Innovation-Performance relationship: the moderating role of the Degree of Internationalization of a firm

by

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Abstract

Moderator variables are typically introduced when there is an unexpectedly weak or inconsistent relationship between a predictor and a criterion variable (Baron and Kenny, 1986). Holak, Parry and Song (1991) and Zhang, Li, Hitt, and Cui (2007) found an inconsistent relationship between R&D spending (a measure of innovation) and firm performance and so concluded that this relationship should be studied under different contextual factors. One such factor is the Degree of Internationalization (DOI) of a firm. Therefore, this paper evaluates the innovation-performance link in the presence of a moderator - the Degree of Internationalization (DOI). It proposes that DOI moderates the innovation-performance relationship. In addition, this research tests the hypothesis that DOI can affect either the form or the strength of the innovation-performance relationship. Only one previous study has evaluated the moderating effect of DOI on innovation-performance relationship, but this paper did not investigate the influence on the form of the relationship.

The findings of this study are based on time series cross-sectional data of 102 large U.S. manufacturing firms from seven different industries. Data for each firm was obtained for eight years (2000-2007) from the Compustat database. Hypotheses were tested using the TSCSREG procedure with Fuller-Battese method implemented in SAS. The identification and the differentiation of the moderation effect into form and strength were carried out by using the typology from the work of Sharma, Durand and Gur-Arie (1981). The results show that DOI moderates the innovation-performance relationship positively and significantly. In addition, DOI affects the form (direct) and is a quasi moderator of the innovation-performance relationship. In terms of theory, there are two implications. First, that DOI is an important contingency factor when examining the innovation-performance relationship. Predicting the innovation-performance relationship without including DOI

may lead to misleading conclusions. Second, when evaluating the relationship between R&D and firm performance, identifying whether DOI moderates the form or the strength of the relationship is needed in order to use a proper analytical technique. In terms of practice, the results sensitize managers to the need to focus not only on innovation activities, but also on their internationalization in order to appropriate the full benefits of their innovations.

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Dedication

I dedicate my thesis to my mother and my wife. My success is due to their prayers and support.

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Chapter 1

1. Introduction

1.1 Background

According to the resource-based view of the firm, firms are bundles of resources and capabilities. These resources and capabilities will provide sustainable competitive advantages and may lead to above normal returns (Barney, 1991; Grant, 1991). Resources include a firm's tangible, intangible and human resources while capabilities refer to a firm's ability to make full benefit of these resources (Grant, 1991). Resources and capabilities will be a source of competitive advantage only if they are rare, valuable, inimitable, and non-substitutable. Barney (1991) defined a firm's resources as resources that include all assets, capabilities, organizational processes, firm attributes, information, knowledge etc. controlled by the firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness. Innovation, measured by Research and Development (R&D) intensity is one such resource that provides competitive advantage to a firm (Hurley and Hult, 1998; Day and Wensley, 1988). The effective deployment of innovation has been widely recognized in recent years as a means of creating sustainable competitive advantage leading to improved organizational performance (Koc and Ceylan, 2007).

The relationship between innovation and firm performance has been studied extensively however, the existing innovation research has yet to provide consistent evidence on the relationship between R&D intensity (a measure of innovation) and firm performance (Li and Atuahene-Gima, 2001; Koc and Ceylan, 2007). Some researchers have found a positive effect of innovation on firm performance (Lopez, Peon, and Ordas, 2005; Prajogo, 2006; Hall and Mairesse, 1995; Adams and Jaffe, 1996) while others have found either no direct relationship between innovation and performance (Zhang et al., 2007) or a negative relationship (Graves and Langowitz, 1993; Kotabe, Srinivasan, and Aulakh, 2002; Oxley and Sampson, 2004). Holak et al., (1991) found that R&D spending can have either a positive or negative influence on the gross margin under various circumstances. These conflicting results suggest that the relationship between innovation and firm performance is more complex than is generally assumed (Coombs and Bierly, 2006) and must be examined within the context in which it occurs (Zhang et al., 2007).

Capon, Farley and Hoenig (1990) reviewed a large body of relevant literature. They also found mixed results. The explanation for contradictory empirical results is that most studies have not examined factors that may moderate the relationship between product innovation and firm performance (Li and Atuahene-Gima, 2001). Baron and Kenny (1986) suggest that moderator variables are typically introduced when there is a weak or inconsistent relation between a predictor and a criterion variable. A number of studies have evaluated the relationship between innovation and firm performance in the presence of moderators such as time (Kafouros, 2005); external monitors including outside board members, investors, and securities analysts (Le et al., 2006); market focus and owner structure (Zhang et al., 2007), organizational learning (Alegre and Chiva, 2008), and type of industry sector (Kessler, 2003). The Degree of Internationalization (DOI, as measured by proportion of income outside the domestic market) is one such factor in which the moderating effect has not been studied previously in the context of innovation-performance link. An exception is a study by Kafouros et al., (2008), the results of which has limited generalizabilty because of utilizing data from United Kingdom only.

The literature on analysis of moderation suggests that researchers should distinguish between moderator variables that influence the form and those the influence the strength of the predictor-criterion relationship because they have different moderating effects and require different analytical methods for evaluation (Sharma et al., 1981). In fact, a moderator variable is defined as a variable that systematically modifies either the form and/or the strength of the relationship between a dependent variable and independent variable (Zedeck, 1971; Baron and Kenny, 1986). Moderators of the strength, also called homologizer variables, influence the degree (nature) of the relationship between a predictor variable X and a criterion variable Y. It reduces the error term and increases the amount of explained variance (Sharma et al., 1981), while moderators of the form affect the slope of the regression line (Slater and Narver, 1994).

1.2 Research Issues

Research on the moderating effect of DOI on the innovation-performance relationship is almost non-existent. The only study that has so far investigated the moderating role of DOI is by Kafouros et al., (2008). Therefore, in order to fill this void, I have examined whether DOI moderates the innovation-performance relationship. I use data from the United States whereas Kafouros et al. studied firms in the United Kingdom. There are important differences between the two countries. The United States has a much larger domestic economy. The large size and relative uniformity of its market provides advantages that smaller countries do not enjoy (Herbig and Miller, 1992). In addition, there is difference between the two countries in terms of their innovation systems. Historically, the US is a leader in innovation while the UK and indeed the whole European Union (EU) lags behind the US (Crescenzi, Rodriguez-pose and Storper, 2007).

In this paper, I investigate if DOI affects the form or the strength of the innovation-performance relationship and if DOI is a pure/quasi moderator (in case of moderation of the form) or a homologizer (in case of moderation of the strength) of the relationship.

1.3 Justification of the Research

The resource based view of the firm posits that firms have a bundle of resources and capabilities at their disposal. These resources are comprised of tangible, intangible, and human resources. Capabilities refer to how firms deploy these resources to gain competitive advantage against its rivals (Barney, 1991; Grant, 1991). Gaining competitive advantage depends on the availability of these resources (Wernerfelt, 1984). Investment in R&D (assumed to lead to innovations) is a resource that could give the firm competitive advantage over competitors (Hurley and Hult, 1998; Day and Wensley, 1988). However, it is the effective deployment of these resources (innovations) that is widely recognized as a means of creating sustainable competitive advantages leading to improved organizational performance (Koc and Ceylan, 2007).

In high-technology industries with rapid technological obsolescence and shorter product life cycles (Chesbrough, 2007), investment in R&D may not be recoverable before innovations become obsolete (Kotabe, 1990). This is especially true in a highly competitive environment. Increasing global competition has placed more emphasis on innovation as a means of competitive advantage (Betis and Hitt, 1995). International diversification (i.e., higher DOI) offers greater opportunity to recover the costs of the investments in R&D by providing larger markets for the products of a firm. Thus, it provides greater opportunities to achieve optimal economic scale and spread investments in critical functions such as R&D over a broader base. As international diversification is positively related to firm innovation, expansion into international markets provides opportunities for greater returns on innovations and so reduces the risk of failure due to a broader base in which a firm innovations may be applied (Hitt, Hoskisson and Ireland, 1994; Kim, Hwang and Burgers, 1993). Innovation is not limited to products, but could be in the form of process improvement leading to reductions in costs. Applying these processes (knowledge) across more markets could lead to better returns for the firm. Competitive advantages, particularly innovations (Prajogo, 2006) that produce greater profitability in domestic markets, provide motivations to apply the same competencies in international markets to further enhance a firm's profitability (Porter, 1990).

1.4 Overview of Research Methodology

This section briefly describes the methodology used in this research: sample selection, the TSCSREG procedure and typology for identification of moderators. The sample for this research was obtained from Compustat, an online database. The initial sample consists of 1400 manufacturing firms, but the final sample included just 102 large manufacturing firms due to the unavailability of data on all the variables of interest for all the years (2000-2007). Although the sample seems to be small, it is comparable with other studies in the area of innovation and internationalization. For instance, Kotabe et al., (2002) obtained data from 49 firms for their study, while Gomes and Ramaswamy (1999) used data from 95 US manufacturing firms. The final sample consisted of firms from seven different industries with eight periods for each firm.

Examining the relationship between innovation and firm performance over a single period does not allow generalization of the results over time. Therefore, following the work of Kotabe et al., (2002) the Time Series Cross-sectional Regression (TSCSREG) procedure with Fuller-Battese method

(Fuller and Battese, 1974) is used for the analysis of the data. This procedure not only takes into account variation between years and across industries, but also increases the degrees of freedom by allowing the use of eight observations from each firm.

The literature on moderation suggests that researchers should distinguish between moderator variables that influence the form and those that influence the strength of the predictor-criterion relationship because they have different moderating effects and require different analytical methods for evaluation (Sharma et al., 1981). Therefore, in order to identify the different moderating effects and to distinguish the effects, I use the typology identified by Sharma et al., (1981). This technique is used extensively (Evans, 1991) and is a "preferred technique" for the identification of moderating effects (Aguinis, 1995; Stone and Hollenbeck, 1984).

1.5 Hypotheses

A number of studies have examined the relationship between R&D intensity and firm performance, but the findings are inconclusive (Li and Atuahene-Gima, 2001; Kocand Ceylan, 2007). This inconclusiveness is also evident from Table 1. The results range from very positive and significant to negative and insignificant. Lopez, Peon and Ordas (2005); Prajogo (2006); Hall and Mairesse (1995) and Adams and Jaffe (1996) have found a positive relationship between innovation and firm performance while Graves and Langowitz (1993), Kotabe et al., (2002) obtained negative results. In addition, Zhang et al., (2007) could not find a direct relationship between innovation and firm performance. The mixed findings of these studies suggests that the relationship between innovation and firm performance is more complex than generally assumed (Coombs and Bierly, 2006) and so need to be examined within the context in which it occurs (Zhang et al., 2007). In this case "context" refers to other factors that may affect the innovation-performance relationship.

Whenever there is a weak or inconsistent relationship between a predictor and a criterion variable, Baron and Kenny (1986) suggest that moderator variables are introduced. Studies have evaluated the innovation-performance relationship under different moderating variables. For instance, Kafouros (2005) studied this relationship in the presence of time as moderator. Similarly, Le et al., (2006) evaluated the innovation-performance relationship in the presence of three different external monitors (outside board members, investors, and security analysts) as moderators of the relationship. In addition other factors studied as moderator of the innovation-performance relationship are market focus, owner structure (Zhang et al., 2007), organizational learning (Alegre and Chiva, 2008) and type of industry sector (Kessler, 2003). Degree of Internationalization has not been studied previously in the context of innovation-performance link, except by Kafouros et al., (2008). This study found that DOI moderates the innovation-performance relationship but the results have limited generalizability as they used data from the United Kingdom only. In order to address the gap in our understanding of the role of internationalization in the innovation-performance relationship and following the arguments presented in section 2.2, 2.3 and 2.4, I test the hypothesis that:

Hypothesis 1: DOI positively moderates the innovation-performance relationship.

The literature on moderation suggests that the researcher should distinguish between moderator variables that influence the form and those that influence the strength of the predictor-criterion relationship (Sharma et al., 1981). Sharma et al., have developed a typology for the identification and differentiation of the moderating effect into two forms. This typology implies that the two effects are mutually exclusive (Le et al., 2006). According to Sharma et al., if an effect of the form is found, it is difficult to investigate the effect of the strength because the error terms are not only affected by the different levels of the moderator (subgroups) but also by the interaction between moderator and the independent variable.

Table 1: Summary of previous studies of the R&D-performance relationship

Author/year	Data	Models	Results
Ettlie (1998**)**	Cross-sectional data of 20 countries	Path analytic analysis using OLS	R&D intensity was significantly associated with increases in market share
Morbey (1988**)**	Cross-sectional data of US (1976-1985)	Correlation analysis	There was no relationship between R&D intensity and profitability; there was a strong association between R&D intensity and subsequent growth in sales
Morbey (1989**)**	Cross-sectional data of US (1976-1985)	Correlation analysis	The relationship between R&D intensity of industries and profit growth in generally was insignificant
Fryxell (1990**)**	Panel data of US (1975-1983)	Covariance structure models	R&D had a positive influence on profitability, but this was not a long-lasting effect
Morbey and Reithner (1990**)**	Cross-sectional data of US (1978-1987)	Correlation analysis	R&D intensity had a strong direct relationship with sales growth and productivity
Lichtenberg and Siegel (1991)	Panel data of US (1972-1985)	OLS and WLS	R&D investment was a significant determinant of productivity growth
Ito and Pucik (1993)	Panel data of Japan (1983-1986)	OLS	R&D expenditure was positively associated with export sales
Lee and Shim (1995)	Cross-sectional data of US and Japan (aggregated average of 1986-1990)	Correlation analysis	R&D had a significant effect on market growth
Ayadi *et al*. (1996)	Cross-sectional data of US (including each year within 1984-1993)	OLS	ROI and ROE respond negatively to changes in R&D Tobin's *q* and excess value responded positively to firm's R&D
McCutchen Jr. and Swamidass (1996)	Cross-sectional data of US (1989)	OLS	R&D cost had a positive and significant influence on the firm's market value
Pegels and Thirumurthy (1996)	Cross-sectional data of US (1991, except R&D is 1989 data)	OLS and three-stage recursive least squares model	R&D expenditure had an indirect positive influence on profitability
Sterlacchini (1999)	Cross-sectional data of Italy (1996)	Tobit, Probit, and Truncated regression	R&D had a significant and positive impact on export sales
Chauvin and Hirschey (1993)	Cross-sectional data of US (1988-1990)	OLS	R&D expenditure had a large and positive influence on firm's market value
Wakelin (2001)	Panel data of UK (1988-1996)	OLS	R&D intensity had a positive and significant influence on the firm's productivity growth

Table 2: Summary of previous studies of the R&D-performance relationship (continued)

Author/year	Data	Models	Results
Rouvinen (2002)	Panel data of 12 OECD countries (1973-1997)	Granger causality test; OLS, 2SLS, ADL	R&D Granger caused productivity but not vice versa
Bae and Kim (2003)	Cross-sectional data of US, Germany and Japan (1996-1998)	OLS	There was a significant positive relation between R&D spending and firm's market value
Monte and Papagni (2003)	Panel data of Italy (1992-1997)	Panel random effect regressions	R&D intensity had a positive and significant influence on the firm's productivity growth
Gou *et al*. (2004)	Cross-sectional data of China (2001)	OLS	R&D intensity had a significant negative impact on profitability
Connolly and Hirschey (2005)	Pooled cross-sectional data of US (1997-2001)	OLS	R&D intensity had a positive and significant influence on the Tobin's *q*
Ho *et al*. (2005)	Panel data of US (1962-2001)	Portfolio analysis; general method of moment regression analysis	R&D intensity was significantly associated with 1-year and 3-year excess market holding period returns
Ho *et al*. (2006)	Panel data of US (1979-1998)	OLS	R&D investment had a significant positive influence on firm's growth opportunities
Huang and Liu (2005)	Cross-sectional data of Taiwan (2003)	OLS	R&D had a nonlinear relationship (inverted U-shape) with ROA and ROS
Lin and Chen (2005)	Cross-sectional data of US (1978-1995)	OLS	Both positive and negative signs existed in the correlations among R&D and performance measures
Hall and Oriani (2006)	Panel data of US, UK, France, Germany and Italy (1989-1998)	OLS and nonlinear least squares	In France, Germany, US and UK, R&D capital was positively valued by the stock value
Lin *et al*. (2006)	Panel data of United States (1985-1999)	Pooled linear regression models	The relationship between R&D intensity and firm's market value was insignificant

Source: Yeh, Chu, Sher and Chiu (2010)

Therefore, the next two hypotheses can be framed as:

Hypothesis 2: DOI affects the form (direct) of the innovation-performance relationship and so is either a pure or quasi moderator.

Hypothesis 3: DOI influences the strength of relationship between innovation and firm performance and so is a homologizer moderator.

1.6 Contributions

This research makes several contributions to the literature on the moderating effect of internationalization on the innovation-performance relationship. First, as this study builds on the work of Kafouros et al., (2008), and provides evidence that is more generalizable to western economies because it confirms the findings obtained by Kafouros et al., by replicating their work in a different environment (country) as suggested by them.

Second, Baron and Kenny (1986) reported that moderator variables are typically introduced when there is an unexpectedly weak or inconsistent relation between a predictor and a criterion variable. Holak et al., (1991) and Zhang et al., (2006) found an inconsistent relationship between R&D spending and firm performance and concluded that this relationship should be studied under different contextual (moderator) factors. Therefore, this study contributes to the literature on the relationship between innovation and firm performance by resolving the inconsistency through the identification of DOI as a moderator (contextual factor) and suggests that future predictions of the relationship between innovation and firm performance should consider this factor.

Third, the literature on moderation suggests that the researcher should distinguish between moderator variables that influence the form and those that influence the strength of the predictor-criterion relationship (Sharma et al., 1981). None of the previous studies have made such a distinction in the case of innovation-performance relationship. This study incorporates the insights of the moderator variable literature into internationalization research to distinguish between the different types of moderating effects and concludes that DOI influences the form of the relationship between innovation and firm performance. Past studies that have only focused on the identification of the effect of the form and overlooked the effect of the strength may have incorrectly concluded that there was no moderating effect if the interaction term was insignificant. An effect of the strength may exist despite insignificant interaction term (Le, Walters and Kroll, 2006).

Finally, as Lu and Beamish (2004) reported, only those firms that deployed their intangible assets in many markets could exploit them to their full value. The results of this study should sensitize managers to the need to focus not only on innovation, but also to focus on internationalization in order to exploit the full value of their innovations. This realization is particularly important for managers of firms that thrive on innovation.

1.7 Organization of the thesis

This thesis consists of four additional chapters. A brief description of each chapter follows: Chapter Two reviews literature on the relationship between innovation and firm performance, the moderating effect of DOI on return to innovation. Chapter Three describes the methodology employed in this study. It consists of: Sample, Panel Data, types of moderator variables and moderated multiple regression technique, TSCSREG procedure, typology for the identification of different types of moderating effects and description of the variables used in this study. Chapter Four reports the analysis and key findings. Finally, Chapter Five presents discussions, limitations and future research in the area and conclusions.

Chapter 2

2. Literature Review

2.1 Introduction

This chapter consists of two sub-sections. The first section sheds light on the relationship between innovation and firm performance by examining a number of empirical studies. The second section describes the moderating effect of DOI on innovation-performance link. It explains the logic behind the moderating role of DOI supported by theory and empirical studies.

2.2 Relationship between innovation and firm Performance

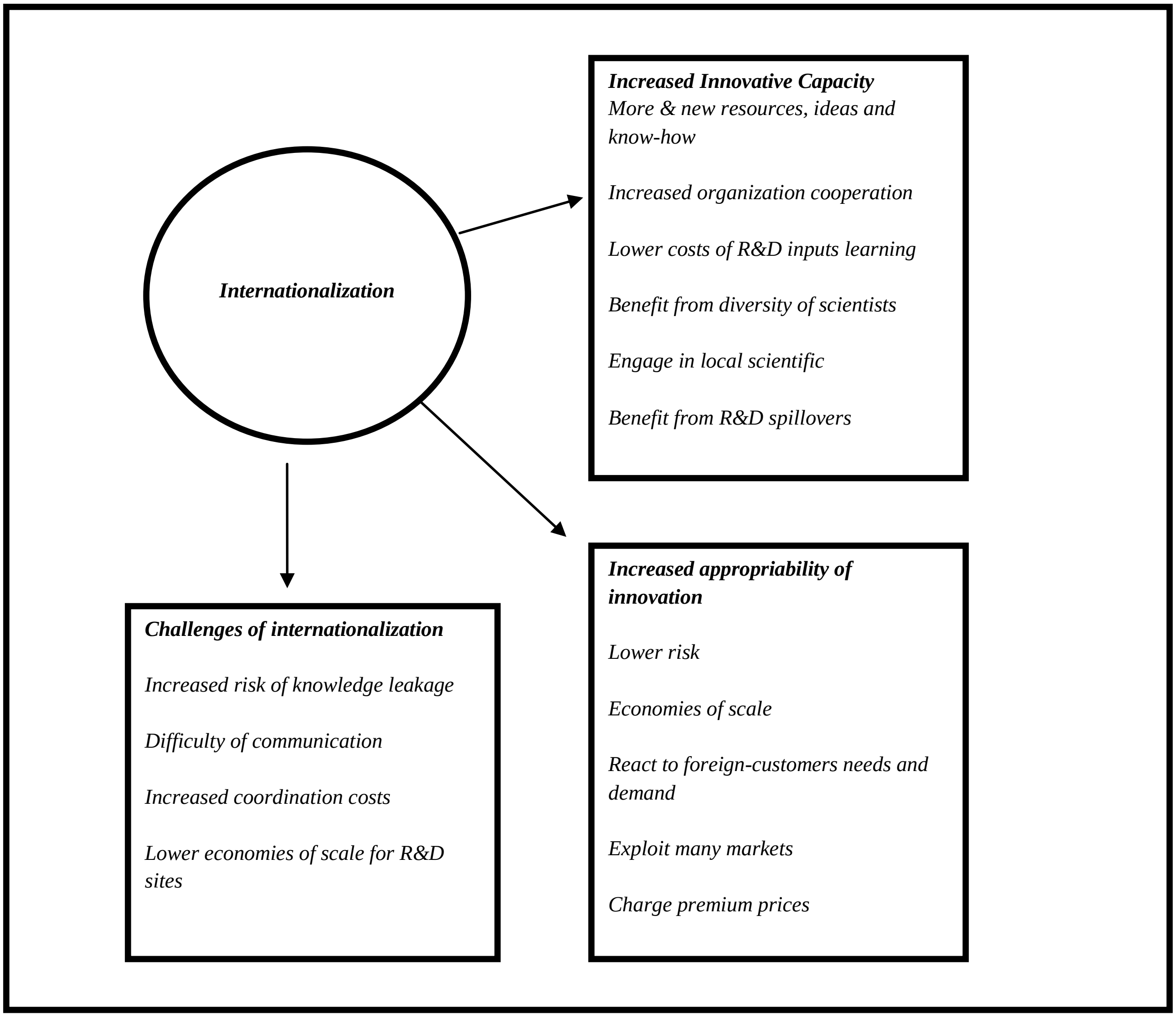
The positive relationship between innovation and firm performance has been shown in a number of empirical studies (e.g., Li and Atuahene-Gima, 2001; Koc and Ceylan, 2007). A study by Deshpande, Farley and Frederick (1993) among Japanese firms indicated that innovativeness is positively related to organizational performance in terms of profitability, size, market share, and growth rate. Dwyer and Mellor (1993) found that Australian firms adopting a technologically offensive strategy had the highest percentage of new products developed and achieved the highest level of performance. Another study based on Canadian firms (Baldwin and Johnson, 1996) also demonstrated a significant return to innovation on a wide variety of business performance measures including market share and return on investment. A study among SMEs, operating in the food industry in Greece (Salavou, 2002), also found that product innovation was a significant determinant of business performance. R&D spending results in new products and process efficiencies, leading to competitive advantage that in turn improves performance (Aboody and Lev, 2000). However, the impact of innovation on firm performance is not always positive. Table 1 provides a brief summary of the previous empirical studies that investigated the relationship between R&D and firm performance.

Shorter product life-cycles, the rising cost of developing innovations (Chesbrough, 2007) and increasing competition may be responsible for a non-positive relationship between innovation and firm performance. For example, Zhang et al., (2007) demonstrated that firms can capture rents from their R&D investments only if they can effectively address the appropriability hazards that exist for innovation. They identified two types of hazards: local market related and local partner related. Due to weak and ineffective laws protecting intellectual property rights, R&D activities may be leaked to local firms and thus internationalizing firms may not realize the full benefits of their R&D investments. Local firms may misuse a multinational corporation's proprietary technologies that are transferred to the local partner (Zhang et al., 2007). Competition, weak appropriability regimes and imitation are some of the factors that prevent firms from fully exploiting their innovations (Teece, 1986).

2.3 The effect of DOI on return to innovation

Internationalization is the geographic expansion of economic activities beyond a firm's home country borders (Mitja, Hisrich, and Antoncic, 2006). Internationalization can bring significant performance benefits to the firm (Gomes and Ramaswamy, 1999). In order to understand the effect of internationalization on returns to innovation, Kafouros et al., (2008) identified two factors. First, innovative capacity, which is the ability of a firm to produce technological innovations. Higher innovative capacity helps firms to develop new and improved products and processes, which can improve performance. Second, exploitation and appropriability of innovations, the ability of firms to exploit its technological achievements. Figure 1 shows how DOI affects these two factors.

Figure 1: Implications of Internationalization



Adapted from Kafouros, et al., (2008)

One way firms can increase their innovative capacity is by having access to knowledge and ideas from several different countries and a larger group of scientists (Kafouros, 2006). Highly internationalized firms have access to global resources (Kotabe, 1990). Highly internationalized firms can borrow and exploit new ideas and integrate new research findings into their products and processes, resulting in an improved innovative capacity (Kafouros et al., 2008).

Organizations need to search for and explore external ideas and sources of information in order to exploit their economic potential (Chesbrough, 2003). Having a presence in many different countries, highly internationalized firms have the opportunity to utilize location-based benefits such as cheaper R&D. A higher degree of internationalization may also improve the quality of new products through networks that enable a continuous flow of information about the changing needs and requirements of customers (Kafouros, 2006). A higher degree of internationalization can also have disadvantages. For example, highly internationalized firms have decentralized knowledge, spread out in many geographic locations. There is a risk of spillover of this decentralized knowledge to competitors, which can substantially reduce a firm's return.

Maintaining control of a global network is another challenge when there is a high degree of internationalization. For this reason, many innovation strategists recommend a centralized network to protect corporate technology (e.g., Kafouros et al, 2008). The substantial transaction cost of coordination and geographical differences between different departments may also lead to inefficiencies in communication. In decentralized firms, coordination and communication can be difficult, costly and time consuming. The transfer of knowledge involves infrequent face-to-face contact, slowing down the knowledge creation process (Kafouros, 2005).

Innovators may not appropriate the full benefits of their innovations for reasons such as those described above. These may also be the reasons for an insignificant or even negative relationship between innovation and performance. Therefore, higher innovative capacity is not a sufficient condition for better firm performance; it needs to be coupled with the ability to exploit and appropriate the capacity.

Internationalization is one factor that could help firms to better exploit and appropriate their innovative capabilities. Offering products over many different markets may spread the cost of their innovations (Kotabe et al., 2002). This might be particularly important when the domestic market is small. Higher internationalization may also enable firms to customize their products for different markets and may provide the opportunity for price premiums in some markets. Firms that deploy their assets in many different markets can not only benefit from diversification itself, but can utilize their full value too (Lu and Beamish, 2004).

2.4 Resource-based view of the firm

This study derives its logic from the resourced-based view of the firm and internalization theory because behavioral theories of international business emphasize the process of internationalization to reduce risk and uncertainty while the basis of resource-based view and internalization is the exploitation of opportunities through efficient resource allocation.

Wernerfelt (1984), Day and Wensley (1988), Barney (1991) and Prahalad and Hamel (1990) developed resource-based theory around the internal competencies of the firm by building on the seminal work of Penrose (1959). According to the resource-based view of the firm, firms are a bundle of resources and capabilities. These resources and capabilities will provide sustainable competitive advantages and may lead to above normal returns (Barney, 1991; Grant, 1991). Resources include a firm's tangible, intangible and human resources while capabilities refer to a firm ability to obtain the full benefit from these resources (Grant, 1991). Amit and Shoemaker (1993) defined resources as tradable and non-specific to the firm while capabilities are firm specific and are used to utilize resources within the firm. Makadok (2001) distinguished between capabilities and resources by defining capabilities as a special type of resource, specifically an organizationally embedded non-transferable firm-specific resource the purpose of which is to improve the productivity of other resources. Resources are stocks of available factors that are owned or controlled by the firm, and capabilities are an organization's capacity to deploy these resources (Makadok, 2001). Basically, it is the packaging of these resources that builds capabilities (Sirmon, Hitt and Ireland, 2007). Resources and capabilities will be a source of competitive advantage only if they are rare, valuable, inimitable and non-substitutable (Barney, 1991). The basis of competitive advantage lies in the application of these valuable resources (Wernerfelt, 1984). Varying performance between firms is the result of heterogeneity of these resources (Helfat & Peteraf, 2003) and a resource-based view of the firm focuses on these factors that cause performance variance (Grant, 1991; Mahoney and Pandian, 1992).

Innovation is one such resource that can provide competitive advantage to a firm (Hurley and Hult, 1998; Day and Wensley, 1988). The effective deployment of innovation is widely recognized as a means of creating sustainable competitive advantage leading to improved organizational performance (Koc and Ceylan, 2007). This is particularly so in high-technology industries with rapid technological obsolescence and shorter product life cycles (Chesbrough, 2007) where investment in R&D may not be recoverable before innovations become obsolete (Kotabe,1990). Increasing global competition has placed more emphasis on innovation as a means of developing competitive advantage (Betis and

Hitt, 1995). International diversification (higher DOI) offers greater opportunity to recover the costs of the investments in R&D by providing more markets for products of a firm. Thus, it provides greater opportunities to achieve optimal economic scale and spread investments in critical functions such as R&D over a broader base. Innovation is not limited to products, but could be in the form of process improvement leading to reduction in costs. Applying these processes across more markets could lead to better returns for the firm.

Competitive advantages, particularly innovations (Prajogo, 2006) that produce greater profitability in domestic markets, provide motivations to apply the same competencies in international markets to improve a firm’s profitability (Porter, 1990). Increasing global competition has resulted in shorter product life cycle and rising cost of developing new technology (Hitt, Hoslisson and Kim, 1997; Chesbrough, 2007). As a result, the generation of innovation may need significant investments of resources. For instance, Chesbrough (2007) gives the example of Intel Corporation’s announcement in 2006 that it would build two new semiconductor fabrication facilities. Each was estimated to cost US $3 billion. Similarly, the cost of developing a successful drug has risen to well over US $800 million, up more than ten-fold from just a decade earlier (Chesbrough, 2007). In addition to the rising cost of developing innovations, shorter product life cycles may prevent firms from recovering investments in innovation. Again, Chesbrough (2007) provides an example. In the computer industry during the early 1980s, hard disk drives would typically ship for four to six years, until a new and better product is developed. The shipping life had fallen to two-to-three years in the late 1980s and to just six-to-nine months in the 1990s. (Chesbrough, 2007). As a result, the generation of innovations may require significant investment of resources. International diversification may generate the resources to sustain a large-scale R&D operation (Kobrin, 1991).

Having access to global resources, a highly internationalized firm may better maintain their innovative capabilities (Kotabe, 1990). Internationally diversified firms have access to more and diversified resources, and due to larger markets and potentially better returns, they might have more resources to invest in innovation. Diverse inputs are often required to develop better innovations. A good example can be found in the aircraft industry. The Boeing Company, using local technologies, developed a series of successful aircrafts for the U.S. market. These aircraft were also sold globally. However, Airbus overpowered Boeing by taking advantage of its diverse sources of expertise. The company obtained wing aerodynamics from United Kingdom, avionics from France and flight-control technology from the United States (Santos, Doz, and Williamson, 2004). Highly internationalized firms have access to a variety of markets and different cultures, providing greater opportunity to obtain new and diverse ideas from different geographical locations. This argument further suggests that highly internationalized firms have access to more knowledge and learning as compared to domestic firms and this new knowledge can lead to innovations (Miller, 1996). Companies can greatly improve the flow of their innovation by assembling the best combination of technical expertise and market knowledge (Santos, Doz and Williamson, 2004). Similarly, internalization theory also explains that firms gain from internationalization because they are able to exploit their networks and core competencies (Buckley and Casson, 1976, 1998; Teece, 1985).

Following this argument, I expect that returns to innovation will be higher in firms that are more internationalized. Thus, my first hypothesis is:

> *Hypothesis 1: DOI positively and significantly moderates the innovation-performance relationship.*

Literature on moderation suggests that researcher should distinguish between moderator variables that influence the form and those influence the strength of the predictor-criterion relationship. These are important differences that require different analytical methods for evaluation (Sharma et al., (1981). Therefore, my second and third hypotheses are:

Hypothesis 2: DOI affects the form (direct) of the innovation-performance relationship and so is a pure or quasi moderator.

Hypothesis 3: DOI influences the strength of relationship between innovation and firm performance and so is a homologizer moderator.

2.5 Summary

The relationship between innovation and firm performance has been studied extensively, but the results are not yet conclusive. The inconclusive results can be attributed to the fact that this relationship is more complex than it seems. It is suggested that there are contingency factors that might affect this relationship. One such contingency factor is DOI. Investment in R&D may not be recoverable due to rising costs of developing innovations, weak appropriabilty regime, imitation, rapid product obsolescence, and increasing competition. A higher degree of internationalization provides firms the opportunity to exploit the full benefits of their innovations by providing access to a broader market base.

Moderator variable literature suggests two types of moderating effects: form and strength. Differentiating the moderating effect into the two types is needed because both require different techniques to evaluate. Moderated Multiple Regression (MMR) is considered a preferred technique to identify the moderating effect and to differentiate it into the two types.

Chapter 3

3. Method

3.1 Introduction

This chapter has six sub-sections. The first section describes how the sample was obtained. The second section illustrates the variables of interest used in the analysis. The third section provides reasons for using panel data. Sub-section four describes the types of moderator variables and how to identify these types, while sub-section five explains a statistical technique called Moderated Multiple Regression (MMR). The last section describes the analytical technique used to test the hypotheses and typology for identifying the type of moderating effect.

3.2 Sample

I obtained data for this study from Compustat database (http://wrds.wharton.upenn.edu) through controlled access from the library at the University of Waterloo. The database has firm level data on different industries classified by SIC codes. The following criteria was used to obtain the sample: (1) the firm must be in a manufacturing industry (for reasons see next page), (2) data should be available for at least two firms in each industry, and (3) complete data for all the variables of interest must be available for the period 2000-2007. Kotabe et al., (2002) used similar criteria to obtain the sample firms for their study. After applying these criteria, the final sample consists of 102 large US manufacturing firms. The small sample could be due the above criteria. In addition, I used many different combination of years ranging 1990 to 2009, but the range 2000-2007 give me the largest number of firms. The main reason for the low sample size is that data was obtained for eight years for each variable. A larger sample can be obtained by reducing the number of periods which will restrict the study to cross-sectional than longitudinal. Table 2 shows a breakdown of the sample by industry sector. Some industry sectors such as electronics, computer and automobiles etc., are missing from the sample probably due to the criteria used for selecting the sample. However, the average pre-tax foreign income and average R & D expense of the industries included is $588.33 million, $329.9 million respectively.

According to the US Census Bureau classifications criteria, manufacturing firms are those with two-digit SIC codes between 20 and 39 (Ho, Keh and Ong, 2005). The reason for restricting the sample is that manufacturing sector is different from service sectors (Contractor, Kundu and Hsu, 2003). Manufacturing firms invest heavily in R&D (Bae, Park and Wang, 2008). The properties of manufacturing and non-manufacturing firms are different in terms of investments in R&D. For example, Ho, Keh and Ong (2005) found that the majority of non-manufacturing firms did not have R&D expense and that R&D investment resulted in a positive return in cases of manufacturing while in cases of non-manufacturing, the result was not positive. They concluded that R&D investment may be more important for manufacturing in generating positive returns as compared to non-manufacturing. Therefore, putting manufacturing and non-manufacturing firms together in a sample may generate misleading outcomes. (Ho, Keh and Ong, 2005).

The effects of R&D are not realized until much later and the lag may be different for different industries. For example, R&D efforts are realized much later in the pharmaceutical industry than they are in the apparel and textile industry (Krishnan, Tadepalli and Park (2009); Ravencraft and Scherer (1982) and Pakes (1985) also reported that the effects of R&D activities on performance may appear after a long and uncertain time. Forey et al., (2007) used a two year lag for R&D intensity and found minimal change with different lags. Following the work of Hall and Mairesse (2010); Pakes and

Schankerman (1984) and Forey et al., (2007), I lagged the R&D intensity variable by two years. The results show that the fit statistics for the data set without lag is better than for the data set with R&D intensity lagged by two years (Appendices 1 and 2) and the fact that an appropriate lag period for R&D intensity has not so far been established, I use the data set without any lag variable.

Table 2: Details of industries included in the sample

SIC Codes	*Details of sectors included in the analysis*	*Number of firms*
2000	Food & Kindred Products	7
2200	Textile Mill Products	2
2600	Paper & Allied Products	11
2800	Chemical & Allied products	62
2900	Petroleum Refining & Related Products	2
3000	Rubber & Plastic Products	13
3200	Stone, Clay, Glass, Concrete Products	5
Total		102

3.3 Variables

3.3.1 Independent Variables

Degree of Internationalization (DOI)

DOI reflects a firm's level of international diversification. DOI has been conceptualized by different measures such as export intensity, international business intensity, internationalization, scale and scope of internationalization, international diversity, geographic diversity and multinationality (e.g., Cavusgil and Zou, 1994; George, Wiklund and Zahra, 2005; Lu and Beamish, 2001, 2004; Pla-Barber and Escriba-Esteve, 2006; Saarenketo et. al., 2004; Sullivan, 1994; Zahra and Gravis, 2000; Zahra, Ireland and Hitt, 2000; Li, 2007; Kotabe et al., 2002).

Measuring the degree of internationalization has been a topic of debate in international business. Sullivan (1994) and Hitt et al., (2006) recommended the use of multidimensional measures for DOI. However, Ramaswamy, Kroeck and Renforth (1996) tested the composite measure developed by Sullivan and found little support for it. Most researchers have used a single measure for DOI. Sullivan (1994) reported 17 studies on the relationship between internationalization and firm performance, where DOI was measured predominantly with a single ratio of foreign sales to total sales. Similarly, Li (2007) reported that 39 out of 43 studies (90%) have used one-dimensional measure for measuring internationalization. As there is no standard approach for measuring DOI, following the work of Kotabe, et al., (2002; Chen, Cheng, He, & Kim, 1997) and the availability of data on the Compustat database, I use a one-dimensional measure for DOI, the ratio of foreign income to total income. Multiple measures improve validity (Hitt, et al., 2006; Sulliva, 1994) but data on multiple measures is not easily accessible especially through secondary sources.

Innovation

In theory, the best output measure of technological capability may be the number of new products and processes developed. However, this measure is very difficult to estimate for several reasons. It is very hard to differentiate truly new products from those products that are changed slightly, where nothing new is really added. In terms of process innovation, quality of an improvement and the secrecy surrounding the development of process improvements must be considered. In addition, the biggest issue is that both product and process innovations are not available through secondary sources (Coombs and Bierly, 2006).

Research and Development intensity is the most popular and frequent (Coombs and Bierly, 2006) surrogate measure of innovation usually available through secondary data sources. R&D intensity has been found to be positively related to measures of innovative output such as patents (Hitt et al., 1991) and new product introductions (Hitt et al., 1996). R&D spending results in product and process efficiencies (Aboody and Lev, 2000). Following the work of Parthasarthy and Hammond (2002), Kotabe et al., (2002) and Gomes and Ramaswamy (1999) and dependence on secondary data, I use R&D intensity-the ratio of R&D expenditure over sales- as a measure of innovation.

3.3.2 Dependent variable

Firm Performance

Performance is a multidimensional construct (Day, Wensley, 1998; Naman and Slevin,1993). Researchers advocate the use of multiple measures to assess performance (e.g., Damanpour, 1991; Weiner and Mahoney, 1981). Therefore, following this advice, I will be measuring firm performance using multiple measures including both financial (Return on Assets; Return on Sales) and operational- the ratio of operating expense to sales (OPSALINV).

Return on Asset (ROA)

ROA is the ratio of net income to total assets. This measure has been extensively used in many studies (Gomes and Ramaswamy, 1999). ROA was used as a measure of firm performance in 23 out of 43 studies identified by Li (2007). It is less sensitive to the firm's capital structure (Michel and Hambrick, 1992).

Return on Sales (ROS) is the ratio of net income to total sales. This measure has also been extensively used in measuring performance of firms in the domain of innovation and internationalization. One advantage of this measure over ROA is that it avoids the effects of different assets valuations resulting from the timing of investments or depreciation (Geringer, Beamish and DaCosta, 1989).

Operational performance was measured as a ratio of sales to operating cost (OPSALINV). Although there has been a predominant use of accounting based measures (ROA, ROS, etc.), in recent years researchers (e.g., Gomes and Ramaswamy, 1999; Ruigrok and Wagner, 2003; Kotabe et al., 2002) have evaluated firm performance using cost-efficiency measures such as OPSALINV. Cost-efficiency measures overcome the shortcomings of accounting based measures such as heterogeneity of accounting methods and managerial manipulation. Following this advice, I also measured performance from the operational perspective using OPSALINV.

3.3.3 Control Variables

Size

Researchers have indicated that variance in firm performance can partly be explain by firm size (Decarolis and David, 1999; Kotabe et al., 2002). Coombs and Bierly (2006) reported that size could be a source of competitive advantage due economies of scale in manufacturing, learning curve effects, market power, scale economies in advertising and new product development. Therefore, control for the size effect on firm performance is needed otherwise parameter estimates may be biased. In order to avoid the confounding effect of firm size on the performance of a firm, I used a natural log of employees as a control measure for the size (Sanders and Boivie, 2004).

Industry

Firm performance may be affected by the industry to which a firm belongs (Le, et al., 2006). Therefore, I included a series of two-digit dummy variables to control for possible industry effects.

3.4 Panel Data

If the same unit of observation in a cross-sectional sample is observed over two or more times, the data is called panel data. Such a data has both cross-sectional and time series dimensions. Panel data is increasingly being used in applied work. There are two important reasons for the increasing interest in using time series cross-sectional data (Panel data). It offers solution to the problem of bias caused by unobserved heterogeneity (Baltagi, 1995; Hitt, Gimeno and Hoskisson, 1998), and may reveal dynamics that are difficult to detect with simple cross-sectional data. Panel data often have a larger number of observations compared to just cross-sectional or time series data. For instance if there are "N" number of cross-sections observed at "T" periods, then the total number of observations is N*T (Dougherty, 2007; Stock and Watson, 2003). Thus panel data increase sample size (Kmenta, 1986). This type of data also decreases the collinearity between variables (Certo and Semadeni, 2006), leading to an overall improvement in estimates.

3.5 Types of Moderator Variables

The term moderator seems to have originated from the work of Saunders (1956). Moderators are variables that explain their effect on the relationship between other variables rather than their own effect on the outcome (Mason, Tu and Cauce, 1996). Baron and Kenny (1986) defined moderator as a variable Z that affects the direction and/or the strength of the relationship between an independent variable (X) and a dependent variable (Y). Sharma et al., (1981) have developed a typology for the identification of two the types of moderator variables: moderator variables that influence the form (direct) of the relationship and moderator variables that affect the strength of the predictor-criterion relationship. This topology, illustrated in Figure 2, has two dimensions. On the horizontal axis, the first dimension addresses whether a moderator variable is related to criterion variable. On the vertical axis, the second dimension addresses whether the specification variable interacts with the predictor variable. For the purpose of this study, the predictor variables were R&D intensity and size, the criterion variables were ROA, ROS, and OPSALINV, and the moderator variable was DOI.

In Figure 2, the moderator variable could be related to the criterion variable or to the predictor variable or to both without interacting with predictor. This type of moderator variable is called intervening, exogenous, antecedent, suppressor, or predictor variable. Quadrant 1 represents these possibilities. The remaining three quadrants represent different types of moderator variables. Quadrant 2 represents a moderator variable that is not significantly related to the criterion and predictor variables and does not interact with the predictor. This type of moderator variable is called homologizer variable. It affects the strength of the relationship between the predictor and criterion variables across homogeneous subgroups (Arnold, 1982). Moderator variables in Quadrant 3 and 4 influence the form of the relationship between the predictor and criterion variables. A moderator variable that influences the form of a relationship implies a significant interaction between the moderator and the predictor variables. Moderator variables in Quadrant 3 are significantly related to the criterion or predictor variables or to both are referred to as quasi moderators. Moderator variables in Quadrant 4 are not significantly related to either criterion or predictor variables are called pure moderators.

Figure 3: Typology of Moderated Forms of Internationalization

	DOI related to performance and/or innovation	DOI not related to performance or innovation
No significant interaction of DOI with innovation	**Quadrant 1** DOI does not act as a moderator	**Quadrant 2** DOI acts as a homologizer (Effect of the strength)
Significant interaction of DOI with innovation	**Quadrant 3** DOI acts as a quasi moderator (Effect of the form)	**Quadrant 4** DOI acts as a pure moderator (Effect of the form)

3.6 Moderated Multiple Regression

Three techniques are typically used to assess moderator variables: Moderated Multiple Regression (MMR), Correlational Analysis (CA), and Multiple Regression with Dichotomized moderator (MRD)/ANOVA (Mason, Tu and Cauce, 1996).

Moderated Multiple Regression (MMR) technique consists of two steps. In the first step, the main effects of the predictor (X) and the hypothesized moderator (Z) are estimated using regression.

$$Y = a + B_1X + B_2Z + e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where a = is the estimate of the intercept, B_1 = the estimate of the population regression coefficient for X, B_2 = the estimate of the population regression coefficient for Z, and e = a residual term.

The second step consists of adding the interaction term to the equation (1) as:

$$Y = a + B_1X + B_2Z + B_3X*Z + e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

B_3 = is the estimate of the population regression coefficient for the product term (X*Z) (Aguinis, 1995).

To evaluate the role of the moderator (Z), the procedure outlined in the analytical section is applied. The importance of using MMR in evaluating the effect of moderator variables is evident from the fact that this technique has been extensively used by researcher (Evans, 1991). Cortina (1993) reported that MMR was used in at least 123 attempts to detect the moderating effects in the 1991 and 1992 volumes of the Journal of Applied Psychology. It is particularly a preferred statistical method to detect moderating effects where the predictor variables are continuous (Aguinis, 1995; Stone and Hollenbeck, 1984). However, MMR has been criticized by a number of scholars (e.g., Cohen and Cohen, 1983; Evans, 1991; Morris, Sherman, and Mansfield, 1968) for resulting in low power, but others (Mason, Tu and Cauce, 1996; Stone and Hollenbeck, 1984) rejected such criticisms. Mason, Tu and Cauce (1996) conducted a pair of computer simulation studies on a large number of samples, to compare the relative power of MMR, CA, and MRD. They found that MMR offered more power than MRD and CA particularly with continuous moderator variable. Stone and Hollenbeck (1984) also demonstrated that conventional moderated regression is well suited for detecting moderating effects.

3.7 Analytical Model

3.7.1 Time Series Cross-sectional Regression (TSCSREG)

The TSCSREG procedure implemented in SAS analyzes panel data sets that consist of multiple time series observations on each of the several cross-sectional units (Industry) (SAS online, 2010). All the explanatory variables that affect the dependent variable cannot be usually specified or observed, leading to omitted variable bias which is summarized in the error term. The TSCSREG procedure used with the Fuller-Battese method adds the individual and time specific random effects to the error term and the parameters are efficiently estimated using the GLS methods. The variance component model used by the Fuller-Battese method is:

$$u_{it} = v_i + e_t + e_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The details of this procedure are given in Fuller and Battese (1974).

Fixed-effects and random-effects models are recommended methods for the analysis of time series across sectional data. Fixed-effects models investigate differences in the intercepts, holding the slopes and constant fixed across groups, while random-effects models investigate differences in the error variance, holding the intercepts and slopes constant. In this study, I use the random-effects model for two reasons. First, cross-sectional dummy variables are collinear with the GVKEY variables in case of a fixed effects model but random effects model do not use cross-sectional dummy variables (the impact of the time series and cross-sectional effects are accounted for in the variance components). Therefore, industry dummies can be included for the random effects model (personal correspondence with SAS Institute, 2010). Second, the random-effects model is more appropriate when the error term may change over time and all members of the group are not included in the sample (Certo and Semadeni, 2006).

3.7.2 Typology for identification of moderation effect

Sharma et al., (1981) developed a typology for identification of specification variables. A specification variable is one that specifies the form or the strength, or both, of the relationship between a predictor and a criterion. Figure 3 identify moderating variables and differentiate them into two types of moderating effects: form and strength. This typology also differentiates the moderating variable into the two categories; pure and quasi moderators. The framework is described as:

Step 1: Use moderated regression analysis to determine whether the suspected moderator (DOI) significantly interacts with the predictor (innovation). If there is significant interaction between the DOI and innovation, go to step 2. Otherwise, go to step 3.

Step 2: Determine whether the moderator variable (DOI) is a quasi or pure moderator by testing whether it is significantly correlated with the criterion variable (ROA). If DOI is significantly correlated to ROA, it is a quasi moderator. If DOI is not significantly correlated with ROA, then DOI is a pure moderator of the relationship between innovation and firm performance. Both the quasi and pure moderators influence the form of the predictor-criterion relationship.

Step 3: Determine whether the hypothesized moderator (DOI) is related to either the criterion (ROA) or predictor (innovation) variable. If it is related, DOI is not a moderator but an exogenous, predictor, intervening, antecedent, or a suppressor variable. If DOI is not related to either the predictor or criterion variable, go to step 4.

Step 4: Split the total sample into subgroups on the basis of the hypothesized moderator variable. The subgroups can be formed by a median, quartile or other type of split. Do a test of significance for difference in predictive validity across subgroups. If significant differences are found, the variable is a homologizer. Otherwise, it is not a moderator.

Figure 5 : Framework for identifying moderator variables

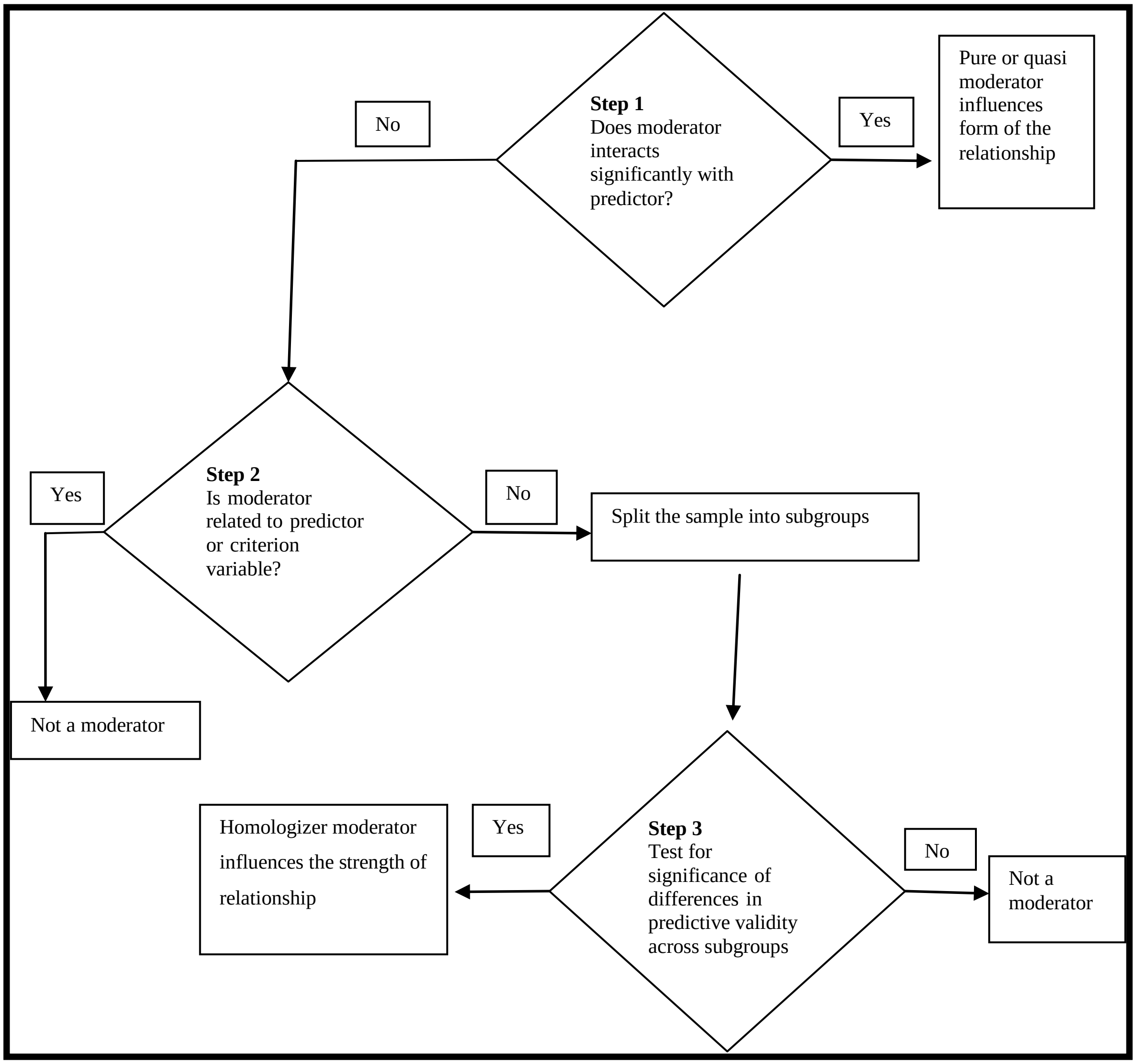


Figure 3 describes the process of identifying moderators of the form and strength described above (Garcia and Kandemir, 2006).

3.8 Summary

Data for this study was obtained from online database called Compustat. Based on the availability of the required data on the measures of interest, there were 102 large US manufacturing firms in the final sample. The variables of interest included DOI, R&D intensity, size, and firm performance. Panel data were used because the results of cross-sectional data are good for a single time period and cannot be generalized over time. Kotabe et al., (2002) suggested that time series cross-sectional regression is a preferred technique to analyze panel data because it accounts for both cross-sectional and time series effect.

Chapter 4

4. Findings

4.1 Introduction

This chapter first presents descriptive statistics and correlations between the independent variables used in the study. It then gives the results of running the TSCSREG procedure for all three measures of firm performance.

4.2 Descriptive Statistics

Table 3 provides descriptive statistics and correlations between variables. The only correlation that is significant is between the variable Size and R&D Intensity but the values is low (.145).Therefore, multicollinearity among the independent variables would not create a problem in statistical analysis. In addition, before creating the interaction term, all the independent variables were mean-centered in order to reduce the potential problem of multicollinearity (Aiken and West, 1991). Mean-centering is the most common strategy to mitigate multicollinearity (Aguinis, 1995; Marsh et.al., 2007). However, a recent study by Echambadi and Hess (2007) show that mean-centering does little to reduce multicollinearity.

Table 3: Descriptive Statistics and Correlations

Variables	*Mean*	*St. Dev*	*1*	*2*
Size	1.8946	1.6999		
DOI	0.277516	2.5486190	0.008	
RDIntensity	0.144288	1.4765270	-.145**	0.012
ROA	0.0352824	0.1233780		
ROS	-0.0685186	1.6897091		
OPSALINV	1.1946282	0.2076383		

** Correlation is significant at the .01 level
*Correlation is significant at the .05 level

4.3 TSCSREG Procedure

Three regression equations (models) were estimated using TSCSREG procedure with Fuller-Battese method (Fuller & Battese, 1974) in SAS, to determine the moderating effect of DOI on innovation-performance relationship. The first model contained control variables and R&D Intensity.

$$P_{it} = \beta_0 + \Sigma\beta_i D_i + \beta_1 \text{ R\&D Intensity}_{it} + \beta_2 \text{Size}_{it} + U_{it} \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where:

$P_{it=}$ performance of firm i in time period t measured by ROA, ROS, and OPSALINV.

$\Sigma\beta_i D_i$ = dummy variables for ith industry sector (6 dummies for 7 industries).

U_{it} = random error of firm i in time period t.

DOI was introduced in the second model as an independent variable to estimate the main effects of both the DOI and R&D Intensity.

$$P_{it} = \beta_0 + \Sigma\beta_i D_i + \beta_1 \text{ R\&D Intensity}_{it} + \beta_2 \text{Size}_{it} + \beta_3 \text{DOI}_{it} + U_i \ldots\ldots.(6)$$

Interaction term between R&D Intensity and DOI was introduced in the third model.

$P_{it} = \beta_0 + \Sigma\beta_i D_i + \beta_1$ R&D $Intensity_{it} + \beta_2 Size_{it} + \beta_3 DOI_{it} + \beta_4 DOI_{it}$ * R&D $Intensity_{it}$ $+ U_{it}$……………………………………………………….(7)

Table 4: TSSCREG (SAS) with ROA as dependent variable

Variables	*Model 1*	*Model 2*	*Model 3*
Intercept	0.037447**	0.037443**	0.035842**
R&D Intensity	-0.00863**	-0.00865**	-0.03881**
Size	0.01726**	0.017261**	0.018058**
DOI		-0.00008	0.004292**
DOIx R&D Intensity			0.057096**
R^2	0.038	0.038	0.064

Significance level: * P<.05, **P<.01
*Industry dummies are included in the model, but are not shown in the table

As the results show the goodness of fit (R^2) values are low for dependent variables ROA (Table 4:0.038-0..064) and OPSALINV (Table 6:0.0921-0.1307), but are still consistent with values Zhang, et al., (2007) obtained (0.09-0.13). However, the good of fit (R^2) for the dependent variable ROS (Table 5) is quite high (0.95).

Model 1 was a base model with control variables and R&D Intensity as independent variables. As evident from Table 4, firm size is found to have positive and highly significant impact on all the dependent variables (consistent with Kotabe et al., (2002). R&D Intensity is highly significant but negatively related to all three of the criterion variables. This result is consistent with results obtained by Kotabe et al., 2002; Coombs & Bierly, 2006 and Morbey & Reithner, 1990). So here, innovation influences a firm's performance but negatively. In Model 2, I introduced the proposed moderator (DOI). It is positive and significantly related to ROA and OPSALINV, positive and highly significantly related to ROS. Model 3 is a full model containing all the variables along with the interaction term (DOI * R&D Intensity). In this model innovation is negatively related to performance for all the criterion variables, but the interaction term is highly significant and positively related to performance for all the criterion variables. In addition, the R^2 in Model 3 (for interaction model) has somewhat improved for ROA and OPSALINV. As the interaction term is highly significant and positive for all the criterion variables while R&D Intensity is highly significant but negatively related to all the criterion variables, this confirms the first hypothesis that DOI moderates the innovation-performance relationship positively and significantly. The positive and higher coefficient for the interaction term in all three cases suggests that returns on innovation become higher as the firm becomes more internationally diversified. This is consistent with the result obtained by Kafouros et al., (2008).

As described in the analysis section, the first step in ascertaining whether a variable is a moderator of either the form or the strength of the relationship between the predictor and dependant variable is to test whether the hypothesized moderator interacts with the predictor variable. Looking at Tables 4, 5, and 6, the interaction term is significant and positively related to the criterion variable (performance) and one of the predictor variables (R&D Intensity) is also significantly related to the criterion variable in all three cases. Therefore, I conclude that DOI affects the form (direct) of the relationship between innovation and performance and is a quasi moderator of the innovation-performance relationship. The results confirm the second hypothesis that DOI affects the form (direct) of the innovation-performance relationship and disproves my third hypothesis that DOI influences the strength of relationship between innovation and firm performance. This result is consistent with that obtained by Kafouros et al. (2008). However, they reported a positive relationship between innovation and performance while my research showed that R&D Intensity is negatively related to firm performance.

Table 5: TSSCREG (SAS) with ROS as dependent variable

Variables	*Model 1*	*Model 2*	*Model 3*
Intercept	-0.04159*	-0.04154*	-0.04814*
R&D Intensity	-1.10842**	-1.10836**	-1.23095**
Size	0.018911*	0.018894*	0.023675*
DOI		-0.00083	0.019308**
DOIxR&D Intensity			0.239174**
R^2	0.9577	0.9577	0.9575

Significance level: * P<.05, **P<.01
*Industry dummies are included in the model, but are not shown in the table

Table 6: TSSCREG (SAS) with OPSALINV as dependent variable

Variables	*Model 1*	*Model 2*	*Model 3*
Intercept	1.218281**	1.218407**	1.217059**
R&D Intensity	-0.0189**	-0.01873**	-0.05346**
Size	0.045251**	0.045347**	0.048071**
DOI		0.00171	0.006829**
DOIxR&D Intensity			0.066025**
R^2	0.0921	0.0938	0.1307

Significance level: * P<.05, **P<.01
*Industry dummies are included in the model, but are not shown in the table

An interesting finding as a result of my study is that the goodness of fit (R^2) value for the dependent variable ROS is high compared to the other two dependent variables as evident from Table 4, 5, and 6. To see if there is any difference between the three dependent variables, correlations between them were calculated as shown in Table 7. Based on the high value of R^2 compared to ROA and OPSALINV, it is expected that the correlation between OPSALINV and ROA shall be higher than between ROS and the other two variables. However, it is not true as evident from Table 7. In all cases the correlation is highly significant, although the correlation coefficient between ROS with the other two variables has a slightly lower value than that between ROA and OPSALINV.

Table 7: Correlation between dependent variables

Variables	*OPSALINV*	*ROS*	*ROA*
OPSALINV	1	0.395**	0.505**
ROS	0.395**	1	0.319**
ROA	0.505**	0.319**	1

** Correlation is significant at the 0.01 level (2-tailed)

4.4 Summary

First, descriptive statistics and correlations between independent variables were presented. The only correlation found significant is between size and R&D Intensity. The mean value of the number of employees is 19 thousands showing the size of the firms included in the sample. The results of the TSCSREG procedure for the three models confirm support for hypothesis 1 and 2. The study confirms the findings of the previous study (Kafouros et al., 2008) by concluding that return to innovation can be higher in the presence of higher degree of internationalization. In addition, the study also concludes DOI has a direct effect on innovation-performance relationship and so is a quasi moderator of this relationship.

Chapter 5

5. Discussions, Limitations, and Conclusions

5.1 Introduction

This chapter presents discussions on the main findings and limitations of this study. It also makes suggestions for other areas of investigation for future researchers and conclusions.

5.2 Discussions

The data produced, as a result of using the three models for all three dependent variables (Table 4, 5, 6), show that R&D intensity is negatively related to firm performance. This result is not unexpected as other studies have resulted in similar findings. (e.g., Graves and Langowitz, 1993; Kotabe et al., 2002; Oxley and Sampson, 2004; Holak et al., 1991). This fact is also evident from Table 1 which reports many studies with negative returns to R&D intensity. One reason for this result could be the measurement of both dependent variable (performance) and independent variable (R&D intensity). Coombs and Bierly (2006) reported that results for R&D intensity and firm performance could vary when different measures are used for both. They measured technological capability using many different measures (e.g., patents, R&D intensity, current impact index, technology cycle time, science strength, science knowledge, and technology strength) as well as firm performance (e.g., market value, MVA, ROS, ROA, ROE, and EVA). The negative relationship between R&D intensity and firm performance confirms the notion that innovation alone is not a sufficient condition for better performance (Baron and Kenny, 1986; Holak et al., 1991: Zhang et al., 2007). In addition, it confirms that this relationship should be considered in the presence of other factors (moderators) such as DOI. Only those firms that deploy their intangible assets in many markets could exploit them to their full value (Lu and Beamish 2004).

I hypothesized that internationalization moderates the innovation-performance relationship and that it moderates either the form or the strength of this relationship. My results confirm the first two hypotheses and reject the third hypothesis. In other words, DOI moderates the innovation-performance relationship and the type of moderation is form and not the strength.

The most important contribution of this study to the literature on innovation and internationalization is that it has distinguished between the two potential effects of internationalization: effects of the form and strength as none of the previous studies have made such a distinction. Although the literature on moderation suggests that researchers should distinguish between moderator variables that influence the form and those that influence the strength of the predictor-criterion relationship because they have different moderating effects and require different analytical methods for evaluation (Sharma et al., 1981), most studies have used traditional moderated regression analysis. Not distinguishing between the two effects may lead to misleading results. For example, studies that focus only on the form (interaction term) and overlook the strength of the relationship may erroneously conclude that there is no moderating effect if the interaction term is insignificant. An effect of the strength may exist in spite of an insignificant interaction term. Therefore, this paper has integrated insights from the literature on moderation into internationalization research to distinguish between the different types of moderating effects when analyzing the moderating role of DOI.

Kafouros et al., (2008) suggested in the limitation section of their article that their study is limited in generalizability because their sample is restricted to firms from the United Kingdom only and, therefore, should be replicated in another environment. This study builds on the work of Kafouros et al, and provides evidence that is more generalizable by confirming the findings that internationalization moderates the innovation-performance relation in different environment (e.g., using a sample of US firms).

In high-technology industries with rapid technological obsolescence and shorter product life cycles (Chesbrough, 2007), investment in R&D may not be recoverable before innovations become obsolete (Kotabe, 1990). This is especially true in highly competitive environments. Increasing global competition has placed more emphasis on innovation as a means of competitive advantage (Betis and Hitt, 1995). International diversification (i.e., higher DOI) offers greater opportunity to recover the costs of the investments in R&D by providing a broader base (more markets) for the products of a firm. Thus, it provides greater opportunities to achieve optimal economic scale and amortize investments in critical functions such as R&D over a broader base. As international diversification is positively related to firm innovation, expansion into international markets provides opportunities for greater returns on innovations and so reduces the risk of failure due to a broader base in which a firm innovations may be applied (Hitt, Hoskisson and Ireland, 1994; Kim, Hwang and Burgers, 1993). Confirming that DOI moderates the innovation-performance relationship, this study sensitizes managers on the need to focus not only on innovation, but also on internationalization in order to exploit the full value of their innovations. This realization is particularly important for managers of the firms that thrive on innovation.

5.3 Limitations and Future Research

This study used R&D intensity as a measure of innovation of a firm however this may not be an appropriate measure for innovation. The results of innovation are either new or improved products or new or improved processes. Therefore, the best way to measure the innovativeness of a firm would be to use the number of new or improved products/processes. However, data on the number of new or improved products/processes is not easily available, particularly through secondary sources. Therefore, future researchers might replicate this study using better measures of innovation.

The effects of R&D are not realized until much later and the lag may be different for different industries. For example, R&D efforts are realized much later in the pharmaceutical industry than they are in the apparel and textile industry (Krishnan, Tadepalli, and Park (2009). Ravencraft, Scherer (1982) and Pakes (1985) also reported that the effects of R&D activities on performance may appear after a long and uncertain time. Forey et al., (2007) used a two year lag for R&D intensity and found minimal change with different lags. Following the work of Hall and Mairesse (2010); Pakes and Schankerman (1984) and Forey et al., (2007), I lagged the R&D intensity by two years. As there is no appropriate lag period, future researchers should use multiple lag periods.

Researchers have analyzed innovation-performance relationship under different moderators such DOI (Kafouros et al., 2008; this study), external monitors (Le et al, 2006); market focus, owner structure (Zhang et al., 2007), organizational learning (Alegre and Chiva, 2008), and type of industry sector (Kessler, 2003). It will be interesting for future researchers to use all those moderators at the same time.

As the data on other measures of internationalization were not available on the Compustat database, I was not able to replicate this study using other possible measures of multinationality. Therefore, one avenue for future researchers is to replicate this study using other measures of multinationality.

A limiting factor of this study is the lack of a sample in all the other industries except Chemical and Allied Products. The sample is more representative of the chemical and allied sector than any other sector because the chemical and allied sector made up for 62 of the 102 firms included in the sample. In addition, some sectors of manufacturing are unrepresented such as electronics, semi-conductors, and computers etc.

5.4 Conclusion

The moderating role of DOI on the innovation-performance relationship has not been studied previously with the exception of one study by Kafouros et al., (2008). Therefore, one contribution of this study has been to add to the limited research and thus enhance our understanding of the relationship. In addition, this study has enhanced the generalizability of that single study by using a different data set and different methodology.

The biggest contribution of this is to differentiate between the two types of moderating effects of DOI on innovation-performance link. None of the previous studies have made such a distinction. Sharma at al., (1981) have suggested differentiating the moderators into the two types: the form and the strength because both effects are different and require different analytical techniques to examine. Differentiating the moderating effect of DOI into the form (direct) and the strength (indirect) will be important both for policy makers and management of R&D intensive firms. For example, knowing that DOI directly affects return to innovation would help mangers to plan on the expansion of the firm geographically at a proper stage. This might be one of the reasons for the rapid internationalization of new ventures and the phenomenon of ‘Born Global’ (Oviatt and McDougal, 1994).

As a whole, the results may sensitize managers on the need to focus not only on the innovation activities, but also to focus on their DOI, in order to exploit the full benefits of their innovations.

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Appendices

Appendix 1-Output with No lag data set

Appendix 1A Results of TSCSREG procedure (SAS) for ROA

The SAS System 19:19 Thursday, July 15, 2010 1

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROA ROA

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	7.6417	DFE	807
MSE	0.0095	Root MSE	0.0973
R-Square	0.0380		

Variance Component Estimates

Variance Component for Cross Sections	0.004305
Variance Component for Time Series	0.000133
Variance Component for Error	0.009425

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	0.037447	0.0103	3.62	0.0003	Intercept
RDIntensitymc	1	-0.00863	0.00287	-3.01	0.0027	RDIntensitymc

Sizemc	1	0.01726	0.00402	4.30	<.0001	Sizemc
ID1	1	-0.01481	0.0534	-0.28	0.7813	ID1
ID2	1	0.003914	0.0305	0.13	0.8978	ID2
ID3	1	-0.00112	0.0246	-0.05	0.9638	ID3
ID4	1	-0.0185	0.0557	-0.33	0.7398	ID4
ID5	1	-0.00474	0.0227	-0.21	0.8343	ID5
ID6	1	-0.02153	0.0345	-0.62	0.5329	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROA ROA

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	7.6439	DFE	806
MSE	0.0095	Root MSE	0.0974
R-Square	0.0380		

Variance Component Estimates

Variance Component for Cross Sections	0.004298
Variance Component for Time Series	0.000132
Variance Component for Error	0.009437

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	0.037443	0.0103	3.62	0.0003	Intercept
RDIntensitymc	1	-0.00865	0.00287	-3.01	0.0027	RDIntensitymc
Sizemc	1	0.017261	0.00402	4.30	<.0001	Sizemc
DOImc	1	-0.00008	0.00142	-0.06	0.9528	DOImc
ID1	1	-0.01479	0.0533	-0.28	0.7816	ID1
ID2	1	0.003912	0.0304	0.13	0.8978	ID2
ID3	1	-0.00112	0.0246	-0.05	0.9638	ID3
ID4	1	-0.01847	0.0557	-0.33	0.7401	ID4

ID5	1	-0.00474	0.0226	-0.21	0.8343	ID5
ID6	1	-0.02148	0.0345	-0.62	0.5340	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROA ROA

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	7.3606	DFE	805
MSE	0.0091	Root MSE	0.0956
R-Square	0.0640		

Variance Component Estimates

Variance Component for Cross Sections	0.00457
Variance Component for Time Series	0.000109
Variance Component for Error	0.009077

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	0.035842	0.0104	3.45	0.0006	Intercept
RDIntensitymc	1	-0.03881	0.00682	-5.69	<.0001	RDIntensitymc
Sizemc	1	0.018058	0.00409	4.42	<.0001	Sizemc
DOImc	1	0.004292	0.00166	2.58	0.0099	DOImc
RDxDOI	1	0.057096	0.0116	4.90	<.0001	RDxDOI
ID1	1	-0.01567	0.0545	-0.29	0.7738	ID1
ID2	1	0.000162	0.0311	0.01	0.9958	ID2
ID3	1	-0.00405	0.0251	-0.16	0.8719	ID3
ID4	1	-0.02281	0.0569	-0.40	0.6885	ID4
ID5	1	-0.00671	0.0231	-0.29	0.7720	ID5
ID6	1	-0.02172	0.0353	-0.62	0.5382	ID6

Appendix 1B Results of TSCSREG procedure (SAS) for ROS

The SAS System
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The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROS ROS

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	75.7149	DFE	807
MSE	0.0938	Root MSE	0.3063
R-Square	0.9577		

Variance Component Estimates

Variance Component for Cross Sections	0.01069
Variance Component for Time Series	0.000308
Variance Component for Error	0.092653

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	-0.04159	0.0202	-2.06	0.0400	Intercept
RDIntensitymc	1	-1.10842	0.00822	-134.79	<.0001	RDIntensitymc
Sizemc	1	0.018911	0.00836	2.26	0.0239	Sizemc
ID1	1	-0.07499	0.1080	-0.69	0.4875	ID1
ID2	1	-0.06215	0.0617	-1.01	0.3143	ID2
ID3	1	-0.06617	0.0498	-1.33	0.1842	ID3
ID4	1	-0.11864	0.1129	-1.05	0.2938	ID4
ID5	1	-0.05454	0.0459	-1.19	0.2347	ID5
ID6	1	-0.09784	0.0699	-1.40	0.1617	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROS ROS

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	75.6860	DFE	806
MSE	0.0939	Root MSE	0.3064
R-Square	0.9577		

Variance Component Estimates

Variance Component for Cross Sections	0.010738
Variance Component for Time Series	0.000327
Variance Component for Error	0.092734

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	-0.04154	0.0203	-2.05	0.0411	Intercept
RDIntensitymc	1	-1.10836	0.00823	-134.68	<.0001	RDIntensitymc
Sizemc	1	0.018894	0.00837	2.26	0.0242	Sizemc
DOImc	1	0.00083	0.00437	0.19	0.8492	DOImc
ID1	1	-0.07526	0.1081	-0.70	0.4866	ID1
ID2	1	-0.06213	0.0618	-1.01	0.3151	ID2
ID3	1	-0.06619	0.0498	-1.33	0.1846	ID3
ID4	1	-0.1189	0.1131	-1.05	0.2934	ID4
ID5	1	-0.05458	0.0459	-1.19	0.2349	ID5
ID6	1	-0.09841	0.0700	-1.41	0.1602	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROS ROS

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	69.6662	DFE	805
MSE	0.0865	Root MSE	0.2942
R-Square	0.9575		

Variance Component Estimates

Variance Component for Cross Sections	0.017405
Variance Component for Time Series	0
Variance Component for Error	0.084499

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	-0.04814	0.0217	-2.22	0.0267	Intercept
RDIntensitymc	1	-1.23095	0.0206	-59.79	<.0001	RDIntensitymc
Sizemc	1	0.023675	0.00931	2.54	0.0112	Sizemc
DOImc	1	0.019308	0.00502	3.85	0.0001	DOImc
RDxDOI	1	0.239174	0.0351	6.81	<.0001	RDxDOI
ID1	1	-0.0776	0.1217	-0.64	0.5238	ID1
ID2	1	-0.07961	0.0696	-1.14	0.2527	ID2
ID3	1	-0.07908	0.0561	-1.41	0.1591	ID3
ID4	1	-0.14203	0.1272	-1.12	0.2644	ID4
ID5	1	-0.06185	0.0517	-1.20	0.2318	ID5
ID6	1	-0.09898	0.0788	-1.26	0.2093	ID6

Appendix 1C Results of TSCSREG procedure (SAS) for OPSALINV

The SAS System
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The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: OPSALINV OPSALINV

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	7.0004	DFE	807
MSE	0.0087	Root MSE	0.0931
R-Square	0.0921		

Variance Component Estimates

Variance Component for Cross Sections	0.027479
Variance Component for Time Series	0
Variance Component for Error	0.008599

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	1.218281	0.0217	56.26	<.0001	Intercept
RDIntensitymc	1	-0.0189	0.00292	-6.47	<.0001	RDIntensitymc
Sizemc	1	0.045251	0.00732	6.18	<.0001	Sizemc
ID1	1	-0.01538	0.1220	-0.13	0.8997	ID1
ID2	1	-0.08452	0.0689	-1.23	0.2205	ID2
ID3	1	-0.0525	0.0560	-0.94	0.3485	ID3
ID4	1	-0.18543	0.1254	-1.48	0.1396	ID4
ID5	1	-0.03818	0.0518	-0.74	0.4612	ID5
ID6	1	-0.0691	0.0789	-0.88	0.3815	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: OPSALINV OPSALINV

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	6.9843	DFE	806
MSE	0.0087	Root MSE	0.0931
R-Square	0.0938		

Variance Component Estimates

Variance Component for Cross Sections	0.027538
Variance Component for Time Series	0
Variance Component for Error	0.00859

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	1.218407	0.0217	56.20	<.0001	Intercept
RDIntensitymc	1	-0.01873	0.00292	-6.41	<.0001	RDIntensitymc
Sizemc	1	0.045347	0.00732	6.19	<.0001	Sizemc
DOImc	1	0.00171	0.00137	1.24	0.2138	DOImc
ID1	1	-0.01588	0.1221	-0.13	0.8965	ID1
ID2	1	-0.0847	0.0690	-1.23	0.2200	ID2
ID3	1	-0.05266	0.0560	-0.94	0.3475	ID3
ID4	1	-0.1865	0.1255	-1.49	0.1377	ID4
ID5	1	-0.03824	0.0518	-0.74	0.4610	ID5
ID6	1	-0.07029	0.0790	-0.89	0.3739	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: OPSALINV OPSALINV

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	8

Fit Statistics

SSE	6.6319	DFE	805
MSE	0.0082	Root MSE	0.0908
R-Square	0.1307		

Variance Component Estimates

Variance Component for Cross Sections	0.028085
Variance Component for Time Series	0.000019
Variance Component for Error	0.008127

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	1.217059	0.0220	55.39	<.0001	Intercept
RDIntensitymc	1	-0.05346	0.00655	-8.16	<.0001	RDIntensitymc
Sizemc	1	0.048071	0.00739	6.51	<.0001	Sizemc
DOImc	1	0.006829	0.00160	4.28	<.0001	DOImc
RDxDOI	1	0.066025	0.0112	5.91	<.0001	RDxDOI
ID1	1	-0.01611	0.1234	-0.13	0.8962	ID1
ID2	1	-0.09224	0.0698	-1.32	0.1865	ID2
ID3	1	-0.05773	0.0566	-1.02	0.3083	ID3
ID4	1	-0.1987	0.1269	-1.57	0.1177	ID4
ID5	1	-0.04021	0.0524	-0.77	0.4432	ID5
ID6	1	-0.07092	0.0799	-0.89	0.3748	ID6

Appendix 2-Output with R-&-D intensity lagged by two years

Appendix 2A Results of TSCSREG procedure (SAS) for ROA

The SAS System 19:28 Thursday, July 15, 2010 1

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROA ROA

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	6.0344	DFE	603
MSE	0.0100	Root MSE	0.1000
R-Square	0.0382		

Variance Component Estimates

Variance Component for Cross Sections	0.004543
Variance Component for Time Series	0.000096
Variance Component for Error	0.009873

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	0.040853	0.0109	3.74	0.0002	Intercept
RDIntensitymc	1	-0.00935	0.00312	-2.99	0.0029	RDIntensitymc
Sizemc	1	0.014684	0.00436	3.37	0.0008	Sizemc
ID1	1	-0.00335	0.0570	-0.06	0.9531	ID1
ID2	1	0.002803	0.0326	0.09	0.9315	ID2
ID3	1	-0.00377	0.0262	-0.14	0.8857	ID3
ID4	1	-0.01264	0.0598	-0.21	0.8326	ID4
ID5	1	-0.01399	0.0242	-0.58	0.5632	ID5
ID6	1	-0.01967	0.0368	-0.53	0.5935	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROA ROA

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	6.0392	DFE	602
MSE	0.0100	Root MSE	0.1002
R-Square	0.0384		

Variance Component Estimates

Variance Component for Cross Sections	0.004525
Variance Component for Time Series	0.000095
Variance Component for Error	0.009891

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	0.040848	0.0109	3.75	0.0002	Intercept
RDIntensitymc	1	-0.00937	0.00312	-3.00	0.0028	RDIntensitymc
Sizemc	1	0.01469	0.00436	3.37	0.0008	Sizemc
DOImc	1	-0.00008	0.00161	-0.05	0.9593	DOImc
ID1	1	-0.0033	0.0569	-0.06	0.9537	ID1
ID2	1	0.002791	0.0326	0.09	0.9317	ID2
ID3	1	-0.00378	0.0262	-0.14	0.8853	ID3
ID4	1	-0.01263	0.0597	-0.21	0.8325	ID4
ID5	1	-0.01397	0.0242	-0.58	0.5635	ID5
ID6	1	-0.01959	0.0368	-0.53	0.5950	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROA ROA

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	5.9061	DFE	601
MSE	0.0098	Root MSE	0.0991
R-Square	0.0514		

Variance Component Estimates

Variance Component for Cross Sections	0.004855
Variance Component for Time Series	0.000039
Variance Component for Error	0.009581

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	0.039961	0.0107	3.72	0.0002	Intercept
RDIntensitymc	1	-0.01055	0.00317	-3.33	0.0009	RDIntensitymc
Sizemc	1	0.01579	0.00446	3.54	0.0004	Sizemc
DOImc	1	-0.00064	0.00160	-0.40	0.6897	DOImc
RDxDOI	1	0.003527	0.00116	3.04	0.0025	RDxDOI
ID1	1	-0.00113	0.0585	-0.02	0.9846	ID1
ID2	1	0.001766	0.0335	0.05	0.9579	ID2
ID3	1	-0.00387	0.0270	-0.14	0.8859	ID3
ID4	1	-0.0158	0.0614	-0.26	0.7969	ID4
ID5	1	-0.01256	0.0248	-0.51	0.6135	ID5
ID6	1	-0.01775	0.0379	-0.47	0.6395	ID6

Appendix 2B Results of TSCSREG procedure (SAS) for ROS

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROS ROS

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	1330.6266	DFE	603
MSE	2.2067	Root MSE	1.4855
R-Square	0.0037		

Variance Component Estimates

Variance Component for Cross Sections	1.177351
Variance Component for Time Series	0.008937
Variance Component for Error	1.970949

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	-0.14318	0.1712	-0.84	0.4033	Intercept
RDIntensitymc	1	-0.00269	0.0474	-0.06	0.9548	RDIntensitymc
Sizemc	1	0.090029	0.0709	1.27	0.2046	Sizemc
ID1	1	0.243696	0.9337	0.26	0.7942	ID1
ID2	1	0.078198	0.5340	0.15	0.8836	ID2
ID3	1	0.128684	0.4302	0.30	0.7649	ID3
ID4	1	-0.14375	0.9789	-0.15	0.8833	ID4
ID5	1	0.210269	0.3964	0.53	0.5960	ID5
ID6	1	0.168237	0.6039	0.28	0.7806	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROS ROS

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	1324.0944	DFE	602
MSE	2.1995	Root MSE	1.4831
R-Square	0.0056		

Variance Component Estimates

Variance Component for Cross Sections	1.192516
Variance Component for Time Series	0.010322
Variance Component for Error	1.961725

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	-0.14107	0.1728	-0.82	0.4146	Intercept
RDIntensitymc	1	0.000383	0.0474	0.01	0.9936	RDIntensitymc
Sizemc	1	0.088892	0.0713	1.25	0.2127	Sizemc
DOImc	1	0.026026	0.0240	1.09	0.2776	DOImc
ID1	1	0.227436	0.9387	0.24	0.8086	ID1
ID2	1	0.079322	0.5368	0.15	0.8826	ID2
ID3	1	0.1301	0.4324	0.30	0.7636	ID3
ID4	1	-0.15095	0.9841	-0.15	0.8781	ID4
ID5	1	0.203215	0.3986	0.51	0.6103	ID5
ID6	1	0.142099	0.6075	0.23	0.8151	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: ROS ROS

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	1014.9315	DFE	601
MSE	1.6887	Root MSE	1.2995
R-Square	0.1700		

Variance Component Estimates

Variance Component for Cross Sections	1.731031
Variance Component for Time Series	0
Variance Component for Error	1.424158

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	-0.19774	0.1955	-1.01	0.3123	Intercept
RDIntensitymc	1	0.068711	0.0439	1.57	0.1178	RDIntensitymc
Sizemc	1	0.137477	0.0807	1.70	0.0890	Sizemc
DOImc	1	0.009774	0.0213	0.46	0.6458	DOImc
RDxDOI	1	0.162926	0.0154	10.57	<.0001	RDxDOI
ID1	1	0.351491	1.0987	0.32	0.7491	ID1
ID2	1	0.067973	0.6271	0.11	0.9137	ID2
ID3	1	0.159726	0.5057	0.32	0.7522	ID3
ID4	1	-0.2591	1.1484	-0.23	0.8216	ID4
ID5	1	0.296173	0.4664	0.63	0.5257	ID5
ID6	1	0.250596	0.7108	0.35	0.7246	ID6

Appendix 2C Results of TSCSREG procedure (SAS) for OPSALINV

The SAS System 19:28 Thursday, July 15, 2010 7

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: OPSALINV OPSALINV

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	3.5763	DFE	603
MSE	0.0059	Root MSE	0.0770
R-Square	0.0516		

Variance Component Estimates

Variance Component for Cross Sections	0.033696
Variance Component for Time Series	0
Variance Component for Error	0.005897

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	1.220343	0.0238	51.19	<.0001	Intercept
RDIntensitymc	1	-0.00877	0.00273	-3.21	0.0014	RDIntensitymc
Sizemc	1	0.038375	0.00826	4.64	<.0001	Sizemc
ID1	1	-0.02636	0.1342	-0.20	0.8444	ID1
ID2	1	-0.07481	0.0760	-0.98	0.3254	ID2
ID3	1	-0.05837	0.0616	-0.95	0.3438	ID3
ID4	1	-0.19132	0.1386	-1.38	0.1679	ID4
ID5	1	-0.05167	0.0570	-0.91	0.3650	ID5
ID6	1	-0.07315	0.0868	-0.84	0.3999	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: OPSALINV OPSALINV

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	3.5603	DFE	602
MSE	0.0059	Root MSE	0.0769
R-Square	0.0550		

Variance Component Estimates

Variance Component for Cross Sections	0.033765
Variance Component for Time Series	0
Variance Component for Error	0.00588

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	1.22053	0.0239	51.15	<.0001	Intercept
RDIntensitymc	1	-0.00869	0.00273	-3.18	0.0015	RDIntensitymc
Sizemc	1	0.03835	0.00826	4.64	<.0001	Sizemc
DOImc	1	0.001885	0.00126	1.49	0.1364	DOImc
ID1	1	-0.02755	0.1344	-0.20	0.8376	ID1
ID2	1	-0.07487	0.0761	-0.98	0.3255	ID2
ID3	1	-0.05836	0.0617	-0.95	0.3443	ID3
ID4	1	-0.19212	0.1387	-1.39	0.1665	ID4
ID5	1	-0.0522	0.0570	-0.92	0.3605	ID5
ID6	1	-0.07509	0.0869	-0.86	0.3880	ID6

The TSCSREG Procedure
Fuller and Battese Variance Components (RanTwo)

Dependent Variable: OPSALINV OPSALINV

Model Description

Estimation Method	Fuller
Number of Cross Sections	102
Time Series Length	6

Fit Statistics

SSE	2.5313	DFE	601
MSE	0.0042	Root MSE	0.0649
R-Square	0.2840		

Variance Component Estimates

Variance Component for Cross Sections	0.035465
Variance Component for Time Series	0.000017
Variance Component for Error	0.004105

Hausman Test for
Random Effects

DF	m Value	Pr > m
0	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	1.218142	0.0246	49.46	<.0001	Intercept
RDIntensitymc	1	-0.0094	0.00232	-4.05	<.0001	RDIntensitymc
Sizemc	1	0.044336	0.00796	5.57	<.0001	Sizemc
DOImc	1	0.000498	0.00107	0.46	0.6427	DOImc
RDxDOI	1	0.011006	0.000784	14.05	<.0001	RDxDOI
ID1	1	-0.01884	0.1384	-0.14	0.8918	ID1
ID2	1	-0.08201	0.0782	-1.05	0.2946	ID2
ID3	1	-0.06028	0.0635	-0.95	0.3425	ID3
ID4	1	-0.21206	0.1423	-1.49	0.1367	ID4
ID5	1	-0.04674	0.0588	-0.80	0.4267	ID5
ID6	1	-0.06929	0.0895	-0.77	0.4394	ID6