them in various methods. On the other hand, if the center runs different areas of research, it will consider ordering multiple packages for multiple applications to fit the needs of different scientists. Therefore, each software package is viewed as a unique feature that provides special capabilities to achieve certain objectives, with buyers having the choice of selecting any combination of these features to meet their needs.

Table 30. Software packages provided by three MRI technologies

Software Packages	GE	Siemens	Philips
Standard Options	18	23	19
Angiography and Cardiac	8	14	10
Brain and Functional	4	7	6
Others (breast, liver, etc)	5	6	4

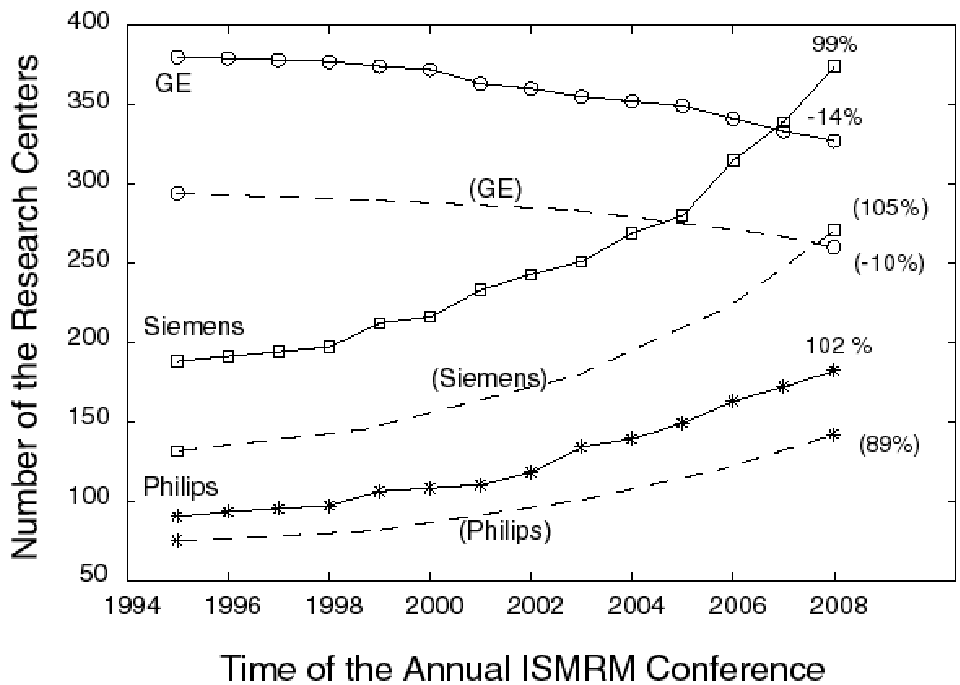
Adding the number of software options of each package, then, to compare different firms based on the total number is not a realistic approach, because each MRI research center considers MRI technology attractive when it meets specific needs, regardless of the extra features that do not add any value for these needs. Hence, it is practical to compare different firms in terms of each group of software packages. Table 30 shows that Siemens and Philips firms offer more advanced packages than GE, in particular for cardiac and brain imaging applications – the leading causes of death in industrial countries, as shown in Chapter 1.

6.4 Comparing Survey Data and Conference Database

In section (6.3.1), I demonstrated how I used conference database to track MRI the switching process from 1995 to 2008, leading to the information in Figure 13 that shows changes in market share of each supplier. To compare this data with survey findings, I added survey results to this figure, where a new figure is produced, Figure 15. In this Figure, dashed lines represent survey results, and parentheses cite company names. Survey results reported for

2008 are reliably placed because the survey was collected on 2008; however, the reported old technology in the survey was not related to a specific time (I did not ask the time of purchasing the old technology), a fact that leads intentionally to place the result at 1995. This is an approximation measure made to generate an acceptable foundation to compare data from two different sources – an approximation believed to be rational so long as the survey data reported in 2008 is indeed reliable.

Figure 15. Comparative findings from conference database and online survey

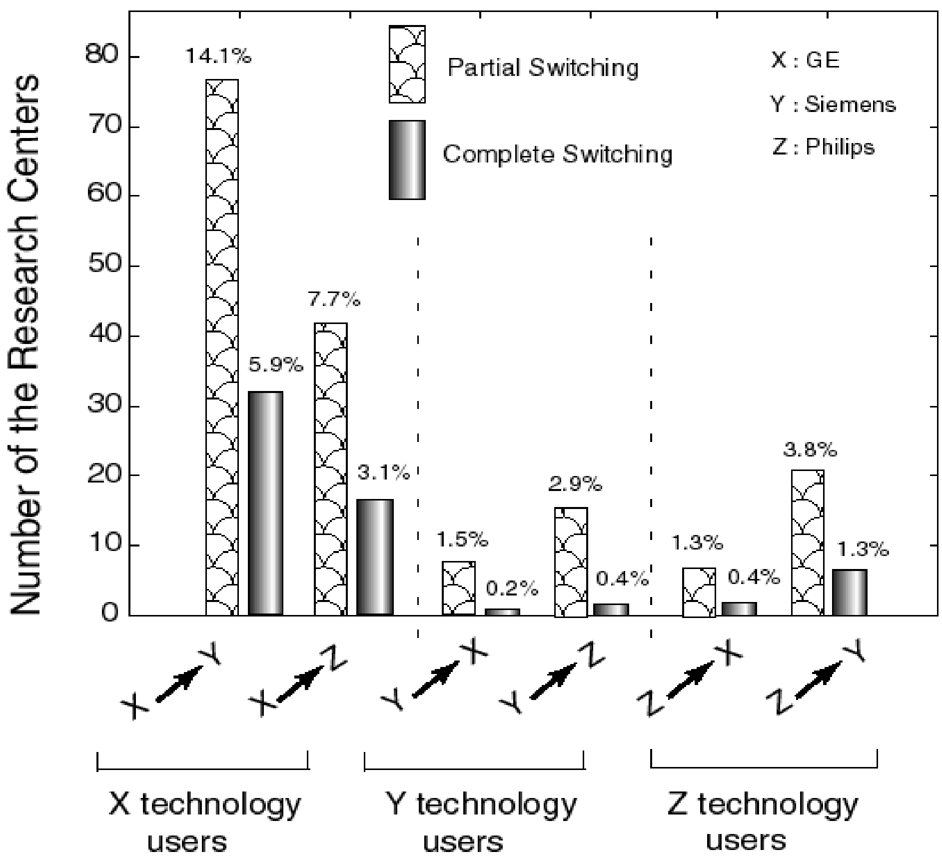


The percentage at the end of each curve represents the change in value reported at 1995.

Interestingly, Figure 15 shows a significant correlation between data from both sources (at 0.01 level), with less overall magnitude for survey data, because the number of participating MRI research centers was less than the number defined from conference database. This high correlation confirms the same finding that was measured using two different sources, that is, MRI switching is taking place within MRI research centers worldwide.

As I did previously, I split the switching process in the survey data to produce two groups: partial switchers and complete switchers, as plotted in Figure 16; by doing so, I can compare this data with data in Figure 14 that was generated from conference database. Figure 16 demonstrates the overall accumulation of switching process over time, so it does not include time as a reference, which was a small concern for Figure 15. This concept establishes a solid foundation for comparing both figures, and concludes that there is indeed a high correlation pattern between the two data sources.

Figure 16. Partial and complete switching for survey data



The percent value above each bar represents a portion of the total number of research centers.

6.5 Comparing Survey Data and Technical Reports

Comparing results from Table 23 of the survey data with Table 30 results from a technical report suggests that there is a strong agreement by MRI buyers, when they ranked different MRI suppliers based on product features (software packages). Ranking of different software packages is based on testing and comparing hardware performance of each MRI technology. The testing is conducted during the purchasing process as explained in Appendix C. Table 29 (from a technical report) confirms that hardware performance of certain MRI technologies is superior, a fact that makes the overall product features more attractive, with Siemens coming first followed by Philips and GE.

A comparing of product features for different MRI technologies in the technical report explains the reason behind switching to certain technologies to acquire more advanced applications. For example, suppose that current GE users would like to buy a new MRI technology; they will conduct the evaluation process of different MRI technologies, as illustrated in Appendix C, and will reach the same evaluation results as reported in Table 29 and Table 30. If GE users are seeking certain advanced capabilities that do not exist in the current technology, they have the alternative to switch to Siemens as the best option, followed by Philips.

6.6 Conclusion

Previous research examined switching behavior in a competitive market. This research explores this behavior in capital-intensive markets, where buyers face many challenges before making the final decision to switch. Despite high switching cost, buyers are forced to switch to a technology that sustains a competitive advantage in an environment characterized by rapid technological changes. In this chapter, a confirmatory study analyses survey data to evaluate the proposed model and identify the most influential variables behind switching behavior. Once independent variables are tested for reliability and validity, the logistic regression analysis determines the independent variables that are significant, which support the equivalent hypotheses. Some hypotheses are rejected because they are not significant toward impacting the final switching decision (including product breadth, cost of verifying technology, and the support of top management). Research results are also presented from multiple sources to provide a comprehensive explanation of the factors underpinning switching behavior of capital-intensive products. Data from different sources are correlated to ensure the reliability of research findings. These results are therefore brought forward for discussion in the next chapter.

Chapter 7
Discussion, Implication, and Limitation

7.1 Introduction

The goal of this research is to investigate the influence of product design on switching decision for capital-intensive technologies, and how other variables might impact this decision. In this chapter, I discuss whether or not the data from the research supports the hypotheses developed in Chapter 4; and I highlight any discrepancy. I also discuss the value of demographic variables to understand the motivation behind switching behavior. Then I focus on the research contribution, implication to practice, what managers can learn from this study, and limitations in generalizing research findings. Finally I offer recommendations for future research to find answers to related questions, and I provide conclusions.

7.2 Discussion

7.2.1 Hypotheses Testing

With the survey data analyzed, the significant variables are presented in the final model (Figure 12). In the model, product features and product variety represent the most influential factors behind switching, because both reflect product capabilities that motivate switching. Participants' ranking of different MRI technologies, Table 23, shows that Siemens technology possesses more attractive features followed by Philips and GE. This distinction in product features has induced some MRI buyers to switch to a new supplier, in order to renew their internal resources and maintain a competitive market position. These findings support previous research about the importance of product design to achieve high market performance (Chang and Hsu, 2005), and the finding that product features are the most important dimension in new product success (Krieg, 2004; Cooper, 1979).

The final model also shows that moving to a new supplier imposes significant challenges, including technology incompatibility, relationship incompatibility, and the cost of learning the technology, all strong barriers to switching, as is high price. If not addressed properly and if appropriate measures are not taken to reduce their impact, such barriers can outweigh switching benefits, which comes from new product features. Research findings about switching barriers (including technology incompatibility, relationship incompatibility, cost of learning technology and price) support previous research outcomes concerning switching (Low and Johnston, 2006; Heide and Weiss, 1995; Wathne et al., 2001). These barriers represent the main obstacle to upgrading the internal resources of organizations to achieve competitive advantages.

The supplier's marketing strategies could be a strong stimulus to help switchers during the transition process by reducing the negative effects of barriers to switching. For example, research collaboration could assist in overcoming technology incompatibility and learning issues, which facilitates a smooth conversion to the new technology and the efficient use of it (Athaide et al., 1996). For buyers, this issue is critical since the new MRI technology contains many complicated capabilities, to which even lead users would find it difficult to adjust without help from the supplier. Research collaboration includes networking opportunities with other users who operate the same technology, in order to exchange experience and best practices in using the technology. Such networking is offered by suppliers through a special online community network that connects the same technology users and enables them to exchange ideas and post feedbacks. The second effective marketing strategy is the provision of a good product service and reliable technical support to remove any concerns about building new and effective relationships (Athaide et al., 1996), an essential strategy to ensure that MRI technology will run constantly and without interruption. If there is an interruption, the supplier is expected to resolve the problem quickly to prevent expensive downtime and schedule changes.

Interestingly, the cost of verifying technology was not included in the final model because it is not significant – perhaps due to the fact that MRI buyers spend time and effort to verify different technologies regardless of the final decision: stay or switch. It seems that switchers are more worried about the post-switching costs mentioned above, which, if not managed and solved effectively, could have negative and costly consequences instead of being advantageous. MRI buyers, as lead users, feel that the cost of verifying different technologies is manageable and can be implemented using their own experience.

Product breadth (or bundling) as a marketing strategy has no significant effect on the final model because it does not directly reduce the impact of switching cost variables, as research collaboration and product service do. Therefore, it appears as a weak marketing strategy in this study. This emphasizes that high technology buyers are mainly focused on having a specialized technology that provides specific features (capabilities) to achieve certain objectives. Any added features (as bundles) that are not related directly to the core capabilities of the product have a minor influence on buyers' decision. However, the literature shows that bundling has a significant influence over the decision to switch in banking industry (Wathne et al., 2001), which is a competitive industry and in which buyers are often indifferent to choice, usually aiming for a purchase that maximizes returns.

Top management support for the decision to switch is in this case also not significant, due largely to departmental influence over the purchasing decision, especially if funding is granted from an external agency that supports research activities. This arrangement allows MRI buyers more flexibility to control the process of purchasing MRI technology. Management influence could be widely different based on the internal policy of each organization, and more influence is expected if the funding is allocated mainly from the hospital budget. When the internal policy follows formalized procedures it limits the ability to switch, because bonding procedures make the process of acquiring information and analyzing is complicated (e.g. Heide and Weiss, 1995). When the policy adopts centralized measures it eases interference; but it will permit switching only if it is critical to the department's interest. Usually, management prefers to have one supplier that handles multiple technologies, to avoid building and maintaining multiple relationships with new suppliers.

The independent variables that were found to be significant in the final model are the same variables that were considered an influential variable in the interviews, score high-ranking; whereas not significant variables in the final model are the same variables that were measured as influential variables in the interviews but score moderate-ranking in the interviews. This emphasizes the importance of the exploratory research stage to identify and include the most relevant factors that could explain the context under investigation.

7.2.2 Demographic Variables

Buyers' characteristics are rarely mentioned in previous literature studies, indicating that buyers switching decision is more rational than in the consumers case to reflect organizational objectives. In general, when buyers are confronted with high technology products, a final decision is made after detailed investigation and analysis to evaluate the potential value of different alternatives, in order to select the one that maximize buyers' benefits. This research confirms this finding, in which participants' demographic variables, location and institution type, had no impact on switching decision. Although most switchers are located in North America, but this was due to GE's domination of this market since MRI technology was launched in the early 1980s, whereas Europe is dominated by Siemens and Philips.

Nonetheless, evaluating different demographic variables between switchers and non-switchers revealed interesting observations that could explain the motivation behind switching to a new supplier. Table 20 shows that universities and educational hospitals are the most likely switchers; they also have the highest percentage of research activities. Both groups, as lead users, have high demand for advanced features to ensure they are capable of achieving their objectives. If their current supplier is not able to provide such advanced capabilities, they have a high incentive to switch to another supplier to protect their market position.

Table 20 shows that other hospitals are also switching their suppliers despite the limited research activities they conduct. This result can be explained by the importance of obtaining advanced technologies in the same hospital to have better diagnostic capabilities for various diseases, instead of continually transferring patients to other hospitals that have superior technologies. The level of switching is higher for large hospitals than for small, perhaps for the following two reasons: First, the financial costs are a high switching barrier for small hospitals, so it takes them a long time to obtain a new technology from a new supplier. Second, at small hospitals, it takes some time to verify the real value of a new technology and how to utilize it efficiently, so small hospitals are reluctant to switch until the new technology has proven itself. It seems that university and educational hospital act as early adaptors, which is one characteristic of lead users (Von Hippel, 1978), whereas other hospitals are late adaptors.

Table 19 shows that the new technology has increased the percentage of research activities, a direct result of recognizing the advantages of adopting a new technology and the potential for accruing large benefits from utilizing it. This shift is a normal behavior because the new technology contains various advanced capabilities under high demand by different individuals in a department. Table 22 expands the previous picture to another level to show that percentage of research activities for switchers is more than for non-switchers, in particular at universities and education/teaching hospitals. This implies that lead users, who adopted a new technology from a new supplier, are determined to accomplish significant advantages from the new capabilities to maintain competitive position (Morrison et al., 2004).

7.2.3 Comparing Data from Multiple Sources

A comparison of data from final survey and conference database has confirmed that switching is taking place among MRI suppliers. Data from both sources have demonstrated a strong correlation, confirming the reliability of research findings. On the other hand, comparison of data from the final survey and technical reports has determined the product capabilities of each supplier that cause switching. Results show that the Siemens MRI technology has many unique features that make it attractive for buyers. Using multiple sources of information was beneficial to enrich this study and support research findings.

7.3 Contribution of the Research

This research contributes to the literature on technology switching by identifying the influence of product design on switching decisions for capital-intensive technologies. Previous studies have rarely mentioned the influence of product design on buyer switching, putting emphasis on other factors instead, such as marketplace characteristics (Heide and Weiss, 1995), switching costs (Low and Johnston, 2006; Wathne et al., 2001), and marketing strategies (Wathne et al., 2001) as the main antecedents of buyer switching. The selection of these factors to explain buyers' decisions can be due to the product nature and competitive market conditions. However, this research shows that buyers of capital-intensive technologies focus mainly on enhancing their internal capabilities by obtaining a product that contains the optimum features to provide the desired capabilities (Liu et al., 2005; Money, 2004; Ping, 1997).

The literature shows that there is no distinctive model to describe or predict consumer and buyer switching behavior. Each study adopted different independent variables to explain this behavior based on the industry or product under investigation (Yanamandram and White, 2006; Lam et al., 2004). This study makes a significant contribution by generating a new model to explain this behavior for capital-intensive markets. This model clarifies our understanding of the switching behavior of capital-intensive products, where successful product design plays a significant role. This behavior is different from that described in previous research conducted mainly in a competitive market with frequently purchased products, where the common prediction is that the incumbent has an advantage over others, because the rapid technological change and high cost of switching increases the probability of resuming the relationship with the existing supplier (Heide and Weiss, 1995).

This research contributes to dynamic capabilities theory by providing empirical evidence to confirm that dynamic capabilities are not processes, but rather routines embedded in processes (Eisenhardt and Marten, 2000). In this perspective, MRI technology switching to renew internal capabilities will not create a competitive advantage by itself (Barney, 1991), because many technology users are switching at the same time to obtain the new technology that has unique features. However, the competitive advantage comes from the way organizations manage their resources to achieve different sources of competitiveness (Wang and Ahmed, 2007). For example, each MRI research center will use the new MRI technology in a slightly different way to achieve a certain research agenda through applying new innovative ideas, which produce various reputable scientific achievements.

The findings of this research contribute to the marketing literature by demonstrating how effective product design can undermine different switching barriers and provide buyers with strong incentives to switch (Wathne et al., 2001), through providing them with advanced capabilities that leverage significant advantages from switching. It also shows that various marketing strategies can be useful to reduce the negative impact of switching costs and provide smooth transition for buyers. These marketing strategies have to be identified accurately for different types of technologies in order to select the most effective strategies that help users switch from one product to another (Low and Johnston, 2006).

The targeting of lead users as part of a supplier strategy to launch a new technology is an effective tactic for capturing the main market, because those early adaptors/switchers will provide other buyers with solid motivation to pursue the same behavior later after they discover the real value of the new product (Teplensky et al., 1993). This research confirms the findings of previous researchers that lead users play a significant role in the market success of a product (Morrison et al., 2004). On the other hand, identifying buyers' preferences of high technology markets is a challenging task because the environment is highly dynamic and the buyers' requirements are changing (Bhattacharya et al., 1998). In such markets, it is difficult to translate buyers' preferences into product features or define certain applications that fit the needs of a specific market segment (Bacon et al., 1994). This challenge in the development process of new products, and new features, can be mitigated by integrating lead users in the product development process (Von Hippel, 1995; Thomke and Von Hippel, 2002). This research demonstrates that lead users are heavily involved in research activities to create new applications that have a direct clinical value. Such users are used by MRI suppliers (through research agreements) to enhance their innovative capacity in generating new product features (Franke et al., 2006).

Each MRI supplier has a special software development tool that creates an interactive environment to access the internal software routines and codes to implement new research ideas. If this development tool is flexible, then the product software platform, which represents the main foundation for building all software components, is also flexible because both are expected to have the same characteristics. Interviews have indicated that Siemens and Philips have flexible development tools compared with GE's, providing more capabilities to integrate new research ideas. From the supplier side, this flexibility in the product platform can be a factor behind the ability to integrate various product features and maintain overall system stability (Krishnan and Bhattacharya, 2002; Worren et al., 2002; Thomke, 1997). Chapter 1 (Figure 4) showed that GE has a strong innovative capacity as demonstrated by its considerable patent portfolio compared with that of the other MRI suppliers. However, research findings show that it has significant difficulty in integrating product innovations and maintaining high system performance (stability).

7.4 Implication for Practice

Managers should find a reliable model to assess antecedents underpinning switching behavior for their industry. They should not rely on their expectation to predict those antecedents, because previous research shows that buyers and suppliers claim different perceptions of the determinants of switching (Wathne et al., 2001). Determining the main factors behind switching is a critical matter when defining the appropriate strategy to keep their market share from eroding. In capital-intensive markets, these factors are related to product features, which enhance the internal capabilities of the buying organization and maintain its competitiveness. However, defining the nature of these features becomes a challenging issue, because this market is characterized by significant difficulties – given the rapid pace of technology change, the changing buyers' preferences, and competitive moves.

These challenges make it difficult for suppliers to determine optimum product features to be developed and integrated into the final product (Bhattacharya et al., 1998; Kreig, 2004). If it does not have the optimum product features, the product will be under constant threat from competitors and may not be extracting the maximum market value. Therefore, it is critical to integrate buyers' knowledge and feedback in selecting the product features in this market (Griffin and Hauser, 1993; Zha and Sriram, 2006); because this knowledge fills the gap between what suppliers think buyers want and will buy and what buyers really want and will really buy.

It is not practical for suppliers to collaborate with just any group of buyers, they should define a specific group with whom it is valuable to build a relationship, which is lead users. Market lead users can be identified as being the early adaptors and as having a high incentive to innovate (Morrison et al., 2004). Mangers should continuously identify those users for the following purposes: Use them as a trusted source of new product ideas, a reliable source of market research, and an influence on others to adopt the same technology, increasing the diffusion rate. These users, being advanced adopters relative to other users, can be approached for forecasting purposes and generate new products based on their advanced application status (Lilien et al., 2002).

Many companies claim they have the knowledge of their buyers, or that they keep tracking of them by conducting a comprehensive market research analysis; but in reality, this information is in a fragmented form, is difficult to analyze, is often incomplete, or is not integrated efficiently in the product design process – finally resulting in inferior product features (Henard and Szymanski, 2001). However, different studies have demonstrated that lead users could enhance the process of product design through their innovative contributions (Von Hippel, 1995; Thomke and Von Hippel, 2002), which constitute advanced features.

7.5 Research Limitations

It is important to mention the main limitation of a study of this kind, which is the ability to generalize research findings. Most of the research on switching behavior focuses on a specific industry or similar industries. From each industry, a specific sample is selected on which to conduct research. When the selected sample is representative of the population, it is feasible to generalize findings to the same industry or similar industries. In this study, I selected MRI research centers as a sample of the MRI market. This sample represents lead users who conduct some research activities as part of their technology usage. However, the majority of the MRI market is dominated by general users, who focus on clinical activities.

The final model is strongly expected to hold for MRI general users, because when the previously adopted technology fails to meet fully the organization’s strategy to secure a competitive advantage (though effective and accurate diagnosis of different diseases), it will be switched for a new technology that helps achieve its objectives efficiently and effectively. This switching is influenced by product features that provide new capabilities that preserve high organizational performance. However, research collaboration is expected to have a limited role for general users, mainly to overcome technology incompatibility (as technology training) and networking with the same technology users. Other factors are expected to have similar impact on the switching decision. The influence of management could be high since funding to buy a new MRI technology is allocated directly from the hospital budget, where senior managers might interfere because of financial constraint.

When generalizing research findings to other similar industries, one should be cautious about extrapolating findings to other contexts. For example, in the airline and heavy machinery industries, the impact of product features on switching decision can be clear, but the meaning of research collaboration would have another interpretation in the new industry, such as "Technology Training" to overcome incompatibility issues. This variable can remain in the same category "Marketing Strategies." The ability to reapply this study in the future for other industries, but with similar characteristics, will increase the capability to generalize research finding with high confidence.

7.6 Future Research Directions

While this research aims to find suitable answers, it leads to further questions that should be researched, including the following. First, how can some suppliers define the optimum buyers' preferences in a high technology market, where the rate of technological change is high and buyers' preferences are changing constantly. In such a market, suppliers should be innovative in collecting information from multiple sources, and defining the most critical product features that would make the product highly attractive and encourage new buyers to own it. An initial investigation on this issue showed that some suppliers use conference meetings and medical community networks as an important source of information to identify highly demanded applications, the limitation of the current technology, and what kind of aspects doctors want in the new product. This information is combined with that from other sources (focused group, personal interview, and market analysis) to identify buyers' preferences, which lead to determining the "right" product features.

Second, many organizations are increasingly seeking to extend their innovative capacity through strategic partnerships with lead users, to leverage the value-creating knowledge and innovation capabilities. MRI lead users are a valuable asset with whom suppliers want to build a strong relationship, in order to increase their innovative capacity. It is interesting to determine the impact of switching on innovative capacity by tracking the number of patents issued over time and correlating that information with switching behavior. It is possible to define the innovator and the assignee (as supplier) of any patent, allowing us to know if the patent is generated by lead users.

7.7 Conclusion

In this research, empirical data is provided to demonstrate the influence of product design on switching behavior for capital-intensive high technology products. It was found that buyers are willing to switch to a different technology in spite of high associated costs, especially when they are using a product that restricts their capabilities. Those early switchers will provide other buyers in the market with solid motivation to pursue the same behavior later, after they discover the real value of the new technology.

Technology switching behavior is an important issue in a market close to maturity, where the only way to expand market share is through encouraging users to switch from competitor firms. If this behavior continues without taking proper actions, it will erode firms' profits and market base. This behavior is different from that described in previous research conducted mainly in a competitive market with frequently purchased products.

Continual monitoring of switching behavior is an important approach to understand the various underpinning factors, and using them as a feedback loop to improve product innovation strategy. This strategy will convince buyers that firms are committed to technological changes and to empowering the product with the required features, so they have less incentive to switch. Such market monitoring can maintain long-term success and ensure buyers satisfaction.

This research fills a gap in our knowledge about the significant value of product design in increasing market share through technology switching, and opens new avenues for future research.

Appendix A

Switching Cost Dimensions

Dimension	Description	Potential Correlation with Antecedents/Consequences	Potential Strategic Implication for Supplier
Lost performance costs	Perceptions of the benefits and privileges lost by switching	Service quality Interpersonal bonds Repurchase intentions	Focus on augmented service Frame benefits to switching as current losses
Uncertainty costs	Perceptions of the likelihood of lower performance when switching	Heterogeneity of service outcomes Intangibility of service Repurchase intentions	Provide tangible quality cues Encourage positive word of mouth Provide service guarantees
Pre-switching search and evaluation costs	Perceptions of the time and effort of gathering and evaluating information prior to switching	Geographic dispersion Limited alternatives Low brand awareness Repurchase intensions	Increase number of locations Increase information availability Provide tangible quality cues Encourage positive word of mouth
Post-switching behavioral and cognitive costs	Perceptions of the time and effort of learning a new service routine subsequent to switching	High customization Detailed service scripts High customer involvement	Create efficient service routines Provide adequate information regarding service roles
Set up costs	Perceptions of the time, effort, and expense of relaying needs and information to provider subsequent to switching	High customization Cumbersome information-gathering procedures	Create efficient & effective modes of communication between customer and service personal Use information technology to enhance information flow
Sunk costs	Perceptions of investments and costs already incurred in establishing and maintaining relationship	Length of patronage Interpersonal bonds High customer involvement Repurchase intentions	Promote fast, easy, and low cost transition between providers Frame sunk costs as minor compared to the stream of future performance benefits lost by not switching

Adopted from Jones et al. (2002)

Appendix B

Interview Questions

General Information:

Q1: Name of old supplier?
□ GE □ Siemens □ Philips

Q2: Name of new supplier?
□ GE □ Siemens □ Philips

Q3: Did you do partial switching, by adding new MRI technology to the existing one, or a complete switching by replacing the old one?
□ Partial □ Complete □ NA

Q4: MRI characteristics of the new MRI technology?
□ 1.5T □ 3T □ NA

While answering the following questions you need to imagine yourself during the process of evaluating and purchasing a new MRI technology, which took place in your department:

Product design:

Q5: Was the old technology limiting your capabilities to conduct/implement your research objectives?
□ yes □ no □ NA

Q6: Did you find that the new supplier provides a wider range of products (as RF coils) that match your area of research?
□ yes □ no □ NA

Q7: Did you find that the new product offers more pulse sequences (clinical packages) and image analysis software, which match your research objectives?
□ yes □ no □ NA

Q8: How do you rate the following suppliers based on the overall performance for different applications (hardware and software)?
□ GE □ Siemens □ Philips

Q9: Were suppliers' future announcements to integrate new features an important factor?
□ yes □ no □ NA

Q10: Can you rank the following factors behind buying a new MRI technology?
□ Factor 1: conduct advance research using better technology. (same research area)

□ Factor 2: expand research activities into new areas (functional, cardiac, diffusion…).
□ Factor 3: looking for more research collaboration.
□ Factor 4: we got a special deal on different devices (bundling).

Market characteristics:

Q11: Since each supplier provides different MRI technology platform, which means that both technologies are heterogeneous, did this situation impacts your decision to switch to different product?
□ yes □ no □ NA

Q12: It is well-known that the rate of technological changes in MRI industry is very high. For example, the old supplier could soon integrate similar features to those in the new product. Did this situation impact your decision to switch to a different product?
□ yes □ no □ NA

Q13: Do you think that your prior experience has an influence over your decision to switch the technology?
□ yes □ no □ NA

Marketing Strategies:

Q14: Was the product price an important factor in the evaluation process?
□ yes □ no □ NA

Q15: Was there a significant difference in products' prices?
□ yes □ no □ NA

Q16: Was product bundling with other equipment an important factor?
□ yes □ no □ NA

Switching Costs:

Q17: Were you concerned about building a new and effective relationship with the new supplier?
□ yes □ no □ NA

Q18: Were you concerned about technology compatibility issues, which lead to spending significant time to learn and use the product effectively in research operations?
□ yes □ no □ NA

Q19: Regarding the financial switching costs; how expensive was it to complete the entire switching process (including learning how to operate the new technology effectively)?

☐ yes ☐ no ☐ NA

Q20: Did you verify the performance of product features by yourself, or did you just trust what each supplier provided you?
☐ yes ☐ no ☐ NA

Influence of Top Management:

Q21: Was there any influence from the top management in your institution over the final decision?
☐ yes ☐ no ☐ NA

Consultation:

Q22: Did you seek any expert advice to help you in evaluating different products?
☐ yes ☐ no ☐ NA

Q23: Did you contact current users of the new technology to ask for more information?
☐ yes ☐ no ☐ NA

Purchasing Process of MRI Technology

Q24: Can you explain the process of purchasing a new MRI technology?

Q25: Can you identify some factors/items that would characterize each variable in the purchasing process?

Q26: Do you know about other variables that might influence the process of purchasing MRI technology, which are not mentioned in this model?

Final Marks:

Q27: Can you tell if the new technology meets your expectation (performs as expected)?
☐ yes ☐ no ☐ NA

Q28: Would you recommend the new technology to anyone who might seek your advice?
☐ yes ☐ no ☐ NA

Q29: Do you think that the new technology is helping to achieve your objectives as initially anticipated? Tell me how?
☐ yes ☐ no ☐ NA

Appendix C

General Procedure to Evaluate and Select MRI Scanner

The process of evaluating and buying an MRI scanner could differ slightly based on the condition of each MRI research center and the internal policy. However, the following steps represent the general theme:

1- A special scientific committee is established to look after the purchasing process; this committee includes key individuals in radiology department and some management representatives. Usually, the new MRI scanner is expected to be used by certain group of people who are involved in specific area of research, for example brain and neuro-imaging; at this point, the focus will be on certain aspects of MRI product. However, if the new MRI is expected to accommodate the need of larger group of scientists; for example cardiologist, neurologist, and psychologist; then the product is expected to contain certain level of technology to accommodate wider range of demands. This will make the evaluation process more challenging and complicated.

2- Since the main goal of buying an MRI for research centers is conducting advanced research (in addition to clinical operations), it is important that the product contains the state of the art technology to be used as a base line to build/test new ideas on it.

   Different individuals have demonstrated the importance of the following factors in the new MRI scanner, which represent the overall performance of its features:

   - High hardware performance of different MRI components: such as magnet linearity (to reduce ghosting), gradient strength (for fast imaging and higher resolution), signal homogeneity in RF coils (for high quality images), in addition to image processing speed.
   - More software clinical packages (to image different body parts) and more image analysis tools (for image post processing).
   - Flexible research environment to develop and integrate new ideas, which should be easy to access to modify internal programs, in order to test new ideas.

   Because MRI technology is becoming more complex and sophisticated, to the limit it is hard to be fully understood by MRI users. Keeping in mind that MRI product is designed and integrated by a large number of scientists and engineers. This situation makes MRI users more interested in establishing research collaboration agreement with suppliers, which helps them to solve and integrate any new ideas. As a result, scientists can progress their research quicker and save significant time and efforts trying to figure out the optimal way of integrating new innovative and challenging ideas.

3- The assigned committee writes a document that specifies the characteristics and specifications of MRI scanner in general terms (what are the clinical applications that would be investigated and requirements of each one). For example, a special section lists cardiac applications and the expected imaging protocols, another section lists brain imaging.

   Then a tender is opened, where each supplier asks for this document. Suppliers can contact the scientific committee asking for more information or details about specific sections, so they can work out their offer in delegate manner. In this document, it is stated clearly that suppliers should response within certain time.

   Before the deadline, each supplier should provide an offer (bid) with price and product service plan; where the committee studies each one carefully to find the most capable product that meets the initial demands listed in the document.

4- In the initial document, it is specified that committee members would like to see the scanner working on patients (clinical site) or in factory, to ensure that specifications are accurate as they are written in each offer. During this stage, different imaging protocols are run in front of the scientific committee to test different hardware components, where a set of parameters (measurements) are recorded for later analysis. This analysis will identify the actual MRI hardware performance and stability under different settings (long scans and hard scans). The scientific committee conducts an analysis for the three suppliers' products using similar testing protocols, in order to be objective and accurate in the final comparison.

   The main goal behind visiting different MRI sites and collecting data for further analysis is to verify the information reported by each supplier, because MRI industry is not fully regulated, and there is a concern that different suppliers can present their product configurations in different ways, where the presented values are different from those someone would get in real operating mode.

5- Committee members evaluate each offer carefully and quantify the information to say that this product is better than others because of these aspects, and so on. If any of the initial requirements, which is set in the original document, is found missing from any product, it should be clearly stated as a disadvantageous point.

   Then products are ranked based on overall performance, possibility of research collaboration, cost, and service contract. The importance of the missing requirements is evaluated in depth to make the final ranking. At this point, conflict of interest appears on surface, because each committee member has certain concerns about the significance of the new technology to prompt his research activities.

Final ranking of different MRI scanners is made. Suppliers in the third position and after are taken away from the competition, because they are evaluated low at different fronts, and they do not meet important requirements.

6- The final stage takes slightly different forms based on the internal policy of each research center:

- If number one ranked supplier is found superior in meeting all the initial requirements and financial cost was not a limiting factor, then it is selected as a winning supplier to provide the new MRI scanner.
- However, if initial requirements were closely met by both suppliers and there is a significant difference in price, then the negotiating phase could start by informing supplier 2 about his ranking in the second place and that his price estimate was higher, in order to get a better deal from him (extra product features). The price difference between supplier ranked first and second is not disclosed, because once the price is writing on contract, it can’t be changed (or released) due to legal issues.

Now supplier ranked second can improve his position (or ranking) by offering some free hardware upgrade or giving more supplementary equipment for certain price in the next purchase, or free equipment at the time of MRI delivery. Based on the final negotiation, the final decision is made to select a supplier.

7- In the final stage, the top management personnel (hospital director, VP, or any selected member) could take a part or full control of running this stage, based on the internal policy. If he takes a full control, he will hold a discussion session with the scientific committee to review the importance of each supplier in matching the initial requirements. Then he manages the negotiation process to reach the final decision.

Appendix D
Online Survey

UNIVERSITY OF
Waterloo

Technology Switching between MRI Suppliers

Dear MRI Users,

This survey consists of two parts. In the first part, you will be asked to provide general information about you and your department. In the second part, a number of statements will be presented to you, where you will be asked to indicate how those statements are similar to your opinion about your department.

Please note that:

1. Your point of reference should be your department, when it purchased the last MRI scanner from a different supplier.
2. "We" and "Our" used in the study refers to you and/or your colleagues within the department.

Demographics Information:

For each question, please check the item that applies to your case, the rest can be left blank:

1) My position at the department:
   - ☐ Department Chair
   - ☐ Medical Doctor (MD)
   - ☐ Physicist/ Engineer
   - ☐ Scientist
   - ☐ Chief technologist
   - ☐ Technologist
   - ☐ Post Doc.
   - ☐ Other

2) Number of years of my total MRI working experience:
   _____ years

3) Number of scientists (as principal investigators) in my department that use our current MRI scanner(s) to conduct research:
   _____ scientists

4) My department is located in this country:
   ______

5) My department is part of:
   - ☐ Large hospital (400+ beds)
   - ☐ Medium hospital (250-399 beds)
   - ☐ Small hospital (1-249 beds)
   - ☐ University
   - ☐ Educational hospital

6) The following clinical applications represent the primary areas of research in my department: (check all that apply)

☐ Cardiac	☐ MR Angiography	☐ Contrast Enhanced MRA
☐ Brain (general)	☐ Functional MRI (fMRI)	☐ Neuro-imaging
☐ Spine	☐ Body (general)	☐ Cancer
☐ Spectroscopy	☐ Molecular imaging	

7) In the past, my department had an MRI scanner from a certain supplier, but now we don't have any relationship with this supplier, or we are not using its MRI scanner anymore: (If the answer is YES, please write the name of supplier(s); otherwise leave it blank)

   ____

8) In the past, I have been involved personally in the process of purchasing the MRI scanner for my department:

☐ Yes ☐ No

9) If you have not been involved personally in the purchasing process, to what extent are you familiar with this process at your department?

- ☐ Not at all familiar
- ☐ A little familiar
- ☐ Somewhat familiar
- ☐ Very familiar

(Dependent Variable: Technology Switching)

10) Please select the option that most likely describes your department:

- ☐ Currently, my department owns "multiple" MRI scanners from the "same supplier".
- ☐ Currently, my department owns "multiple" MRI scanners from "different suppliers".

11) Name of the last two MRI scanners that purchased from two different suppliers:

The last MRI scanner: ________________ (for example, GE)

Before the last MRI scanner: ________________ (for example, Philips)

In the following pages, you will be presented with different statements concerning the new (or the last) MRI scanner purchased by your department.

(The answers for the following questions are based on this scale, which is placed directly after each question)

Strongly Disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly Agree
☐	☐	☐	☐	☐	☐	☐

Survey Main Items:

In this study, it is assumed that MRI features consists of two parts:

(I) Hardware components: such as gradient system and internal RF-system (with multi-channel capabilities).

(II) Software applications: such as pulse sequences, post processing, and post analysis tools.

12) Based on this assumption, to which extent do you agree or disagree with the following statements about the decision to buy the new MRI scanner?

(Product features)

- Since our department is working on different clinical applications, we selected a scanner that provides a wide range of software applications with the highest hardware performance in market.

- We selected a scanner that has new pulse sequences that are not available on other scanners.

- Overall, the new scanner provided unique features and capabilities that are not offered by other scanners, which are important to generate reputable research (or clinical findings) compared to other MRI users.

- The new scanner provided better work flow, post processing, post analysis and reporting tools compared to other MRI scanners.

(Product variety)

- We selected the scanner because it is more dedicated (or specialized) to serve specific applications (for example cardiac or neuro-imaging), which is not offered by other suppliers.

- We selected the scanner because of its wider range of RF coils for different applications, which are not offered by other suppliers.

- Since our department is working on different clinical applications, it is essential to have a variety of advanced RF coils for different areas of research.

13) Since different MRI scanners come with different platforms, switching to a new MRI scanner from a new supplier can be a challenging procedure due to numerous factors.

The following statements represent different switching barriers that could discourage MRI users to switch to a new supplier. To which extent do you agree or disagree with these statements about the decision to buy the new MRI scanner?

(Technology incompatibility)

- Incompatibility of the new MRI scanner with existing MRI scanner(s) is a critical issue in our department.
- Existing research projects (including pulse sequences) could be incompatible with the new MRI scanner.
- Incompatibility could restrict our collaboration with other departments or hospitals.

(Relationship incompatibility)

- Because we have a close working relationship with the old supplier, it would be difficult to build a similar relationship with a new supplier.
- Developing new procedures to deal effectively with a new supplier would take a lot of time and effort, which could negatively impact our regular operations.
- We are concerned that the new relationship will not be as effective as that with the old supplier.

(Cost of learning technology)

- It takes significant time for technologists to learn how to operate the new scanner effectively.
- After switching, continuing effective research operations on the new scanner requires learning the new pulse sequence language and hardware communications.
- Transferring existing research projects (including previous pulse sequences) onto a new scanner would require significant time and effort.

(Cost of verifying technology)

- It takes significant time to complete the installation and calibration process of a new scanner.
- We independently verify MRI features and performance for different MRI scanners by visiting different sites, in addition to relying on the technical reports given by suppliers.
- It takes significant time and effort to evaluate and compare different MRI scanners, and then determine which one matches our department objectives.

14) Assume that the new MRI scanner provides the optimal MRI features and high performance, but for the highest price in market.

To which extent do you agree with the following statements about the decision to buy a new MRI scanner?

(Price)

- To achieve our department objectives, we focus on having the optimal MRI scanner regardless of price.
- Having the best MRI scanner is important, but the price is a critical issue due to limited financial resources.
- Since we focus on general (or less advanced) clinical applications, we are in less need of the most expensive MRI scanner.

(Bundling)

- Offering additional medical equipment (as bundling) or free scanner upgrades will increase the probability of buying the new MRI scanner.
- We are not interested in any additional bundling offers, our main goal is to buy the optimal scanner that achieves our objectives.

15) MRI service contract and research collaboration with MRI supplier could have a different level of importance for MRI users.

To which extent do you agree with the following statements about the decision to buy a new MRI scanner?

(Product service)

- Offering a good service contract will significantly increase the probability of buying the new MRI scanner.
- Having immediate response service is important to reduce scanner downtime, which negatively impacts our regular operations.
- The scanner service provided by the old supplier was not satisfactory and causes significant interruption to our regular operations.

(Research collaboration)

- Offering good research collaboration will significantly increase the probability of buying the new MRI scanner.

- Since our department is heavily focused on research, we need to have a strong research collaboration in order to solve technical problems.

- The old supplier offers limited research collaboration when we face any research related difficulties.

- Facilitating collaboration with other MRI users (through community of users support) will increase the probability of buying the new MRI scanner.

16) In your institution, how supportive was the top-level management for the medical team (or scientists) during the process of selecting and purchasing the new MRI scanner?

(Support of top management)

- Final decision to buy a new scanner was determined only by higher-level management.

- Higher-level management was supportive of the medical team in finding the best scanner, regardless of price.

- To a large extent, the medical team was in full control of the process to buy a new scanner.

17) To which extent do you agree with the following statements when it comes to your department satisfaction of the new MRI scanner?

- The new MRI improved our capability to investigate new clinical applications, which was not possible using the old scanner.

- The new MRI increased our capability to produce reputable research, which was not possible using the old scanner.

- The new MRI enabled us to increase the number of publications.

- The capabilities of the new MRI scanner helped us to attract more grants and funding.

- Research collaboration with the new supplier assisted in implementing our research project more effectively.

- The new MRI helped to scan more patients per day, which was not possible using the old scanner.

- The new supplier provided responsive and reliable service compared to the old supplier.
- The new MRI has less downtime
- Facilitating collaboration with other MRI users (through community of users support provided by the new supplier) was effective in advancing our research projects.

18) Rank in ascending order the importance of the following factors that lead to buy a new MRI scanner (1 = most important factor and 5 = least important factor):

______ Overall features and high performance
______ Contract service
______ Price
______ Research collaboration
______ Bundling with other equipment

19) Estimate the time it takes to buy a new scanner, starting from the time of evaluating different scanners till the final installation:
______ months

20) Estimate as a percentage of total time, the time spent on research operation on the new MRI scanner:
________ (For example 60%)

21) Estimate as a percentage of total time, the time spent on research operation on the old MRI scanner:
________ (For example 60%)

22) Based on your knowledge, interaction with colleagues, and monitoring research outcome of different MRI users; can you write the supplier name that offers the best MRI features of the following applications?

______ Angiography and Cardiac Imaging

______ Breast MRI
______ Functional MRI (fMRI)
______ Molecular Imaging
______ Neuro-imaging
______ Spectroscopy

Thank you for participating in the survey. Your responses are very valuable.

Appendix E

Invitation Letter

UNIVERSITY OF
Waterloo

Technology Switching between MRI Suppliers

Dear MRI User,

I am Sam Al-Kwifi, a PhD student at the Department of Management Sciences of the University of Waterloo, Canada. I am in the process of conducting a survey as part of my Ph.D. dissertation under the supervision of Professor Rod McNaughton. I am inviting you to participate in this survey, which I hope you will find interesting. My research assesses the factors that lead MRI users to decide to acquire MRI scanners from a supplier (vendor) different from the one that supplied their current scanners.

The survey should take less than 30 minutes to compete. The findings should benefit participants in the following ways:

1- Identify the criteria utilized by MRI users to select a scanner that meets certain needs.
2- Provide a better understanding of the factors that cause MRI users to switch to a new supplier.
3- Identify how MRI suppliers are able to reflect MRI users' demands.
4- Evaluate the influence of supplier's marketing strategies to attract new MRI users.

At the end of the survey you will be offered the opportunity to receive a copy of the results.

You can participate in this study even if your department has one or multiple MRI scanners from the same supplier. To participate, please visit the Study Website at (Survey Link). If a small pop up message appears to block your access, please select OK to access the survey site.

The survey is completed anonymously. You may decline to answer any questions that you do not wish to answer and you can withdraw your participation at any time by not submitting your responses. This research is not supported by any industrial or marketing organization. There are no known or anticipated risks from participating in this study.

If you have any questions regarding this study, please contact either me at (519) 888-4567 ext. 36099, oalkwifi@uwaterloo.ca or my supervisor, Dr. Rod McNaughton at (519)888-4567 ext. 32713, rmcnaughton@uwaterloo.ca. I would like to assure you that this study has been reviewed and received ethics approval through the Office of Research Ethics at the University of Waterloo.

Thank you for considering participation in this study. I truly value your time and assistance in this study.

Yours Sincerely,

Sam AL-KWIFI
Student investigator

Appendix F

Sample of Conference Database Abstract

Comparing the Limits of Contrast Enhanced MRA at 1.5 and 3T

XX, YY, ZZ
Dept. of Medical Imaging, University of West

Introduction: Advantages of 3T could open new avenues for many clinical applications especially for MR angiography (MRA), where increasing spatial resolution remains a critical issue for improved assessment of various vascular diseases. Prior reports have demonstrated the importance of doubling the signal-to-noise ratio (SNR) at 3T [1,2]. In addition, improved contrast may be achieved as a result of different tissue relaxation times, where longer T1 values at 3T improve background suppression. In this study, the SNR behavior at 1.5 and 3T using 3D CE MRA with different spatial resolutions has been investigated to illustrate the limitation of both field strengths in producing sufficient SNR for diagnosis in intracranial arteries. In addition, the role of an 8-channel coil, with and without parallel imaging, in improving the limited SNR and/or reducing scan times at high resolutions at 1.5T is evaluated.

Method: The 1.5T exams were performed on a GE Signa (TwinSpeed or EchoSpeed, Milwaukee, WI), and the 3T exams were obtained on GE Signa (VH/i, Milwaukee, WI). Both scanners are provided with a standard head coil. The study was divided into four cases: **1) low resolution, single coil:** using a 3D CE MRA clinical protocol at 1.5T with the following parameters: TR/TE 6.2-7.4/1.7ms, 30°, FOV 22cm, phase FOV .75, 320x320, slice thickness .8mm, 80 slices, resulting in spatial resolution of .68x.68x.8 and scan time approximately 2:08 minutes. The same parameters were adapted at 3T with TR/TE 5.8/1.5ms. Five patients underwent this exam at both field strengths using 30mL of gadolinium-based contrast with injection rate of 3mL/sec and an auto-triggering tool to detect contrast arrival [3]. By simulating the blood and background signals, based on their T1 values at 1.5 and 3T [1] and measuring actual signal levels in 1.5T and 3T source images, the optimal flip angle that produces maximum contrast was calculated for both fields and adopted in later studies. **2) High resolution, single coil:** to study SNR behavior at higher spatial resolution, three patients were scanned at 3T using slice thickness .5mm, 416x416, and 40°; two patients were scanned at 1.5T with the same parameters, resulting in a spatial resolution of .53x.53x.5 and scan time of 3 minutes. **3) High resolution, 8-channel coil:** to address the SNR reduction at 1.5T when .5mm resolution is used, a study using an 8-channel head coil (MRI Devices Corporation, Waukesha, WI) was performed with the previous parameters. **4) High resolution, 8-channel coil, parallel imaging:** the role of parallel imaging in reducing the scan time, which increases dramatically at high resolutions and could affect signal behavior due to contrast wash out, was evaluated by running the ASSET technique with an ASSET factor of 2 [4] along with the 8-channel head coil, resulting in scan time of 1:30 minutes.

Results and Discussion: The simulation revealed that a 40° flip angle optimizes contrast between blood and background at both fields. In case **(1)**, SNR is doubled at 3T compared with 1.5T in agreement with [5]; image quality at both 1.5 and 3T was considered diagnostic. However, background suppression and vessel conspicuity were higher at 3T, as shown in figure 1. In case **(2)**, SNR drops dramatically for both fields resulting in images evaluated as unacceptable at 1.5T, whereas image quality at 3T remains acceptable, as shown in figure 2. This indicates that an SNR of about 20 is desirable. In case **(3)**, using an 8-channel coil at 1.5T improves SNR particularly near the head surface [6], while at the center of the head, where our

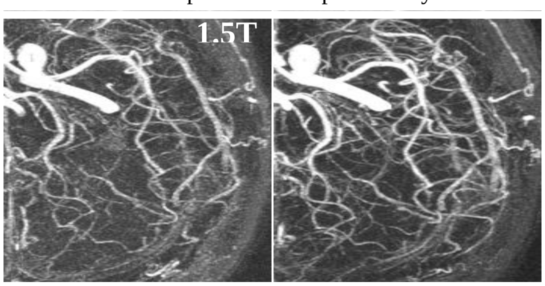


Figure 1. MIP images for the same patient at spatial resolution of (.68x.68x.8) at both field strengths. Image quality at both fields is good, but better background suppression and vessel delineation are noticed.

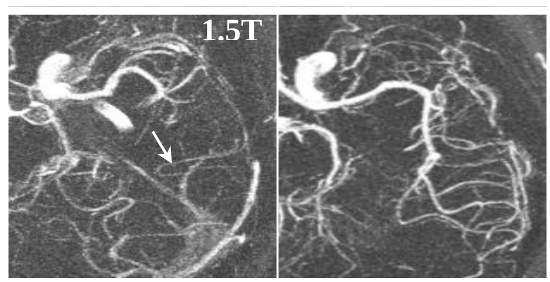


Figure 2. MIP images for different patients at spatial resolution of (.53x.53x.5). Reducing SNR at 1.5T results in poor visualization of blood vessels, where image quality remains acceptable at 3T.

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