Multi-Jurisdictional Tax Incentives and the Location of Innovative Activities

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners

I understand that my thesis may be electronically available to the public.

Christy MacDonald

ABSTRACT

In this dissertation, I explore the effect of tax incentives on where U.S. multinationals decide to locate their innovative activities worldwide. Research and development (R&D) tax incentives offered by foreign countries and differences between U.S. and foreign tax rates provide opportunities that may influence where multinationals decide to locate their innovative activities. Using firm-level patenting data that identifies the country-specific location of innovations from 1986 to 2000, I examine the relation between innovative activities performed in a foreign country and these tax incentives using the Heckman (1979) two step estimation approach. I find evidence that the foreign percentage of innovative activities is associated with the attractiveness of foreign R&D tax incentives and with an increase in the effect of U.S. R&D allocation rules. In addition, the results suggest that firms in excess foreign tax credit positions decrease the amount of R&D activities in a foreign location with increased foreign tax rates, consistent with income shifting incentives. In contrast, I find that the firms in deficit foreign tax credit positions increase their foreign R&D activities with increasing foreign tax rates. This study is the first to examine and provide evidence of the influence of foreign R&D tax incentives and income shifting incentives on a U.S. multinational's decision on where to locate R&D activities.

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DEDICATION

This thesis is dedicated to my husband, Jeremy and our children, Tyler and Kaiya.

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CHAPTER 1: INTRODUCTION

1.1 Motivation

In this dissertation, I examine the association between multi-jurisdictional tax incentives and a firm's decision on where to locate their innovative activities. In recent years, research and development (R&D) expenditures by U.S. multinationals (MNCs) in foreign locations has grown faster than their R&D spending in the United States. U.S. majority-owned foreign affiliates' investment in R&D increased 132% from $11.8 billion in 1994 to $27.5 billion in 2004. In comparison, U.S. parent corporations had a slower increase in R&D investment over this same period of 66%, from $91.6 billion to $152.4 billion (Yorgason, 2007). R&D tax incentives and differences in corporate tax rates across countries provide opportunities that may influence a U.S. multinational's decision on whether to conduct its R&D in the United States or abroad. A limited number of empirical studies have provided evidence of the influence of tax policies on the decision on where to locate R&D activities. As described more fully below, these studies have focused on the U.S. tax policies related to R&D and in particular, policy changes introduced by the Tax Reform Act of 1986 (TRA86). Using data aggregated at a country-level, Hines (1994) finds no evidence of a change in R&D performed abroad after the TRA86 while Vines and Moore (1996) find evidence of industries in excess foreign tax credit positions moving more R&D offshore under the R&D allocation rules. Hines and Jaffe (2001) demonstrate, at firm-level, that R&D performed abroad decreased after the change in the R&D allocation rules introduced by TRA86. Taken together, the evidence is unclear as to the effect of the U.S. R&D tax policies on the location decision for R&D.

Differences in corporate tax rates create incentives to shift income out of high-tax jurisdictions into low-tax jurisdictions to minimize tax payments. A number of studies have provided evidence suggesting that U.S. multinationals engage in cross-jurisdictional income shifting including Harris et al. (1993), Klassen at al. (1993), Harris (1993), Jacob (1996), Collins et al. (1998), Klassen and Laplante (2008) among others. Kemsley (1998), Newberry and Dhaliwal (2001), Grubert and Slemrod (1998) and Grubert (2003) provide evidence of the income shifting incentive influencing the location decision for certain corporate activities. These activities included the location of production, interest deductions and capital investment. The association between income shifting and the location decision for R&D has not been explored. Because the value of intellectual property resulting from R&D activities can be particularly difficult to value, the location of R&D activities can be a useful method of achieving income shifting.

1.2 Research Study

To investigate the role of tax incentives on the international location of R&D activities, I develop a simple model for the decision of where to locate R&D activities. The model assumes managers determine where to locate their R&D activities by examining the difference in profits between a domestic and a foreign location.   Analysis of the model reveals that firms will increase their innovative activities in a foreign location in response to greater foreign R&D tax incentives and greater effects of the U.S. R&D allocation rules. However, firms differ in their responsiveness to income shifting incentives based on their foreign tax credit positions. Firms with excess foreign tax credits (i.e., firms with average foreign tax rates greater than the U.S. tax rate) reduce their foreign activity in favor of domestic R&D activities as the foreign tax rate rises but firms in a deficit foreign tax credit position (i.e., firms with average foreign tax rates less than the U.S. tax rate) do not respond to changes in the foreign tax rate.

I explore the predictions from this model by using data on patenting activity provided by the U.S. Patent and Trademark Office (USPTO). The patenting data allows me to infer the location of R&D activities based on the reported location of the inventors. R&D expenditures reported on a firm's financial statements has traditionally been used as a measure of innovative activities. However, the data on R&D expenditures is insufficient for my analysis since firms are not required to disclose the specific location of where the R&D occurred. Patenting data was used to exploit the location information.

For my analysis, I collect firm-level data on patenting activity in 20 Organisation for Economic Co-operation and Development (OECD) countries for the period 1986 to 2000. The sample was restricted to U.S. multinationals due to the availability of data in the patenting database and the matching of this database to financial data. Using these data, I regress the percentage of patenting activity in a specific foreign country on proxies for the R&D tax incentives, the U.S. R&D allocation rules, the income shifting incentives, and control variables. The empirical model is estimated using the Heckman (1979) two step estimation approach to control for the potential self selection bias in my sample. With this approach, I first estimate a selection model where firms decide whether to perform R&D activities home or abroad. From this regression, I extract the selection correction variable and include it in the estimation of the main empirical model.

Consistent with the hypotheses, my results indicate that the percentage of innovative activities in a foreign country is associated with the attractiveness of the foreign R&D tax incentives and with an increased effect of the U.S. R&D allocation rules. In addition, I find evidence that U.S. MNCs in excess foreign tax credit positions decrease the amount of R&D activities in a foreign location as the foreign tax rate rises, consistent with the income shifting hypothesis. However, in contrast to expectations, I find evidence of a positive relation between the foreign innovative activities and the foreign tax rate for firms in a deficit foreign tax credit position. These findings are generally robust to various specification checks. However, the conclusion related to the U.S. R&D allocation rules should be treated with caution as it was not robust to changes in the timing of its measurement, to changes in the estimation approach and to changes in the sample restrictions.

1.3 Contributions and Implications

This study makes several contributions. First, it provides the first evidence of the influence of R&D tax incentives provided by countries other than the U.S. on where U.S. multinationals decide to locate their innovative activities. To date, the research on R&D tax incentives has focused mainly on the response of U.S. companies to U.S. tax policies. As discussed by Hines (1994), U.S. policy makers are concerned about the growing amount of innovation offshore, and so my evidence of the positive association between foreign activity and foreign R&D tax incentives provides one reason why firms are moving innovative activities offshore. In addition, the evidence is informative to foreign policy makers who are looking to attract U.S. R&D activities from U.S. MNCs. In particular, a foreign country can increase the R&D activities from U.S. MNCs by increasing its R&D tax credit. To illustrate, suppose the value of R&D tax incentives increased by 0.1 which could occur if Canada, for example, increased their R&D tax credit for foreign-controlled corporations by 15%, from 20% to 35%. If the average foreign value of R&D tax incentives increased by 0.1, U.S. MNCs would increase their foreign patenting activity by 9.4% on average, based on the coefficients estimated below.

Another contribution of this study is that it adds evidence to the conflicting conclusions found in the literature investigating on the effect of the U.S. R&D tax policies. My firm-level evidence supports and extends the country-level findings of Vines and Moore (1996) that the greater the effect of U.S. R&D allocation rules, the greater the foreign R&D activity. My evidence conflicts with the firm-level evidence provided by Hines and Jaffe (2001).

In addition, the study provides the first investigation into the effect of the income shifting incentive on the location decision for R&D. The evidence gives new information on the foreign tax rate a corporation relies on to determine its location for R&D. The results suggest that the firm's average foreign tax rate appears to be important to the location decision while the specific host country's tax rate is not. This study also provides additional evidence to the literature on multi-jurisdictional income shifting that has found the firms in excess foreign tax credit positions shift income into the U.S. by extending it to the location decision for R&D. Finally, this study offers new firm-level evidence on the response of firms in deficit foreign tax credit positions to income shifting incentives. The results suggest that as the foreign tax rate decreases, firms in the deficit foreign tax credit positions move R&D activities to the U.S. This counter-intuitive finding may be explained by viewing royalty payments from the foreign subsidiary to the U.S. parent as flexible. If the royalty is difficult to determine objectively, then the potential for future profit-shifting will increase with domestic R&D activity. The benefit of a flexible royalty increases as the foreign tax rate decreases for firms in a deficit foreign tax credit position. However, further investigation is required.

1.4 Dissertation Outline

The remainder of this dissertation is organized as follows. Chapter 2 provides a description of the previous literature. Chapter 3 discusses background institutional features regarding R&D tax incentives, income shifting incentives and the U.S. tax credit system. These features are incorporated into a model of the location decision for R&D. Using this model, I derive my hypotheses. Chapter 4 and 5 specify the research design and empirical results, respectively. Chapter 6 provides specification checks of the results reported in Chapter 5. Chapter 7 summarizes the conclusions.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This dissertation examines the effect of tax incentives on where U.S. multinationals decide to locate their innovative activities. In this chapter, I review the literature related to the R&D tax incentives in Section 2.2 and the literature on multi-jurisdictional income shifting in Section 2.3. Section 2.4 summarizes the chapter.

2.2 R&D Tax Incentives

Research on R&D tax incentives has primarily investigated the question of whether the tax incentives for R&D are cost-effective since there is little debate over whether the incentives should exist (Klassen et al., 2004). Overall, the evidence suggests that R&D tax incentives increase R&D expenditures. Firm-level studies examining the U.S. tax credit and its impact on R&D spending in the U.S. have found that the credit induces R&D spending of at least a dollar for each dollar of revenue foregone. For example, Berger (1993), Gupta et al. (2004) and Klassen et al. (2004) estimate that the U.S. tax credit induces approximately $1.74, $2.40, and $2.96, respectively of R&D spending per dollar of revenue foregone. Further evidence is provided in a recent study by Brown and Krull (2008) who find that R&D spending is positively related to the R&D tax credit rate and this association is increasing in R&D option exercises.

Firm-level evidence of the cost-effectiveness of R&D tax incentives of countries other than the United States has been limited but generally supports the conclusion that R&D tax incentives increase R&D spending. A survey of the literature on the cost-effectiveness of the R&D incentives by Hall and Van Reenen (2000) finds only 9 research studies using firm-level data to investigate the R&D tax incentives of countries other than the U.S. These studies cover only 5 countries – Australia, Canada, France, Japan, and Sweden – with more than half focusing on the Canadian R&D tax incentive system. For example, Bernstein (1986) estimates a cost effectiveness ratio for the Canadian incentives of between 0.8 and 1.7 using data on 27 firms from 1984. More recently, Klassen et al. (2004), in their study comparing the R&D expenditures in the United States and Canada, find that the Canadian system induces $1.30 of additional R&D spending per dollar of taxes foregone compared to $2.96 by the U.S. system.

Few studies have attempted to compare the effectiveness of R&D tax incentives across countries, mainly because of the difficulty in understanding the details of each system and in determining a comparable measure (Hall and Van Reenen, 2000). These studies have been limited to country-level analysis. Guellec and Van Pottelsberghe (2003) and Falk (2006) study the impact of R&D tax incentives at a country-level for panels of OECD countries over the past two decades using the B-Index methodology developed by Warda (1996). The B-index provides a composite measure of the attractiveness of R&D tax systems across countries. They both find evidence that R&D tax incentives have a significant and positive impact on business R&D spending. Bloom et al. (2002) estimate the user cost of R&D for nine OECD countries over a 19 year period and similarly find that R&D incentives are effective in increasing R&D intensity.

A small number of studies examine how R&D tax incentives alter the decision of where to locate R&D activities and these studies have focused primarily on the U.S. R&D tax policies. The research by Hines (1994), Vines and Moore (1996) and Hines and Jaffe (2001) examine the impact of U.S. R&D tax incentives on the location of R&D activities of U.S. multinationals. Hines (1994) uses data aggregated at the country-level from the U.S. Bureau of Economic Analysis (BEA) to investigate whether U.S. corporations significantly increased the percentage of R&D performed abroad after the passage of TRA86. TRA86 reduced the R&D tax credit from 25% to 20% and introduced the R&D allocation rules, effectively increasing the cost of R&D conducted in the U.S. Based on these changes, U.S. firms were expected to increase the amount of R&D performed abroad. However, Hines found that the percentage of R&D performed abroad stayed approximately the same at 10%. Hines posits that after the passage of TRA86, the cost of R&D increased for some corporations but decreased for other corporations depending on their foreign tax credit positions, resulting in little overall movement of R&D abroad. However, since Hines used aggregated data, he was unable to examine whether U.S. corporations, based on their foreign tax credit positions, responded differently to the changes of TRA86.

Vines and Moore (1996) examine whether the U.S. R&D allocation regulations and the R&D tax credit rules alter the worldwide location of R&D expenditures by U.S. MNCs. Based on data aggregated at the country and industry for 1977, 1982 and 1989, the authors provide evidence that under the allocation rules,[1] industries in excess foreign tax credit positions are more likely to locate R&D offshore than those with deficit foreign tax credit positions. They also find that industries with high R&D growth decreased the percent of foreign-performed R&D in response to the R&D credit introduction in 1981 as the cost of U.S. R&D decreased for these corporations. This evidence suggests that U.S. MNCs move R&D activity abroad if there is an increase in the after-tax cost of domestic R&D created by the U.S. R&D tax policy.

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[1] R&D expenditures were required to be allocated to foreign-source income from 1977 through to 1981. From 1982 through 1986, the allocation regulations were suspended but after 1986, the regulations were again required (Vines and Moore, 1996).

Hines and Jaffe (2001) investigate the effect of the introduction of the R&D allocation rules by TRA86 on the distribution of inventive activity between the United States and foreign countries. Using firm-level data on patenting activities, Hines and Jaffe classify patenting activity as foreign or domestic based on the location of the first inventor listed on the patent. In contrast to Vines and Moore (1996), they find that the level of R&D performed abroad decreased after TRA86 for U.S. MNCs in excess foreign tax credit positions even though the allocation rules increased the after-tax costs of domestic R&D for these firms. Hines and Jaffe argue that this counter-intuitive finding may be because foreign and domestic innovative activities are complements rather than substitutes. Another possibility for the counter-intuitive finding is the lack of control variables included in the analysis other than controlling for the level of foreign sales. Additional country- and firm-level non-tax factors may change the outcome of the results.

In this dissertation, I also use patenting activity to determine the location of R&D activity at a firm-level similar to Hines and Jaffe (2001). But, I examine innovative activity in specific countries to investigate how foreign R&D tax incentives and a foreign country's income tax rate alter the decision on where to locate R&D activities. In addition, I investigate the influence of the R&D allocation rules on the location decision. Hines and Jaffe (2001) consider total foreign activity, not country-specific, and only investigate the effect of the R&D allocation rules on the location decision.

In addition, this dissertation addresses the conflicting evidence provided by Hines (1994), Vines and Moore (1996) and Hines and Jaffe (2001) by providing further firm-level evidence on how U.S. MNCs respond to the U.S. R&D tax policies. This research also expands the investigation to include how R&D tax incentives and corporate income tax rates from foreign countries and other non-tax factors effect where U.S. multinationals locate their R&D activities worldwide.

2.3 Income Shifting Incentives

Multinational corporations can reduce their tax liabilities by shifting income from high to low tax jurisdictions. Existing studies find evidence consistent with this income shifting incentive at both country- and firm-levels. Using 1982 data, Grubert and Mutti (1991) and Hines and Rice (1994) find a negative relationship between profit measures and foreign tax rates using country-level aggregate data on U.S. majority-owned affiliates. The negative relationship is consistent with firms moving income from high-tax rate jurisdictions to low-tax rate jurisdictions. At a firm-level, further evidence of cross-jurisdictional income shifting by U.S. multinationals is provided by several studies. Harris et al. (1993) find that the U.S. tax liability is related to the location of foreign subsidiaries for the period from 1984 to 1988 and the relation is consistent with tax-motivated income shifting. Klassen et al. (1993), Harris (1993) and Jacob (1996) examine U.S. multinationals response to the tax rate reductions of the TRA86. Klassen et al. (1993) find that firms shifted income into the United States with the decrease in the tax rate from 46% to 34% in 1987 but firms shifted income out of the United States in 1988 with the reduction in tax rates in other countries. Harris (1993) also documents shifting into the U.S. after TRA86 with firms that are classified as highly flexible (high levels of interest, R&D, rent, and advertising) reacting more strongly to the income shifting incentives. Jacob (1996) extends Harris (1993) by relating income shifting to the amount of international intrafirm transfers. He finds that firms with large amounts of intrafirm transfers pay lower global taxes than other similar firms both before and after

TRA86, consistent with shifting income through transfer prices to reduce worldwide taxes.

Collins et al. (1998) examine the difference in income shifting activities between firms facing high average foreign tax rates and firms facing low average foreign tax rates. They find evidence that suggests U.S. multinationals with average foreign tax rates that exceed the U.S. tax rate shift income into the Unites States. On the other hand, the income shifting effect is considerably smaller for firms with average foreign tax rates less than the U.S. tax rate. Klassen and Laplante (2008) examine this asymmetric income shifting response. They posit that tax planning for income shifting is a multi-period consideration and so, the income shifting incentive should be measured over multiple periods and not annually as calculated by Collins et al. (1998) among others. Using a multi-period analysis, Klassen and Laplante (2008) find that U.S. multinationals are equally engaged in shifting income into and out of the United States on average. Thus, their study highlights the importance of considering how to measure the income shifting incentive as conclusions may change if the incentive is measured over multiple periods rather than annually.

Rego (2003) and Krull (2004) also provide firm-level evidence consistent with cross-jurisdictional income shifting activities. Rego (2003) finds that firms with more extensive international operations have lower worldwide effective tax rates (ETRs) and lower foreign ETRs, which is consistent with foreign operations improving a company's ability to engage in income shifting. Krull (2004) provides evidence that changes in permanently reinvested foreign earnings are negatively related to the tax benefit of deductible repatriations,[2] suggesting that firms shift income in response to tax incentives.

Several studies investigate the sources of income shifting that provide firms with the greatest opportunities and incentives to shift income. As previously discussed, Harris (1993) finds that firms with flexible expenses (high levels of interest, rent, advertising and R&D) are more likely to engage in income shifting activities. However, the separate role of each of these expenses is not explored. Jacob (1996) provides evidence that income shifting is related to a firm's volume of intrafirm payments. Further studies suggest that tax motivated income shifting is more easily accomplished when intrafirm payments involve difficult-to-value intellectual property and other intangibles. Generally, these intangibles are related to R&D activities (Matthews, 2002; Grubert, 2003; and Mills and Newberry, 2004). Matthews (2002) extends Collins et al. (1998) by examining the response of R&D intensive firms and finds that these firms are more likely to be engaged in income shifting activities, on average, than other firms. Grubert (2003) finds that approximately half of the income that is shifted is related to R&D based intangibles and that R&D intensive firms appear to engage in more intercompany transactions and therefore, are engaged in more income shifting activities. He does not find similar results for firms with intangibles linked to advertising. Mills and Newberry (2004) find that income shifting incentives influence a multinational's U.S. tax reporting but they did not find that firms with intangibles assets were more likely to engage in income shifting than other firms. However, they use the ratio of reported intangible assets to total assets to investigate the role of intangibles associated with R&D activities.

[2] Deductible repatriations include payments of interest, rent, royalties, transfer prices and management fees from the foreign subsidiary to the U.S. parent.

Reported intangibles may consist of mainly purchased goodwill which is unrelated to intangibles such as intellectual property and so, is not a strong proxy for R&D intangibles.

Although there is evidence that firms with R&D activities appear to engage in more income shifting activities, the literature has not yet explored whether the income shifting incentive alters the decision on where firms decide to locate their R&D activities. Previous literature has not provided evidence of the relationship between income shifting incentives and the decision to locate innovative activities as they did not use firm-level data that identified the country-specific location of R&D activities. Financial disclosures of R&D expenditures do not provide specific detail on where R&D expenditures were incurred. Therefore, these studies are unable to determine whether the R&D intensive firms shift income through reporting activities or through tax motivated location choices. Collins et al. (1998) discuss this potential issue by suggesting that their cross-jurisdictional income shifting results for multinationals are also consistent with tax motivated location choices. However, due to data constraints, they are unable to distinguish between the two possibilities. The firm's choice of where to locate high- and low-margin activities may account for the association between R&D expenditures and income shifting incentives found in previous studies if R&D intensive firms are more likely to locate high-margin activities in low-tax jurisdictions and low-margin activities in high-tax jurisdictions. For example, Pfizer Inc., a pharmaceutical company, decided to locate the production of its top-selling drug, Lipitor, in the low tax jurisdiction of Ireland but distribute the drug through subsidiaries in the United States, a higher tax jurisdiction. The production of the drug can be viewed as a high-margin activity while the distribution can be seen as a low-margin activity. Thus, in this situation, there would be an association between income shifting incentives and R&D expenditures since Pfizer is an R&D intensive firm and has higher income reported in a low-tax jurisdiction. This association would result from the decision to locate the high-margin activity in the low-tax jurisdiction.

Several studies have shown that the income shifting incentive is a significant influence on the location decision for certain corporate activities. Kemsley (1998) investigates whether the difference in tax rates and export tax rules have an effect on the MNC's production location choices. He finds evidence that U.S. MNCs respond to the combined tax incentives by making real changes in the location of production. Newberry and Dhaliwal (2001) examine whether tax incentives influence where U.S. MNCs locate their interest deductions worldwide. Their results are consistent with U.S. MNCs locating interest deductions in different tax jurisdictions as a method of achieving tax-motivated income-shifting. Finally, Gruber and Slemrod (1998) and Grubert (2003) analyze how the choice of location for capital investment is influenced by income-shifting incentives. Grubert and Slemrod (1998) focus on U.S. investment in the low-tax country, Puerto Rico and find that the income shifting advantage is the main reason for U.S. investment in that country. Grubert (2003) examines U.S. investments in both high-tax and low-tax countries. Using tax return data for 1996, Grubert finds evidence that R&D-intensive firms respond to opportunities for income shifting by investing in countries with either very high or very low statutory corporate tax rates. Grubert suggests that intangible assets generated from R&D activities aid in shifting income in and out so that a very high or very low statutory rate attracts R&D intensive companies.

In this dissertation, I provide additional evidence on how income shifting incentives influence the location decision for U.S. multinationals. Specifically, I directly examine the relationship between income shifting incentives and where a U.S. multinational decides to locate its R&D activities. Unlike previous studies, I am able to determine the location of R&D activities through the use of data on patents rather than relying on R&D expenditures. The patent database contains very detailed information about patented innovations including the location of the inventor. Data on R&D expenditures does not provide this amount of detail.

2.4 Chapter Summary

Extant literature provides evidence that the domestic R&D spending and the location of that spending is influenced by the home-country R&D tax incentives. I extend this literature by examining how the R&D tax incentives provided in foreign countries alter the location decision. I also add additional evidence of the influence of the U.S. R&D allocation rules and its foreign tax credit system on the placement of R&D activities. The literature on income shifting indicates that firms do shift income to reduce their corporate tax burden and that this incentive does influence the corporate decision on where to locate production, interest deductions and capital investment. I add to this literature by providing evidence of the influence of the income shifting incentive on the location decision for R&D activities.

CHAPTER 3: TAX INCENTIVE INSTITUTIONAL FEATURES AND HYPOTHESIS DEVELOPMENT

3.1 Introduction

In this chapter, I begin with a discussion of the location decision facing U.S. multinationals for their R&D activities in Section 3.2 This discussion is followed by an explanation of the R&D tax incentives and income shifting incentives facing U.S. multinationals and the implications of the U.S. foreign tax credit system on these incentives in Section 3.3. In Section 3.4, I develop a model of the decision on where U.S. multinationals decide to locate their R&D that includes consideration of the tax implications. Using this model, I derive my hypotheses. Section 3.5 provides a summary of the chapter.

3.2 Development of Innovation

Innovations required by foreign subsidiaries to generate foreign sales can be provided to the foreign subsidiaries of multinationals using two basic methods: either the technology can be developed by R&D activities of the foreign subsidiary or the technology can be developed domestically and exported to the foreign country. According to American tax law and the tax laws of many other countries, the foreign subsidiary is required to pay royalties to the parent based on the fair market value of the technology provided by the U.S. parent (Hines, 1995).

Based on data collected by the U.S. Department of Commerce (2001) on the R&D and royalty activities of majority-owned foreign affiliates of U.S. multinationals, U.S. multinationals use both methods to provide innovations to their foreign subsidiaries. In 1999, majority-owned foreign affiliates spent $18 billion on R&D activities and paid $25 billion in royalties to U.S. parents. The information on the R&D activities of foreign affiliates is collected directly, but information on technology exports to foreign affiliates must be inferred by the royalty payments paid by the foreign affiliate. Royalty payments should, theoretically, represent the value of exported technologies used (Hines, 1995).

Firms must consider a variety of factors in their decision on where to develop their innovations. Nontax factors include the availability of skilled workers, the legal environment such as patent protection laws and enforcement, proximity to customers, and the innovative environment of the country. In addition, tax policies can be an important consideration in the decision process. By engaging in the global environment, a U.S. MNC faces not only the U.S. tax policies but also the policies of the foreign countries that they enter. The following section outlines the potential tax policies and incentives facing a U.S. MNC.

3.3 Tax Incentives

3.3.1 R&D Tax Incentives

Investment in R&D has "always been extremely important to the economic well-being of a country, resulting in the creation of new products, high-paying jobs, and high-value exports" (Rashkin, 2007). Consequently, to encourage and promote investment in R&D within their borders, many governments offer very attractive tax incentives relating to R&D. For example, Canada provides a 20% tax credit for every dollar of qualified expenditures in R&D plus tax credits provided by the provinces. As discussed in Warda (2002), tax incentives for R&D generally take three forms: tax credits, special allowances deducted from taxable income, and tax deferrals. Both tax credits and allowances reduce the amount of tax owed by a corporation but tax credits are applied directly against tax owed while allowances are additional deductions over current business expenses that reduce the taxable income of the corporation, which also lowers the amount of tax owed. Tax deferrals refer to incentives that delay the payment of tax such as accelerated deprecation rates and current deduction of R&D expenses. The majority of countries have R&D incentives that allow firms to immediately deduct their R&D expenses against their taxable income. In addition, many countries provide additional credits and/or allowances as shown in Table 1. In 1999-2000, of the OECD countries included in Table 1, Canada, France, Italy, Japan, Korea, Mexico, Netherlands, Portugal, Spain and United States provide special tax credits. Special allowances are provided by Australia, Austria, Belgium, Denmark and Ireland. As a result, fifteen out of the 21 OECD countries included in Table 1 provide special tax credits or allowances for R&D activities.

3.3.2 Income Shifting Incentives

Differences between U.S. and foreign tax rates create incentives for U.S. MNCs to shift income out of high-tax jurisdictions into low-tax jurisdictions. Firms can use this geographic income shifting as a planning method to minimize their taxes. From 1999 to 2002, U.S. multinationals have increased profits by 68 percent from foreign countries with low or no corporate income tax rates while total foreign profits earned by U.S. multinationals has increased by only 23 percent (Sullivan, 2004).

Tax-motivated income shifting can be more easily accomplished when difficult-to-value intangibles are involved. All intrafirm transactions are subject to transfer pricing rules as required by American tax law and the tax laws of most other countries. These rules specify that intrafirm transactions are to be at arm’s length prices. However, finding valid arm's length transactions that are comparable for intangibles related to R&D activities can be very difficult (Grubert, 2003). Thus, paying royalties for the use of innovations is one method of facilitating income shifting. For example, Merck & Co., one of the largest pharmaceutical corporations in the United States, reduced its U.S. tax liabilities by approximately $1.5 billion over 10 years by transferring patents related to two of its highly successful drugs to Bermuda, a tax haven, and paying the Bermuda subsidiary for the use of the patents (Drucker, 2006). However, the Internal Revenue Service (IRS) challenged this arrangement in 2006 and Merck paid $2.3 billion in back taxes, interest and penalties as a settlement (Drucker, 2007).

The income shifting incentives facing a U.S. multinational must also be considered with the U.S. foreign tax credit system. As discussed in the next section, the foreign tax credit system can alter the income shifting incentive.

3.3.3 Foreign Tax Credit System and Related Incentives

For the description of the U.S. foreign tax credit system and the related incentives, I use the following information throughout the discussion as a simple illustration of the tax rules. The details and related calculations used in the illustrations are summarized in Table 2. Consider a U.S. multinational that has U.S. income of $1,000 and foreign income of $600 repatriated to the U.S. for a total worldwide income of $1,600. The U.S. income includes $200 of R&D expenditures and a $100 royalty payment received from a foreign subsidiary. In addition, U.S. sales are $4,000 while foreign sales are $1,000. Assume that the U.S. tax rate is 35%. For the example, the U.S. multinational is in two possible situations; first, the firm faces an average foreign tax rate of 20% and second, the firm faces an average foreign tax rate of 50%.

3.3.3.1 Foreign Tax Credit System [3]

The U.S. tax law imposes taxes on the worldwide income of U.S. corporations regardless of where it is earned. Taxable worldwide income includes income from U.S. sources and income from its foreign subsidiaries only when repatriated (in the form of dividends).[4] Since both the U.S. and the host foreign countries may tax the same foreign-source income, the U.S. tax law provides a foreign tax credit for income taxes paid to foreign governments. Thus, the worldwide tax liability for a U.S. multinational is:

$$\text{Worldwide Tax Liability} = \text{Net U.S. Tax on Worldwide Income} + \text{Foreign Income Taxes}$$

where the net U.S. tax on Worldwide Income is:

$$\text{Net U.S. Tax on Worldwide Income} = \text{Gross U.S. Tax on Worldwide Income} - \text{Foreign Tax Credit}$$

The foreign tax credits can be applied against U.S. income tax liabilities but the U.S. tax law imposes limitations on the extent the foreign tax credits can reduce the U.S. tax liabilities. This foreign tax credit limitation is calculated as:

$$\text{Foreign Tax Credit Limitation} = \frac{\text{Foreign-source Income}}{\text{Worldwide Income}} * \text{Gross U.S. Tax on Worldwide Income}$$

If the U.S. tax rate is t_{US}, then the gross U.S. tax on worldwide income is t_{US} * Worldwide income. Thus, the foreign tax credit limitation generally simplifies to: [5]

$$\text{Foreign Tax Credit Limitation} = \text{Foreign-source Income} * t_{US}$$

[3] Description of the U.S. foreign tax credit system follow explanations provided by Scholes et al. (2005).
[4] Taxable worldwide income also includes income from foreign branch profits. In addition, Subpart F rules cause the passive income of subsidiaries to be taxed as earned. However, these profits are not considered as part of the model developed in Section 3.4.
[5] If the multinational has domestic losses so that the foreign-source income is greater than worldwide income, the United States requires that the ratio of foreign-source income to worldwide income be restricted to one. Thus, in this situation, the foreign tax credit limitation is restricted to the U.S. tax on worldwide income.

As a result, the foreign tax credit is calculated as:

Foreign Tax Credit = min(Foreign Taxes Paid, t_{us} * Foreign-Source Income)

To illustrate, consider the U.S. multinational described above. For a firm facing the foreign tax rate equal to 20%, the firm owes $560 in gross U.S. taxes before foreign tax credits on its worldwide income and $120 of foreign taxes as seen in column (1) of Table 2. The foreign tax credit, assuming at this point that the foreign-source income and the foreign income on which foreign taxes have been paid are the same, is:

Foreign Tax Credit = min[$120 (Foreign Taxes), $210 (35% * Foreign-Source Income)]

Therefore, the foreign tax credit is $120 so that net U.S. tax owing is $440 for a worldwide tax liability of $560. In this situation, U.S. MNCs are said to be in a "deficit-of-credit" position, or referred to as a deficit foreign tax credit position. Although they receive a full credit for every dollar of foreign taxes paid, they still owe net U.S. tax on the foreign source income. The net U.S. tax will be the difference between the U.S. tax rate (35%) and the foreign tax rate (20%) multiplied by the foreign-source income, or $90.

Now, suppose instead that the U.S. multinational faces an average foreign tax rate of 50%. In this case, the gross U.S. tax before the foreign tax credit remains at $560 but the foreign tax credit is now $210 as seen in column (2) of Table 2. The foreign tax credit is the minimum of $300 of foreign taxes and $210 of U.S. tax on the foreign-source income. The U.S. tax on the foreign income is fully offset by the $210 foreign tax credit. But, the foreign tax credit limitation only allowed the credit to increase by $90, although the increase in the foreign tax rate increases foreign taxes by $180. Thus, the firm is said to be in an "excess" foreign tax credit position because it can only apply a partial credit for the foreign taxes paid. The excess foreign taxes of $90 are eligible for carryover provisions.

An important feature of the U.S. tax system is the deferral of U.S. taxation on certain foreign earnings. A subsidiary's foreign income is taxed initially in the foreign country where it is reported, but it is only taxable in the U.S. when that foreign income is repatriated to the United States. This may appear to create an incentive for corporations with foreign earnings taxed at a low rate (i.e. in a deficit foreign tax credit position) to reinvest abroad and delay repatriating income from their foreign subsidiaries. Referring back to the example, the firm in a deficit position paid $90 in U.S. tax on its foreign earnings on repatriation. This $90 of U.S. tax could be deferred if the repatriation of the foreign earnings is delayed. However, the firm in an excess foreign tax credit position does not pay any additional U.S. tax on the foreign earnings, and so does not benefit from any deferral. Therefore, reinvesting the foreign earnings abroad defers the U.S. tax on repatriation if the firm is in a deficit foreign tax credit position but as outlined by Scholes et al. (2005), "this benefit is offset by the fact that reinvesting causes the deferred taxes to grow in direct proportion to the growth of the investment" (p. 306). Then, as initially shown by Hartman (1985), if the domestic and foreign pre-tax returns are similar, the present value of U.S. tax payments on deferring repatriation is not reduced.

3.3.3.2 U.S. R&D Allocation Rules[6]

The current U.S. tax law allows for an immediate deduction of R&D expenditures that otherwise might be capitalized. However, for the foreign tax credit calculations only, the U.S. tax law prevents U.S. corporations with foreign income from deducting all of

[6] Description of the U.S. R&D allocation rules follows explanations provided by Hines and Jaffe. (2001) and Hines (1998).

their U.S. R&D expenditures against their U.S.-source income. Instead, U.S. tax law requires the R&D expenditures to be allocated between domestic- and foreign-source incomes through a couple of specified methods outline in Appendix A. As discussed by Hines and Jaffe (2001), the purpose of the allocation rules is to maintain the relatively generous treatment of R&D, but only for that part of a firm's R&D expenditures that is necessary to generate sales in the domestic markets. At least some of the R&D activities of firms with foreign sales and foreign income are presumed to enhance foreign profitability. Further technical details on the application of the R&D allocation rules, refer to Appendix A.

For taxpaying firms, the allocation of the R&D expenditures between foreign and domestic income for the foreign tax credit calculation may potentially be quite important. For the purposes of U.S. foreign tax credit purposes only, R&D expenditures that are deemed to be foreign reduce foreign taxable income. Foreign governments are not obligated to use the allocation methods used by the U.S., and so generally do not allow U.S. corporations to reduce their taxable income in foreign countries on the basis of R&D undertaken in the U.S. As a result, an R&D expenditure allocated against foreign-source income only benefits the firm if the firm pays U.S. tax on the foreign-source income. If the firm is in a deficit foreign tax credit position, then the firm pays some U.S. tax on its foreign income, and so any R&D deductions allocated against foreign income reduces the firm's U.S. tax owing on the foreign income. Therefore, allocating R&D expenses between foreign-source and domestic-source income does not change the net U.S. tax owing for firms in a deficit foreign tax credit position and so these firms are indifferent to the allocation rules. However, if a firm is in an excess foreign tax credit position, the

R&D allocation rules can increase the amount of net U.S. tax owing since the allocation rules decrease the foreign tax credit limitation. Foreign tax credits applied by firms in excess foreign tax credit positions are constrained to the foreign tax credit limitation.

To illustrate how the U.S. allocation rules influence the amount of worldwide taxes owing, column (3) and (4) of Table 2 incorporates the $200 in domestic R&D expenditures included in the U.S. Income for the example U.S. multinational into the foreign tax credit calculation. Under the allocation rules, $20 of the $200 in R&D expenditures is allocated to the foreign-source income for the foreign tax credit calculations only.[7] Now, the foreign-source income for the foreign tax credit is $580 so that the foreign tax credit cannot be greater than $203 as seen in column (3) and (4) Table 2. In column (3) where the firm faces a foreign tax rate of 20% (i.e. a deficit foreign tax credit position), the worldwide tax liability of $560 for the U.S. multinational has not changed with the allocation rules since the minimum for the foreign tax credit remains the foreign taxes paid of $120. On the other hand, in column (4) where the average foreign tax rate is 50% (i.e. an excess FTC position), the worldwide tax liability has now increased to $657. In this case, in comparison to no allocation rules, the allocation of R&D expenditures to foreign-source income reduced the applicable foreign tax credit by $7 (35%*20) from $210 to $203 and so, the net U.S. tax liability increased by $7. This demonstrates that the allocation of domestic R&D expenditures can actually increase the amount of net U.S. tax owing.

[7] Based on the allocation method based on sales described in Appendix A, the allocation is determined as 50% * foreign sales/worldwide sales * R&D expenditures or 50%*20%*$200.

3.3.3.3 Taxation of Royalty Receipts

For U.S. foreign tax credit purposes only, royalty income received by a U.S. MNC from a foreign subsidiary is deemed to be foreign-source income of the MNC. For this reason, foreign tax credits can be applied against the gross U.S. tax owing on the royalty receipts even though no foreign tax has been paid on that royalty. U.S. MNCs with deficit foreign tax credits must pay net U.S. income tax on these royalty receipts as the MNCs do not have unused credits available to offset the net U.S. tax owing. Turning back to the example, consider the $100 in royalty payments from the foreign subsidiary to the U.S. parent included in the U.S. income for the example U.S. multinational as seen in column (5) and (6) of Table 2. In both cases, the foreign source income is now adjusted to include the $100 royalty payment for a total of $680 so that the foreign tax credit limitation is now $238. As seen in column (5) of Table 2 , where the average foreign tax rate is 20%, once again, the worldwide tax liability remains at $560.

In contrast, multinationals with excess foreign tax credits can apply excess credits against U.S. taxes due on the royalties, essentially eliminating the U.S. tax liability generated by the royalty receipts. Thus, even if its foreign subsidiary faces a lower foreign tax rate, the multinational with excess foreign tax credits may choose to shift income into the U.S. using royalties. This is evident by considering the change in taxes owing on the firm when it faces the average foreign tax rate of 50% in the example. Comparing column (4) and (6) of Table 2, the foreign tax credit increases from $203 to $238 and the worldwide tax liability decreases from $657 to $622. Thus, the worldwide tax liability is reduced by the net U.S. tax on the royalty of $35 since the royalty receipt was deemed to be foreign-source and the firm was in an excess foreign tax credit position.

3.3.3.4 Summary of Foreign Tax Credit Rules

In summary, the U.S. foreign tax credit rules add complexity to how taxes influence the decisions of multinational corporations. For firms in deficit foreign tax credit positions, the R&D allocation rules and the treatment of royalty payments paid from foreign subsidiaries to U.S. parents do not change the amount of net U.S. tax owing. However, if a firm is in an excess foreign tax credit position, the R&D allocation rules can increase the amount of net U.S. tax owing while the treatment of royalties can decrease the amount of net U.S. tax owing. The R&D allocation rules and treatment of royalties have implications for multinationals that decide to have domestic R&D activities.

3.4 Framework for Analysis and Hypothesis Development

I develop a simple model to explain the location decision for R&D activities and incorporate the tax implications described above. From this model, I derive the hypotheses to be tested.

First, consider a U.S. multinational corporation with established operations in a foreign subsidiary. Part of the foreign subsidiary's operations includes income generated from some innovative output.[8] The R&D activities required to produce the future innovative output can either be performed by the foreign subsidiary or the U.S. parent corporation. The source of the financing required to perform the R&D activities in either

[8] Following Hines and Jaffe (2001), I assume that firms are able to determine the ultimate location of the uses of their innovative output at the time they perform the initial R&D.

location is independent of the decision of where to locate the R&D so it is ignored throughout the analysis. In addition, I assume that taxable revenue and cash flow from the innovation is equal. If the R&D activities are performed by the foreign subsidiary, the expected present value of after-tax profits per $1 of foreign R&D investment, π_{Abroad} is as follows:

$$\pi_{Abroad} = CF(1 - t_F^*) - (1 - RDI_F) \quad (1)$$

CF is the expected present value of innovation-related cash flows generated by the foreign subsidiary. The expected present value of the foreign tax incentives available for the R&D activities are reflected in RDI_F so that $(1 - RDI_F)$ is the foreign after-tax cost of $1 of expenditure on R&D.

The income of the foreign subsidiary is first taxed by the foreign government at the foreign statutory corporate tax rate (t_F) when the income is earned. However, the foreign income is also potentially subject to U.S. tax when the foreign earnings are repatriated to the parent in the form of the dividend. Thus, the "effective" foreign tax rate, t_F^*, reflects the potential impact of the repatriation decision by the U.S. multinational. As a simplifying assumption, firms are assumed to repatriate their foreign earnings immediately. Further discussion on the effects of the repatriation decision is discussed below.

The R&D activities of a foreign subsidiary could also be used to enhance the sales of the domestic U.S. parent. However, U.S. multinationals perform the majority of their R&D in the United States. In 2005, R&D conducted by U.S. parents accounted for 86 percent of worldwide expenditures by U.S. multinationals (Mataloni, 2007). As discussed by Hufbauer (1992), one reason for the relatively small amount of R&D

performed abroad is that U.S. multinationals prefer to conduct the majority of their R&D close to home, also referred to as the "headquarters effect." Thus, R&D directed at the U.S. market by U.S. multinationals is likely performed in the U.S. in most cases. There is also a very strong tax reason for why U.S. multinationals perform little R&D abroad for use in the U.S. market. As described by Hines (1994), one of the difficulties faced by U.S. multinationals in such situations is that the royalty payment required from the U.S. parent to the foreign subsidiary will essentially be taxed twice. Under Subpart F income rules, the royalty income received by the foreign subsidiary will be immediately taxable in the U.S. rather than taxable on repatriation into the U.S. The royalty income will be deemed US source for US tax purposes and therefore, the foreign tax credits from the foreign tax paid will not be applicable against the US tax liability. As a result, the U.S. MNC will pay both full U.S. and foreign tax on the royalty income, a very expensive endeavor. For these reasons, the analysis does not consider that the R&D performed by the foreign subsidiary could be exploited in the U.S.

The alternative to having the R&D activities performed in the foreign country is to develop the innovations domestically. If the U.S parent develops the innovations, U.S tax law and most foreign tax laws effectively require the foreign subsidiary to pay rents or royalties to the parent for the fair market value of innovations used by the foreign subsidiary. As a result, the foreign subsidiary's cash flows related to the innovation will be the difference between the gross profit generated from the innovation in the foreign market and royalty payments made to the parent corporation while the parent firm will have royalty receipts from the foreign subsidiary less the costs of developing the innovation. The multinational corporation that generates the innovations domestically and then provides the innovations to the foreign subsidiary has the expected present value of after-tax profits, $\pi_{Domestic}$:[9]

$$\pi_{Domestic}=[CF - R](1 - t_F^*) + R(1 - t_{US}) - [1 - RDI_{US}] + z[R - ALLOC]t_{US} \qquad (2)$$

In equation (2), R is the expected present value of royalties that the subsidiary is required to pay to the U.S. parent corporation for use of the parent's innovations; and t_{US} is the domestic tax rate. The expected present value of the U.S. tax incentives available for the R&D activities is captured by RDI_{US}. *ALLOC* is the fraction of the domestic R&D expenditures to be deducted against foreign source income for foreign tax credit tax purposes. Finally, z is an indicator variable that is equal to one if the firm is in an excess foreign tax credit position and is equal to zero if the firms is in a deficit foreign tax credit position.

The final expression, $z[R - ALLOC]t_{US}$, in equation (2) represents the effects of the foreign tax credit position on the expected profit of the firm. The foreign tax credit position is important as it influences the effect of U.S. taxes on royalties and the U.S. R&D allocation rules. For purposes of this analysis, the foreign tax credit position is treated as exogenous and so, the two possible conditions, excess and deficit, are separately considered here.

First, I consider the implications for firms in excess foreign tax credit positions (i.e. $z = 1$). Recall that royalty income received by the U.S. parent will be classified as foreign-source income for the foreign tax credit calculation. As a result, the U.S. tax on royalty receipts is offset by the increase in the foreign tax credit if the firm is in an excess foreign tax credit position. Thus, royalty income for such firms is effectively untaxed.

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[9] The model assumes that the cost of an R&D input to produce an innovative activity is similar across countries. In the empirical model, I control for difference in costs to the extent that this is not true.

However, these firms are also influenced by the U.S. allocation rules. As discussed previously, firms are required to allocate domestic R&D expenditures between U.S.-source and foreign-source income for purposes of the foreign tax credit calculations. A firm in the excess foreign tax credit position does not pay U.S. tax on the foreign income and so a reduction in foreign income through the R&D expenditure allocation does not provide a tax benefit to the firm. Therefore, the allocation rules reduce the benefit of R&D deductions for these firms. Based on this discussion, equation (2) for firms in the excess foreign tax credit position (z = 1), can be reduced to the following:

$$\pi_{Domestic\text{-}Excess} = (CF - R)(1 - t_F^*) + R - (1 - RDI_{US}) - (ALLOC)(t_{US}) \qquad (3)$$

The multinational corporation can decide where to locate innovative activities by simply comparing the after-tax profits from the two alternatives [$\pi_{Abroad} - \pi_{Domestic\text{-}Excess}$ or $\Delta\pi_{Excess}$].[10] If this difference is greater than zero, the multinational will locate R&D activities in the foreign location to maximize technology-related profits and if the difference is less than zero, the multinational will locate R&D activities domestically. Thus, in the first situation where z = 1, subtracting (3) from (1):

$$\Delta\pi_{Excess} = [CF(1 - t_F^*) - (1 - RDI_F)] - [(CF - R)(1 - t_F^*) + R - (1 - RDI_{US}) - (ALLOC)(t_{US})]$$

$$= R(1 - t_F^*) - R - (1 - RDI_F) + (1 - RDI_{US}) + (ALLOC)(t_{US})$$

$$= R(-t_F^*) + (RDI_F - RDI_{US}) + (ALLOC)(t_{US}) \qquad (4)$$

[10] The model assumes that the choice of location is between the U.S. and one foreign country. In reality, the U.S. multinational may consider more than one foreign country in their decision. In this case, they can compare the potential after-tax profits from the foreign countries to determine the optimal foreign country to locate R&D activities. For example, if the U.S. multinational was considering placing R&D activities in either Canada or Mexico, they can compare $\pi_{CAN} = CF(1 - t_{CAN}) - (1 - RDI_{CAN})$ and $\pi_{MEX} = CF(1 - t_{MEX}) - (1 - RDI_{MEX})$ so that the additional optimality condition is $\pi_{CAN} - \pi_{MEX} = CF(t_{MEX} - t_{CAN}) + (RDI_{CAN} - RDI_{MEX})$. Thus, introducing more than one foreign country just adds to the conditions.

The U.S. tax rate (t_{US}) and the U.S. R&D tax incentives (RDI_{US}) have minimal changes during the time period from 1986 to 2000 investigated in this study. For this reason, t_{US} and RDI_{US} are not included as part of the hypotheses developed below.

Equation (4) shows that a U.S. multinational's decision on where to locate innovative activities can be influenced by several factors. Clearly, the R&D tax incentives available in the foreign country and in the U.S. (i.e. RDI_F - RDI_{US}) impact where the U.S. multinational will locate R&D activities. If the foreign country provides more generous R&D tax incentives than the U.S. (i.e. $RDI_F > RDI_{US}$), the multinational has the incentive to locate the R&D activities in the foreign country. Therefore, I hypothesize the following:

> HYPOTHESIS 1a: For firms in excess foreign tax credit positions, the greater the foreign R&D tax incentives (RDI_F), the more U.S. multinationals locate innovative activities in the foreign location, ceteris paribus.

The U.S. allocation rules for domestic R&D expenditures are represented by *ALLOC* in equation (4). For firms in an excess foreign tax credit position, the allocation rules increases the cost of R&D activities located in the U.S. for use abroad. The allocation rules reduce foreign source earnings, leading to less U.S. tax allocated to foreign earnings for the foreign tax credit calculation. This adjustment is only costly to the firm if U.S. tax on foreign earnings is constraining; e.g. when foreign tax rates exceed the U.S. tax rate. With the increase in cost of domestic R&D activities, the U.S. multinational has an incentive to locate the activities in the foreign country. Thus, my second hypothesis, stated in the alternative is:

> HYPOTHESIS 2: For firms in excess foreign tax credit positions, the greater the effect of the U.S. allocation rules (*ALLOC*), the more U.S. multinationals locate innovative activities in the foreign location, ceteris paribus.

The incentive to shift income to the foreign jurisdiction is represented by the first term, $R(-t_F^*)$, in equation (4). For firms in an excess foreign tax credit position, repatriation does not trigger any additional U.S. taxes and so the "effective" foreign tax rate (t_F^*) in equation (4) is approximately equal to the statutory foreign tax rate, t_F.[11] Therefore, U.S. multinationals have greater incentives to shift income into the U.S. to reduce the worldwide tax burden as the foreign tax rate increases. This leads to the third hypothesis, stated in the alternative:

> HYPOTHESIS 3: For firms in excess foreign tax credit positions, the greater the foreign tax rate for U.S. multinationals (t_F), the less U.S. multinationals innovate in the foreign country, ceteris paribus.

For the remaining discussion, I consider the implications for firms in a deficit foreign tax credit position, (i.e. $z = 0$) in the final expression, $z[R - ALLOC]t_{US}$, of equation (2). Firms in this position receive a foreign tax credit equal to all foreign taxes paid. Thus, such a firm will owe U.S. taxes on the royalty receipts even though they are considered to be foreign earnings for the foreign tax credit calculation. But, the U.S. taxes owed by these firms also will not be altered by the allocation rules represented by *ALLOC*. Therefore, when $z = 0$, equation (2) will be:

$$\pi_{Domestic\text{-}Deficit} = (CF - R)(1 - t_F^*) + (R)(1 - t_{US}) - (1 - RDI_{US}) \qquad (5)$$

Comparing the after-tax profits from performing the R&D activities in a foreign location or domestically ($\pi_{Abroad} - \pi_{Domestic\text{-}Deficit}$ or $\Delta\pi_{Deficit}$) by subtracting (5) from (1), results in the following:

$$\Delta\pi_{Deficit} = [CF(1 - t_F^*) - (1 - RDI_F)] - [(CF - R)(1 - t_F^*) + R(1 - t_{US}) - (1 - RDI_{US})]$$

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[11] As a simplifying assumption, I assume immediate repatriation of foreign earnings. If the foreign earnings are never repatriated, the effective foreign tax rate, t_F^*, remains the foreign tax rate, t_F. Thus, Hypothesis 3 does not change by relaxing the repatriation assumption.

$$= R(t_{US} - t_F^*) - (1 - RDI_F) + (1 - RDI_{US})$$

$$= R(t_{US} - t_F^*) + (RDI_F - RDI_{US}) \qquad (6)$$

If equation (6) is greater than zero, then the U.S. multinational will prefer to locate R&D activities in the foreign country. But if the equation is less than zero, the U.S. multinational will prefer to locate in the United States.

Based on equation (6), the decision on where to locate R&D activities is influenced by the R&D tax incentives and income shifting incentives for firms in a deficit FTC position. Similar to firms in an excess FTC position, the R&D tax incentives available in the foreign country, relative to that in the U.S. can alter a U.S. multinationals' decision on where to locate R&D activities. As a result, Hypothesis 1b mirrors Hypothesis 1a for firms in deficit foreign tax credit positions:

> HYPOTHESIS 1b: For firms in deficit foreign tax credit positions, the greater the foreign R&D tax incentives (RDI_F), the more U.S. multinationals locate innovative activities in the foreign location, ceteris paribus.

In testing, hypotheses 1a and 1b are tested together.

The incentive to shift income to a foreign jurisdiction is represented by $R(t_{US} - t_F^*)$ for firms in a deficit foreign tax credit position. This expression is altered by the U.S. taxes required on repatriation. The repatriated earnings will effectively bear U.S. tax on the difference between the foreign tax rates and the U.S. tax rate. In this case, the effective foreign tax rate, t_F^* may approach the U.S. tax rate, t_{US}. Thus, the $t_{US} - t_F^*$ from equation (6) while positive, may be approximately zero. So I predict that the equation (6) and hence, the decision to locate R&D activities in a foreign location, is unrelated to the statutory foreign corporate tax rate.[12] Even though I don't expect to reject the null based on this analysis, my fourth hypothesis, stated in the alternative form is:

> HYPOTHESIS 4: For firms in deficit foreign tax credit positions, a U.S. multinational's decision on where to locate R&D activities is related to the foreign tax rate (t_F), ceteris paribus.

3.5 Chapter Summary

U.S. multinationals may decide to locate their R&D activities either domestically in the United States or in a foreign location. This decision may be influenced by a variety of factors including tax incentives related to R&D and income shifting. However, it is important to consider the effect of the U.S. foreign tax credit system on these incentives. Under the U.S. foreign tax credit system, U.S. multinationals with excess foreign tax credits may be able to eliminate U.S. taxes owing on royalty receipts by applying their excess foreign tax credits against the U.S. tax owing on the receipts. But, they may not be able to fully realize the benefit of their U.S. R&D expenditures under the allocation rules. In contrast, the tax treatment of royalties or the allocation rules for domestic R&D deductions do not alter the taxes owing for multinationals in deficit foreign tax credit positions.

I develop a model of the location decision for innovative activities and incorporate the tax incentives and U.S. tax system described in this chapter. Based on this model, I hypothesize that the foreign R&D activity of domestic U.S. multinationals is influenced by the R&D tax incentives provided by the foreign country. In addition, the

[12] If the foreign earnings are reinvested and repatriated sometime in the future rather than immediately, the effective foreign tax rate will still approach the U.S. tax rate. As initially discussed by Hartman (1985), for firms in a deficit position, reinvesting abroad defers the tax on repatriation but the benefit of the deferral is offset by the increase in the future repatriation taxes on the growth of the reinvestment abroad. Based on the present value analysis by Scholes et al. (2005), there is little or no benefit to deferring repatriation from a low-tax rate foreign jurisdiction if the after-tax foreign rate of return is the same as the after-tax domestic rate of return.

U.S. R&D allocation rules may alter this location decision. Finally, I hypothesize that a firm's decision to where to locate R&D activities is negatively related to the foreign corporate tax rate if the firm is in an excess foreign tax credit position. However, a firm in a deficit foreign tax credit position will not be influenced by the income shifting incentive.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

This chapter describes the research design and sample used to test the hypotheses developed in Chapter 3. I begin with a description of how I determine where firms locate their innovative activities using patents in Section 4.2. Section 4.3 describes the empirical model and Section 4.4 describes the sample used to test the hypotheses. Section 4.5 concludes.

4.2 Measure of Innovative Activities

Testing the hypotheses developed in the previous chapter requires an observable measure of where U.S. MNCs are performing their innovative activities. A common proxy for R&D activities in firm-level studies has been R&D expenditures reported in the financial statements. However, reported R&D expenditures do not specify where the expenditures were incurred as firms are not required to provide specific detail on the location of the expenditures. Following Hines and Jaffe (2001), I use data on patents as an alternative proxy for innovative activities. According to Hall et al. (2005), economic literature has viewed patents as a very rich source of data for the study of innovation and technological change for a very long time. However, using patents as an indication of innovation does have some drawbacks as discussed by Griliches (1990) and Hall et al. (2005) who point out that "not all inventions are patentable, not all inventions are patented and the inventions that are patented differ greatly in quality, in the magnitude of output associated with them" (p.1669). Before estimating the empirical model, I verify the strong relationship between R&D activities and patenting in Section 5.2.

I obtain data on patenting activities from the United States Patent and Trademark Office (USPTO). The patent database created by the National Bureau of Economic Research (NBER) and Case Western Reserve University [13] contains detailed information about patents granted by the USPTO including technological classification of the patents, the inventors, the geographic location of the inventors, corporate assignee (if any) to whom the patent rights are transferred by the inventors, citations between patents, etc. This database has been linked to Compustat based on the assigned corporation.

The patent information allows me to identify the location of innovative activities based on the geographic location of inventors specified on each patent. [14] Based on these locations, I can determine the number of patents granted to each country for each firm. Thus, I calculate the dependent variable, *PATENT%*, as the yearly percentage of patents granted to a particular country for each firm as follows:

$$PATENT\%_{i,j,t} = \frac{\text{\# of patents granted to firm } i \text{ in country } j \text{ in year } t}{\text{total \# of patents granted to all countries for firm } i \text{ in year } t}$$

A patent may potentially list multiple inventors from multiple locations. If a patent lists multiple inventors from one particular country, the patent is only counted as one. For example, a patent listing three inventors who are all from Canada will be counted as one patent from Canada. Another possibility is a patent listing inventors from multiple jurisdictions. In this case, the patent is counted as a fraction of a patent granted to a foreign country. For example, if a patent has inventors from both Canada and the United States, the patent is counted as ½ Canadian. The number of patents that have

[13] For a detailed description of the database, see Hall et al. (2001).
[14] The locations of inventors identified on the patent applications are domestic residences and not citizenships or nationalities (Hines and Jaffe, 2001).

inventors from multiple countries is fairly small as approximately 97% of the patents included in my analysis have inventors listed from one country.[15]

My analysis includes only those patents that have been assigned to a corporation at the time of application. Patents must be taken out by the individual or individuals who created the invention. Thereafter, the title or right to a patent can be transferred or assigned to third party such as a firm, a person, a government organization, university, etc. The first assignment of a patent usually takes place within the firm at which the inventor is employed. Labor contracts generally specify that employees must assign the rights of their inventions to the firm or organization in which they work (Serrano, 2006). Approximately 78 per cent of all patents are assigned at the time of patent application to a corporation (Hall et al., 2001).

Each patent contains two dates; the date the inventor filed for the patent and the date the patent was granted. Clearly, the patented invention would be completed closer to the application date rather than to the grant date. Inventors have a strong incentive to apply for a patent as soon as possible following the completion of an innovation, whereas the grant date depends upon the review process at the Patent Office, which takes on average about 2 years (Hall et al., 2001). Consequently, patents are allocated to a particular year based on the application date of a patent.

Another important consideration for this study is the timing of the decision on where to locate the R&D activities and the related patenting activities. Hall et al. (1986) find evidence suggesting that the bulk of the relationship between R&D expenditures and patent activity is close to contemporaneous. Significant lag effects are also found but are

[15] Jaffe et al. (1993) report similar statistics in their investigation of the extent of geographic dispersion among inventors.

relatively small and not well estimated. Based on these findings, I measure the country-level and firm-level factors effecting the decision on where to locate innovative activities contemporaneously. In supplemental analysis, I also estimate the empirical model described below using one-year and two-year lags to explore how using lags of the variables may change the conclusions.

4.3 Empirical Model

To explore the firm and country-level characteristics that may have an effect on the percentage of innovative activities that a U.S. MNCs undertakes in a particular foreign country, I estimate the following model:

$$PATENT\%_{i,j,t} = \beta_0 + \beta_1 RDI_{j,t} + \beta_2 ALLOC_{i,t} + \beta_3 FTR_{i,t} + \beta_4 FTC_{i,t} + \beta_5 FTR_{i,t}{*}FTC_{i,t} + \beta_6 I\_Index_{j,t} + \beta_7 RDWage_{j,t} + \beta_8 FSR_{i,t} + \beta_9 Q_{i,t} + \beta_{10} ROA_{i,t} + \beta_{11} CITES_{i,t} + \beta_{12} InvMills_{i,t} + \sum \beta_{13} YEAR_t + \sum \beta_{14} IND_i + \varepsilon_{i,j,t} \quad (7)$$

where:

$PATENT\%_{i,j,t}$	=	the number of patents granted to a foreign country *j* for firm *i* in year *t* divided by the total number of patents granted to all countries for firm *i* in year *t*;
$RDI_{j,t}$	=	a measure of the R&D tax incentives available for country *j* in year *t*;
$ALLOC_{i,t}$	=	a continuous measure of the effect of the R&D allocation rules on the marginal benefit of domestic R&D deductions with zero equaling no effect and one equaling maximum impact;
$FTR_{i,t}$	=	the foreign corporate tax rate;
$FTC_{i,t}$	=	1 if firm *i* is in an excess foreign tax credit position and zero if firm *i* is in a deficit foreign tax credit position in year *t*;
$I\_Index_{j,t}$	=	the Innovation Index as developed by Porter and Stern (1999);
$RDWage_{j,t}$	=	the natural logarithm of R&D wages in US$ of engineers of comparable qualifications in the jth country;
$FSR_{i,t}$	=	the ratio of foreign sales to worldwide sales for firm *i* in year *t*;
$Q_{i,t}$	=	the natural logarithm of Tobin's q measured as a firm's market value of assets over book value of assets;
$ROA_{i,t}$	=	the pre-R&D return on assets for firm *i* in year *t*;

$CITES_{i,t}$	=	the average number of patent citations for firm *i* in year *t* less average number of citations in the industry for firm *i*;
$InvMills_{i,t}$	=	Inverse Mills ratio from the first-stage of the Heckman (1979) two-step estimation;
$YEAR_t$	=	a vector of year-specific indicator variables; and
IND_i	=	a vector of industry dummy variables based on Fama-French 12 industries.

The subscripts *i, j,* and *t* refer to firm, country, and year, respectively.

As described in the previous section, *PATENT%* captures the percentage of innovative activities a firm has in a foreign country. *PATENT%* is restricted to being greater than zero.

4.3.1 Tax variables

The R&D tax incentives provided by foreign countries discussed in Hypothesis 1 is measured using *RDI*. The R&D tax incentives may take a variety of forms, making international comparison difficult. The B-Index, developed by Warda (1996), is a method of measuring the attractiveness of R&D tax systems among jurisdictions. The B-Index is a composite index calculated as the present value of income before taxes required to cover the initial investment in R&D and the corporate income taxes (See Appendix B for further details). Algebraically, the B-index is the ratio of the after-tax cost of US$1 of R&D divided by 1 less the corporate income tax rate where the after-tax cost is the net cost of investing in R&D, taking into account all available tax incentives (corporate tax rates, R&D tax credits and allowances, and depreciation rates).[16] In my regression model, *RDI* captures the expected net present value of the tax incentives available for the R&D activities which is *RDI* from the B-Index calculation outlined in

[16] For complete description of the B-Index, refer to Warda (1996).

Appendix B. A higher *RDI* value reflects larger R&D tax incentives. Therefore, I expect the coefficient on *RDI* to be positive in accordance with Hypothesis 1.

The effect of U.S. R&D allocation rules on the marginal tax benefit of domestic R&D expenditures is measured by the variable, *ALLOC*. The calculation of *ALLOC* follows a similar calculation used to measure the marginal tax benefit of domestic interest deductions by Collins and Shackelford (1992) and Newberry and Dhaliwal (2001). *ALLOC* is a continuous measure equal to zero if there is no effect (i.e. the allocation rules do not change the marginal tax benefit of the domestic R&D expenditures) and one if there is a maximum effect (i.e. the marginal tax benefit of a domestic R&D expenditure is zero). I predict a positive relation between *PATENT%* and *ALLOC* as U.S. multinationals have incentives to locate innovative activities in foreign locations if the foreign tax credit limitations impair their ability to use domestic R&D expenditures.

A detailed calculation of the effect of allocation rules on the marginal tax benefit of domestic R&D expenditures is outlined in Appendix A. If a corporation is in a deficit foreign tax credit position (Case A in appendix A), there is no effect on the tax benefit of domestic R&D expenditures. In this situation, *ALLOC* is coded as zero. I also code *ALLOC* as zero if a firm pays no foreign income taxes or if a firm has worldwide losses and pays no U.S. taxes. For corporations in an excess foreign tax credit position (Case C), I code *ALLOC* as one if domestic-source income is negative and there is positive worldwide income. Otherwise, *ALLOC* equals 50 per cent of the ratio of foreign to worldwide sales based on the R&D allocation rules (Case B). Firms also have the option of determining the allocation of R&D between foreign and domestic source based on gross income. I decided to use only the foreign sales ratio in the calculation of *ALLOC* as more firms reported foreign sales than foreign gross income. However, recalculating *ALLOC* based on the ratio of foreign to worldwide gross income or based on the optimal choice of the firm between the two alternatives does not alter the results.

I measure the multinational income shifting tax incentives using the variable *FTR* which is defined as the foreign corporate tax rate. I use two alternative measures of the foreign corporate tax rate. First, I simply use the statutory foreign country corporate tax rate. In this case, *FTR* is equal to the sum of each country's top national and local tax rates.[17] However, this approach can be problematic as it does not capture any firm-specific variation in marginal tax rates within a country. In addition, it does not capture any special tax breaks for income related to research and development. As an alternative, following Kemsley (1998), Collins et al. (1998), Newberry and Dhaliwal (2001), Mills and Newberry (2004) and others, I use the firm-specific average foreign tax rate which is calculated as the total current plus deferred foreign taxes divided by total foreign pretax income.[18] This firm-specific average foreign tax rate provides a proxy of a multinational's worldwide mix of tax rates based on it current mix of foreign operations. Klassen and Laplante (2008) suggest that by considering a corporation's mix of foreign tax rates based on current foreign operations may "allow the researcher to anticipate the tax benefit of shifting the next dollar to the optimal location" (p.10), assuming that the mix does not change with the additional tax planning activities. However, as discussed by Mills and Newberry (2004), using the average foreign tax rate is limited as "it is a

[17] The statutory tax rates are from Devereux et al. (2002). The statutory tax rates for Denmark, Korea and Mexico were not available and so, these rates were obtained from *Corporate Taxes – A Worldwide Summary* by Price Waterhouse.

[18] A more recent working paper by Klassen and Laplante (2008) use the average foreign tax rate over time rather than an annual specification because firms are more likely to respond to the expected or typical foreign tax rate, especially for long-term decisions such as the decision on where to locate innovative activities. In addition, the ability to carry-over foreign tax credits suggests a multi-year calculation. In sensitivity analyses, I will include this alternative specification for the average foreign tax rate.

broad tax position measure that does not lend itself to specific inferences regarding where the next dollar of income will be placed" (p. 95).

The foreign tax credit position of the firm is captured using the variable *FTC*. If the multinational is in an excess foreign tax credit position (i.e. average $FTR_{i,t} > t_{US}$), then *FTC* is equal to one, and if the multinational is in a deficit foreign tax credit position (i.e. average $FTR_{i,t} < t_{US}$), *FTC* is equal to zero. According to Hypothesis 3, I expect that interaction *FTR* to be negatively related to a multinational's incentive to innovative in a foreign country only if the corporation is in an excess foreign tax credit position; thus I predict that the coefficient on *FTR*FTC* is negative. According to Hypothesis 4, I predict that U.S. multinationals with average foreign tax rates that are less than the U.S. tax rate (i.e. in a deficit foreign tax credit position) will not be influenced by the foreign corporate rate and so I have no prediction regarding the coefficient on *FTR*.

4.3.2 Non-tax Control Variables

4.3.2.1 Firm-level Variables

I include *FSR* to control for the proportion of the corporation's total sales that are derived in foreign markets as in previous research (Mansfield et al., 1979; Vines and Moore, 1996; Hines and Jaffe, 2001). I expect a positive relation between *FSR* and the choice of whether to innovate in the U.S. or in a foreign country because as the percentage of foreign sales increases, the firm is more global in nature and management, making it more likely that R&D will be performed offshore to serve the foreign markets.

Both Tobin's q (*Q*) and pre-R&D return on assets (*ROA*) are included as control variables following previous firm-level studies on R&D expenditures and the U.S. R&D tax credit (Berger, 1993; Gupta et al., 2004; Klassen et al., 2004; and Brown et al, 2008).

Tobin's q is a common measure of a firm's investment opportunities or stock of intangible assets and is generally estimated as the market-to-book value of a firm. Holding the degree of foreign activity constant, firms with greater value of intangible assets (i.e. greater value of q) may be concerned with having valuable intangible assets close to home and so, may do less R&D activities offshore. Thus, I include the natural logarithm of Tobin's q (*Q*) as a control and predict a negative coefficient on *Q*. *ROA* measures a firm's profitability before R&D expenditures and is measured as net income before R&D divided by total assets. I expect firms that are more profitable to be more likely to go abroad.

One of the drawbacks of patent data is that the innovations patented may differ greatly in their economic significance as discussed by Hall et al. (2005). I control for the economic significance of a corporation's patent portfolio by including *CITES* in my empirical model. This variable measures the difference between a corporation's average citations on its patent portfolio and the industry average of citations. A citation of a prior patent implies that the current patent has built on previously existing knowledge represented by the prior patent over which the current patent cannot have a claim.[19] Thus, the citations serve to limit the scope of the property rights awarded by the patent. Patent citations appear on the front page of the public patent document issued by the patent office and are determined by the inventor's attorney or patent office examiners.

[19] Citation counts suffer from a truncation problem as described by Hall et al. (2005). Patents continue to receive citations over long periods of time but the database only contains citations up to the last year of available data. Hall at al. (2005) address this problem by estimating the shape of the citation-lag distribution. Based on this distribution, they estimate that total citations of any patent for which only a portion of the citation life is observed. These citation estimations are included in the NBER/CWRU database.

Evidence of the patent citations being indicators of economic impact or value of patents has been provided in the economic literature. (Harhoff et al, 1999; Hirschey et al. 2001, Lanjouw and Schankerman, 2004; and Hall et al., 2005). Following this literature, I include patent citations as a proxy for the economic value of the corporation's patent portfolio. The direction of the coefficient on *CITES* is ambiguous as it may be positive if firms are only willing to invest the time and cost to move R&D offshore if it is economically significant or it may be negative if firms prefer to keep significant innovations close to home.

The persistence of innovations in a particular country is not included as a control. The firm-level and country-level variables included in the analysis are relatively stable over time and so the factors that would have influenced the original decision to locate in a particular country will be similar to the decision to locate the new R&D activities. As a result, I do not include the lag of innovative activities in my regression.

Finally, I include industry and year indicator variables to control for possible differences in the choice to locate R&D activities in a foreign country across industries and time.

4.3.2.2 Country-Level Variables

There are many features of a foreign country that may attract the R&D activities of a U.S. MNC. I capture the overall innovative environment of a country by using the Innovation Index (*I_Index*) developed by Porter and Stern (1999) and Furman et al. (2002). The index is the weighted sum of the following country-level factors: total personnel employed in R&D, total R&D expenditures, the strength of protection for intellectual property, the percentage of GDP spent on higher education, a nations' GDP per capita, a nations GDP, the percentage of R&D expenditures funded by private industry, the concentration of patents across broad technological areas, and the percentage of R&D performed by universities (Gans and Stern, 2003).[20] The weights were determined through a regression analysis of these factors on a national measure of innovative output ("international" patenting per capita). The Index has been calculated using 29 OECD countries from 1980 to 2000. The Innovation Index is a quantitative measure of a country's ability to produce innovative output. A higher index indicates that a country has a more attractive innovation environment. Thus, I anticipate a positive relation between *PATENT%* and *I_Index*.

Although including multiple country factors in the single composite measure, *I_Index*, reducing the potential collinearity found in the country-level variables, the index can present other problems for the empirical analysis. Potentially, the effect of each factor may cancel out each other, reducing the variation captured by the index. Thus, as a specification check in Chapter 6, I re-estimate equation (7) with country factors included separately rather than as part of the *I_Index*.

Although the Innovation Index includes many country factors that impact innovation, it does not consider the relative cost of R&D for each country. Following Kumar (2001), the cost of R&D is proxied by the relative cost of hiring an engineer of comparable qualification in the country (*RDwage*). I obtain data on R&D wages in US$ from *Price and Earnings around the Globe* published by the Union Bank of Switzerland. Countries with higher levels of R&D wages and so, R&D activities are more expensive, are less likely to attract innovative activities from US MNCs.

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[20] Previous economic research on the determinants of the location of overseas R&D activities, such as Kuemmerle (1999), Kumar (2001), Guellec et al. (2003) and Falk (2006) include similar country-level factors.

4.3.3 Selectivity Bias

Investigating the determinants of a firm's decision to locate innovative activities in a foreign location is problematic because the analysis omits firms with only domestic innovations, creating a potential selection bias in the regression tests. As a result, I control for the self selection bias using the Heckman (1979) two-step estimation approach. In the first step, I estimate the selection model where the firms chose between performing their innovative activities in a foreign location or solely in a domestic location. From the selection model, I extract the inverse Mills' ratio, $InvMills_{i,t}$, and include this variable in estimating equation (7) to control for the effects of selection. I define the selection model for the first-stage of the Heckman as follows:

$$ABROAD_{i,t} = \alpha_0 + \alpha_1 ALLOC_{i,t} + \alpha_2 FSR_{i,t} + \alpha_3 ROA_{i,t} + \alpha_4 LnTA_{i,t} + \alpha_5 RDIntensity_{i,t} + \alpha_6 CITES_{i,t} + \sum \alpha_7 YEAR_t + \sum \alpha_8 IND_i + \xi_{i,t} \quad (8)$$

where:

$ABROAD_{i,t}$	=	1 if firm i has foreign R&D activity in year t and zero, otherwise;
$ALLOC_{i,t}$	=	a continuous measure of the effect of the foreign tax credit limitation on the marginal benefit of domestic R&D deductions with zero equaling no effect and one equaling maximum effect;
$FSR_{i,t}$	=	the ratio of foreign sales to worldwide total sales;
$ROA_{i,t}$	=	the pre-R&D return on assets;
$LnTA_{i,t}$	=	the logarithm of total worldwide assets;
$RDIntensity_{i,t}$	=	the ratio of research and development expenses to worldwide sales;
$CITES_{i,t}$	=	the average number of patent citations for firm i in year t, less average # of citations in industry for firm i;
$YEAR_t$	=	a vector of year-specific indicator variables; and
IND_i	=	a vector of industry dummy variables based on Fama-French 12 industries.[21]

The subscripts i and t refer to firm and year, respectively.

[21] Fama-French 12 Industry definition is available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/.

ABROAD is an indicator variable equal to 1 if the firm has foreign innovative activities and zero, otherwise. The firm-level explanatory variables in equation (8) include *ALLOC*, *FSR*, *ROA*, *CITES*, *YEAR* and *IND* which are all included in the primary empirical model specified in equation (7) and are measured as describe above.

As outlined by Heckman (2000), Puhani (2000), and Francis and Lennox (2008), to successful identify selectivity, the model must have "exclusion restrictions." These exclusion restrictions refer to having at least one variable in the selection equation that does not influence the dependent variable in the second-stage equation. According to Puhani (2000), failure to implement these exclusion restrictions can result in severe multicollinearity problems in the regression. Thus, I include two firm-level variables, *lnTA* and *RDIntensity* that effect the decision of whether to go abroad (selection model) but should not effect the percentage of R&D activity in a specific foreign location (main model). First, I include *lnTA* as a control for size. Larger firms are expected to have access to more resources to be able to move R&D abroad and so, be more likely to move R&D activities abroad. However, once abroad, the decision of where to locate the R&D should not depend on the size of the firm. Secondly, I expect firms with greater R&D intensity, *RDIntensity*, to be more likely to locate abroad. However, once the decision has been made to go abroad, I don't expect firms with greater R&D intensity to differ from firms with lower R&D intensity in their decisions on the percentage of R&D activity performed in a specific foreign location.[22]

[22] When the control for size (*lnTA*) and R&D Intensity of the firm (*RD*) were included in the second equation, both variables do not load significantly.

4.4 Sample

To explore the effect of tax incentives on the location decision for R&D activities, I include all U.S. firms with foreign sales and tax information available in the 2007 *Compustat* database and with patenting data from the USPTO during the sample period of 1986 to 2000.[23] The sample was restricted to include the U.S. multinationals with patenting in at least one foreign country. As a result, the final sample used to estimate equation (7) includes 3,948 observations for 413 firms in 20 OECD countries. Unfortunately, the B-Index is not calculated for each OECD country and so, limited the number of countries included in the sample. The sample used to estimate the selection model specified in equation (8) includes the sample described above and U.S. MNCs with patents granted only in the United States. This sample includes 6,708 observations for 917 firms.

Table 3 provides industry, time-period and country descriptions of these two samples of observations over the period 1986 to 2000. Panel A presents industry classifications using the Fama-French industry definitions. The two largest industry groups in my main sample used to estimate equation (7) are Business Equipment[24] with 33.9% of the observations; and Manufacturing[25] with 23.5% of the observations. The distribution of the selection model sample is quite similar. The breakdown of the sample by year is presented in panel B. The observations for the two samples are fairly evenly spread over the sample period.

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[23] Although the patent database includes patenting activity up to 2002, the sample period does not extend beyond 2000 due to the average 2 year lag between the patent application and the grant date. Therefore, for the last two years of data, the database includes only a small fraction of the patents applied for that will eventually be granted.

[24] Includes Computers, Software, and Electronic Equipment

[25] Includes Machinery, Trucks, Planes, Office Furniture, Paper and Printing

Panel C of Table 3 shows the allocation of the observations from the main sample between the 20 OECD countries. The countries with the largest patenting activity by U.S. firms in my sample include Great Britain with 18.1%, Germany with 13.0%, Canada with 12.3%, Japan with 11.0%, and France with 10.3%. This concentration of foreign patenting in a relatively small number of countries is not unexpected and is also outlined by Hines and Jaffe (2001).

4.5 Chapter Summary

In this Chapter, I discuss an empirical model for testing the four hypotheses outlined in Chapter 3 related to the location of innovative activities. First, I describe how the dependent variable, PATENT%, will be measured using data on patenting. Then, I specify a regression model that explains how U.S. MNCs decide where to locate their R&D activities using both tax and non-tax variables. The explanatory variables include both firm and country-level factors relevant to the location decision. To control for the potential selectivity bias in my sample, I use the Heckman (1979) two-step estimation procedure where I extract the inverse mills ratio from an estimation of a selection model. The inverse mills ratio (*InvMills*) is then include in the primary regression model as a control for selectivity. The main sample used to estimate the regression model includes 3,948 observations from 413 firms while the selection model sample includes 6,708 observations from 917 firms. The following chapter presents the results from estimating the empirical model using the sample specified.

CHAPTER 5: RESULTS

5.1 Introduction

This chapter presents and discusses the results from the estimation of the empirical model specified in equation (7) using the Heckman (1979) two-step procedure. Section 5.2 examines the relationship between patenting and R&D expenditures. Section 5.3 provides the univariate analysis while section 5.3 presents the multivariate results. Section 5.4 summarizes the chapter.

5.2 Relationship between R&D Expenditures and Patents

Before examining the results for the empirical model, I first verify the relationship between R&D expenditures and patents. Based on the sample of firms with patenting activities, either domestic or foreign, described in Section 4.5, the correlation between the R&D and total patents in all countries is 0.708. Following Hines and Jaffe (2001), I further examine of the firm-level relationship between R&D and patents by regressing the log of total patents on the log of R&D expenditures. The regression results are reported in Table 4. Consistent with Hines and Jaffe (2001), I find a strong positive relationship between R&D expenditures and patents in column (1) of Table 4. Column (2) of Table 4 includes the log of total assets to control for size and the results indicate that the strong relationship between R&D and patents remains even after controlling for size.

5.3 Univariate Analysis

Table 5 provides descriptive statistics for the firms with foreign R&D activities for the period 1986 to 2000. The mean (median) value for the dependent variable, *PATENT%,* is 0.087 (0.022) indicating that on average, U.S. MNCs firms are placing less than 10% of their innovative activities in one foreign country. This is consistent with statistics reported by Hines (2001) that U.S. firms overall foreign activity of about 10%. The mean (median) of *RDI* is 0.383 (0.384) suggesting that firms are innovating in foreign countries that offer some tax incentives for R&D activities. The U.S. R&D allocation rules have some effect on average with a mean (median) value of 0.123 (0.000). The statistics indicate that the mean (median) average foreign tax rate is 0.327 (0.346) while the foreign corporate statutory tax rate is 0.398 (0.360). It appears that U.S. firms are innovating in foreign countries with statutory rates that are higher than the firm-specific average foreign tax rates face by these firms.

In Table 6, I report the Pearson correlation coefficients between the regression variables. As expected, the variables *RDI* and *I_Index* are positively correlated with the dependent variable while the interaction of *FTR* and *FTC*, *RDWage, Q*, and *CITES* are all negatively correlated. Although the correlation between the PATENT% and each of the variables *ALLOC*, *FSR* and *ROA* is expected to be positive, the correlation between *PATENT%* and each of these variables is surprisingly negative.

The correlations between the explanatory variables reported in Table 6 are important to note. The inverse mills ratio (*InvMills*) that is extracted from the selection model is highly correlated with several firm-level variables included in equation (7). For example, the correlation between *InvMills* and *FSR* is -0.506 and between *InvMills* and *ROA* is -0.240. The high correlation is not unexpected as both *FSR* and *ROA* are also included in the selection model. However, this highlights the importance of checking for the potential impact of multicollinearity from the use of the Heckman (1979) two-step estimation approach on the estimations from the main empirical model. There is also high correlation between *ALLOC*, *FTR*, and *FTC* and between *I_Index* and *RDWage*.

Comparative descriptive statistics between firms with foreign R&D activities and firms with only domestic R&D activities are presented in Table 7. The differences in mean values between the two samples are statistically significant at the 1% level for all of the explanatory variables except for the R&D Intensity ratio (*RDIntensity*) which is not statistically different between the two samples. Thus, U.S. MNCs with foreign R&D activities are generally larger with a higher mean value for the natural logarithm of total assets (*LnTA*), more profitable with higher mean *ROA* and have higher foreign sales-to-worldwide sales ratio (*FSR*). In addition, firms with foreign R&D activities appear to be impacted more by the R&D allocation rules as indicated by the significantly higher value of *ALLOC*. Finally, the economic significance of a firm's patent portfolio as measured by *CITES* is significantly different between the two samples of firms.

5.4 Multivariate Analysis

The results of estimating the regression specified in equation (7), using the Heckman two-stage procedure, are provided in Table 8. The regression estimates in column (1) represent the results using the average foreign tax rate as a proxy for the foreign corporate tax rate and column (2) represents the results using the statutory foreign tax rate. Since the estimates are generally consistent between the two columns except for the variables related to the foreign tax rate, I focus the discussion solely on the estimates provided by column (1). The differences between the two columns in the estimates of the tax variables are further discussed below.

The response of U.S. MNCs to the R&D tax incentives is represented by the coefficient on *RDI*. *RDI* is a measure of the tax incentives available for R&D activities provided by each country. As predicted by Hypothesis 1, U.S. MNCs in this sample appear to locate more innovative activities in foreign countries that offer larger R&D tax incentives as indicated by the positive and significant coefficient on *RDI*. The coefficient on R&D tax incentive variable is 0.082 and statistically significant at the 5% level using a one-tailed test. This suggests that on average, a foreign country can attract R&D activities from U.S. MNCs by increasing the R&D tax incentives provided. To illustrate, suppose the value of *RDI* increased by 0.1. The value of *RDI* could increase by this amount if Canada, for example, extended the enhanced R&D tax credit, currently available to smaller Canadian controlled private corporations, to foreign-controlled corporations. This would increase the R&D tax credit available to foreign-controlled corporations from 20% to 35%, leading to an increase in the value of *RDI* for Canada from 0.437 to 0.537. Therefore, holding everything else constant, if the average value of *RDI* increased by 0.1, the percentage of foreign patenting by U.S. MNCs would increase by 9.4%.[26] This implies a foreign country can increase the patenting activity from U.S. multinationals by providing a more generous tax credit.

The effects of the U.S. R&D allocation rules are captured by the variable *ALLOC*. According to Hypothesis 2, *ALLOC* is expected to have positive impact on the foreign activities of a U.S. MNCs. As expected, the coefficient on *ALLOC* is positive and statistically significant at the 5% level using a one-tailed test (*z-statistic* = 1.98). This indicates that U.S. allocation rules for domestic R&D expenditures have some impact on the decision on whether the U.S. MNC innovates in a foreign country.

The income shifting incentives outlined in Hypothesis 3 and Hypothesis 4 are measured using the foreign tax rate (*FTR*), the foreign tax credit position (*FTC*) and the

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[26] Calculated as the change in average *RDI* value (0.1) multiplied by the estimated coefficient (0.082) divided by the average foreign patenting percentage (0.087)

interaction of these two variables. Based on Hypothesis 3, where the foreign tax rate increases, U.S. MNCs in excess foreign tax credit positions (i.e. *FTC*=1) will be less likely to innovate in a foreign country. The coefficient on the interaction of *FTR* and *FTC* tests this hypothesis. Consistent with Hypothesis 3, the negative coefficient on *FTR***FTC* that is significant at the 1% level reported in column (1) of Table 8 indicates that U.S. MNCs in excess foreign tax credit positions appear to respond to the incentive to shift income into the U.S. by decreasing R&D activities outside the U.S. as foreign tax rates rise. On the other hand, U.S. MNCs in a deficit foreign tax credit position are not expected to be effected by the foreign tax rate as specified in Hypothesis 4. Contrary to this hypothesis, the estimated coefficient on *FTR* is positive (0.108) and significant at the 1% level. This suggests that these U.S. MNCs will locate more innovative activities in a foreign country as the tax rate increases. Klassen and Laplante (2008) posit that the proxy for income shifting, an annual average foreign tax rate, used by Collins et al. (1998) and others is flawed and that a more appropriate measure would consider a multi-year approach. In specification analysis, I employ a multi-year measure to investigate the sensitivity of my findings to the measure of the average foreign tax rate. Another possible explanation is that the royalty payment for use of U.S. innovations outside the U.S. is not fixed. The model in Chapter 3 assumes that a market rate of royalties, *R*, is always fixed. However, if the royalty is flexible, then undertaking R&D in the U.S. increases future profit-shifting flexibility. The benefit of this flexibility increases as the foreign rate declines for deficit foreign tax credit firms.

In contrast to the results in column (1) of Table 8, I do not find income shifting incentive effects when the U.S. multinationals' income shifting incentive are measured using the country statutory tax rate in column (2). For both *FTR* and the interaction of *FTR* and *FTC*, the estimated coefficients are highly insignificant when *FTR* is measured using the country statutory tax rate. As previously discussed, this measure is problematic as it does not consider the multinationals worldwide operations and potential access to other tax haven jurisdictions (Mills and Newberry, 2004). Also, since the effect of foreign tax rates works through the company's foreign tax credit position, the tax rate for the country of innovation is weakly related to the company's tax position. The correlation between the average foreign tax rate and the country statutory tax rate is only 0.11 for my sample. In addition, the country statutory tax rate is the rate applied to the top income bracket and may not accurately reflect the actual tax rate faced by U.S. multinationals on income from R&D activities in the foreign country. The insignificant results using the foreign statutory corporate tax rate suggests that for the decision on where to locate innovative activities, firms may not rely on the country's foreign corporate tax rate, but use the average foreign tax rate.

The remaining results reported in Table 8 are for the control variables included in the regression model. The country-level control variables include the *I_Index*, a measure of a country's innovative capacity, and *RDwage*, a measure controlling for the cost of R&D. As expected, the coefficient on *I_Index* is positive at 0.035 and significant at the 5% level while the coefficient on *RDwage* is negative (-0.042) and significant at the 5% level. The firm-level control variables include the foreign sales ratio (*FSR*), Tobin's q (*Q*), and the average citations (*CITES*). *FSR* is positive and significant at the 1% level while both *Q* and *CITES* are negative and significant at the 1% level. The negative and significant coefficient on *Q*, the control for the stock of intangibles, suggests that firms with higher valued intangibles are less likely to innovate in a foreign country. Similarly, the estimated negative coefficient on *CITES*, the control for the economic significance of a firm's patents, indicates that corporations are less willing to move economically significant innovations offshore and prefer to keep it close to home.

5.4.1 Selectivity Bias

I control for the potential selectivity bias in my sample by including the inverse mills ratio, *InvMills* in equation (7). *InvMills* is extracted from the estimate of the selection model specified in equation (8). The results of this estimation are reported in Table 9. Estimates of the coefficients for the explanatory variables in equation (8) are all positive and significant at the 1% level as expected. The coefficient on *InvMills* is 0.267 and is significant at the 1% level using a two-tailed test. This provides evidence that the selection bias is important and should be included in equation (7).

5.4.2 Multicollinearity

A concern with the Heckman (1979) two-step approach is the potentially severe multicollinearity due to the inclusion of similar variables in both the selection equation and main equation (Puhani, 2000 and Francis and Lennox, 2008). The potential multicollinearity may be reduced by including "exclusion restrictions." To investigate the influence of multicollinearity on my results, I compute the variance inflation factors (VIFs) for the variables in equation (7). The VIFs measure the increase in the variance of a coefficient that results from collinearity (Greene, 2005). Generally, multicollinearity is seen as high (very high) when VIFs exceed 10 (20). For the explanatory variables in equation (7), the VIFs are report in Table 10. The potential multicollinearity in the equation (7) as a result of estimating the equation using the Heckman (1979) two-step approach appears to be low based on the VIF of 2.22 reported for the inverse mills ratio (*InvMills*). Thus, using exclusion restrictions appears to have been effective in reducing the effect of potential multicollinearity from the Heckman (1979) two-step approach.

The remaining VIFs reported in Table 10 are generally less than 2 except for the variables *FTR*, *FTC* and their interaction which have higher VIFs of 4.02, 11.98 and 16.92, respectively. Although higher, the VIFs on these variables are still below the threshold of 20 above which multicollinearity is deemed to be very high. The higher VIFs on these variables are to be expected due to the interaction of the two variables. Recalculating the VIFs without including the interaction of FTR and FTC reduces the VIFs on these two variables to 2.42 and 2.94, respectively.

5.5 Conclusion

The results reported in this chapter suggest that U.S. multinationals are influenced by the R&D tax incentives provided by foreign countries. In addition, evidence suggests that the U.S. R&D allocation rules have a positive impact on the percentage of innovative activities that firms locate in a foreign country. Finally, the income shifting incentive also appears to be influential on the location decision. U.S. multinationals in excess foreign tax credit positions are less likely to locate innovative activities in a foreign country as the tax rate increases. On the other hand, firms in deficit foreign tax credit positions are more likely to move innovative activities offshore as the tax rate increases. In the following chapter, I perform a series of specification checks to investigate the robustness of these results.

CHAPTER 6: SPECIFICATION ANALYSIS

6.1 Introduction

This chapter provides the results from performing a series of specification checks on the main results reported in Chapter 5. For the specification checks, the estimations of the selection model of the Heckman (1979) two-step approach are generally similar to the main results in Chapter 5 and are not reported unless the results vary significantly from those reported in Chapter 5. Section 6.2 discusses the results of re-estimating equation (7) using alternative measures of the explanatory variables. Section 6.3 provides results using different estimation approaches and section 6.4 provides results from alternative model specifications to address multicollinearity issues. Section 6.5 outlines the results of changing the sample used in the main empirical investigation and Section 6.6 addresses the potential dependence of observations over time. Section 6.7 discusses the *ALLOC* variable and Section 6.8 concludes.

6.2 Alternative Measures of Explanatory Variables

6.2.1 R&D Tax Incentives

The R&D tax incentives provided by each country may take a variety of forms and so, creating a measure for international comparison is difficult. The main results reported in Chapter 5 were estimated using a component used to calculate the B-Index developed by Warda (1996). The B-Index has also been used to compare the international R&D tax incentives in studies by Guellec et al. (2003) and Falk (2006). Bloom et al. (2002) develop an alternative measure to the B-Index for international comparison. Similar to the B-Index, Bloom et al. (2002) combine tax rates, depreciation allowances and integration of personal and corporate income taxes to measure a "tax cost" (*Bloom*) of R&D across countries and time. They derived their measure of the R&D incentives for nine countries,[27] including the United States from 1979 to 1997. Since this measure was available for fewer countries and did not cover all the years of my sample, the measure was not used in the main regression analysis. For comparison purposes, I estimate the regression model using the smaller sample using both the *RDI* and *RDI_Bloom* in reporting the results in Table 11. *RDI_Bloom* is measured as [1 – *Bloom*(1– *t*)] to be consistent with the measurement of *RDI*. The correlation of the *RDI* and *RDI_Bloom* is 0.8564 suggesting that the two measures are quite similar. Reviewing the results of estimating equation (7) using *RDI_Bloom* reveals that its positive and significant coefficient at the 10% level is consistent with the main results that higher R&D tax incentives attract R&D activity from U.S. MNCs. The positive and significant coefficient of *RDI* on the smaller sample also confirms the previous conclusions.

6.2.2 Income Shifting Incentives

Although the estimated coefficient on the average foreign tax rate (*FTR*) was predicted to be insignificant according to Hypothesis 4, the estimated coefficient is significantly positive. A potential explanation for this counter-intuitive result is that my measure of *FTR* is inappropriate. Although the most common method of calculating *FTR* has been an annual average, Klassen and Laplante (2008) suggest that a multi-year approach is more appropriate as planning to income shift is usually a multi-period consideration and so, income shifting behavior and income shifting incentives should be measured over multiple periods. Income shifting may be considered over multi-periods rather than annually because multi-jurisdictional income shifting can create significant

[27] The countries include Australia, Canada, France, Germany, Italy, Japan, Spain, United Kingdom and the United States.

transaction costs and changes in earnings patterns can be a signal to tax administrators. In addition, foreign tax credits have multi-year carry-over provisions so incentives created by fluctuating foreign tax rates are smoothed across years. Using a multi-period approach, Klassen et al. (2008) demonstrate that by using an annual average foreign tax rate, a positive association can be found between the foreign tax rate and foreign profit margin but if the foreign tax rate is calculated using a multi-period approach the association is negative. Thus, my main results may be sensitive to how the foreign tax rate is measured.

Based on Klassen et al. (2008), I re-estimate the foreign tax rate using a multi-period perspective as follows:

$$\overline{FTR_t} = \frac{\sum_{m=0}^{4} IT_{t-m}}{\sum_{m=0}^{4} PFI_{t-m}}$$

where *IT* is the foreign tax expense and *PFI* is the pre-tax foreign income. $\overline{FTR_t}$ is initially calculated using a 5-year moving average where firms must have at least 3 years of data to calculate the average. I also calculate $\overline{FTR_t}$ using a 3-year moving average where firms must have at least 2 years of data. Incorporating a multi-period approach, the regression model in equation (7) is modified as follows:

$$\begin{aligned} PATENT\%_{i,j,t} = {} & \beta_0 + \beta_1 \overline{RDI}_{j,t} + \beta_2 \overline{ALLOC}_{i,t} + \beta_3 \overline{FTR}_{i,t} + \beta_4 \overline{FTC}_{i,t} + \beta_5 \overline{FTR}_{i,t} * \overline{FTC}_{i,t} \\ & + \beta_6 \overline{I\_Index}_{j,t} + \beta_7 \overline{RDWage}_{j,t} + \beta_8 \overline{FSR}_{i,t} + \beta_9 \overline{Q}_{i,t} + \beta_{10} \overline{ROA}_{i,t} \\ & + \beta_{11} CITES_{i,t} + \beta_{12} InvMills_{i,t} + \sum \beta_{13} YEAR_t + \sum \beta_{14} IND_i + \varepsilon_{i,j,t} \quad (9) \end{aligned}$$

and the selection model is:

$$\begin{aligned} ABROAD_{i,t} = {} & \alpha_0 + \alpha_1 \overline{ALLOC}_{i,t} + \alpha_2 \overline{FSR}_{i,t} + \alpha_3 \overline{ROA}_{i,t} + \alpha_4 \overline{LnTA}_{i,t} \\ & + \alpha_5 \overline{RDIntensity}_{i,t} + \alpha_6 CITES_{i,t} + \sum \alpha_7 YEAR_t + \sum \alpha_8 IND_i + \xi_{i,t} \quad (10) \end{aligned}$$

The variables in equation (9) and (10) are as previously defined in Chapter 5 but averaged over 5 or 3 years except *PATENT%, ABROAD* and *CITES*. *PATENT%* is not averaged over 5 or 3 years in the regression model as patents represent the culmination of R&D activity performed in the past and thus, is measured annually. *CITES* is also measured annually as it is a variable that is directly related the patents. *ABROAD* is calculated directly from *PATENT%* and therefore, is also measured annually.

The results for estimated the modified equation are tabulated in columns (1) and (2) of Table 12. Column (1) reports the 5-year average and column (2) reports the 3-year average. Despite the changes in the definition of the foreign tax rate variable, the conclusions remain consistent with the main results. Firms in deficit foreign tax credit positions still appear to increase their innovative activities with an increase in the average foreign tax rate while firms in excess foreign tax credit positions decrease their foreign innovative activities as the average foreign tax rate increases. For both the 5-year average and 3-year average, the coefficient on *FTR* increases from the main results in magnitude and significance. The coefficient on the interaction of *FTR* and *FTC* is fairly similar to the main results for the 3-year average estimations but for the 5-year estimation the magnitude is not quite as negative as the main results and also has a lower z-statistic.

The statistical significance of the coefficients generally declines from the 3-year moving average estimates to the 5-year estimates. Particularly, in the 5-year estimation, *ALLOC* is no longer statistically significant. A potential explanation for the overall decline in the statistical significance is that R&D projects are generally carried out over a period shorter than 5 years and so, estimating the regression model using 3-year moving averages reflects more closely a shorter decision period for R&D locations.

Table 13 reports the estimation of the selection model. The results for the 3-year estimates are generally similar to those reported for the main results in Table 6. But, for the 5-year estimates, the estimations of *ALLOC* and *RDIntensity* are now insignificant.

6.2.3 Country-level Control Variables

The overall innovative environment of a country is captured by the Innovation Index (*I_Index*) in the main regression analysis. Using one variable to control for a number of factors conceals the influence of each factor and the separate effects of the factors may cancel each other out. As an alternative to the *I_Index*, I re-estimate equation (7) but replace *I_Index* with the following country factors:

$RDPerson_{j,t}$	=	the natural logarithm of the aggregate personnel employed in R&D;
$GERD_{j,t}$	=	the natural logarithm of the total R&D expenditures in Year 2000 US$;
$IPR_{j,t}$	=	the strength of protection for intellectual property for country *j* in year *t*;
$GDP\_Capita_{j,t}$	=	the natural logarithm of GDP per capita for country *j* in year *t*;
$GDP_{j,t}$	=	the natural logarithm of GDP in year 2000 US$ for country *j* in year *t*;
$IndFund_{j,t}$	=	R&D expenditures funded by industry divided by total R&D expenditures for country *j* in year *t*; and
$Specialization_{j,t}$	=	the total number of patents in ICT and BIO technology sectors for the *j*th country in year *t* divided by the total number patents in ICT and BIO technology sectors for the 20 OECD countries included in the sample for year *t*.

RDPerson measures the overall supply of scientific and technically trained individuals available in each country while *GERD* is a measure of the total R&D expenditures for each country and captures the availability of funding for innovation-related investments. The strength of protection for intellectual property is measured by the Ginarte-Park (1997) Index (*IPR*) which ranges from 0 to 5 with higher numbers indicating stronger protection. *GDP_Capita* proxies for the living standard of a country while *GDP* captures the size of the country. The percentage of R&D expenditures funded by private industry is measured by *IndFund*. A higher value of *IndFund* is an indication of a more favourable innovation environment. *Specialization* measures the concentration of patents in two technology areas, Information and Communications Technology (ICT) and Biotechnology (BIO) relative to other the other 20 OECD countries included in the sample. *Specialization* attempts to capture the geographical clustering of these technology sectors and at the least provides the relative specialization of national economies in these two specific areas.[28]

The estimated coefficients and z-statistics for this re-estimation are reported in column (1) of Table 14. Similar to the reported results in Chapter 5 for the main regression, *RDI*, *ALLOC*, *FTR* and *FTC* remain positive and significant while the interaction of *FTR* and *FTC* is significantly negative. The firm-level control variables also remain similar to previously reported results. However, contrary to expectations, the estimates of the country-level control variables are mostly insignificant except for *GERD.* As is evident from the correlation table in Table 15, the country factors are highly correlated, particularly *RDPerson, GERD* and *GDP* which have correlation in excess of 0.97. The VIFs reported in Table 14 confirm that the high correlation between the country-level control variables is likely a problem. *RDPerson*, *GERD* and *GDP* have VIFs of 89.58, 51.76, and 36.14, respectively which are well above the very high threshold of 20. Therefore, to address this potential problem, I re-estimate the regression

[28] Porter and Stern (1999) and Gans and Stern (2003) use similar country factors to calculate the Innovation Index. Two factors used by these studies, share of GDP spend on higher education and percentage of R&D performed by universities, have not been included as consistent data was not found.

model with the country factors but include each of *RDPerson*, *GERD*, and *GDP* in separate equation in column (2), (3), and (4) respectively. The VIFs reported beside the estimates are now well below the threshold of 20. In each case, the conclusions related to the main hypotheses do not change.

6.2.4 Lagged Variables

As previously discuss in Chapter 4, the timing of patent activities and the decision on where to locate R&D activities is an important consideration for this study. Although evidence suggests that the relation between R&D expenditures & patenting activity is close to contemporaneous, I re-estimate the Heckman (1979) two-stage model using both one-year and two-year lag of the variables to investigate whether my results reported in the previous chapter are sensitive to the when the variables are measured. Results are tabulated in Table 16. As is evident from Table 16, the re-estimation of the Heckman (1979) two-stage model using both a one-year and two-year lag produces coefficients for the variables related to my hypotheses that are fairly similar in sign, magnitude and significance. One notable difference is the lack of significance on the variable *ALLOC* which measures the impact of the U.S. R&D allocation rules when measured using a one-year lag. Although with the correct sign, *ALLOC* is not significant with a z-statistic of 1.01 using the one-year lag. However, with a two-year lag, it is once again positively significant at the 5% level. Based on this specification check, the conclusions related to *ALLOC* should be taken with some caution.

6.3 Estimation Approach

To test the hypotheses, equation (7) is estimated using the Heckman (1979) two-step approach. By applying this procedure, I control for the potential selection bias in my sample. To check if my conclusions are sensitive to this choice of procedure, I re-estimate equation (7) using the maximum likelihood estimation (MLE) approach rather than the two-step procedure. In order for the maximum likelihood to converge, *ALLOC* needed to be removed for the estimation of the selection model specified in equation (8). The maximum likelihood approach is sensitive to multicollinearity and has difficulty converging if the correlation between variables is high. *ALLOC* is highly correlated with the variables *FTR*, *FTC* and their interaction in equation (7) and so, caused problems in the estimation using MLE. Results in Table 17, column (1) are generally consistent with the results reported in the previous chapter except that although *ALLOC* is positive, it is no longer significant with a z-statistic of 1.22. Table 18 reports the estimation of the selection model using MLE. The estimation and significance of the variables are mostly similar to the results in Table 6 for the main selection model results. One important difference is the estimation of *RDIntensity*. In contrast to the significantly positive coefficient found in the main selection results, *RDIntensity* is significantly negative. The change in the direction of *RDIntensity* may be a result of excluding *ALLOC* from the selection model in the MLE estimation.

As a second alternative to the Heckman (1979) two-step procedure, I estimate equation (7) using OLS. By using OLS, I ignore the potential selection bias in my sample. The estimated coefficients and their t-statistics are reported in column (2). Surprisingly, the estimated coefficients on *FTR* and *FTC* are negative while the coefficient on their interaction is positive. This is opposite to the hypotheses and the main reported results. However, the R^2 is extremely low suggesting that equation (7) may be missing some important explanatory variables that may be correlated with the independent variables. In column (3), I re-estimate equation (7) using OLS but also include *lnTA* and *RDIntensity* that are included in the selection model but not the primary regression equation. With the inclusion of these additional variables, the signs on *FTR* and *FTC* are positive while the sign on their interaction is negative, consistent with the main results.

The coefficient estimates for several control variables are of concern. In column (3), the estimated coefficients on *lnTA* and *ROA* are significantly negative. *FSR* is also negative but not significant. Each of these control variables is expected to have a positive influence on the foreign innovative activities of a U.S. MNC. These inconsistent results may suggest that the variables, in the absence of the selection model, are capturing something in addition to what was intended. Thus, I conclude that OLS is not appropriate in this setting.

6.4 Alternative Model Specifications to Address Multicollinearity

A concern with the results reported in the previous chapter is the influence of multicollinearity on the results. The analysis of the variance inflation factors of the explanatory variables in Table 10 revealed fairly high values for the *FTR*, *FTC* and the interaction of the two variables. In addition, although the VIF on *ALLOC* was not high, the variable *ALLOC* is highly correlated with these tax variables. In review of the correlation table in Table 6, it is evident that the variables *ALLOC*, *FTR*, *FTC* and the interaction of *FTR* and *FTC* are highly correlated: their correlation ranges from 0.466 to 0.951. To ensure that the estimated coefficients and their statistical significance is not driven by the high correlation, I re-estimate the regression equations by first eliminating *ALLOC* and second by eliminating the *FTR*, *FTC* and their interaction. The results of these two re-estimations are reported in Table 19. The direction, estimated coefficient and the statistical significance of the explanatory variables are consistent with the main regression results. Thus, it appears that the high correlation of the variables is not an important influence on the results reported in Chapter 5.

6.5 Main results with Restricted Samples

6.5.1 Profitable Multinationals

The incentives for firms that are in loss positions are more difficult to define than profitable firms. Therefore, following Klassen and Laplante (2008) and Collins et al. (1998) among others, I exclude firms with negative pretax domestic or foreign income from the main sample. Based on this restriction, the observations with foreign R&D activity are reduced to 3,114. Results of re-estimating the regression model on this restricted sample is tabulated in column (1) of Table 20. The positive coefficient on *RDI* has a slightly stronger significance level of 1%. The interaction of *FTR* and *FTC* remains significantly negative but at a slightly lower statistical level of 5%. Lastly, the control variables are consistent with the estimations reported in the main results.

However, the coefficients on *ALLOC* and *FTR* lose significance when the estimation is determined on the restricted sample. For U.S. multinationals, the greatest influence of the U.S. R&D allocation rules (i.e. *ALLOC* = 1) occurs when the domestic source income is negative but the worldwide income is positive. In the restricted sample, these firms are classified as loss firms because their domestic source income is less than zero. Thus, the restricted sample does not include firms for which the allocation effect is the strongest and so, the standard deviation of *ALLOC* is reduced 0.201 to 0.125. In addition, the correlation between *ALLOC*, *FTR*, *FTC* and the interaction of *FTR* and *FTC* increases with the restricted sample suggesting that multicollinearity may be causing the lack of results. However, re-estimating the regression model on profitable firms but removing *ALLOC* and then removing *FTR*, *FTC* and their interaction does not alter the results for the profitable firms as seen in Table 20, column (2) and (3). The coefficient on *FTR* also loses significance suggesting the profitable firms in deficit foreign tax credit positions do not respond by changing their foreign innovative activities as the tax rate changes. Although this is consistent with my hypothesis 4, it is inconsistent with the main results.

6.5.2 Main Foreign Country with R&D Activity

The main sample may include multiple observations for one firm for any particular year as firms may patent in more than one country. In my sample, firms innovated anywhere from one to sixteen foreign countries but on average, firms innovated in approximately two foreign countries. Firms with multiple observations will be more heavily weighted in the empirical estimations and so, may have a stronger influence the results. To investigate how multiple annual observations for a firm may alter the results, I restrict the sample to include only one firm observation per year. I selected the firm-country observation for which the firm had the highest innovative activity for a particular year. I dropped firms from the sample in cases where the highest innovative percentage for a firm was the same for multiple countries. As a result, the main sample is reduced to 1,489 observations for 404 firms. Generally, the results reported in Table 20 for the sample restricted to one firm-country observation per year are consistent with the main results but are stronger in significance. Therefore, allowing multiple observations for a firm to be included in my main sample does not appear to alter my conclusions.

6.6 Dependence of Observations over Time

The data used in my analysis are both time-series and cross-sectional. A concern with this data is the possible dependence of errors over time and across firms. Since the Heckman (1979) two-stage approach is estimated using the standard OLS and probit models, the error terms can be biased if residuals are correlated across observations. I address this concern using two different methods. First, I restrict my sample to one observation per firm. I select the observation where the firm first entered into my sample resulting in a sample of 335 observations for firms with foreign R&D activities and 618 observations for firms with domestic R&D only. Estimates of the Heckman (1979) two-stage approach are provided in column (1) of Table 21 and Table 22. Consistent with the main results, the coefficients on *FTR* remains positive and significant while the coefficient on the interaction of *FTR* and *FTC* remains negative and significant as seen in Table 21. However, the coefficients on *RDI* and *ALLOC* are now insignificant. In addition, the country-level control variables, *I_Index* and *RDWage* are insignificant. For the selection model in Table 22, *FSR*, *lnTA* and *CITES* remain significant while the remaining variable are now insignificant. The change in the significance of the results may suggest that the dependence of the errors over time may contribute to some of the conclusions reported in Chapter 5. Another possible reason for the lack of significance these variables may be the reduction in the number of observations. By restricting the sample to include only one observation per firm, the number of observations per country is greatly reduced. This may be one reason why the coefficients on the country level variables (*RDI, I_Index* and *RDWage*) are now insignificant.

Peterson (2009) suggests that one method to produce unbiased standard errors in data sets with error terms that are correlated both across time and across firms is by including dummy variables for each time period and clustering the errors by firm. Therefore, as a second approach, I re-estimate the main empirical model using standard errors that are clustered by firm since the main empirical model already includes time dummy variables. Column (2) of Table 21 and Table 22 report the results from estimating the Heckman (1979) two-stage approach using standard errors clustered by firm. The results are similar to the results reported in Chapter 5 for both the main empirical model and the selection model. As seen in Table 21, the coefficients on *RDI*, *ALLOC*, and *FTR* are all positive and significant while the interaction of *FTR* and *FTC* is negative and significant. The results for the selection model in Table 22 remain similar to the selection model results in Chapter 5. Thus, adjusting for the dependence of the errors over time does not alter the results.

6.7 ALLOC Variable

The specification checks described above indicate that the results for the *ALLOC* variable are inconsistent and so the conclusion of a significant effect of the U.S. R&D allocation rules as outlined in Hypothesis 2 may not be reliable. The inconsistent results may be due to a number of issues in measuring *ALLOC*. First, *ALLOC* is not a truly continuous variable. *ALLOC* has a large number of observations valued at zero (56 percent) and very few observations valued at one (3 percent). The remaining observations are concentrated between 0 and 0.5. A second problem is that *ALLOC* is highly correlated with a number of other variables including *FTC*, *FTR* and *FSR*. The high correlation between these variables is not unexpected as they are used in the calculation *ALLOC*. To address these problems, one alternative approach to measuring the *ALLOC* variable could be to examine each of the situations (Case A, Case B and Case C) described in Appendix A separately. However, a variable representing Case A will be the same as the *FTC* variable and so I would not be able to distinguish between the allocation effect and the income shifting effect for firms in deficit foreign tax credit positions. Thus, the effect of the R&D allocation rules can only be examined for firms in excess foreign tax credit positions (Case B and Case C).

6.8 Conclusion

The specification checks reported in this chapter suggest that the conclusions drawn from the main results in the previous chapter are generally robust. Re-estimating the regression model using alternative measures of the R&D tax incentives, the income shifting incentives and the timing of the explanatory variables, different estimation approaches, alternative model specifications to address multicollinearity, alternative sample restrictions and different specifications to address the potential dependence of errors terms over time do not appear to significantly alter the results. One exception is the results related to the U.S. R&D allocation rules as measured by *ALLOC*. When using the lag of *ALLOC*, estimating the equation using MLE and restricting the sample to only profitable firms, *ALLOC* loses significance. Thus, conclusions reached in the previous chapter regarding the positive influence the U.S. R&D allocation rules have on the foreign innovative activity of U.S. MNCs should be treated with caution.

CHAPTER 7: CONCLUSION

In this study, I investigate the association between multi-jurisdictional tax incentives and the location decision for R&D activities. I specifically focus on the tax incentives related to R&D and income shifting. In the analysis, I also consider the influence on the U.S. foreign tax credit system on these incentives.

I use data on patenting from the USPTO to determine the firm-level innovative activity in 20 OECD countries for the period 1986 to 2000. Then, using the Heckman (1979) two-step estimation approach, I regress the percentage of innovative activity in specific foreign country on proxies for R&D tax incentives, the U.S. R&D allocation rules, income shifting incentives, and both firm- and country-level control variables.

I find evidence that the percentage of foreign innovative activities is associated with the attractiveness of the foreign R&D tax incentives and with an increase in the effect of the U.S. R&D allocation rules. In addition, the results suggest that firms in excess foreign tax credit positions decrease the amount of R&D activities in a foreign location with increasing foreign tax rates, consistent with income shifting incentives. However, contrary to expectations, I find a positive relation between the amount of foreign activities and the foreign tax rate.

Specification tests show that the results are robust to an alternative measure for the country-specific R&D tax incentives, alternative measures for the income shifting incentives, and alternative country-level control variables. Further tests to address the potential effect of the high multicollinearity and the dependence of errors over time on the results are also consistent with the main results reported.

Some caution is needed in interpreting the significant results associated with the U.S. R&D allocation rules. Alternative lags for the measurement of the explanatory variables, alternative estimation approaches to the Heckman (1979) two-step procedure, and restricting the sample to profitable firms generally provide results consistent with the main results except for the effect of the U.S. R&D allocation rules. The significantly positive relation between the percentage of foreign patent activity and the allocation rules is not robust to the alternative specifications of a one-year lag in measurement or the MLE estimation approach.

The results of this study contribute to the literature on tax incentives related to R&D and income shifting in several ways. First, to my knowledge, it is the first study to examine and provide evidence of the influence of R&D tax incentives provided by foreign countries on a U.S. multinational's decision on where to locate innovative activities. As well, this study provides additional evidence related to the question of the effect of the U.S. R&D policies. The evidence that the greater the effect of U.S. R&D allocation rules, the greater the foreign R&D activity confirms the country-level findings by Vines and Moore (1996) but does not support the firm-level findings by Hines and Jaffe (2001).

In addition, this study is the first to investigate the role of income shifting incentives on the location decision of R&D. The results suggest that the average foreign tax rate is more important to the location decision than the country-specific tax rate. This provides new insight on the foreign corporate tax rate that a corporation relies in its decision to locate R&D. The study extends the literature on multi-jurisdictional income shifting that has found that firms in excess foreign tax credit positions shift income into the U.S. by providing evidence of the association between income shifting incentives and the location decision for R&D activities. Finally, the study also offers new firm-level evidence on the response of firms in deficit foreign tax credit positions to shift income shifting incentives. It appears that firms in deficit foreign tax credit positions move R&D activities offshore as the foreign tax rises. This is consistent with the explanation that if the royalty payment from the foreign subsidiary to the U.S. parent is flexible, then undertaking R&D in the United States increase future profit-shifting flexibility. Thus, the benefit of the flexibility decreases with an increase in a foreign rate decreases.   However, further investigation is required.

Appendix A:
Foreign Tax Credit Limitations and the Marginal Tax Benefit of Domestic R&D expenditures

Allocation Rules and Foreign Tax Credit Calculation[29]

For U.S. foreign tax credit calculations only, domestic R&D expenditures cannot be fully deducted against domestic source income under the U.S. allocation rules. The current allocation rules were implemented with the 1995 Treasury regulations.[30] The regulations specify two alternative methods of determining the allocation between domestic- and foreign-source income:

◊ 25 percent of U.S.-based R&D expenses allocated to domestic source with the remaining 75 percent allocated between domestic and foreign source based on gross income and

◊ 50 percent of U.S.-based R&D expenses allocated to domestic source with the remaining 50 percent allocated between domestic and foreign source based on sales.

These R&D allocation rules change the foreign tax credit limitation by altering the foreign source income. As discussed in Chapter 3, if the U.S. tax rate is t_{US}, the foreign tax credit limitation is calculated as:

$$\text{Foreign Tax Credit Limitation} = t_{US} \text{ x Foreign-Source Income}$$

Based on the first allocation method, the R&D allocation regulations enter the foreign tax credit limitation computation by changing the foreign-source income (*FSI*) to [*FSI* –

[29] Similar calculations are outlined by Collins and Shackelford (1992) and Newberry and Dhaliwal (2001) to determine the impact of foreign tax credit limitations on the marginal benefit of domestic interest allocations.

[30] See Hines and Jaffe (2001) for a detailed history of the allocation rules.

0.75*(*FI*/*WI*) * R&D] where *FI*/*WI* is the ratio of foreign to worldwide gross income, and *R&D* equals the amount of domestic R&D expenditures. If the second allocation method was used, the ratio of foreign to worldwide sales would change to the ratio of foreign to worldwide sales and be multiplied by 50 per cent (0.5 * *FS*/*WS*). For the following discussion, the corporation is assumed to use the second allocation method.

The foreign tax credit is the lesser of the foreign taxes paid or the limitation amount but must not be less than zero. The present value of foreign tax credit carryovers and the corporation's ability to deduct foreign taxes rather than claiming the credit are not included in this foreign tax credit equation. Thus, foreign tax credit is calculated as:

$$\text{Foreign Tax Credit} = \min(\text{Foreign Income Taxes}, [FSI - 0.5(FS/WS)*\text{R\&D}]*t_{US}) \quad \text{(A)}$$

Impact on Marginal Tax Benefit of Domestic R&D Expenditures[31]

The constraints outlined in equation (A) will determine the effect of the foreign tax credit limitations have on the marginal tax benefit of a domestic R&D expenditure. The total tax liability for a U.S. multinational is:

$$Tax = USTax + FTax - FTC$$

where: *Tax* = total worldwide tax liability,
USTax = U.S. income taxes on worldwide income,
FTax = foreign income taxes, and
FTC = foreign tax credit.

[31] The calculations outlined in this section follow similar calculations used by Collins and Shackelford (1992) and Newberry and Dhaliwal (2001) to determine the impact of foreign tax credit limitations on the marginal tax benefit of domestic interest deductions.

CASE A: *FTC = FTax*

This case can occur when the multinational is in a deficit foreign tax credit position (i.e. t_{us} > average foreign tax rate) and there are no significant domestic losses. In this case, the total tax liability will be equal to *USTax* and the marginal tax benefit of a domestic R&D expenditure will be determined by the U.S. corporate tax rate, t_{us}. Essentially, the foreign tax credit limitation does not have any effect on the marginal tax benefit of a domestic R&D expenditure. This can be seen in the total tax calculation:

$$Tax = [USTax - R\&D(t_{us})] + FTax - FTax$$
$$\partial Tax / \partial R\&D = -t_{us}$$

CASE B: *FTC* = [*FSI* – 0.5(*FS*/*WS*)(*R&D*)]t_{us}

This case occurs when the multinational corporation is an excess foreign tax credit position (i.e. t_{us} < average foreign tax rate) and domestic-source income is positive. In this situation, the foreign tax credit is reduced by $0.5(FS/WS)t_{us}$ with an increase in the allocable domestic R&D expenditures. This means that the foreign tax credit limitation decreases the marginal tax benefit of a domestic R&D expenditure by the 0.5 (*FS*/*WS*) ratio as seen in the total tax calculation:

$$Tax = [USTax - R\&D(t_{us})] + FTax - [FTI - 0.5(FS/WS)(R\&D)]t_{us}$$
$$\partial Tax / \partial R\&D = - t_{us}[1 - 0.5(FS/WS)]$$

CASE C: *FTC = USTax*

This case occurs when domestic-source income is less than or equal to zero and *FTax* is greater than or equal to *USTax*. If domestic-source income is less than or equal to zero, the foreign tax credit limitation is equal to *USTax*.[32] The corporation is in an excess foreign tax credit position if *FTax* is greater than or equal to *USTax*. In this case, the marginal benefit of a domestic R&D expenditure is reduced to zero. The relation can be shown using the total tax calculation:

$$Tax = [USTax - R\&D(t_{us})] + FTax - [USTax - R\&D(t_{us})]$$
$$\partial Tax / \partial R\&D = -t_{us} + t_{us} = 0$$

[32] Recall that U.S. tax law restricts the ratio of foreign income to worldwide income to be less than or equal to one. Thus, if the domestic-source income is negative and the foreign-source income is positive, the foreign tax credit limitation will be the U.S. tax before foreign tax credits.

Appendix B:
The B-Index Model[33]

The B-Index model is a method of measuring the attractiveness of R&D tax systems among jurisdictions. The B-Index is simply the ratio of the after-tax cost of a $1 expenditure on R&D divided by 1 less the corporate income tax rate. The after-tax cost is the net cost to the corporation of investing in R&D, taking into account the available tax incentives for R&D including:

- the time period over which both current and capital expenditures on R&D may be written off against taxable income;
- the existence of any deductions, including accelerated and bonus deductions, from taxable income that are based on the level or change in the level of R&D spending;
- the availability of any tax credits that are based on the level or change in the level of R&D spending; and
- the rate at which corporate income is taxed.

The basic formula for the B-Index is as follows:

$$B = (1 - RDI)/(1 - t)$$

Rearranging provides the formula for *RDI*:

$$RDI = 1 - B(1 - t)$$

Where t is the corporate income tax rate and *RDI* is the net present value of the tax value of depreciation allowances, tax credits and the tax value of special allowances for R&D

[33] Portions of this description are excerpted from Warda (1996, 2002) and Guellec and van Pottelsberghe (2003).

assets. In a country with a full write-off for R&D assets but no other incentives, $RDI = t$ and therefore, $B = 1$. The more attractive a country's tax treatment of R&D, the lower its B-Index.[34]

The calculation of the B-Index requires a number of simplifying assumptions. First, the index assumes that firms have sufficient taxable income to claim the full amount of R&D tax incentives in the current year. Due to this assumption, limits on income and caps on claimability of tax incentives are ignored.   Second, the B-Index model focuses on the tax treatment of R&D for large corporations as they generally perform the bulk of R&D. Third, the corporate tax rate or tax incentive is assumed to be applicable to the top income tax bracket. In addition, the index does not differentiate between refundability and non-refundability provisions of tax incentives. Finally, the B-Index formula ignores differences across countries in the definition of R&D, in the tax treatment of dividend and capital gains, in the personal income tax rates and in the interest rates.

As an illustration, the B-Index for Australia is outlined below.

Australian R&D Tax Incentives

Australia does not offer any tax credits but under the R&D Tax Concession Law companies incorporate in Australia can write off up to 125 per cent of current expenditures for R&D incurred in the year. Capital R&D expenditures for machinery and equipment can be written off at 125 per cent over three years on a straight-line basis. Capital expenditures on buildings face the normal write-off on a straight-line basis over 40 years.

[34] The individual parameters used to calculate the B-Index are not available in most cases. Thus, in calculating *RDI* from the B-Index, assumptions about the corporate tax rate were required and so, some error may be introduced.

B-index Formula:

$B_{aus} = (1 - .9z_1t - .05t(z_2 + z_3)]/(1 - t)$

Where:

t	=	corporate income tax rate (0.36);
z_1	=	present value of current R&D expenditure (1.25);
z_2	=	present value of depreciation of R&D machinery and equipment (1.113);
z_3	=	present value of depreciation of R&D buildings (0.269);
.90	=	proportion of R&D expenditure deducted immediately; and
.05	=	proportion of R&D expenditure incurred on machinery and equipment and on buildings, respectively.[35]

Based on this calculation, the B-index for Australia is 0.890. In comparison to a country that provides 100% write-off of R&D expenditures (i.e. B = 1), Australia's 125% write off is more attractive as indicated by the lower B-Index of 0.890. Note that the *RDI* for Australia will be 0.430.

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[35] Labour, current, capital and building components of R&D expenditures can be taxed differently. To ensure comparability between jurisdictions, the proportion of R&D expenditures is always assumed to be 90 per cent for current expenses (including 60 per cent for wages and salaries), 5 per cent for machinery and equipment, and 5 per cent for buildings and structures (Warda, 1996).

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Table 1
B-Index and General R&D Tax Incentives for 21 OECD Countries, 1999-2000

	B-Index[1]	CIT Rate[2]	Current Deduction	Depreciation ME	Depreciation Building	Tax Credit (TC) or Allowance (A)	Rate on Level	Rate on Increment
Australia	0.89	36%	100%	3 years	40 years	A	125%	
Austria	0.88	34%	100%	5 years	25 years	A	125%	35%
Belgium	1.01	40%	100%	3 years	20 years	A	113.5%	
Canada (Fed)	0.83	32%	100%	100%	4%	TC	20%	
Denmark	0.87	52%	100%	100%	100%	A	125%	
Finland	1.01	28%	100%	25%	20%	-		
France	0.92	40%	100%	40%	20 years	TC		50%
Germany	1.04	52%	100%	30%	4%	-		
Ireland	0.94	10%	100%	7 years	4%	A		40%
Italy	1.03	41%	100%	10 years	33 years	TC	30%	
Japan	0.98	41%	100%	18%	50 years	TC		20%
Korea	0.92	31%	100%	5 years	5 years	TC		50%
Mexico	0.97	35%	100%	35%	20 years	TC		20%
Netherlands	0.90	35%	100%	5 years	25 years	TC	12.5%	
Norway	1.02	28%	100%	20%	5%	-		
Portugal	0.85	37%	100%	4 years	20 years	TC	8%	30%
Spain	0.69	35%	100%	100%	33 years	TC	20%	40%
Sweden	1.02	28%	100%	30%	25 years	-		
Switzerland	1.01	32%	100%	40%	8%	-		
United Kingdom	1.00	30%	100%	100%	100%	-		
United States (Fed)	0.93	35%	100%	5 years	39 years	TC		20%

[1] For large corporations
[2] Corporate Income Tax Rate (CIT)

Source: Warda (2001)

Table 2
Illustration of U.S. Foreign Tax Credit Rules

	No allocation rules/ No royalties		R&D Allocation Rules		R&D Allocation & Royalties	
	Situation 1	Situation 2	Situation 1	Situation 2	Situation 1	Situation 2
U.S. Income	1,000	1,000	1,000	1,000	1,000	1,000
Foreign Income:	600	600	600	600	600	600
Adjustments for FTC calculation:						
R&D Allocation[1]	-	-	(20)	(20)	(20)	(20)
Royalty Payment	-	-	-	-	100	100
Foreign-Source Income for FTC:	600	600	580	580	680	680
U.S. Tax Rate	35%	35%	35%	35%	35%	35%
Average Foreign Tax Rate	20%	50%	20%	50%	20%	50%
Foreign Taxes Paid:[2]	120	300	120	300	120	300
FTC Limitation	210	210	203	203	238	238
FTC = min(Foreign Taxes, FTC limitation)	120	210	120	203	120	238
U.S. Taxes Before FTC[3]	560	560	560	560	560	560
FTC	120	210	120	203	120	238
U.S. Taxes after FTC	440	350	440	357	440	322
Worldwide Tax Liability[4]	560	650	560	657	560	622

Additional assumptions: The U.S. income includes \$200 in R&D expenditures and \$100 royalty payments from a foreign subsidiary. U.S. sales are \$4,000 and Foreign sales are \$1,000.

[1] Based on sales allocation method described in Appendix A, the allocation is determined as 50% * foreign sales/worldwide sales * R&D expenditures or 50% * (\$1,000/\$5,000) *\$200.

[2] Foreign Income * t_F

[3] (U.S. Income + Foreign Income) * t_{US}

[4] U.S. Taxes after FTC + Foreign Taxes Paid

Table 3
Sample Characteristics

Panel A: Industry Breakdown (using Fama-French 12 Industry Definition)

Fama-French Industry Grouping	Main Sample Frequency	Main Sample Percent	Selection Model Sample Frequency	Selection Model Sample Percent	Name
1	67	1.7	217	3.2	Consumer NonDurables
2	219	5.6	375	5.6	Consumer Durables
3	929	23.5	1,806	26.9	Manufacturing
4	64	1.6	112	1.7	Oil, Gas and Coal Extraction and Products
5	572	14.5	754	11.2	Chemicals and Allied Products
6	1,340	33.9	2,396	35.7	Business Equipment
7	0	0	0	0	Telephone and Television Transmission
8	0	0	0	0	Utilities
9	4	0.1	7	0.1	Wholesale, Retail and Some Services
10	739	18.7	980	14.6	Healthcare, Medical Equipment, and Drugs
11	0	0	0	0	Finance
12	14	0.4	61	0.9	Other
	3,948	100.0	6,708	100.0	

Table 3
Sample Characteristics (continued)

Panel B: Annual Breakdown

	Main Sample		Selection Model Sample	
Year	**Frequency**	**Percent**	**Frequency**	**Percent**
1986	158	4.0	302	4.5
1987	174	4.4	316	4.7
1988	179	4.5	324	4.8
1989	182	4.6	330	4.9
1990	188	4.8	340	5.1
1991	177	4.5	338	5.0
1992	215	5.5	421	6.3
1993	276	7.0	494	7.4
1994	294	7.5	517	7.7
1995	331	8.4	562	8.4
1996	375	9.5	585	8.7
1997	425	10.8	636	9.5
1998	331	8.4	552	8.2
1999	343	8.7	528	7.9
2000	300	7.6	463	6.9
	3,948	100.0	6,708	100.0

Table 3
Sample Characteristics (continued)

Panel C: Country Breakdown for Main Sample

Country	**Frequency**	**Percent**
Australia	119	3.0
Austria	25	0.6
Belgium	187	4.7
Canada	486	12.3
Denmark	63	1.6
Finland	14	0.4
France	406	10.3
Germany	512	13.0
Great Britain	714	18.1
Ireland	107	2.7
Italy	190	4.8
Japan	436	11.0
Korea	65	1.7
Mexico	26	0.7
Netherlands	224	5.7
Norway	29	0.7
Portugal	7	0.2
Spain	66	1.7
Switzerland	152	3.9
Sweden	120	3.0
	3,948	100.0

Table 4
Relationship between R&D Expenditures and Patenting

Explanatory Variable	**(1) (t-statistic)**	**(2) (t-statistic)**
Constant	-0.007	-0.714***
	(-0.27)	(-15.33)
ln(R&D)	0.614***	0.441***
	(69.97)	(32.73)
ln(Total Assets)		0.202***
		(16.91)
R^2	0.501	0.520
N	7,064	7,064

Note: *** statistically significant at 1% in a two-tailed test.

This table reports the estimated coefficients from regressing the log of total patents on the log of R&D expenditures using OLS. Column (1) reports the regression without consideration for firm size while Column (2) includes ln(Total Assets) to control for firm size.

Table 5
Descriptive Statistics for Firms with Foreign R&D Activities

Variable	Mean	Median	Minimum	Maximum	Standard Deviation
$PATENT\%_{i,j,t}$	0.087	0.022	0.0001	1.000	0.183
$RDI_{j,t}$	0.383	0.384	0.083	0.692	0.095
$ALLOC_{i,t}$	0.123	0.000	0.000	1.000	0.201
Average $FTR_{i,t}$	0.327	0.346	0.000	0.980	0.174
Statutory $FTR_{j,t}$	0.398	0.360	0.100	0.627	0.103
$FTC_{i,t}$	0.475	0.000	0.000	1.000	0.499
$I\_Index_{j,t}$	0.775	0.687	0.004	1.972	0.443
$RDWage_{j,t}$	10.638	10.631	9.012	11.193	0.298
$FSR_{i,t}$	0.436	0.449	0.002	1.000	0.155
$Q_{i,t}$	0.577	0.493	-2.347	3.476	0.548
$ROA_{i,t}$	0.130	0.125	-0.415	0.885	0.094
$CITES_{i,t}$	4.012	2.591	-5.203	51.618	4.710
$InvMills_{i,t}$	0.404	0.251	0.001	3.302	0.431

The sample of firms with foreign R&D activities consists of 3,948 firm-years for 413 firms in 20 OECD countries for the period 1986 to 2000. $PATENT\%_{i,j,t}$ denotes the portion of patents developed in a foreign country divided by the total number of patents in all countries granted to a firm. $RDI_{j,t}$ is the present value of R&D tax incentives available in country *j* in year *t* as calculated by Warda (1996). $ALLOC_{i,t}$ is a continuous measure of the impact of the foreign tax credit limitation on the marginal benefit of domestic R&D deductions with zero equaling no impact and one equaling maximum impact. The average $FTR_{i,t}$ is the firm-specific tax rate calculated as current and deferred foreign taxes divided by foreign pretax income while the statutory $FTR_{j,t}$ is the country-specific statutory foreign corporate tax rate. $FTC_{i,t}$ is a dummy variable equal to one if the firm is in an excess foreign tax credit position and zero if the firm is in a deficit foreign tax credit position. $I\_Index_{i,t}$ is an index of the innovation environment of country *j* in year *t* developed by Porter and Stern (1999). $RDWage_{j,t}$ is the natural logarithm of R&D wages of engineers of comparable qualifications in the *j*th country. $FSR_{i,t}$ is foreign sales divided by worldwide sales for firm *i* in year *t* and $Q_{i,t}$ is the natural logarithm of Tobin's q. $ROA_{i,t}$ is the pre-R&D return on assets and $CITES_{i,t}$ is the average number of patent citations for firm *i* in year *t* less the average # of citations in the industry for firm *i*. $InvMills_{i,t}$ is the inverse mills ratio obtained from the selection equation specified in equation (8).

Table 6
Pearson Correlation Table
(n = 3948)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. $PATENT\%_{i,j,t}$											
2. $RDI_{j,t}$	0.016										
3. $ALLOC_{i,t}$	-0.027	0.009									
4. Average $FTR_{i,t}$	-0.106	0.054	0.466								
5. $FTC_{i,t}$	-0.065	0.029	0.642	0.726							
6. $I\_Index_{j,t}$	0.043	-0.333	-0.019	-0.027	-0.025						
7. $RDWage_{j,t}$	-0.007	-0.199	-0.026	-0.072	-0.029	0.595					
8. $FSR_{i,t}$	-0.102	-0.078	0.263	0.101	0.105	0.038	0.050				
9. $Q_{i,t}$	-0.074	-0.077	-0.080	-0.036	-0.060	0.060	0.101	0.070			
10. $ROA_{i,t}$	-0.131	-0.037	-0.025	0.101	0.017	0.052	0.051	0.126	0.592		
11. $CITES_{i,t}$	-0.010	0.087	0.029	0.046	0.060	-0.080	-0.094	0.060	-0.150	0.019	
12. $InvMills_{i,t}$	0.448	0.043	-0.160	-0.199	-0.102	-0.018	-0.029	-0.506	-0.157	-0.240	0.030

This table reports the Pearson correlations for the main empirical model. See Table 5 for variable definitions.

Table 7
Comparative Descriptive Statistics for Firms with Foreign R&D Activities vs. Firms with Domestic R&D Activities Only

Variable	N	Mean	Median	Standard Deviation
Panel A: Foreign R&D Firms				
$ALLOC_{i,t}$	3,948	0.123***	0.000	0.201
$FSR_{i,t}$	3,948	0.436***	0.449	0.155
$ROA_{i,t}$	3,948	0.130***	0.125	0.094
$LnTA_{i,t}$	3,948	8.193***	8.455	1.680
$RDIntensity_{i,t}$	3,948	0.083	0.062	0.162
$CITES_{i,t}$	3,948	4.012***	2.591	4.710
Panel B: Domestic R&D only Firms				
$ALLOC_{i,t}$	2,760	0.066	0.000	0.159
$FSR_{i,t}$	2,760	0.290	0.269	0.169
$ROA_{i,t}$	2,760	0.094	0.096	0.156
$LnTA_{i,t}$	2,760	5.846	5.769	1.605
$RDIntensity_{i,t}$	2,760	0.083	0.038	0.302
$CITES_{i,t}$	2,760	5.064	2.021	9.745

Note: *, **, and *** statistically significant at 10%, 5%, and 1%, respectively, between foreign R&D firms and domestic only firms.

$ALLOC_{i,t}$ is a continuous measure of the impact of the foreign tax credit limitation on the marginal benefit of domestic R&D deductions with zero equaling no impact and one equaling maximum impact. $FSR_{i,t}$ is foreign sales divided by worldwide sales for firm *i* in year *t* and $ROA_{i,t}$ is the pre-R&D return on assets. $LnTA_{i,t}$ is the natural logarthim of total assets and $RDIntensity_{i,t}$ is R&D expenditures divided by worldwide sales for firm *i* in year *t*. $CITES_{i,t}$ is the average number of patent citations for firm *i* in year *t* less the average # of citations in the industry for firm *i*.

Table 8
Results from Second Stage of Heckman (1979) Two Step Regression

$$PATENT\%_{i,j,t} = \beta_0 + \beta_1 RDI_{j,t} + \beta_2 ALLOC_{i,t} + \beta_3 FTR_{i,t} + \beta_4 FTC_{i,t} + \beta_5 FTR_{i,t}*FTC_{i,t} + \beta_6 I\_Index_{j,t} + \beta_7 RDWage_{j,t} + \beta_8 FSR_{i,t} + \beta_9 Q_{i,t} + \beta_{10} ROA_{i,t} + \beta_{11} CITES_{i,t} + \beta_{12} InvMills_{i,t} + \sum\beta_{13} YEAR_t + \sum\beta_{14} IND_i + \varepsilon_{i,j,t}$$

Explanatory Variable	**Predicted Sign**	**(1) Average $FTR_{i,t}$ (z-statistic)**	**(2) Statutory $FTR_{j,t}$ (z-statistic)**
Intercept	?	0.130	0.154
		(0.76)	(0.91)
$RDI_{j,t}$	+	0.082**	0.090**
		(2.08)	(2.24)
$ALLOC_{i,t}$	+	0.050**	0.050**
		(1.98)	(2.04)
$FTR_{i,t}$	?	0.108***	
		(2.85)	
$FTR_{j,t}$	?		-0.020
			(-0.41)
$FTC_{i,t}$	?	0.069***	-0.007
		(2.80)	(-0.28)
$FTR_{i,t}*FTC_{i,t}$	-	-0.220***	
		(-3.66)	
$FTR_{j,t}*FTC_{i,t}$	-		0.001
			(0.01)
$I\_INDEX_{j,t}$	+	0.036***	0.037***
		(3.46)	(3.51)
$RDWage_{j,t}$	-	-0.042***	-0.041***
		(-2.55)	(-2.50)
$FSR_{i,t}$	+	0.261***	0.261***
		(8.73)	(8.99)
$Q_{i,t}$	-	-0.026***	-0.025***
		(-3.09)	(-3.04)
$ROA_{i,t}$	+	-0.074*	-0.050
		(-1.52)	(-1.06)
$CITES_{i,t}$	?	-0.005***	-0.006***
		(-6.15)	(-6.57)
$InvMills_{i,t}$	?	0.265***	0.258***
		(25.69)	(26.29)
R^2		0.288	0.284
N		3,948	3,925

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) estimates the two-stage Heckman (1979) using the average foreign tax rate ($FTR_{i,t}$) while Column (2) uses the country statutory tax rate ($FTR_{j,t}$).

See Table 5 for variable definitions. Year and industry coefficients included but not reported.

Table 9
Results from First Stage of Heckman (1979) Two Step Regression

$$ABROAD_{i,t} = \alpha_0 + \alpha_1 ALLOC_{i,t} + \alpha_2 FSR_{i,t} + \alpha_3 ROA_{i,t} + \alpha_4 LnTA_{i,t} + \alpha_5 RDIntensity_{i,t} + \alpha_6 CITES_{i,t} + \sum \alpha_7 YEAR_t + \sum \alpha_8 IND_i + \xi_{i,t}$$

Explanatory Variable	Predicted Sign	Coefficient (z-statistic)
Intercept	?	-4.600*** (-29.05)
$ALLOC_{i,t}$	+	0.349*** (3.17)
$FSR_{i,t}$	+	2.307*** (19.55)
$ROA_{i,t}$	+	0.445*** (2.48)
$LnTA_{i,t}$	+	0.451*** (37.22)
$RDIntensity_{i,t}$	+	0.189*** (2.57)
$CITES_{i,t}$	?	-0.009*** (-2.80)
Pseudo R^2		0.3732
N		6,708

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise.

See Table 7 for variable definitions. Year and industry coefficients included but not reported.

Table 10
Multicollinearity Diagnostics
Variance Inflation Factors (VIFs)

Explanatory Variable	**VIFs**
$RDI_{j,t}$	1.07
$ALLOC_{i,t}$	1.73
$FTR_{i,t}$	4.02
$FTC_{i,t}$	11.98
$FTR_{i,t}*FTC_{i,t}$	16.92
$I\_INDEX_{j,t}$	2.03
$RDWage_{j,t}$	1.71
$FSR_{i,t}$	1.72
$Q_{i,t}$	1.30
$ROA_{i,t}$	1.37
$CITES_{i,t}$	`1.05
$InvMills_{i,t}$	2.22
Mean VIF	3.93

See Table 5 for variable definitions.

Table 11
Specification Check of the Measure of R&D Tax Incentives:

Explanatory Variable	(1) ***RDI_Bloom*** (z-statistic)	(2) ***RDI*** (z-statistic)
Intercept	-0.109	0.070
	(-0.47)	(0.29)
$RDI_{j,t}$		0.150**
		(2.20)
$RDI\_Bloom_{j,t}$	0.171*	
	(1.63)	
$ALLOC_{i,t}$	0.073**	0.073**
	(2.22)	(2.22)
$FTR_{i,t}$	0.135***	0.136***
	(2.72)	(2.74)
$FTC_{i,t}$	0.082***	0.082***
	(2.60)	(2.64)
$FTR_{i,t}*FTC_{i,t}$	-0.262***	-0.264***
	(-3.39)	(-3.42)
$I\_INDEX_{j,t}$	0.014	0.018
	(1.05)	(1.36)
$RDWage_{j,t}$	-0.039**	-0.050**
	(-1.67)	(-2.03)
$FSR_{i,t}$	0.336***	0.335***
	(8.15)	(8.16)
$Q_{i,t}$	-0.037***	-0.038***
	(-2.83)	(-2.87)
$ROA_{i,t}$	-0.081	-0.081
	(-1.20)	(-1.19)
$CITES_{i,t}$	-0.006***	-0.006***
	(-5.96)	(-5.97)
$InvMills_{i,t}$	0.258***	0.257***
	(20.77)	(20.78)
R^2	0.295	0.293
N	2,143	2,143

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) reports estimations of the regression using *RDI_Bloom*. Column (2) re-estimates regression with *RDI* but on the reduced sample used to test *RDI_Bloom*.

See Table 5 for variable definitions except *RDI_Bloom*. *RDI_Bloom* is the present value of tax incentives available in country *j* in year *t* as calculated by Bloom et al. (2002). Year and industry coefficients included but not reported.

Table 12
Specification Check of *FTR* Measure:
Main Empirical Model

$$PATENT\%_{i,j,t} = \beta_0 + \beta_1 \overline{RDI}_{j,t} + \beta_2 \overline{ALLOC}_{i,t} + \beta_3 \overline{FTR}_{i,t} + \beta_4 \overline{FTC}_{i,t} + \beta_5 \overline{FTR}_{i,t} * \overline{FTC}_{i,t} + \beta_6 \overline{I\_Index}_{j,t} + \beta_7 \overline{RDWage}_{j,t} + \beta_8 \overline{FSR}_{i,t} + \beta_9 \overline{Q}_{i,t} + \beta_{10} \overline{ROA}_{i,t} + \beta_{11} CITES_{i,t} + \beta_{12} InvMills_{i,t} + \sum \beta_{13} YEAR_t + \sum \beta_{14} IND_i + \varepsilon_{i,j,t} \quad (9)$$

Explanatory Variable	**(1)** **5-Year Average** **(z-statistic)**	**(2)** **3-year Average** **(z-statistic)**
Intercept	-0.289	-0.187
	(-1.39)	(-1.01)
$\overline{RDI}_{j,t}$	0.082**	0.075**
	(1.73)	(1.85)
$\overline{ALLOC}_{i,t}$	-0.009	0.051**
	(-0.44)	(2.17)
$\overline{FTR}_{i,t}$	0.136***	0.151***
	(2.77)	(3.70)
$\overline{FTC}_{i,t}$	0.043*	0.072***
	(1.54)	(2.86)
$\overline{FTR}_{i,t} * \overline{FTC}_{i,t}$	-0.167***	-0.224***
	(-2.33)	(-3.63)
$\overline{I\_Index}_{j,t}$	0.014	0.018**
	(1.18)	(1.74)
$\overline{RDWage}_{j,t}$	-0.006	-0.012
	(-0.32)	(-0.74)
$\overline{FSR}_{i,t}$	0.324***	0.272***
	(7.12)	(7.21)
$\overline{Q}_{i,t}$	0.003	-0.001
	(0.69)	(-0.11)
$\overline{ROA}_{i,t}$	-0.244***	-0.189***
	(-3.65)	(-3.44)
$CITES_{i,t}$	-0.005***	-0.005***
	(-4.77)	(-5.34)
$InvMills_{i,t}$	0.284***	0.261***
	(11.60)	(12.73)
R^2	0.278	0.277
N	3,537	3,833

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) reports results using 5-year averages of explanatory variables and column (2) reports results using 3-year averages.

See Table 5 for variable definitions except the variables in this Table are measured over 5 or 3 years except for $CITES_{i,t}$ and $PATENT_{i,j,t}$. $CITES_{i,t}$ and $PATENT\%_{i,j,t}$ are not averaged but measured annually. Year and industry coefficients included but not reported.

Table 13
Specification Check of FTR Measure:
Selection Model

$$ABROAD_{i,t} = \alpha_0 + \alpha_1 \overline{ALLOC}_{i,t} + \alpha_2 \overline{FSR}_{i,t} + \alpha_3 \overline{ROA}_{i,t} + \alpha_4 \overline{LnTA}_{i,t} + \alpha_5 \overline{RDIntensity}_{i,t} + \alpha_6 CITES_{i,t} + \sum \alpha_7 YEAR_t + \sum \alpha_8 IND_i + \xi_{i,t} \quad (10)$$

Explanatory Variable	(1) 5-Year Average (z-statistic)	(2) 3-Year Average (z-statistic)
Intercept	-4.745***	-4.767***
	(-26.45)	(-28.26)
$\overline{ALLOC}_{i,t}$	-0.002	0.424***
	(-0.02)	(3.82)
$\overline{FSR}_{i,t}$	2.950***	2.742***
	(19.17)	(20.53)
$\overline{ROA}_{i,t}$	1.257***	0.897***
	(4.56)	(3.87)
$\overline{LnTA}_{i,t}$	0.464***	0.462***
	(32.73)	(35.33)
$\overline{RDIntensity}_{i,t}$	0.175	0.151*
	(1.21)	(1.57)
$CITES_{i,t}$	-0.008**	-0.008**
	(-2.13)	(-2.36)
Pseudo R^2	0.400	0.360
N	2,103	2,512

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) reports results using 5-year average of explanatory variables and column (2) reports results using 3-year averages.

See Table 7 for variable definitions except the variables in this Table are measured over 5 or 3 years except for $CITES_{i,t}$ and $PATENT_{i,j,t}$. $CITES_{i,t}$ and $PATENT\%_{i,j,t}$ are not averaged but measured annually. Year and industry coefficients included but not reported.

Table 14
Specification Check of Country-Level Control Variables

Explanatory Variable	(1) Country Factors Examined Separately		(2) Country Factors without *GERD* & *GDP*		(3) Country Factors without *RDPerson* & *GDP*		(4) Country Factors without *RDPerson* & *GERD*	
	Estimates (z-statistic)	VIFs	Estimates (z-statistic)	VIFs	Estimates (z-statistic)	VIFs	Estimates (z-statistic)	VIFs
Intercept	0.140 (0.37)		-0.601*** (-2.74)		-0.536*** (-2.55)		-0.683*** (-3.05)	
$RDI_{j,t}$	0.101** (1.89)	1.86	0.074* (1.60)	1.47	0.085** (1.85)	1.45	0.086** (1.87)	1.46
$ALLOC_{i,t}$	0.050** (1.96)	1.84	0.050** (1.97)	1.84	0.050** (1.97)	1.84	0.050** (1.97)	1.84
$FTR_{i,t}$	0.108*** (2.82)	3.96	0.111*** (2.89)	3.93	0.111*** (2.88)	3.92	0.112*** (2.90)	3.92
$FTC_{i,t}$	0.071*** (2.86)	13.01	0.072*** (2.92)	13.00	0.072*** (2.91)	13.01	0.072*** (2.92)	13.01
$FTR_{i,t}*FTC_{i,t}$	-0.224*** (-3.66)	18.81	-0.228*** (-3.73)	18.79	-0.227*** (-3.72)	18.79	-0.228*** (-3.73)	18.79
$RDPerson_{j,t}$	-0.031 (-0.90)	89.58	0.013*** (2.83)	1.96				
$GERD_{j,t}$	0.073** (2.34)	51.76			0.013*** (3.15)	1.74		
$GDP\_Capita_{j,t}$	0.029 (0.98)	3.98	0.064*** (2.66)	2.81	0.063*** (2.71)	2.80	0.073*** (3.06)	2.88
$GDP_{j,t}$	-0.038 (-1.61)	36.14					0.013*** (2.60)	1.76
$IPR_{j,t}$	-0.013 (-1.04)	1.65	-0.001 (-0.05)	1.42	-0.004 (-0.35)	1.45	-0.002 (-0.16)	1.45
$IndFund_{j,t}$	-0.046 (-0.82)	3.17	0.010 (0.18)	2.43	0.011 (0.24)	2.38	0.020 (0.39)	2.60
$Specialization_{j,t}$	0.004 (0.08)	4.77	-0.070* (-1.79)	3.83	-0.066* (-1.81)	3.37	-0.067* (-1.73)	3.84
$RDWage_{j,t}$	-0.045*** (-2.36)	1.88	-0.044*** (-2.45)	1.73	-0.047*** (-2.57)	1.77	-0.047*** (-2.55)	1.80
$FSR_{i,t}$	0.268** (8.85)	1.46	0.268*** (8.84)	1.45	0.267*** (8.84)	1.45	0.267*** (8.83)	1.45
$Q_{i,t}$	-0.026*** (-3.02)	1.70	-0.027*** (-3.08)	1.65	-0.026*** (-3.07)	1.65	-0.026*** (-3.09)	1.65
$ROA_{i,t}$	-0.078* (-1.58)	1.67	-0.076* (-1.55)	1.67	-0.076* (-1.54)	1.67	-0.076* (-1.53)	1.67
$CITES_{i,t}$	-0.006*** (-6.29)	1.27	-0.006*** (-6.20)	1.15	-0.006*** (-6.22)	1.14	-0.006*** (-6.20)	1.15
$InvMills_{i,t}$	0.266*** (25.44)	1.52	0.266*** (25.44)	1.52	0.265*** (25.45)	1.52	0.266*** (25.45)	1.52
R^2	0.295		0.293		0.293		0.292	
N	3,846		3,846		3,855		3,855	

Note: *, **, *** significant at 10%, 5% and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) estimates of regression replacing $I\_Index_{j,t}$ with $RDPerson_{j,t}$, $GERD_{j,t}$, $GDP\_Capita_{j,t}$, $GDP_{j,t}$, $IPR_{j,t}$, $IndFund_{j,t}$ and $Specialization_{j,t}$. The remaining columns estimate the regression in column (1) but include $RDPerson_{j,t}$, $GERD_{j,t}$, and $GDP_{j,t}$ separately. Column (2) includes only $RDPerson_{j,t}$, column (3) includes only $GERD_{j,t}$ and column (4) includes only $GDP_{j,t}$. Year and Industry coefficients included but not reported.

See Table 5 for variable definitions except for the following. $RDPerson_{j,t}$ is the natural logarithm of the aggregate personnel employed in R&D and $GERD_{j,t}$ is the natural logarithm of total R&D expenditures in Year 2000 US$. $IPR_{j,t}$ measures the strength of protection for intellectual property. $GDP\_capita_{j,t}$ is the natural logarithm of GDP per capita and $GDP_{j,t}$ is the natural logarithm of GDP. $IndFund_{j,t}$ is the R&D expenditures funded by industry divided by the total R&D expenditures in country *j* and $Specialization_{j,t}$ is the total # of patents in ICT and BIO technology in country *j* divided by total # patents in ICT and BIO technology in 20 OECD countries.

Table 15
Pearson Correlation Table: Country-Level Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. $RDI_{j,t}$										
2. $I\_Index_{j,t}$	-0.350									
3. $RDPerson_{j,t}$	0.059	0.442								
4. $GERD_{j,t}$	-0.021	0.467	0.983							
5. $IPR_{j,t}$	-0.317	0.335	0.143	0.204						
6. $GDP_{j,t}$	0.047	0.322	0.970	0.957	0.167					
7. $GDP\_Capita_{j,t}$	-0.386	0.814	0.371	0.390	0.330	0.248				
8.. $IndFund_{j,t}$	-0.343	0.723	0.244	0.274	0.383	0.126	0.581			
9. $Specialization_{j,t}$	-0.039	0.668	0.650	0.608	0.161	0.546	0.609	0.615		
10. $RDWage_{\mathrm{j,t}}$	-0.216	0.579	0.159	0.196	0.390	0.134	0.552	0.413	0.209	

See Table 5 and Table 14 for variable definitions.

Table 16
Specification Check of One- and Two-Year Lags

Explanatory Variable	**(1)** **One-year lag** **(z-statistic)**	**(2)** **Two-year lag** **(z-statistic)**
Intercept	0.006	0.010
	(0.04)	(0.07)
RDI_j	0.079**	0.067**
	(2.17)	(1.92)
$ALLOC_i$	0.024	0.047**
	(1.01)	(2.07)
FTR_i	0.132***	0.104***
	(3.76)	(3.00)
FTC_i	0.064***	0.062***
	(2.79)	(2.81)
FTR_i*FTC_i	-0.198***	-0.203***
	(-3.55)	(-3.82)
I_Index_j	0.029***	0.019**
	(2.98)	(2.09)
$RDWage_j$	-0.026**	-0.019*
	(-1.77)	(-1.33)
FSR_i	0.247***	0.219***
	(8.57)	(7.59)
Q_i	-0.034***	-0.038**
	(-3.72)	(-4.02)
ROA_i	-0.049	0.002
	(-0.96)	(0.03)
$CITES_i$	-0.004***	-0.003***
	(-4.81)	(-5.07)
$InvMills_i$	0.237***	0.219***
	(22.89)	(20.57)
R^2	0.252	0.223
N	3,729	3,485

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) and column (2) report the results of estimating the regression equation using one- and two-year lags, respectively

See Table 5 for variable definitions. Year and industry coefficients included but not reported.

Table 17
Specification Check of the Estimation Approach:
Main Empirical Model

Explanatory Variable	**(1) Heckman MLE (z-statistic)**	**(2) OLS (t-statistic)**	**(3) OLS with Size Variable (t-statistic)**
Intercept	-0.224***	0.624***	0.915***
	(-2.98)	(4.73)	(7.41)
$RDI_{j,t}$	0.022*	0.075***	0.082***
	(1.40)	(2.37)	(2.90)
$ALLOC_{i,t}$	0.010	0.028	0.033*
	(1.22)	(1.10)	(1.50)
$FTR_{i,t}$	0.081***	-0.132***	0.054*
	(5.19)	(-3.18)	(1.48)
$FTC_{i,t}$	0.052***	-0.017	0.064***
	(4.51)	(-0.79)	(3.27)
$FTR_{i,t}*FTC_{i,t}$	-0.175***	0.063	-0.181***
	(-6.39)	(1.13)	(-3.56)
$I\_Index_{j,t}$	0.007*	0.039***	0.037***
	(1.62)	(4.27)	(4.36)
$RDWage_{j,t}$	-0.001	-0.041***	-0.042***
	(-0.11)	(-3.23)	(-3.65)
$FSR_{i,t}$	0.293***	-0.080***	-0.066
	(17.51)	(-3.29)	(-0.31)
$Q_{i,t}$	-0.014***	-0.017**	-0.029***
	(-4.01)	(-2.06)	(-3.86)
$ROA_{i,t}$	0.015	-0.178***	-0.149***
	(0.60)	(-3.80)	(-3.61)
$CITES_{i,t}$	-0.004***	-0.005***	-0.005***
	(-6.94)	(-4.05)	(-5.17)
$LnTA_{i,t}$			-0.049***
			(-21.15)
$RDIntensity_{i,t}$			-0.033*
			(-1.64)
$InvMills_{i,t}$	0.198		
R^2	0.209	0.0671	0.236
N	3,948	3,948	3,948

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) reports estimation of equation (7) using MLE approach. Column (2) and (3) estimate equation (7) using OLS. Column (3) includes additional variables, *lnTA* and *RDIntensity*, which are not in equation (7).

See Table 5 for variable definitions. Year and industry coefficients included but not reported.

Table 18
Specification Check of the Estimation Approach:
Selection Model (MLE only)

Explanatory Variable	(1) Heckman MLE (z-statistic)
Intercept	-2.533 (-17.72)
$FSR_{i,t}$	1.792 (22.52)
$ROA_{i,t}$	0.352 (3.36)
$LnTA_{i,t}$	0.188 (14.50)
$RDIntensity_{i,t}$	-0.102 (-3.03)
$CITES_{i,t}$	-0.010 (-3.84)
N	8,493

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) reports estimation of equation (8) using MLE approach.

See Table 7 for variable definitions. Year and industry coefficients included but not reported.

Table 19
Alternative Specifications of the Equation (7) to Address Multicollinearity

Explanatory Variable	**(1) Eliminating ALLOC (z-statistic)**	**(2) Eliminating FTR, FTC and FTR*FTC (z-statistic)**
Intercept	0.131	0.165
	(0.77)	(0.99)
$RDI_{j,t}$	0.082**	0.084**
	(2.06)	(2.18)
$ALLOC_{i,t}$		0.039**
		(1.91)
$FTR_{i,t}$	0.105***	
	(2.76)	
$FTC_{i,t}$	0.074***	
	(3.14)	
$FTR_{i,t}*FTC_{i,t}$	-0.221***	
	(-3.69)	
$I\_INDEX_{j,t}$	0.036***	0.036***
	(3.44)	(3.52)
$RDWage_{j,t}$	-0.042***	-0.043***
	(-2.55)	(-2.67)
$FSR_{i,t}$	0.275***	0.264***
	(9.39)	(9.08)
$Q_{i,t}$	-0.027***	-0.025***
	(-3.20)	(-3.08)
$ROA_{i,t}$	-0.075*	-0.053
	(-1.54)	(-1.12)
$CITES_{i,t}$	-0.005***	-0.006***
	(-6.21)	(-6.59)
$InvMills_{i,t}$	0.265***	0.259***
	(25.77)	(26.36)
R^2	0.288	0.284
N	3,948	3,948

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) reports the estimation of equation (7) without *ALLOC* and Column (2) reports without *FTR*, *FTC* and *FTR*FTC*.

See Table 5 for variable definitions. Year and industry coefficients included but not reported.

Table 20
Specification Check Using Restricted Samples

Explanatory Variable	(1) Profit Firms (z-statistic)	(2) Profit Firms Without ALLOC (z-statistic)	(3) Profit Firms Without FTR, FTC, & FTR*FTC (z-statistic)	(4) Main Country with R&D Activity (z-statistic)
Intercept	0.117	0.117	0.131	0.473
	(0.63)	(0.64)	(0.72)	(1.81)
$RDI_{j,t}$	0.111***	0.110***	0.111***	0.339***
	(2.64)	(2.63)	(2.65)	(4.70)
$ALLOC_{i,t}$	0.051		0.013	0.116***
	(0.61)		(0.33)	(2.45)
$FTR_{i,t}$	0.056	0.045		0.259***
	(0.94)	(0.75)		(4.18)
$FTC_{i,t}$	0.040	0.038		0.149***
	(1.19)	(1.39)		(3.45)
$FTR_{i,t}*FTC_{i,t}$	-0.133**	-0.125**		-0.509***
	(-1.74)	(-1.66)		(-4.90)
$I\_INDEX_{j,t}$	0.032***	0.031***	0.031***	0.086***
	(2.89)	(2.86)	(2.89)	(4.57)
$RDWage_{j,t}$	-0.038**	-0.038**	-0.038**	-0.120***
	(-2.18)	(-2.17)	(-2.20)	(-3.83)
$FSR_{i,t}$	0.246***	0.260***	0.258***	0.460***
	(6.04)	(8.00)	(7.44)	(8.10)
$Q_{i,t}$	-0.025**	-0.025***	-0.024**	-0.045***
	(-2.50)	(-2.51)	(-2.45)	(-3.32)
$ROA_{i,t}$	-0.131**	-0.134**	-0.131**	-0.096
	(-1.83)	(-1.91)	(-1.86)	(-1.19)
$CITES_{i,t}$	-0.004***	-0.004***	-0.004***	-0.008***
	(-4.13)	(-4.17)	(-4.34)	(-6.16)
$InvMills_{i,t}$	0.244***	0.243***	0.243***	0.358***
	(21.41)	(21.46)	(21.78)	(16.08)
R^2	0.268	0.266	0.267	0.276
N	3,114	3,114	3,114	1,489

Note: *, **, *** significant at 10%, 5% and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) estimates the regression in equation (7) excluding firms with negative pretax domestic or foreign income. Column (2) and (3) estimates the regression in equation (7) without *ALLOC* and *FTR*, *FTC* and *FTR*FTC*, respectively excluding firms with negative pretax domestic or foreign income. Column (4) estimate equation (7) allowing one observation per firm per year.

See Table 5 for variable definitions. Year and industry coefficients included but not reported.

Table 21
Specification Check Examining Dependence of Errors:
Main Empirical Model

Explanatory Variable	**(1) One Observation Per Firm (z-statistic)**	**(2) Standard Errors Clustered by Firm (t-statistic)**
Intercept	0.520	0.130
	(0.65)	(0.54)
$RDI_{j,t}$	0.147	0.082**
	(0.87)	(1.86)
$ALLOC_{i,t}$	0.098	0.050**
	(0.83)	(2.07)
$FTR_{i,t}$	0.529***	0.108***
	(3.71)	(2.43)
$FTC_{i,t}$	0.091	0.069**
	(0.72)	(2.51)
$FTR_{i,t}*FTC_{i,t}$	-0.617**	-0.220***
	(-2.29)	(-3.04)
$I\_INDEX_{j,t}$	0.077	0.036**
	(1.49)	(2.21)
$RDWage_{j,t}$	-0.093	-0.042**
	(-1.17)	(-1.95)
$FSR_{i,t}$	0.228**	0.261***
	(1.78)	(5.39)
$Q_{i,t}$	-0.070**	-0.026**
	(-2.02)	(-2.05)
$ROA_{i,t}$	-0.234*	-0.074*
	(-1.39)	(-1.39)
$CITES_{i,t}$	-0.008***	-0.005***
	(-2.76)	(-4.60)
$InvMills_{i,t}$	0.404***	0.265***
	(5.02)	(11.26)
R^2	0.251	0.288
N	335	3,948

Note: *, **, *** significant at 10%, 5% and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) estimates equation (7) using only the first observation of a firm in the main sample. Column (2) estimates equation (7) on the main sample using standard errors clustered by firm.

See Table 5 for variable definitions. Year and industry coefficients included but not reported.

Table 22
Specification Check Examining Dependence of Errors: Selection Model

Explanatory Variable	(1) One Observation Per Firm (z-statistic)	(2) Standard Errors Clustered by Firm (z-statistic)
Intercept	-2.758***	-4.600***
	(-7.37)	(-13.75)
$ALLOC_{i,t}$	0.035	0.349**
	(0.14)	(2.20)
$FSR_{i,t}$	0.896***	2.307***
	(3.51)	(8.85)
$ROA_{i,t}$	0.034	0.445*
	(0.10)	(1.59)
$LnTA_{i,t}$	0.238***	0.451***
	(8.26)	(16.49)
$RDIntensity_{i,t}$	0.237	0.189
	(0.23)	(1.22)
$CITES_{i,t}$	-0.010**	-0.009*
	(-1.98)	(-1.94)
Pseudo R^2	0.101	0.3732
N	953	6,708

Note: *, **, and *** significant at 10%, 5%, and 1%, respectively, with a one-tailed test for variables with a sign prediction and a two-tailed test, otherwise. Column (1) estimates equation (8) using only the first observation of a firm in the main sample. Column (2) estimates equation (8) on the main sample using standard errors clustered by firm.

See Table 7ered by firm.

See Table 7 for variable definitions. Year and industry coefficients included but not reported.