# IMPROVING CANADA'S INNOVATIVE CAPACITY THROUGH INTERNATIONAL PATENTING

by

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PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF PUBLIC POLICY

In the
Faculty
of
Arts and Social Sciences



SIMON FRASER UNIVERSITY

Spring 2006

# Abstract

Innovation, as a key contributor to economic growth, is a priority for governments around the world. Accurate indicators of innovation are essential to developing effective policies and reliable benchmarks. One such indicator is priority triadic patent families, which is a refined measure of international patenting developed by the OECD. The focus of this study is Canada's inability to increase its international patenting rate relative to other economies and the ways in which Canada may improve its position. Literature suggests that key factors leading to increased patenting are R&D expenditures, a skilled workforce, openness to trade, and outward foreign direct investment. Quantitative analysis of countries holding foreign patents reveals population, high-income status, outward foreign direct investment and R&D expenditures correlate significantly with international patenting. Accordingly, this study recommends Canada-specific policy options to increase outward foreign direct investment and improve the efficiency of R&D expenditures.

# Executive Summary

This research study aims to determine the factors that influence a country's level of international patenting and to recommend how Canada can increase its patent filing abroad by using international patenting as a proxy for innovation. It is widely agreed that innovation is necessary for economic growth and improved standards of living. Through effective public policies, governments can play an important role in expanding innovation and encouraging innovative pursuits. Accordingly, defining appropriate indicators of innovation is crucial. A standard, but often-misused proxy for innovation is patenting. In the sphere of patent activity, Canada is losing ground. It has experienced small, incremental increases in patents filed domestically and a decline in patents filed internationally. At the same time, new competitors like Taiwan and Israel are gaining ground, patenting at a faster rate than Canada. It is therefore imperative for Canada to renew its focus on innovation and develop policies to improve its performance.

**Patenting as a Measure of Innovation**

Patenting is a strong measure of innovation; however, there are two major limitations. One, it measures invention, not innovation; and two, it does not capture all inventions. Unlike input indicators, such as the number of scientists in the workforce or research and development (R&D) expenditures, patenting is an output with a closer relationship to the commercialisation of knowledge. A combination of measurements, both as inputs and outputs is ideal, but access to reliable data, particularly for a large number of countries, is problematic. For these reasons, patenting is the best proxy for innovation when studying a large sample of countries.

General patent counts based on applications are not sufficient to capture innovation adequately. To ensure the best possible measure of a country's innovative capacity, one must specify the following:

- Patents should be calculated based on filing at three or more major patent offices to reduce the probability of capturing novelty patents. Patent owners who file internationally do so anticipating their invention will generate a financial return.

- Patents must be attributed to the inventor's country of residence instead of the patent owner's country of residence, thereby capturing the inventive output of the country.
- Patents with more than one inventor residing in different countries should be assigned to each inventor's country using fractional attribution.
- Given the length of time it takes to approve and issue a patent, the reference year should be the priority date, not the grant date as the priority date is the first recorded date that is closest to the year of invention.

**Methodology**

This study comprises both a literature review and a regression analysis. The literature review provides the justification for the variables used in the regression analysis and how the variables are measured. It also informs the background, context, analysis, and recommendations. The analytical model, a multivariate linear regression, establishes the relationship between international patenting and six explanatory variables. It is designed to accommodate the greatest number of countries that filed international patents in the reference year. Each country in the sample filed a patent as classified by the International Patent Classification (IPC) in the priority year 2000. Of the 65 countries that filed in that year, data exist for 47.

**Variables**

The dependent variable is the number of priority triadic patent families filed in the reference year. Triadic patent families are patents filed at the European, Japanese and American patent offices that share one or more priority dates.

There are six explanatory variables: tertiary education spending, foreign students, outward foreign direct investment, research and development (R&D) spending, population, and high-income status. The data for all variables except tertiary education spending and R&D are converted to natural logarithms to manage the scale and to reference the data in terms of percentage changes.

The model includes tertiary education because innovation has been associated with a skilled workforce. As such, the percent of a country's education spending dedicated to tertiary education is used as a proxy for a skilled workforce. The number of foreign students is included based on the results of a study conducted in the United States that found in years when there are greater numbers of foreign students, the number of patents applications and later the number of patents awarded increase. Data show that transnational firms patent more than other types of

companies. Outward foreign direct investment flows are hypothesised to correlate positively with triadic patent families as these firms seek protection of their inventions in the countries in which they do business. In addition, studies have shown that lagged R&D is significantly correlated with increases in patenting. R&D in this study has been lagged by three years to represent that investment in R&D occurs prior to output. Further, it is believed that high-income countries patent more based on the ability of residents to access funds necessary to engage in inventive activity. The hypothesis is that high-income status will positively correlate with triadic patenting. Finally, population is used as an explanatory variable. Holding all other variables constant, it is anticipated that more potential inventors will lead to more internationally patented inventions.

**Findings and Analysis**

This study shows that as a top ten triadic patenting country, Canada's position is favourable. In light of recent competition from new entrants in the international patenting sphere, the regression results prove instructive. The model supports all hypotheses, except those concerning foreign students and tertiary education. These two variables are not significant. In the case of tertiary education, the results show that the correlation is in fact negative, not positive as hypothesised. Outward foreign direct investment and R&D spending are significant and positively correlated. Determining how Canada can increase these two factors is essential to securing Canada's position relative to other countries. This leaves high income and population. For the purpose of developing policy alternatives, this study does not further explore these variables. Canada is already a high-income country and it is not reasonable to suggest that Canada increase its population solely to achieve increased triadic patenting.

**Alternatives**

In recent years, Canada has experienced declining outward foreign direct investment (FDI). At the same time, its performance in translating R&D spending into commercial outputs has been unsatisfactory. Another important consideration is Canada's proportionately higher level of small and medium-sized enterprises (SMEs) to larger firms. Together, the regression results and these facts have informed the policy alternatives identified. Accordingly, six alternatives are suggested to facilitate increased outward FDI and effective R&D spending.

Bilateral investment treaties (BITs), an expansion of the small and medium-sized export development program, and the provision of foreign market information to Canadian business are policy options that may prove successful in increasing outward FDI. Liberalised trade in general and BITs in particular have been found to stimulate outward FDI. SMEs make up a large

proportion of Canadian businesses. As such, policies that help SMEs access new export markets may lead to increased outward FDI in the longer term. By expanding existing SME export development programs to facilitate exporting to non-traditional markets, SMEs can test these markets and potentially expand operations locally. Finally, accurate, distilled information is a premium commodity for Canadian businesses. Organising the vast resources of government to collect and distribute foreign market information including investment climate, political stability, and economic prospects will provide businesses with the data they require to make informed decisions on where to conduct business.

There are also three options to improve R&D spending. First, the status quo is a viable option because Canadian R&D spending has increased in recent years and Canada ranks in the top ten of triadic patenting. Yet, there are areas to increase R&D spending. For example, foreign ownership restrictions exist in a few key industries that engage in considerable R&D spending. These are telecommunications and commercial aviation. Reducing or eliminating foreign ownership restrictions will expose these two industries to more foreign capital, which may then be spent on R&D activity. Increasing R&D spending, however, does not address Canada's poor R&D performance. Commissioning an R&D study to examine the issue will produce recommendations on how to better invest in Canadian R&D.

The assessment comprises evaluating each alternative against a set of criteria: effectiveness, political acceptability, government costs, and multiple objectives. Effectiveness refers to the impact that an alternative would have on increasing outward FDI, R&D spending and ultimately triadic patenting. A high ranking for political acceptability requires the alternative be viewed favourably by government; consistent with domestic and international laws; and pose few intergovernmental impediments to adoption and execution. Low government costs are seen as better than high government costs. In this context, costs include administrative, human resource, and direct financial expenses. Lastly, alternatives that meet multiple objectives related to international patenting or broad national objectives are viewed as better than single objective policy options.

**Recommendations**

After analysing the alternatives, the following recommendations emerge:

- Pursue bilateral investment treaties with a new emphasis on emerging and developing economies;

- Reduce foreign ownership restrictions in the telecommunications sector for distribution only; and
- Initiate and fund a commission on R&D and innovation in Canada.

Taken together these recommendations will lead to expanded outward FDI, more efficient R&D spending, and increased triadic patenting. Looking to the future, Canada can expect to advance its innovation performance, secure its position relative to other countries, and improve the overall well-being of Canadians.

# Dedication

To my dear mother for your strength, determination and perseverance.

# Acknowledgements

This project could not have been possible without the guidance and support of the faculty and staff of the Master of Public Policy Program. In particular, I would like to extend my deep appreciation to Professor Douglas McArthur for his guidance and encouragement throughout this process. I owe a special thank you to Dr. John Richards for his generosity and the wealth of information he has shared in and out of the classroom. I would also like to thank Dr. Dominique Gross for the hours of invaluable econometrics advice.

Thanks are due to Dumitru Olariu at the Canadian Intellectual Property Office and Sean Irvine at the University of British Columbia.

To my friends and family, I express my sincere gratitude for your support. I want particularly to acknowledge Wesley Trotman, Sharon Hummel, Genevieve Pfieffer, and Karma Call.

Ruth Abrahamson, without you I may not have started this journey. Thank you.

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# List of Acronyms and Abbreviations

| Term | Definition |
|---|---|
| BIT | Bilateral Investment Treaty |
| CIDA | Canadian International Development Agency |
| CIPO | Canadian Intellectual Property Office |
| EPO | European Patent Office |
| FDI | Foreign Direct Investment |
| GERD | Gross Domestic Expenditure on Research and Development |
| GPT | General Purpose Technology |
| IFDI | Inward Foreign Direct Investment |
| IPC | International Patent Classification |
| JPO | Japanese Patent Office |
| Ln | Natural Logarithm |
| MNC | Multinational Corporation |
| OECD | Organisation for Economic Co-operation and Development |
| OFDI | Outward Foreign Direct Investment |
| PCT | Patent Cooperation Treaty |
| R&D | Research and Development |
| SME | Small and Medium-Sized Enterprise |
| TNC | Transnational Corporation |
| TRIPS | Trade-Related Aspects of Intellectual Property Rights |
| UNCTAD | United Nations Conference on Trade and Development |

| Term | Definition |
|---|---|
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| USPC | United States Patent Classification |
| USPTO | United States Patent and Trademark Office |
| WIPO | World Intellectual Property Organization |
| WTO | World Trade Organisation |

# 1 Introduction

Innovation is seen today as a driving force that builds strong economies, and creates and sustains wealth. There is no consensus; however, on the policies governments should promote to facilitate innovation. Further, the common indicators used to measure innovation are inadequate, posing considerable challenges to developing effective policy strategies. Accordingly, researchers continuously pursue more effective and comprehensive measures in this respect. The predominant, but often misused proxy for innovation is international patenting. The aim of this research study is to determine the factors that influence a country's level of international patenting in an attempt to explain how Canada can increase its patent filing abroad. A secondary objective is to develop a system that more accurately measures inputs and outputs of innovative activity. Based on a new measure of international patent filing, this paper reveals Canada's position compared to other countries. Finally, this study provides policy recommendations on the best course of action to foster Canadian international patent filing abroad.

## 1.1 Policy Problem

Canada has experienced small increases in patent applications filed domestically (see Figure 7, page 62) and a decline since 1998 in patents filed internationally (see Figure 8, page 63). At the same time, Canada has not been able to improve its patent filings abroad when measured against other countries. In a comprehensive assessment of innovation and productivity sponsored by Industry Canada, it was discovered that Canadian international patenting per capita "has been overtaken by a group of 'high-tech' countries" (Trajtenberg, 2002, p. 245). These countries are Finland, Israel, Taiwan, and South Korea. According to Trajtenberg (2002), from 1992 to 1997, these countries out-patented Canada with annual patenting growth rates of 12, 12.9, 19.7, and 29.5 per cent respectively (p. 256). By contrast, Canada's growth rate in the same period was only 6.4 per cent. One can attribute these results to the expanding high-technology sectors in these countries. Moreover, the Conference Board of Canada reported in its 2005 annual study on Canada's performance and potential that:

> the vitality of the global economy has shifted its centre from the aging industrial economies of Europe and Japan to the expanding economies of the larger

> emerging countries. This transformation brings new opportunities in the form of enhanced markets for our goods and services, but it also poses challenges as Canadian businesses and policy-makers adjust to the changed competitive landscape" (Barrett, Golden, Lafleur, & Warren, 2005, p. 3).

With respect to Canada's competitiveness, the Conference Board attributes the rise of these so-called emerging countries to the concerted effort of these countries to gain ground on established players as well as Canada's falling behind (Barrett et al., 2005). This study seeks to understand why Canadian international patenting is not increasing relative to other countries, and how this can be rectified.

# 2 Background

## 2.1 Patent Definition

The World Intellectual Property Organization (WIPO), a United Nations Agency, defines intellectual property (IP) as creations of the mind including inventions, literary and artistic works, and symbols, names, images, and designs used in commerce. Intellectual property is divided into two categories: copyright, which includes literary and artistic works, like performances of artists; and industrial property, which includes inventions, known as trademarks, industrial designs, geographic indications of source, and patents (World Intellectual Property Organization, n.d.). A patent is a form of intellectual property that "cover[s] new inventions or any new and useful improvement of an existing invention" (Canadian Intellectual Property Office, 2004, p.7). Patent rights are protected by international and domestic laws and enforced by judicial decisions. For a specified period, patent rights "allow a patentee to exclude others from making, using or selling the claimed invention without the patentee's permission. A patentee can enforce these rights by suing an infringer for monetary compensation" (Duy, 2001, p.3).

In order to obtain a patent, owners of inventions typically submit a formal application to the patent and trademark office of their home country first, followed by submissions to the countries in which they desire patent protection for their invention. They may do so using international patent treaties and agreements. For example, WIPO created the Patent Cooperation Treaty (PCT) that allows an individual or group to submit, through a single application, patents to all PCT member countries in which patent protection is required. Within Canada, applications for patent protection describe the invention and define the protection being sought. Patents are scrutinised by patent examiners who determine the validity of the patent as well as its compliance with the *Patent Act* and *Patent Rules.* There are three conditions that the invention must meet: novelty, utility, and inventiveness (Canadian Intellectual Property Office, 2004). If an examiner rejects a patent application, applicants may appeal the decision to the Patent Appeal Board. The appeal board reviews the application and later passes on its recommendation to the Commissioner of Patents who makes a final decision. If the appeal is again rejected through this process, it may be appealed at the Federal Court of Canada.

A patent not only protects the rights of the inventor, but also provides a repository of information for the public (Canadian Intellectual Property Office, 2004). Without patent protection, the risks and financial and time investment would prove too great for many to create or improve products. This means the expected costs would outweigh the potential benefits.

> Our society would be deprived of thousands of innovations, from the proverbial better mousetrap to new medicines, communications systems, energy sources, and so on. And without new products the economy would quickly stagnate. (Canadian Intellectual Property Office, 2004, p.5)

Park (2000) articulates this notion further claiming that international patenting "is an important source of the international diffusion of technology: it involves not only the diffusion of new products and processes but also 'knowledge spillovers' from the information *disclosed* by inventors in exchange for the patent protection they receive"(p. 47).

In the same vein, the Canadian Intellectual Property Office (CIPO) maintains that patents, as a means of technological exchange, "promote the sharing of knowledge. As such, they are vital resources for businesses, researchers, inventors, academics and others who need to keep up with developments in their fields" (Canadian Intellectual Property Office, 2004, p.5).

## 2.2 Brief Canadian Patent History

According to Duy (2001), patents were granted in ancient times, but patent legislation did not arise until the Middle Ages.

> While originally patents were granted as forms of privilege, favour or royal patronage, it is generally believed that patents based on legislation were granted by governments to promote their national interests. However, some have argued that the notion of patent rights is not solely derived from a legislated right, but also from an inherent right of creators and inventors, and that statutes do not create these rights as much as develop and limit them. The former view, that patents are granted to promote national interests, is generally accepted in Canada and many other countries. (Duy, 2001, p. 9)

Over time, Canada has become legally bound to international treaties, agreements and standards. "Increased trade in the middle of the 19th Century led patentees to seek protection for their technologies abroad" (Duy, 2001, p.16). This eventually led to a series of international conventions and treaties on intellectual property. In order to manage them, the United Nations created WIPO to administer these international agreements and promote the protection of all intellectual property, not solely patents. In addition, the World Trade Organisation (WTO) created the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement. As a WTO

member, Canada must meet the minimum standards on IP protections set out by TRIPS. This agreement brings intellectual property rights under a set of common international rules for all WTO member countries and outlines minimum standards each member country must provide to all other member countries. The agreement specifies how the principles of IP should be applied, how countries should give protection to and enforce IP rights, and how to settle disputes. It further outlines transitional arrangements for periods when a new system is being introduced (World Intellectual Property Organization, n.d.). Specific to patents, the agreement outlines the minimum rights a patent holder must enjoy, whether a national or foreign patent filer, including the 20-year minimum patent right guarantee.

Canada's patent legislation and policies have evolved based on the country's patent ownership profile as Canada not only imports more technology than it exports, but foreigners, mostly Americans, hold more than 90 per cent of all patents filed in Canada. Canada also has "one of the lowest propensities to file patents at home of any of the major industrialised countries" (Trajtenberg, 2002, p. 246).

The nature of patenting in Canada is somewhat different from its peers. Canada has a large share of inventions in traditional, lower-technology fields as opposed to computers and communications, which has become the dominant technology area in the rest of the world (Trajtenberg, 2002, p. 245). Looking solely at patents filed in the United States from 1991 to 1996, Canada patented more in transportation, furniture and house fixtures, agriculture, husbandry and food, and earth-working and wells. By comparison, Americans patented more in computer hardware and software, surgery and medical instrumentation, resins, and power systems (Trajtenberg, 2002, p. 261) over the same period of time. While the areas where Canada dominates in patenting do reflect to a certain extent comparative advantage and the relative size of sectors, Canada's focus outside the realm of computers and communications, which is now a general purpose technology (GPT), does not allow it to "develop and enhance capabilities to harness the GPT for growth" (Trajtenberg, 2002, p. 264).

## 2.3 The Link between Patents and Innovation

For many, innovation is an ill-defined concept. The Canadian government defines innovation as "the process of transforming knowledge into new products, processes and services" (Western Economic Diversification, n.d., para.1). In this way, innovation is both a process and an outcome. Today, knowledge has become a key component of economic success. It is widely accepted that innovation is a major contributor to economic growth and a necessary condition for

productivity advances[1] (Dernis and Khan, 2004, Idris, 2003, and Sharpe and Someshwar, 2001). This means that a country's economic performance is in part dependent on its ability to innovate. The economic benefits realised by countries with high levels of inventive output include increased technology innovations, increased transfers of knowledge within a country, higher standards of living, and enhanced quality of life.

Greater innovation is an advantage that allows increased competitiveness for businesses at home and in the global marketplace. Further, innovative firms are more productive, and tend to produce quality, well-paid employment for workers (Government of Canada, n.d.). Through research, fundamental empirical links have been made between innovation and productivity. For example, in a study of Canadian manufacturing firms, from 1988 to 1997, it was shown that "[i]nnovation is a main factor contributing to labour productivity growth, gains in market share and survival" (Statistics Canada, 2004, para.1). In an Industry Canada-sponsored collection of studies on productivity in Canada, it was expressed that "innovation is a necessary condition for productivity advances" (Rao and Sharpe, 2002, p.7). Mork and Yeung (2002) confirm that "innovative countries and firms do in fact register superior economic performance" (p. 8). Taken together, these realities lead not only to economic success for firms, but also provide the basis for improvements in the quality of life for a citizenry.

> When new technologies and other kinds of innovations are developed here, Canadians enjoy the double benefit of the improvements they bring to quality of life and the economic benefits they yield in terms of job creation. With innovation-driven economic growth comes more opportunity and greater choice for citizens — including the wealth needed for new social investments in areas such as education, health and culture. (Government of Canada, n.d., para. 12)

The Conference Board of Canada confirms that positive spill over effects translate into the social arena. "At the international level, there is good reason to believe that more innovative countries enjoy superior social and economic outcomes" (Barrett et al., 2005, p. 4). Further, it has been observed that "more innovative countries appear to be better at extracting value from their investments" (Barrett et al., 2005, p. 4).

For the reasons outlined above, promoting innovation has become imperative for countries around the world. To illustrate, more than 100,000 patent applications were filed at the European Patent Office (EPO), and close to 180,000 patents were approved by the US Patent and Trademark Office (USPTO) in 2000, compared with 60,000 and 100,000, respectively, in 1991

[1] Studies indicate that patenting computer software and related knowledge actually hinder innovation. In 2001 and 2004, software patents accounted for approximately 15 per cent of all patents (Besson and Hunt, 2004).

(Dernis and Khan, 2004). In recent years, innovation has become increasingly important to the Canadian government. It launched an innovation strategy in 2002 and indicated its intentions to increase innovative activity in the country through the release of "A Plan for Growth and Prosperity" in 2005.

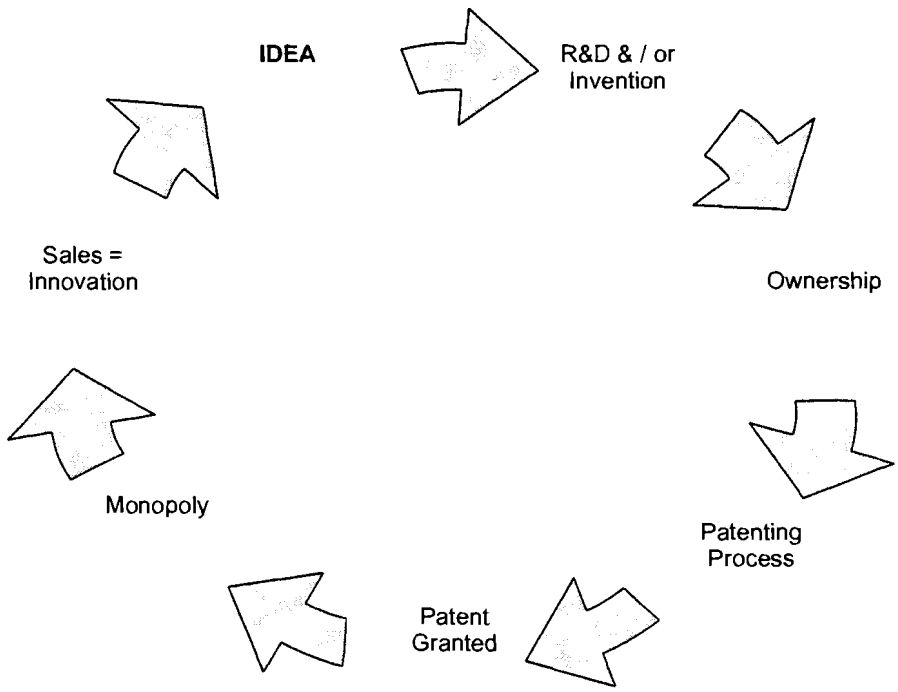
When measuring innovation, there is much disagreement among researchers. Because innovation concerns incremental change as well as new inventions, innovation is sometimes characterised as a qualitative process. Innovation does not necessarily require inputs like research and development (R&D), scientists, or outputs like tangible inventions measured by patenting. For example, if a business streamlines a process to increase efficiency, yet does not require R&D spending to do so, and does not seek a patent, it is still an innovation. As such, individual indicators only partially reflect of the amount and degree of innovation.

There is considerable debate on whether R&D is an appropriate measure of innovation, as innovation does not necessarily result from R&D activity. In fact, it is possible to invest billions of dollars into an idea that fails to translate into a commercial product. In an attempt to capture as much innovative activity as possible, some researchers supplement patenting with R&D spending statistics and other indicators. The Conference Board of Canada, in its assessment of innovation among OECD countries uses 11 measures of innovation - some quantitative, others qualitative. The Conference Board's list includes R&D spending, openness to foreign ideas, technical cooperation, scientific and engineering publications, the degree of entrepreneurship, R&D tax treatment, the number of researchers, industry collaboration with governments and universities, triadic patent families filed, and the percent of patents with foreign investors. It becomes practically impossible to include all of these measures if one wants to study a large number of countries. For example, the Conference Board of Canada was only able to review 24 of the 30 OECD countries because of the lack of available information for the remaining six. Furthermore, not all indicators were available for each country reviewed. Moreover, in-depth analysis was only conducted on the top 12 performers in the category.

Some researchers would prefer to supplement input and output measures by surveying firms regarding their ability to translate ideas into commercial success, and reveal details about their technical collaboration with other organisations. Yet it is unlikely that a sufficient number of firms would disclose this type of information as the data required are generally confidential and competitive. To this end, the collection and measurement of innovation-related data is highly complex and to some degree unsatisfactory. The challenge is to determine the strongest measure of the level of innovative output.

Given R&D is not directly related to the commercialisation of inventions, and there are constraints on the availability of more accurate indicators, patenting has become the predominant measure of innovation. Patenting, however, is not without its limitations. It is imperative to clarify the distinction between invention and innovation. Innovation "carries invention further with the commercial realization [sic] of the value of the invention or the receipt of an economic return" (Feldman, 2004, p.3). The economist, Joseph Schumpeter, proposed the idea that technological change comprises three stages: invention, innovation and diffusion. The first stage concerns the generation of new ideas; the second, the translation of ideas into marketable products and services; and the final stage concerns the spread of new products to a market (Mahdjoubi, 1997). Figure 1 below shows a more detailed version of innovation based on the patenting model.

*Figure 1: Patenting Continuum*




Another issue in using patents as a proxy for innovation is that many inventions, which have innovative capacity, are not patented. The reasons for not patenting are diverse. One major

reason is the cost barrier in the patenting process. Application fees[2] in the United States are approximately U.S. $2,000, but legal fees can rise to U.S. $35,000 (Cukier, 2005, p. 5). Another reason for not patenting is the desire to withhold competitive information or trade secrets from competitors. Patent details are public information and patenting requires disclosing complete information about the invention and its component parts. Also, some societies are more competitive and tend not only to patent more, but patent first. They possess a patent culture. China and India "have a culture of keeping technology to themselves. The Western concept of patents is fairly new to them, and has proved controversial for countries at their stage of development" (Cukier, 2005, p. 15). Many have argued that Americans exhibit a strong patenting culture, but a measure has not yet been developed to substantiate this.

Associated with this idea is the fact that many countries do not have the institutional stability, resources and experience to manage the processing of patents and enforcing patent rights. This affects an owner's decision to patent. Other factors involved in the decision to patent are the various regulations and the length of the administrative process. Furthermore, the potential benefits to a business may not be as great as the potential benefits to society as a whole. Feldman contends that:

> the social value of knowledge is greater than the value that the creator may be able to capture, a classic case of an externality. Private firms are likely to under-invest in knowledge production since the returns to the firm are smaller than the returns to society. Patents and copyrights, which extend property rights to knowledge and ideas, are one way, although imperfect, to create markets for the use of new ideas" (Feldman, 2004, p. 7).

Notwithstanding the challenges outlined above, international patenting, as an output, relates to the commercial realisation of new knowledge, and thus innovation more so than other indicators. The Organisation for Economic Co-operation and Development (OECD) contends that "[p]atents play an increasingly important role in innovation and economic performance" (Organisation for Economic Co-operation and Development, 2004, p.5). Schumpeter asserted that the impact of innovation occurs at the time of diffusion and so one might argue that the measurement of innovation should reflect that stage (Mahdjoubi, 1997). Currently, the only available and related measure is patenting. Choosing to patent internationally at multiple patent offices implies the patent owner believes his invention holds the potential for financial return - a return greater than the costs of filing. While international patenting measures invention, it is

[2] This estimate does not include language translation fees.

closely related to innovation. As such, international patenting provides a stronger indication of innovation than other available measures and is the proxy for innovation used in this study.

The fact that knowledge has public good characteristics highlights the importance of government policies and incentives to encourage firms, individuals and other institutions to pursue patenting. "Starting with the earliest patent legislation, nations have used the patent system to improve their economies by encouraging specific kinds of behaviour by the business community" (Duy, 2001, p. 10). In order to support patenting, in the home country and abroad, and therefore innovation, countries have adjusted and in some cases, overhauled their legal and regulatory frameworks to include more items on the list of patentable products. An example is biotechnology and software, which were once not patentable (Organisation for Economic Co-operation and Development, 2004). At the same time, there has been an increase in the use of patents across the board. As proof, in the decade from 1992 to 2002, patent applications filed in Europe, Japan and the United States increased by more than 40 per cent (Organisation for Economic Co-operation and Development, 2004). Further, the Economist claims that technology-licensing revenue is close to $100 billion worldwide (Cukier, 2005, p. 3). This is not only a high-income country phenomenon. Developed countries are increasing their patent activity. For example, patents filed in China have increased three-fold over the past four years (Cukier, 2005, p.4). India, too, has been aggressive, moving from dependence on foreign firms for technology and the accompanying royalties paid to those firms towards the development of its own technologies.

It is also important to recognise that while changes in domestic patent policies and international agreements as well as increased enforcement worldwide have increased the use of patents, "few systematic economic evaluations have been carried out to better inform policy choices" (Organisation for Economic Co-operation and Development, 2004, p.5). There is no clear understanding what impact these changes have had, if any, and further, there is little consistency in how patenting is measured and analysed.

## 2.4 Measuring Patents

The above has established there is a strong link between international patenting and innovation. Nevertheless, there are several issues concerning the use of international patent filings to measure innovation. The primary issue is that there is little consistency in the way patents are counted. The patenting system is complex and lengthy, but does provide a wealth of information that researchers may use. A consequence of the abundance of accessible data is that studies on the

topic are rarely comparable because researchers reference different parts of information found in the patent application. For example, one may use the grant date of a patent, which is the date when a patent application has been approved by a specific patent office. Others may use the priority date, the date a patent is first filed anywhere in the world. The priority date is the date that most closely mirrors the date of invention, as it is the first official date in the process that is recorded. Also, as the methods used to measure patenting become increasingly sophisticated, comparability becomes less valid.

Regarding attribution, there is contention about how patents should be assigned to individuals and countries for the purpose of studies. Patent applications require statement of both the inventor's country of residence and the owner's country of residence. Since many inventors work for companies, the owner and the inventor are likely to reside in different countries, particularly if the inventor works for a subsidiary. If the goal is to measure the inventive output of a particular country, one must use the inventor's residence, as opposed to the owner's country of residence (Dernis and Khan, 2004). Moreover, inventions are increasingly being developed by many parties working together, whether they be scientists at research institutions in different countries or competing and complementary businesses working together to develop products that are interoperable. The Economist has pointed out that this has consequently led to an increase in "pooling patents and cross-licensing agreements" (Cukier, 2005, p. 4). Often, one can no longer fully attribute a patent to a single country.

Another related issue is the timing lag between the priority date and the grant date. Many researchers do not use the priority date because it is not recent enough for their research purposes. It can take up to five years in an industrialised, developed country to process an application; it may take even longer in a lesser developed country. And this time lag is increasing as patent offices worldwide struggle to keep up with the increase in applications. This means that if one wants to use patents as a proxy for innovation in a particular year, one must use a patent that has been approved to show that it actually represents a new invention and has the capacity to generate a financial return. In addition, one must refer to the priority year to show the year closest to the date of invention. To illustrate, for patents filed in the year 2000, one cannot expect to access reliable data for applications that were granted until the year 2004 or 2005.

One contentious problem is determining where patents are filed. Most patents are filed in the home country first. Domestic filing, however, creates a bias in that it is easier and less expensive to file domestically and so there are many more patents filed in the home country than abroad. It has been suggested (Dernis and Khan, 2004) that filing internationally is the best way

to measure a country's inventive capacity. Filing abroad shows the invention's owner believes there is an opportunity to gain a financial return, which takes an invention closer to innovation. To this end, patents filed outside the home country are a better source for measuring innovation. This study provides guidance on how governments generally and Canada specifically can take action to increase international patent filing and, therefore innovation.

# 3 Methodology

This research proceeds in two steps. The first is an exhaustive literature review that serves three purposes: to provide the background and context for the project in terms of the new contributions required to supplement existing literature; to provide the justification for the variables chosen and how these variables are measured; and to inform the analysis and the context for the recommendations.

The second step is a regression analysis. The main objective is to assemble the data in a manner that best reflects the patenting output of a country. Most studies on patenting simply accept patent counts provided by patent offices without concern for duplicate filings. Moreover, few studies take the date of invention into consideration; rather, they generalise based on granting dates, which can be processed up to five years after the initial filing. This means that in any given year, a study of patent filings can be grossly over- or underestimated. It would not be appropriate to compare patent filings from a particular year to other indicators, like education or R&D spending, that do not correspond to the date closest to invention. This study corrects for these factors.

The 47 countries used in the analysis reflect the availability of data. Each country has filed a patent as classified by the International Patent Classification (IPC) in the priority year 2000. Where data for an independent variable could not be found, the country was removed from the analysis. Initially, the 65 countries that filed triadic patents in the reference year were included; however, complete data for each independent variable were available only for 47 of the 65 countries. In the case of China and Chinese Taipei (Taiwan), Chinese Taipei was removed from the model because certain data sources view Chinese Taipei as independent for economic and financial indicator purposes and other organisations do not for political reasons. While most data sources referenced the two countries separately, some sources do not provide data for Chinese Taipei[3].

[3] Refer to Appendix B for further information on data availability.

## 3.1 Regression Model

The model used is a multivariate linear regression, which evaluates the relationship between the endogenous, dependent variable and six exogenous, explanatory variables: population, foreign students, tertiary education spending, outward foreign direct investment, and research and development (R&D) spending. The data for all variables except tertiary education spending and R&D have been converted to natural logarithms to manage the scale and to reference the data in terms of percentage changes. The two exceptions are expressed as percentages in the original data sources. I collected most of the data[4] used in the regression from United Nations Conference on Trade and Development (UNCTAD), United Nations Educational, Scientific and Cultural Organization (UNESCO), Organisation for Economic Co-operation and Development (OECD) and World Bank, which are all credible and reliable sources.

### 3.1.1 Dependent Variable

The dependent variable is the number of priority triadic patent families filed in the year 2000. Triadic patent families are defined by the OECD as "a set of patents taken at the EPO, JPO and USPTO that share one or more priorities" (Dernis and Khan, 2005, p.46). The term priority refers to the priority date. Patents are often filed at various patent offices at different times. When a patent is filed, the application requires the date the patent was first filed anywhere in the world. This is the priority date. The term triadic refers to the world's three major patent offices - the European, Japanese and American patent offices. To be considered triadic, the patent must have been filed at all three of these offices. And the term family means that all patents included in one family reference the same technology. These data are taken from Database: 3 - Triadic Patent Families, the OECD's patent database.

The methodology ensures only patents applied for in the same set of countries are included (Dernis and Khan, 2005, p.46). Further, the use of triadic patent families avoids multiple-counting of the same patent. This study attempts to mitigate the "home advantage" bias, where, proportionate to their inventive activity, domestic applicants tend to file more low-value, novelty patents compared to foreign applicants because of the increased costs and time delays to file at multiple patent offices. The use of three patent offices as opposed to one reduces the likelihood of capturing novelty patents.

[4] See Appendix B for complete list of supplementary data sources.

To reflect the inventive performance of each country and maintain inter-country comparability, the following calculations ensure the integrity of the dependent variable. Triadic patent families are calculated using the IPC patent classification system[5]. The reference date used is the priority date because application dates and grant dates are far removed from the date of invention. In addition, there are differences in the time that it take various patent offices to grant and publish applications. Due to the time difference between the priority date and the availability of patent data, 2000 is the most recent year in which one can reasonably guarantee the validity of the data.

Inventions are increasingly more integrated and one can no longer solely attribute patents to a single country. Individuals, governments, businesses and research institutions collaborate with one another with little regard to state borders. A better way to assess the inventive capacity of a country is to calculate patent filings based on the inventor's country of residence as opposed to the owner's country of residence. "Inventors are a critical component of the patent system, since they are the creators of patented technologies. However, the great majority of patents are granted not to inventors but to their employers who normally own the patent rights to their employees' inventions" (Duy, 2001, p.10). To this end, patents are attributed to inventor countries of residence using a fractional system. For example, if the partner inventors of a single patent resided in three different countries, each country would be accorded one third of the patent family. This explains why the dataset contains fractions.

Some researchers study only what they consider high-value or high-tech patents. This study considers all patents filed and granted because as Feldman (2004) points out most inventive activity is merely an improvement to existing inventions:

> While not particularly glamorous these activities add economic value and, in sum, provide a basis for sustained competitive advantage... The view that innovation is limited to new science-based or so-called high technology industries is a myopic as it ignores the equally transformative nature of innovation in existing mature industries that are already in place. (p.9)

### 3.1.2 Explanatory Variables

The regression analyses six explanatory variables to determine if a correlation exists with patenting activity.

[5] A comparison of the IPC and USPC classification systems shows that while the categories differ, the number of applications made by each country is identical.

#### 3.1.2.1 Population

The size of a country's population is expected to have an impact on international patenting. Measuring the dependent variable per capita would force into the model a relationship between patenting and population. Instead, population is treated as an independent variable to determine if such a relationship exists. Population data was taken from the World Bank's Key Development and Statistics database.

#### 3.1.2.2 Foreign Students

A joint World Bank, University of Colorado study on patenting discovered that in the United States, foreign graduate students had a positive impact on patenting and patents awarded to universities and non-university institutions (Chellaraj, Maskus, & Mattoo, 2005). This study was given credence in a New York Times editorial on the same topic (New York Times, 2005) which indicated that for every 100 foreign students who received an American PhD degree, the United States benefited from 62 patent applications. Given these results, this study uses foreign students as an independent variable to learn if this finding is valid for all countries, not simply the United States. This data is taken from UNESCO.

#### 3.1.2.3 Tertiary Educational Expenditure (as a percentage of total education spending)

As mentioned above, inventors are generally well-educated. Bernstein (2002) has indicated among the major determinants of innovation, the education and skill level of the workforce ranks high. Spending on higher education is hypothesised to be positively correlated with international patent filing. Tertiary education expenditure is measured as the per cent of a country's total education expenditure allocated to tertiary education. This data represents education spending for the 1999 academic year and is therefore lagged by approximately one year. Data availability for preceding years is limited and so do not allow for a greater lag time. The data source for tertiary education spending is UNESCO.

#### 3.1.2.4 Outward Foreign Direct Investment Flows (measured in millions of dollars)

Transnational corporations (TNCs), which are enterprises often linked by ownership and operate in more than one country, generate a large percentage of the home country's patent activity (Vander Stichele, 1998). As such, most increases in patenting occur among this group more so than among small and medium-sized enterprises (SMEs). The use and integration of innovative products and processes is common in subsidiaries, however, most inventions take

place in the home country where research and development is likely to occur. Holding international patents is one way that businesses and other organisations protect their inventions when conducting business abroad. This is not simply a matter of extracting value from consumers for products sold in foreign markets, but also extends to the highly profitable business of issuing compulsory licenses and engaging in cross-licensing activity.

Some existing empirical evidence suggests foreign direct investment (FDI) "and patent distribution shows a positive correlation in most advanced countries between innovative intensity on the one hand, and export performance and international production on the other hand" (Balcet and Evangelista, 2005, p. 55). Lately, researchers have begun noticing that emerging economies are not only recipients of FDI, but are exporting investment dollars. The most explosive example is China. Emerging and developing economies also represent an increase in investment among one another. Supplementary evidence of this is the increasing number of bilateral investment treaties (BITs) among these countries, which typically include provisions for patent protections. Taking into account the above, the hypothesis is that with increased outward FDI (OFDI), international patenting will increase because companies will protect their inventions in the countries in which they invest. This data is taken from UNCTAD.

#### 3.1.2.5 Lagged Research and Development Spending (as a percentage of GDP)

Studies at the industry level and at the business level (Bernstein, 2002) show a positive correlation between research and development (R&D) spending and patenting. It is anticipated that R&D spending three years prior[6] to priority filing will correlate with increased patenting. The type of R&D spending used in this study is gross domestic expenditure on R&D (GERD), which is the total intramural expenditure on R&D performed in the home country during a given period expressed as a percentage of the country's GDP. It includes R&D performed within a country and funded from abroad, but excludes payments made abroad for R&D. The source for this data is UNESCO.

#### 3.1.2.6 High Income

Most studies on patenting, not surprisingly, focus on high income or OECD countries. The reasons are that there is greater availability of data and patenting is concentrated mostly among high-income countries. This is not simply a question of having resources for public

[6] Refer to limitations (section 3.3, page 1818) for an explanation of why R&D expenditures are lagged by three years.

education spending, R&D expenditure and the like. Rather, it is a result of opportunity and culture. Some countries simply patent more and these countries tend to be high-income countries. This study examines countries in all income categories: high income, upper middle income, lower middle income, and lower income. Countries were placed into two categories: high-income countries and all other income rankings. It is hypothesised that high-income countries, as defined by the World Bank, will be a significant explanatory variable, showing a propensity to greater patenting. The income level ranking was taken from the World Bank's Key Development and Statistics database.

## 3.2 Variables Not Considered

### 3.2.1 Patent Protection

Empirical evidence shows that the patent environment, particularly strong patent protection through effective enforcement of patent laws and straightforward administrative procedures, stimulates patenting (Park, 2000). While variation inevitably exists among the sample of countries used in this study, all are WTO members and thus subject to the minimum standards outlined in the TRIPS agreement. This is not to suggest that the domestic patenting environment is irrelevant. To the contrary, it is believed that the patent environment does impact patent activity in countries around the world. Nevertheless, the patent environment is not an issue because this study only references the triadic patent offices. Patents filed at these three offices receive high standards of patent protection within the jurisdiction.

### 3.2.2 Patent Culture

Literature suggests that there is an additional factor that may explain a country's level of patenting, domestically and internationally. This is often referred to as patent culture. As previously mentioned, some countries, like the United States, are assumed to display a strong patent culture, which includes the drive to patent and to patent first. Other countries, assumed to be those with collectivist tendencies, have weak patent cultures. This concept is ill-defined and difficult to measure. Thus, it is not possible to include patent culture in this study.

## 3.3 Limitations

While this study has taken precautions to ensure that accurate and reliable data are used, there are a few limitations. First, the reference year for the data is 2000. This means that countries

could have taken action through policies, practices or legislation to change their situation since 2000 and, therefore, the ranking of countries may not apply today. This is an acceptable limitation as the factors that impact patenting are not expected to change significantly except over long periods of time. Second, data are not accessible for all independent variables in the reference year. For some cases, the year prior or year following were used (see Table 7, p. 56 for details). This, too, is considered an acceptable limitation as there is little year-over-year change in the data in most cases. Third, while software patents are seen as the only type of patenting that may hinder innovation, the way patents are classified makes is exceptionally difficult to isolate software patents from other types of patents. Thus, software patents are included. Fourth, R&D spending in the reference year does not necessarily correspond with R&D conducted in the year of the invention. In fact, some R&D may have been conducted many years in advance. This is a substantial limitation of this study, but it is not feasible to determine the length of time of R&D activity and the corresponding years of R&D without surveying each patent holder individually. Based on the practices by other researchers in patent estimating studies, R&D is lagged by three years (Trajtenberg, 2002; Bernstein, 2002; Chellaraj et al., 2005). This is not perfect as some R&D activity would take place five or more years prior to filing, as in the case of pharmaceutical R&D; and in other cases, within the year of filing. Further, data availability does not allow for tertiary education spending to be lagged by more than one year. Finally, it is impossible to assess effective or efficient spending. This means it is assumed that more spending is better than less spending.

# 4 Descriptive Statistics

Table 1 below shows that the mean of triadic patents is 598 and the median is 11, indicating that the distribution[7] is skewed with more countries patenting below the mean than above. In fact, the United States represents the maximum at 10,327; the minimum is 0.17 for Tunisia. Canada's triadic patenting lies below the mean at 334.

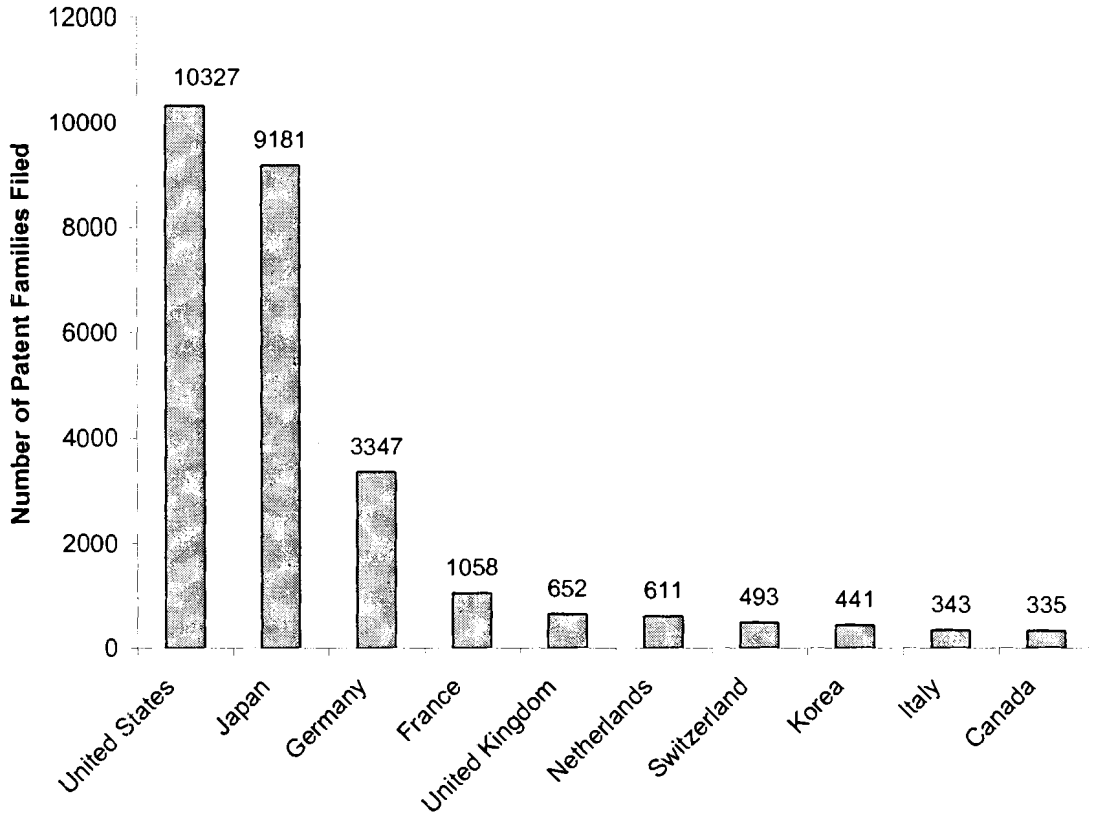
*Table 1: Summary Statistics for Key Variables (Year 2000)*

| | **Patent Families** | **Population** (millions) | **Foreign Students** | **Tert. Ed.** (% Total) | **OFDI** (millions $) | **GERD** (% GDP) |
|---|---|---|---|---|---|---|
| **Mean** | 598.26 | 84.58 | 37807.30 | 22.29 | 25125.02 | 1.36 |
| **Median** | 10.90 | 11.20 | 8699.00 | 20.60 | 2420.00 | 1.05 |
| **Max** | 10327.42 | 1265.83 | 475169.00 | 35.70 | 245375.00 | 3.65 |
| **Min** | 0.17 | 0.28 | 403.00 | 13.50 | -3180.00 | 0.18 |
| **Standard Deviation** | 2022.10 | 231.31 | 80658.67 | 5.89 | 50868.74 | 0.91 |
| **Skewness** | 4.30 | 4.42 | 4.06 | 0.58 | 2.89 | 0.80 |
| **Kurtosis** | 18.20 | 19.74 | 19.29 | -0.70 | 8.78 | -0.35 |

As Figure 2 illustrates, the distribution of patent families among the top ten countries in this category is highly skewed. It is expressly clear that the United States, Japan, Germany and France far exceed the other countries. Combined, these four countries account for 85 per cent of all patents filed by the 47 countries observed in this study. In the priority year 2000, Canada's closest competitors are Sweden (226), Italy (343), and Korea (441).

[7] After converting the dependent variable to a natural logarithm, the distribution becomes normal.

*Figure 2: Triadic Patent Family Distribution: Top 10 Patenting Countries*



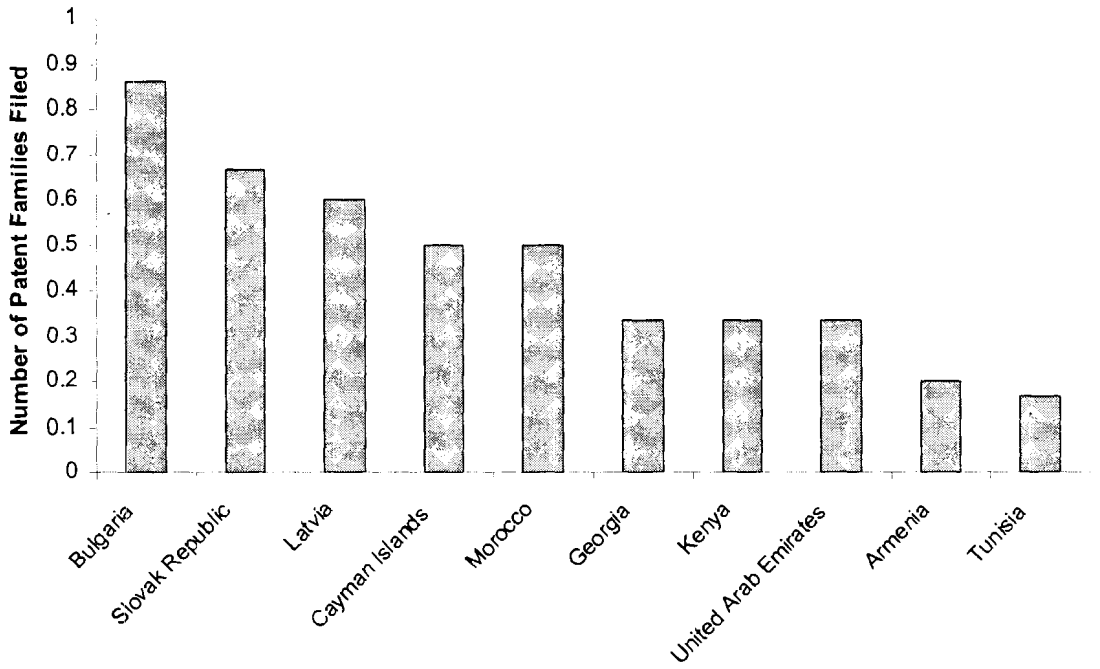
The data presented in Table 2 show that Canada's position is relatively favourable. Per capita, Canada's ranks 16th out of 47 countries; and 10th out of 47 when not accounting for population. Canada ranks in the top ten in foreign students, tertiary spending, and outward FDI. In terms of research and development spending, Canada ranks 12th.

*Table 2: Ranking of Top Ten Countries by Key Variables*

| Rank | **Patent Families** | **Patent Families** (per capita) | **Foreign Students** (millions) | **Tert. Ed. Spending** (% Total) | **OFDI** (millions) | **R&D Spending** (% GDP) |
|---|---|---|---|---|---|---|
| 1 | U. S. | Japan | U.S. | Portugal | U.K. | Sweden |
| 2 | Japan | Switzerland | U.K. | **Canada** | France | Finland |
| 3 | Germany | Germany | Germany | Finland | U.S. | Japan |
| 4 | France | Netherlands | France | Hong Kong | Belgium | Iceland |
| 5 | U.K. | U.S. | Australia | Ukraine | Netherlands | U.S. |
| 6 | Netherlands | Finland | China | Malaysia | Germany | Korea |
| 7 | Switzerland | Sweden | Russia | Turkey | Spain | Switzerland |
| 8 | Korea | Austria | Japan | Greece | **Canada** | Germany |
| 9 | Italy | Denmark | Spain | Denmark | Switzerland | Denmark |
| 10 | **Canada** | France | **Canada** | Netherlands | Sweden | France |

The countries clustered around the lower end of the scale are beneficiaries mostly of partnerships with other countries. This is evident by the fractional nature of the scores as illustrated in Figure 3 below.

*Figure 3: Triadic Patent Family Distribution: Bottom 10 Patenting Countries*




High-income countries account for more than 99 percent of patent families filed in the year 2000 when taking the 47 countries used in this study into consideration. The allocation of patent families by country income level shows the extraordinary difference based on income, particularly the average patent per country.

*Table 3: Patenting Distribution by Income Level*

| | Low Income[8] | Lower Middle Income | Upper Middle Income | High Income | Total |
|---|---|---|---|---|---|
| **Patents** | 28 | 57 | 96 | 27,936 | 28,118 |
| **Countries** | 1 | 8 | 13 | 25 | 47 |
| **Average Patent/Country** | 28 | 7 | 7 | 1,117 | 598 |
| **% of Total** | 0.1% | 0.2% | 0.3% | 99.4% | 100 |

*Income levels determined by World Bank.*

[8] The sole country in this category is India.

# 5 Regression Findings

Table 4 below summarises the hypotheses and the regression outcome. These hypotheses, save for the one on tertiary education spending, were supported by the regression analysis. The results show the model is sound (refer to Appendix C), with no serial correlation among the explanatory variables and no hetereoscedasticity. The regression model is a good fit with an adjusted $R^2$ value of .867. This signifies the model can account for 87 per cent of the variation.

*Table 4: Hypothesis vs. Expected Outcome*

| Hypothesis | Regression Outcome |
|---|---|
| ↑ percentage of tertiary education spending = ↑ patent families filed | ↑ percentage of tertiary education spending = ↓ patent families filed |
| ↑ GERD = ↑ patent families filed | ↑ GERD = ↑ patent families filed |
| ↑ foreign students = ↑ patent families filed | ↑ foreign students = ↑ patent families filed |
| ↑ outward FDI = ↑ patent families filed | ↑ outward FDI = ↑ patent families filed |
| ↑ population = ↑ patent families filed | ↑ population = ↑ patent families filed |
| High income country = more patent families filed | High income country = more patent families filed |

## 5.1 Regression Analysis

The study reveals four significant explanatory variables: R&D spending, population, high income and outward FDI. The constant value in Table 5 below represents the natural logarithm of systematic effects of the dependent variable. This means the constant value expresses the level of patenting that would occur in any of the countries studied in the absence of the explanatory variables.

*Table 5: Coefficients and Collinearity Statistics*

| | **Unstandardized Coefficients** | | **t** | **Sig.** | **Collinearity Statistics** | |
|---|---|---|---|---|---|---|
| | B | Std. Error | | | Tolerance | VIF |
| (Constant) | -3.450 | 1.143 | -3.019 | .004 | | |
| **Ln pop (millions)*** | **.582** | .127 | 4.578 | **.000** | .491 | **2.038** |
| Ln Foreign Students | .173 | .140 | 1.232 | .225 | .456 | 2.192 |
| Tertiary Ed. Expend % of Total Ed. Expenditure | -.010 | .027 | -.391 | .698 | .859 | 1.165 |
| **Ln Outward FDI*** | **.143** | .077 | 1.868 | **.069** | .259 | **3.863** |
| **GERD % GDP*** | **1.486** | .249 | 5.963 | **.000** | .460 | **2.172** |
| **High Income*** | **1.258** | .624 | 2.017 | **.050** | .217 | **4.613** |

* significant <.1

The regression results highlight that tertiary education spending is both insignificant and negatively correlated to patenting, contradicting both the hypothesis and available literature. Also somewhat surprising is the result for foreign students. This variable is not significant; however, the direction of the relationship remains true to the original hypothesis. Some possible explanations are outlined below.

### 5.1.1 Population

Not surprisingly, population is significant in explaining increased patenting. Holding the other explanatory variables constant, countries with greater numbers of residents will inevitably patent more. Common sense bears out the thinking behind this finding and the model supports the hypothesis showing that a one per cent increase in population will lead to a 0.6 per cent increase in patenting in the countries represented in this sample.

### 5.1.2 Foreign Students

While the variable measuring foreign students was significantly correlated with increased patenting in a U.S-based study, it appears that the significance is weak when considering other countries. As a result, the sample rejects the hypothesis. One possible explanation is that the U.S. study applied solely to domestic patents and not to international patents. It is conceivable that the potential value extracted from filing foreign-student generated patents abroad is low or valued less by transient students or the domestic patent owners. Also, the U.S. study considered PhD students only. Unfortunately, data limitations do not allow this study to distinguish PhD foreign students from foreign students in general.

Since the model indicates that the variable is not significant, I hypothesised that the relationship between foreign students and patenting differs depending on whether a country has high-income or low-income status. Accordingly, I experimented with additional variables to account for high income country differences. Unfortunately, the regression result was too collinear to make any conclusions.

### 5.1.3 Tertiary Education Spending

The model indicates that increased spending in tertiary education results in less patent filing; however, the result is not significant. This result is unexpected since the literature has suggested and it appears intuitive that greater spending on higher education would correlate with increased patenting. The model does not bear out this expectation.

The result does not suggest that tertiary education spending is unimportant; it simply means that for this specific sample it has negligible impact on patenting. It is possible that tertiary education spending is more or less important to countries based on their individual circumstances. Specific to Canada, it may be wise to develop a time-series study to verify the hypothesis. A study of this nature may show that in years when Canada has higher tertiary education spending there is a correlation with higher international patenting.

Another suitable explanation may be that secondary or perhaps primary education may be the more appropriate area for increased education spending. Or, it is possible that education spending, beyond a threshold does not need to be increased in order to achieve increased patenting. It is important to note that all countries used in the analysis have strong literacy and education levels. Perhaps it is not the distribution of the education budget, but the level of overall

education spending at the primary, secondary and tertiary levels. Since the result is insignificant, it is difficult to infer meaning from the negative correlation.

### 5.1.4 Outward Foreign Direct Investment

The regression result reveals that outward FDI has a significant and positive correlation with triadic patenting showing the sample supports the hypothesis. This outcome directly reflects the hypothesis and the studies that informed the hypothesis. The model shows increases in outward FDI have an elasticity estimate of 0.14, meaning that a one per cent increase in OFDI leads to a 0.14 per cent increase in triadic patenting. In the case of Canada, which has experienced declining OFDI over the past several years, policies that facilitate greater OFDI among Canadian businesses, could reasonably lead to greater innovative potential among Canadians firms as they expose their inventions to more markets. In sum, policies that encourage OFDI should lead to increased international patent filing, and therefore increase innovation among Canadian firms as they extract greater value from their inventions.

### 5.1.5 Lagged Research and Development

The regression substantiates the hypothesis that greater R&D expenditures lead to an increase in the output of patented inventions. Keeping all other variables constant, a one per cent increase in the per cent of R&D spending per GDP will lead to a 1.3 per cent increase in patenting. Changes in this variable have the greatest impact on triadic patent filing than other variables included in the analysis. The relatively large beta coefficient of this variable highlights the importance of effective R&D spending. One reason that Canada's triadic patenting has fallen from 1997-2000 is that Canadians are not able to efficiently translate R&D spending into profitable R&D output.

The model was not designed to indicate which types of R&D spending (tax incentives or direct investment) or which spenders (business, government, non-profit, higher education, or foreign) are most productive in terms of patents. This requires further investigation because it is the key to a country's success in translating R&D investment to patenting and then to innovation. Looking at Canada, studies have indicated that despite increasing R&D expenditures, the correlation with innovation is insufficient. This issue is discussed in detail in the next section.

### 5.1.6 High Income

As expected, being a high-income country is a significant factor in explaining increased patenting. Lower-income countries, holding all other variables constant, actually engage in less triadic patenting. High-income countries have an advantage over lower-income countries, not the least of which, the financial resources to invest in inventions and the patent system. One may suspect that high-income countries are more able to protect and enforce patent rights, which is important because most inventors or owners of inventions file domestically first. Canada's high-income status is a significant benefit that correlates with higher levels of triadic patenting.

# 6 Goal and Considerations

## 6.1 Policy Goal

The overall policy goal is to increase innovation. One of the means for doing so is to increase the amount of triadic family patenting. The results indicate that the way to accomplish this is through increased R&D spending and outward FDI. Complementary evidence for this focus is that the top five patenting countries (per capita) in this study (Japan, Switzerland, Germany, Netherlands, United States) are top ten performers in all significant variables, except Japan in outward FDI and the Netherlands in R&D.

## 6.2 The Canadian Experience

Before developing the policy alternatives, it is important to outline and explain some facts and policies that have an impact on OFDI and R&D, with emphasis on Canada's experience. As the results show, countries with high levels of OFDI and R&D spending patent more internationally. Canadian OFDI is troubling. It decreased by 50 per cent in just one year from 1998 to 1999. While R&D expenditures are on the rise, Canada's ability to extract value from R&D expenditures appears weak. These two facts, decreasing OFDI and weak R&D output, explain why Canadian triadic patenting has fallen in the years prior to the study reference year.

### 6.2.1 Outward Foreign Direct Investment

Conventional economic analysis suggests outward FDI is beneficial for a domestic country's economy. Many people find this notion puzzling. They assume that the result is job losses and a reduction in national production in the home country. In the short term, this is true. If one looks at manufacturing, for example, OFDI has reduced manufacturing jobs in Canada. However, in the longer-term, OFDI brings greater returns to the home economy than would otherwise occur. OFDI can be seen as complementary to domestic country production as a firm may expand its production base and create new exporting and importing opportunities. The Conference Board of Canada explains:

> While the benefits of outward FDI may be less well understood by the Canadian public, the Canadian economy is reaping the rewards of investing in foreign markets. FDI from Canada to another country generates investment and jobs in the recipient country. This increases profits for the Canadian company, and more importantly, it raises export volume from Canada. The impact of trade creation is especially significant when the recipient country is a developing country. (Barrett et al., 2005, p. 85)

What's more, it has been found that there is a stronger demand for Canadian goods and services in FDI recipient countries from a variety of Canadian businesses, not only from the companies that invest in the recipient country.

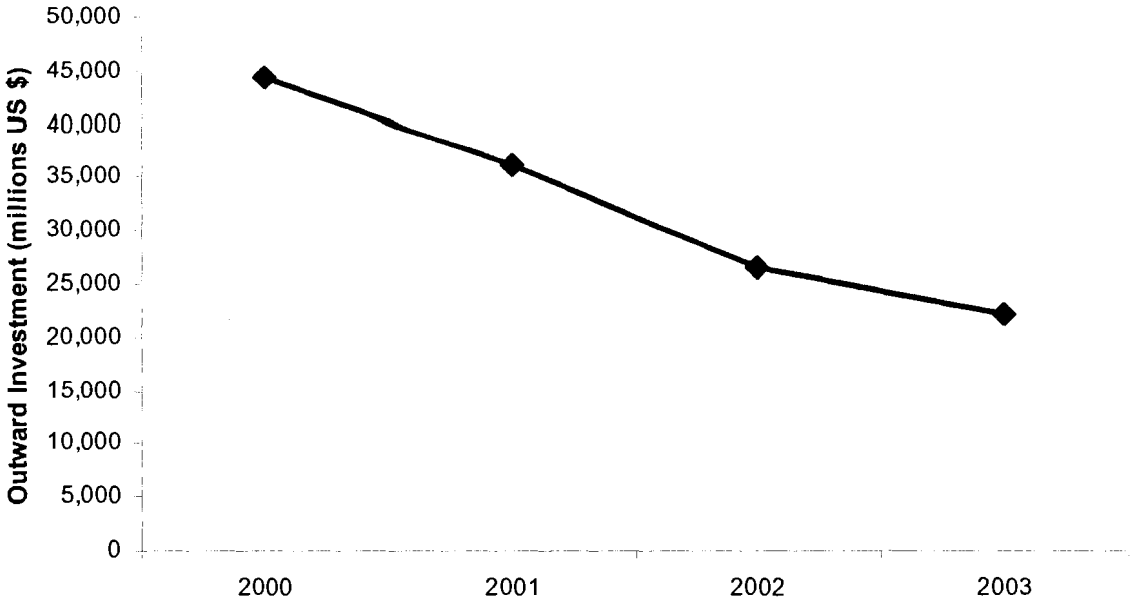
> Studies have shown that:
>
> host governments are rarely neutral towards inward foreign direct investment (IFDI). Virtually all host governments have barriers to FDI of greater or lesser formality, and greater or lesser transparency. At the same time, many of those governments offer explicit and implicit incentives to foreign-owned multinational corporations (MNCs) to establish affiliates in their host markets. (Globerman, 1996, p. 513)

This means that Canada may be able to work with host governments to ensure favourable investment climates for Canadian businesses.

It is important to remember that MNCs patent more and are more innovative than SMEs. In Canada SMEs, firms employing 500 employees or less, account for the greatest part of the economy and proportionally more compared to the United States (Rao and Sharpe, 2002). In 1999, Canada had 1,439 home-based TNCs and 3,725 foreign affiliates of home-based TNCs (United Nations Conference on Trade and Development, n.d.) The SME share of private firms in Canada is high at 99.8 per cent. The share is the same or higher in the following countries: France (99.9), Netherlands (99.8), Sweden (99.8), and the United Kingdom (99.9) (Industry Canada, 2002). Further, Canada's OFDI has been declining since 2000[9] as shown in Figure 4 below, which makes the status quo not an option.

[9] Incidentally, inward FDI has been declining year-over-year as well, from a high of 66,144 million US dollars in 2000 to 6,273 million US dollars in 2003 (UNCTAD, n.d.).

*Figure 4: Canadian Outward FDI (2000 - 2003)*




*Source: UNCTAD, FDI Country Profiles*

Canada's FDI legal framework mostly concerns inward FDI, but the Investment Canada Act also outlines details regarding outward FDI. Specifically, there are no restrictions in Canada on the movement of funds into or out of the country. Transfer royalties and fees, profits or dividends are not restricted, but may be subject to withholding taxes (UNCTAD, n.d.). Moreover, the corporate income tax was lowered from 28 per cent to 22 per cent in 2004 and the Conservative Party of Canada's election platform indicated the party would seek a further reduction.

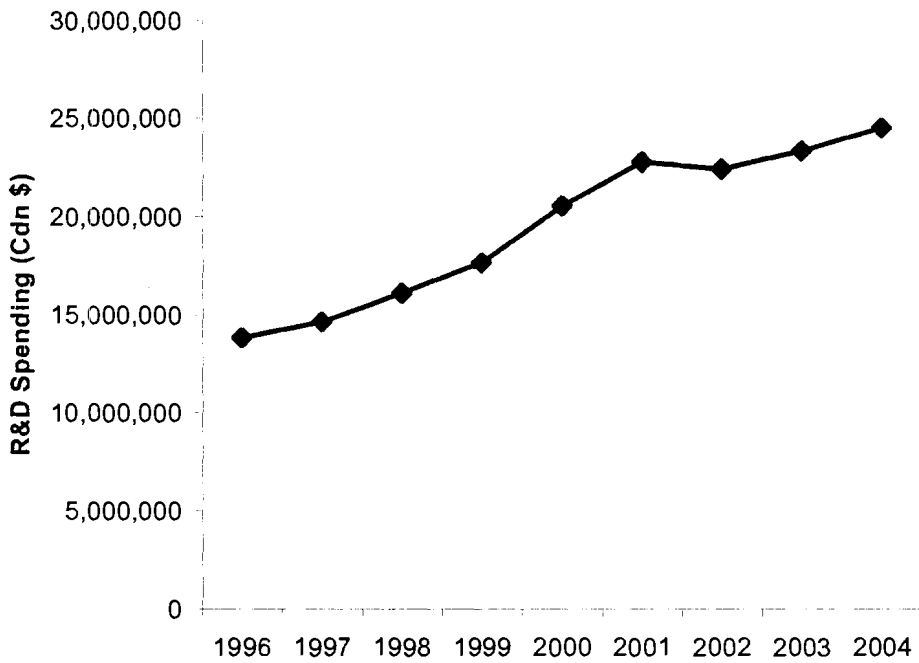
Also, it has been shown empirically that trade agreements lead to greater outward FDI (Rao and Sharpe, 2002; Globerman, 1999). Canada has signed a significant number of avoidance of double taxation treaties, but not nearly as many treaties on the protection and promotion of investments. The Canada-U.S. Free Trade Agreement and the North America Free Trade Agreement are examples in the Canadian context. Canadian businesses tend to base their investment activities in countries with similar languages that are close in geographic proximity. As a related point, Canadian businesses locate their outward FDI activity more in the United States than anywhere else in the world. This is not the experience of other countries, which tend to diversify their investment locales based on returns to investment, not geographic and language considerations. Interestingly, OFDI in Canada is strongly represented by finance and insurance

companies (25% at the end of 1991). In summary, if Canada takes a comprehensive approach to increasing innovation, it is important to determine effective strategies to encourage Canadian companies to pursue OFDI.

### 6.2.2 Research and Development

On paper, Canadian governments at the federal and provincial levels appear to be investing in all of the areas that researchers claim boost R&D activity, including R&D spending. From 1996 to 2004, R&D spending increased not only in real numbers, but as a percentage of GDP as well, with a plurality of funds coming from the private sector. In 2004, 46 per cent of R&D spending came from businesses, as opposed to 35 per cent from government.

*Figure 5: Canadian R&D Spending (1996 - 2004)*




*Source: UNESCO Institute for Statistics, 2005*

The Canadian experience regarding R&D is that Canada currently provides, and has for some time, provided generous R&D tax subsidies, and has substantial funds committed to an array of research-related initiatives, for example, Canada Research Chairs Program, Canadian

Foundation for Innovation, and the promise to double federal R&D spending by 2010. Despite these expenditures, output has been weak. Canadian R&D is lacking, particularly in the R&D intensive high-tech sector, which is relatively small in size (Rao and Sharpe, 2002, p. 17). The Conference Board of Canada has found that Canada is "missing opportunities to extract adequate value from innovation-related activities" (Barrett et al., 2005, p. 37). It goes on to say that "R&D expenditures are high, but R&D performance is low" (Barrett et al., 2005, p. 38) and that "Canada is weak at taking new ideas to market and producing more revenue from new or significantly improved products or services" (Barrett et al., 2005, p. 39). This is perplexing because one would expect that the array of policies Canada has pursued would result in a much higher level of R&D output. Accordingly, it is difficult to find answers to the questions raised by the Conference Board of Canada and other experts.

One possible explanation for this apparent lack of translation of ideas to revenue is that Canadian firms can access new technologies from abroad in a more cost-effective manner either from parent firms or through licensing agreements. In addition, Canada has proportionately more SMEs and they account for a larger share of output and employment than in the U.S., for example. As a rule, SMEs are significantly less innovative and less productive than larger firms. Furthermore, "while Canada has a respectable standing with respect to patents/capita and R&D/capita, the growth rates of other countries [Finland, Israel, South Korea and Taiwan] have been 2 to 5 times faster than Canada" (Trajtenberg, 2002, p. 255). Moreover, there is some indication that a major issue involving government intervention is "political rent seeking," where government becomes beholden to special interests. In this way, it may be surmised that respect for the normal course of business and the protection of contracts are better ways to translate innovation than government subsidy programs. The main areas where government can act yet leave minimal negative imprint is through the financial system. "An efficient and competitive financial system helps innovative small players grow large quickly and displace established wealth" (Mork and Yeung, 2002, p. 408).

These facts are important to consider when creating policy alternatives. Recommendations from existing literature on how governments can encourage R&D have been adopted by Canadian governments, but have not translated into strong R&D performance. Instead, it may be useful to evaluate why Canada has not been successful in this realm prior to acting on ill-informed policy alternatives.

# 7 Alternatives

Care must be taken in recommending government intervention to encourage innovation in the private sector. Mork and Yeung (2002) contend that ultimately "consumer demand and the supply of different inputs determine the course and speed of innovation" (p. 400). These authors further explain "the private sector has a track record of funding successful innovations over several centuries, and the increasing pace of innovation suggests it may be getting steadily better at the task" (p. 400). They point to Japan as an example of government innovation financing that was shown, through a statistical study, to subsidise companies whose innovation performance worsened after receiving the grants (pp.400-401).

In light of Canada's experience and policies in the areas of patenting, outward FDI, and R&D, the following alternatives have been developed to meet the goal of increased triadic patent filing by augmenting R&D expenditures and OFDI. These alternatives are not assumed to be mutually exclusive.

## 7.1 Foreign Direct Investment

### 7.1.1 Bilateral Investment Treaties

Bilateral Investment Treaties (BITs), which are agreements between two governments to guarantee non-discriminatory treatment of direct investments in either country, have been shown to produce a positive effect on outward FDI. Indeed all forms of trade liberalisation are generally seen as positive from a long-term economic perspective. Bernstein (2002) argues that openness to foreign trade, foreign direct investment, and foreign knowledge transfers are determinants of innovation. The preference for multilateral trade agreements is undeniable. Notwithstanding recent failures to secure a WTO multilateral trade agreement by the international community, Canada should continue to pursue negotiations of this nature. Since multilateral agreements take years, even decades to negotiate, Canada may initiate BITs in the interim to achieve a marginal level of trade liberalisation in key markets where the greatest value can be extracted for Canadian businesses.

Currently, Canada is negotiating free trade with the Americas (FTAA), Central America Four, European Free Trade Association (EFTA), Republic of Korea, Singapore, Andean Community Countries, The Caribbean Community and Common Market (CARICOM), and the Dominican Republic. The Canadian government is also in the midst of two other major initiatives. The first is the Canada-European Union - Trade and Investment Enhancement Agreement, which includes special provisions concerning small and medium sized enterprises. The second is the Canada-Japan Economic Framework, which includes a memorandum of understanding on bilateral investment promotion cooperation.

Canada should continue to pursue these agreements aggressively, but may additionally negotiate BITs with non-traditional developing and emerging economies. In particular, Canadian firms could benefit from conducting business in developing economies outside of Latin America, where it already has signed BITs. Canada may attempt to tie its pursuit of BITs to countries in which it has development goals through CIDA or through other Canadian multilateral aid commitments. This pursuit will also help Canada compete with developing countries that are increasingly signing BITs with one another, freezing out developed countries because of the latter's reluctance to enter into non-traditional or unknown markets. This so-called South-South BIT phenomenon has allowed some developing countries, like China, to avoid export quotas and also access natural resources and supplies not available in the domestic country. In Canada's case, it could expand access to natural resources in developing countries and benefit from a wider market base.

### 7.1.2 Expand SME Export Development Programs

Exporting is considered the first stage in OFDI. Typically, companies begin or increase their exporting activity in a country before deciding to set up shop. This allows them to test the market and better understand local practices (Vaughn & West, 1997). By funding export-oriented activities of SMEs that target developing and emerging markets, Canada can use its greatest business resource, SMEs, and at the same time, expose SMEs to a larger market that demands lower-tech products and services, which is where Canada tends to patent more. This option takes the existing practice of financing export-related activities through credit or loans further by developing export-facilitation programs specifically geared to non-traditional markets. The Conference Board of Canada recommends the pursuit of new business in emerging high potential markets (Barrett et al., 2005, p. 2). Expanding the SME Export Development Program may be one way to do so.

Canada may encourage this behaviour by providing profiles of developing countries that are business-friendly; researching and promoting investment programs aimed at developing countries; and advertising international and Canadian government-funded projects. The government may then disseminate this information through small business associations like the Canadian Federation of Independent Business, and online using Export Development Canada's Web site. Government officials might also hold workshops for program participants and promote the program at business conferences and symposiums. This option may involve integration of Canada's aid program with Canadian investment opportunities. Further, the Government of Canada may also provide financing options and grants to SMEs that conduct business in countries where CIDA concentrates its development assistance. Finally, Canada's export development programs to the United States, Western Europe and certain Asian countries are relatively effective and learnings from these programs may be incorporated in a program geared towards developing countries.

### 7.1.3 Foreign Market Research and Information Dissemination

The Canadian government can use the vast resources it has within various departments that follow international markets and international politics to collect and synthesise information that Canadian businesses require, housing it in a central location. Information could be tailored to specific industries that Canada would like to develop or expand. This option would require a high level of collaboration among provincial governments, and federal government departments. The government currently has this information in some form; however, it is time intensive for small business to find relevant details. In fact, combing and cross-referencing existing information could be the first step leading to the subsequent phase of reformatting the information in a way that is most appropriate for Canadian businesses. For example, the government may categorise information for key audiences, such as SMEs, TNCs, export-oriented businesses, resource-based companies, service-based companies, et cetera.

## 7.2 Research and Development

### 7.2.1 Status Quo

R&D spending is increasing (see Figure 5, page 32) and Canada is, by all accounts, adopting the policies the literature recommends in terms of encouraging R&D. As previously mentioned, Canada has a generous R&D tax credit offering, invests heavily into R&D and supports and promotes R&D clusters and collaboration. Perhaps, over time, if Canadian

governments continue with the policies to which they have committed, Canada will more efficiently translate R&D spending into valuable innovation. Or, one may speculate that it is simply more cost effective for Canadian businesses to purchase innovation rather than create it.

### 7.2.2 Reduce Foreign Ownership Restrictions in Key Industries

Reducing foreign ownership barriers provides domestic firms with greater access to equity capital and debt. Bernstein (2002) has noted that high levels of foreign ownership accompany low levels of R&D intensity in the manufacturing industry. Nevertheless, this does not appear to be the case in companies with generally high levels of R&D propensity. In Canada, foreign ownership restrictions still exist in the commercial aviation, fisheries, energy and mining, and telecommunications industries. Now might be an appropriate time to reduce the restrictions on some of these industries, namely, commercial aviation and telecommunications. The direct benefit is that investment funds from outside the country could free up resources to invest in R&D and expand capital expenditures, particularly for smaller companies. An additional, indirect advantage is that suppliers and other complementary businesses in Canada could benefit from collaborating with firms that have extra investment capital.

### 7.2.3 Pan-Canadian Research and Development Commission

There is general agreement that there is a fundamental problem with Canadian R&D expenditures, as the innovative output appears too low given the level of R&D spending input. As aforementioned, Canada's capacity to translate R&D and inventive products into revenue is poor relative to its OECD counterparts. Previous studies have indicated that Canada would benefit from qualitative research on the factors that produce a more innovative culture as this area is poorly understood. Working with businesses and research institutions, the Government of Canada might set up a commission to study why, despite increasing Canadian investment in R&D in both the private and public sector, Canada's R&D output is not as impressive as expected.

It may be that R&D expenditures must complement the unique characteristics of the regional and national market and studies cannot be generalised to all OECD or high-income countries. For example, in the Conference Board of Canada's 2005 ranking of OECD countries, both Sweden and the United States rank high in the category of innovation. Yet, Sweden does not provide R&D tax credits and the United States offers generous R&D tax credits. Perhaps due to Canada's SME domination, the tax treatment and accompanying requirements are not effective as these types of credits tend to favour larger firms. It has been suggested that "the most effective

measure the government could take to increase R&D would be to lower corporate tax rates" (Rao and Sharpe, 2002, p. 21). Further research is required to bear out this assumption, as it is important to remember that, "few reliable benchmarks exist to measure the performance of any country" (Barrett et al., 2005, p. 39).

The Industry-Canada sponsored research volume on productivity in Canada calls for more research in this arena and acknowledges that "the policy environment and the programs aimed at stimulating productivity growth could still be improved" (Rao and Sharpe, 2002, p. 20). The policy problem has befuddled academics and economists alike and the government is spending substantial tax revenue without fully understanding the strengths and weaknesses of the policies. In effect, the problem is that a comprehensive and appropriate evaluation on the impacts of various types of R&D spending in Canada is non-existent. To truly understand the impacts of Canada's R&D spending and where stakeholders can contribute, a commission with a narrow and focussed mandate is proposed.

To pursue this option, the government would outline the parameters of the policy problem, design a framework, provide funds, and appoint a number of respected and influential experts in the field to manage the process. The commissioners would receive the freedom to set agendas, hire staff and consultants, and independently come to conclusions and recommendations. The main issue to be addressed is why R&D expenditures do not appear to match innovative output and how Canada can efficiently increase R&D expenditures, and in what areas, to maximise economic value. The study would necessarily recommend how R&D expenditures and the tax regime could be improved.

# 8 Criteria

Taking the goal and considerations into account, the following criteria were developed to assess and evaluate the policy alternatives.

## 8.1 Effectiveness

This criterion may be summed up as the "makes a difference test." This means that the policy option ultimately must lead to measurable increases of patents filed abroad. In the interim, the option must lead to increased R&D spending or increased outward FDI.

## 8.2 Political Acceptability

This criterion addresses three major factors required to recommend an alternative. The first is whether the government of the day would find the alternative acceptable. The second is whether the alternative accommodates existing domestic and international laws. Third, given Canada's jurisdictional realities, it is important to assess the level of government responsible as well as the likelihood of intergovernmental cooperation.

## 8.3 Government Costs

No investment in an option would be sound if the financial cost is prohibitive. The types of costs assessed in this analysis are the direct financial costs as well as the administrative and human resource costs borne by Canadian governments.

## 8.4 Multiple Objectives Test

There are two components to this consideration. First, the alternative must be evaluated to determine whether it positively or negatively affects the other factors (R&D spending, OFDI, or international patenting). For example, would an alternative designed to increase R&D also influence outward FDI? Second, alternatives that meet multiple objectives for multiple stakeholders are more beneficial than alternatives that solely meet the goal of this study. For example, the alternative could provide linkages to objectives that are unrelated to patenting and

innovation. Conversely, it is important that alternatives do not negatively affect other areas of the economy. For example, it has been determined that increased domestic labour costs increase outward FDI (Hatzius, 2000), however, this would not necessarily be positive for Canadian business in general.

# 9 Analysis of Policy Alternatives

This study takes a multi-criteria approach to the analysis of alternatives. The criteria outlined in the previous section were assessed against the six alternatives. Table 6 below represents a summary of the analysis, which is expanded following the table. The complete analysis identifies how the ratings represented in the table were chosen and applied.

*Table 6: Alternatives / Criteria Matrix*

| | Effectiveness | Political Acceptability | Government Costs | Multiple Objectives Test |
|---|---|---|---|---|
| **FDI** | | | | |
| **1. Bilateral Investment Treaties** | High | Moderate to High | Low | Yes |
| **2. Expand SME Export Development Programs** | Low | Low to Moderate | High | Yes |
| **3. Foreign Market Information Dissemination** | Low to Moderate | Moderate | High | Yes |
| **R&D** | | | | |
| **1. Status Quo** | Low | Short-term: High / Longer-term: Low | Low | No |
| **2. Reduce Foreign Ownership Restrictions** | Moderate | Low to Moderate | Low to Moderate | Yes |
| **3. Invest in Canadian R&D Commission** | Short-term: Low / Longer-term: High | Moderate | Low | No |

## 9.1 Bilateral Investment Treaties

*Government Costs:* The costs to engaging in bilateral investment treaties are relatively low. They mostly entail human resource costs, including the salaries and travel expenses of bureaucrats, lawyers, and elected officials. Other costs comprise monitoring and enforcement of the agreements as complaints and disputes will inevitably arise over the course of the treaty. To this end, costs to government are assessed as low.

*Political Acceptability:* Government is already pursuing bilateral investment treaties as they are seen as necessary to the country's economic success. The treaties and agreements that are underway meet both domestic and international laws and respect Canada's existing jurisdictional realities. In that sense, this option is highly feasible. With respect to expanding BITs to developing countries and certain emerging economies, there could be some political resistance, particularly with respect to developing countries that are traditionally seen as politically unstable or unfriendly. Nonetheless, the list of countries to approach need not contain politically unstable or unfriendly countries.

*Effectiveness:* BITs have been found to be highly effective compared to other policies in terms of directly leading to outward FDI. BITs not only open the door, but provide the legal and administrative assurances that a company can engage in business in the host country with minimal barriers. BITs generally include provisions for patent rights and corresponding protections. When Canadian companies take their products overseas, particularly for production purposes, they tend to patent inventions in these countries to ensure they are protected, and more importantly, that they generate revenue from the temporary monopoly. The BIT ensures that firms will receive a comparable level of patent protection as received in Canada. History has shown that this policy option does lead to increased international patenting.

*Multiple Objectives Test*: In addition to leading to increased OFDI and patenting, this alternative also meets political diplomacy objectives. Canada has an opportunity to engage with countries, particularly developing countries, in a way that is closer to a partnership than the standard, recipient-donor relationship that is typical of developed and developing country interactions. Moreover, it allows for greater exporting and knowledge sharing that accompanies most forms of trade liberalisation. Finally, BITs may potentially lead to increased R&D. At minimum, they do not negatively affect R&D. This option meets the multiple objectives test.

## 9.2 Expand SME Export Development Programs

*Government Costs:* The costs to expanding export development programs for SMEs are relatively high. Stable yearly costs are expected for the duration of the program, with higher set-up and promotion expenditures in the first one or two years. Costs include diverting existing resources from programs that are currently known to produce positive results, to an unknown, untested program. In addition, the financial costs of coordinating the various federal departments with NGOs and matching their objectives may prove extensive. Further, there are enormous labour requirements to format and distribute the information in a way that is useful for SMEs, which makes this option highly costly. Information dissemination is one of the costliest government endeavours, when one takes into account labour and consulting fees, translation, and dissemination. Moreover, the costs of providing grants and other forms of financing are expected to be high compared to the uncertain return it would potentially generate.

*Political Acceptability*: Export development programs in Canada are generally effective mostly because Canadian companies focus on countries possessing characteristics similar to Canada: middle and high-income, free markets, political stability. Expanding these programs to encourage exporting to higher risk countries entails considerable political risk. In addition, financing and grants in support of development programs in the absence of other developmental initiatives would be seen as unimportant. In conjunction with foreign aid initiatives, however, this option becomes more politically feasible. Also, the dissemination of information is highly politically acceptable, from a desirability perspective, but becomes less so when taking into consideration the enormous level of integration necessary among the Canadian International Development Agency, Industry Canada, Export Development Canada, and the Department of International Trade Canada. For these reasons, this option is considered low to moderately politically feasible.

*Effectiveness*: The outcome of this alternative is largely unknown. While exporting is generally the first step in the process of outward FDI, it is not a guarantee that a company will see or realise the benefits of outward FDI. In addition, SMEs generally do not have the size or scale of operations to justify developing subsidiaries, certainly not in the short-run. Over time, this option may lead SMEs to increase in size based on new, overseas markets. Subsequently, a business may find it more cost effective to expand its operations in another country to better serve the local market, but this is a best case scenario for the longer-term. Even if this option does lead SMEs to OFDI, they tend not to patent much, choosing to purchase other companies' innovations

and so may have no need to file patents in the countries where they set up subsidiaries. For these reasons, this alternative is ranked low.

*Multiple Objectives:* Taken in conjunction with developing goals, this option meets the multiple objectives test. Moreover, it also meets other government objectives including increasing exporting, assisting small and medium sized businesses and initiating new types of relationships with non-traditional markets.

## 9.3 Foreign Market Research and Information Dissemination

*Government Costs*: As with all information driven programs, the financial costs, such as, Web site design, hosting, and maintenance fees; brochure printing and distribution; and translation, as well as labour costs are rather high. These costs would be substantially higher in the design phase when the bulk of research is being conducted and distribution mechanisms developed. These costs will reduce; however, to consist of annual expenditures on maintenance and distribution that will last for the duration for the program.

*Political Acceptability*: This option is politically appealing, yet administrative operability is questionable. Priorities change over time and certain collaborators do not maintain sources leading to out-of-date and inaccurate information. This results in ineffective information dissemination. Moreover, there is little incentive for governments to do this work without demand from the public, which does not currently appear to be high. As a result, this option has been classified as moderately politically feasible.

*Effectiveness*: Information is necessary to make good decisions about where to set up operations. Asymmetric information is one reason that Canadian firms tend to rely on traditional markets they know and trust. Unfortunately, reducing asymmetric information does not directly lead to OFDI, nor does it lead to international patenting.

It would be quite difficult to determine if government provision of foreign country business and political climate information would lead to OFDI. Surveys of businesses could confirm this, although, due to the competitive nature of business, one would assume they would be reluctant to provide the specific reasons for investment abroad. Moreover, TNCs have the resources to do this type of research. Plus, to be truly effective the information provided would have to be specific to certain industries, rather than general. This means, it would require a level of specialisation that government officials could not possess without substantial investment in human capital. Therefore, effectiveness for this alternative is considered low to moderate.

*Multiple Objectives*: Information inevitably feeds more needs than can be anticipated. Having business and other organisations, like NGOs and academic institutions access this type of information can only lead to better decision-making in all areas of work, whether it be research-related, business or otherwise.

## 9.4 Research and Development Status Quo

*Government Costs*: The short-term marginal costs to the status quo are zero, however, in the long-run, one may determine that the status quo comprises funds spent in an inefficient manner leading to less R&D than those funds could otherwise generate.

*Political Acceptability*: Quite obviously the status quo is politically feasible. Nevertheless, as more people question Canada's stagnation in this arena it may, in the future, become less politically viable. At present, Canada is spending considerable resources to encourage R&D activity and officials recognise the value of R&D spending, therefore, reductions are not anticipated in the near term.

*Effectiveness*: The status quo is not producing expected results. Accordingly, it is not going to lead to increased output of R&D and consequently increased patenting. Given the competitive environment in this domain, particularly by emerging economies, Canada cannot realistically rely on the status quo and expect to maintain its standing. As such, effectiveness of the status quo is low.

*Multiple Objectives*: This option does not meet any additional objectives.

## 9.5 Reduce Foreign Ownership Restrictions

*Government Costs*: Generally speaking, there are few direct costs to the actual exercise of reducing foreign ownership restrictions. Nevertheless, at minimum some form of public consultation will have to be undertaken. Generally, there are senate committee hearings and submissions. These costs are relatively low and include human resource and administrative expenses. Another unknown cost is the potential loss of tax revenue if Canadian telecommunications or aviation companies become fully owned by foreigners. In that case, profits and other capital could leave the country and with it tax revenue and capital that could be potentially reinvested in the Canadian economy. Nonetheless, the elimination of foreign ownership restrictions is not recommended. Rather, a reduction that still allows for Canadian

majority ownership is proposed. As a result, economic costs have been rated low with the potential to become moderate.

*Political Acceptability*: There appears to be modest appetite for change in this arena, but there is also a considerable amount of resistance. Firms and analysts, particularly in telecommunications, have been lobbying government for decades to remove entirely the restrictions on foreign ownership. While the telecommunications community has received sympathy from business-oriented departments like Industry Canada, particularly under former Minister John Manley, it has been difficult to convince officials at Heritage Canada. Moreover, when polled, Canadians indicate they are not comfortable with foreign ownership in this arena. Senate hearings in early 2003 revealed mixed feelings on the topic (Friends of Canadian Broadcasting, 2004).

The issue with respect to telecommunications mostly surrounds Canadian content regulations. Given television and radio fall under the banner of telecommunications, the restrictions are applied wholly and uniformly to all forms of telecommunications, except for submarine cables and earth stations that provide telecom services by satellite. If the major concern is Canadian content, then perhaps, certain providers, like land line telephony, Internet and mobile phone providers could be exempt within the *Telecommunications Act*, 1993, c.38. In circumstances where companies provide content and distribution, the companies, to be certain, would be willing to split up companies into different legal entities for the purposes of foreign ownership regulations. At any rate, legislative changes would be necessary.

With respect to the other industries still under foreign ownership restrictions, some political hesitancy may exist. Every time a Canadian airline goes through capital restructuring or even bankruptcy, discussion arises on whether aviation should undergo a foreign ownership restriction review. As such, there may be some level of political acceptability; however, the extent is still unknown. This may be achievable in the longer-term.

The jurisdictional issue is not anticipated to be a problem, save for in the areas of fishing, mining and energy, which this author is not suggesting be taken into consideration for the purpose of achieving increased R&D spending or patenting. It is reasonable to limit the discussion of foreign ownership restrictions to telecommunications and commercial aviation. Under this framework, political acceptability is moderate.

*Effectiveness*: While telecommunications, in particular, is one industry that conducts a substantial amount of R&D and undertakes a considerable amount of patenting, it unknown how

much of an impact it would have on R&D investments in the country as a whole, specifically, as a percentage of GDP. Nonetheless, it is known that telecommunications equipment constitutes a high portion of private R&D (Government of Canada, n.d.). In the province of Ontario, for example, R&D for telecommunications equipment constitutes 33 per cent of all service industry private R&D spending, and the aircraft and parts industry makes up nine per cent (Government of Canada, n.d.). Therefore, increases in R&D funds through foreign investment could lead to a significant increase in R&D in Canada, and consequently patenting. This alternative rates moderate in terms of effectiveness.

*Multiple Objectives*: The reduction in foreign ownership restrictions not only will lead to more R&D in these industries, it will also lead to greater capital investment in Canada in the short-run, and potentially over the longer-term. This capital investment will lead to increased capital expenditure resulting in spill-over benefits to supplier and complimentary firms, improving the overall business environment.

## 9.6 Pan-Canadian Research and Development Commission

*Government Costs*: The financial expenditures associated with a major commission cover human resource costs for research grants, consulting fees, and salaries; and public consultation expenses. In addition, a project of this nature will take years to produce so the costs will extend over time. Further, other costs include promotion, information dissemination, the hiring of commissioners and stipends to compensate contributors from the private and not-for-profit sectors. Past Royal Commissions have ranged from $15 million to $60 million. Based on the narrow focus of this proposed commission, expected costs are in the range of $10-12 million, or put another way, approximately one quarter the average cost of larger commissions.

*Political Acceptability*: Inevitably, there will be pressure on governments to study and provide explanations for Canada's lacklustre R&D and innovation performance relative to other countries. At that time, the political acceptability of investing in a study will be heightened. Unfortunately, the current thinking is that Canada has invested heavily in multiple studies of R&D in Canada, particularly at the turn of the century. The issue is that the recommendations mainly point to the need for better data and research. The editors of Productivity in Canada (2004), an Industry Canada-sponsored collection of studies, point out that notwithstanding years of research, current explanations are unsatisfactory. This means that the need for a comprehensive study involving business, academics, governments and other institutions will become politically necessary. For these reasons, political acceptability is moderate.

*Effectiveness:* While the commission is arguably the most necessary option with respect to R&D, it does not actually lead to R&D investment or R&D output and certainly will not increase patenting. The effectiveness specific to these measurements is non-existent. Nevertheless, without fully understanding what is affecting Canada's R&D performance, and to what extent, Canada may never be able to address the issue properly. In essence, this policy option means no immediate effectiveness, but without it, there may be little positive movement in Canada's R&D performance.

*Multiple Objectives*: Investing in a study of this magnitude will inevitably lead to information that may be used by many groups within the Canadian economy and even produce some new knowledge on R&D and OFDI; however, it does not directly impact any other specific national objectives.

# 10 Recommendations

In the absence of context regarding Canada's experience in the areas of OFDI and R&D, it may be tempting to advise that Canada continue on its current path. Indeed, Canada ranks[10] among the top 10 countries in triadic patent family filing, and maintains respectable standing on all other factors. Even critics of Canada's innovation record temper their remarks: "Our [...] performance rankings on all four indicators of the innovation environment mean that we have developed some of the right overarching conditions needed to support and encourage innovation" (Barrett et al., 2005, p. 40).

Yet, it is not advisable that Canada continue on its current track. Since 2000, the reference year for this study, Canada's outward FDI has declined. Further, while R&D expenditures rise, Canada's output performance in R&D is lacking. Given that the growth rates of other countries are outpacing Canada (Trajtenberg, 2002), it is clear Canada must continue to strive for increased international patenting. As other countries increase their investment in innovation and make it a priority, the more difficult it will be for Canada to hold onto its position. The government's role in this respect is to "improve the business climate for investment, innovation, entrepreneurship and risk-taking" (Rao and Sharpe, 2002, p.19) for the benefit of Canadian businesses and the health of the Canadian economy overall.

After evaluating the alternatives, a few winners emerge. It is difficult to justify the high costs of expanding SME export development programs to include developing countries due to the uncertain nature of the benefits. Moreover, government financed programs tend to provide less value than market initiated ventures as rent-seeking businesses would naturally discover these markets on their own and would not require government assistance to do so. For these reasons, this option is not recommended. Nor is the option to pursue foreign market research and information dissemination. It may be more cost-effective and reasonable for the Government of Canada to initiate such a venture with its OECD counterparts or recommend it to an organisation like the OECD to track and report. This information could be made widely available, however, it would even the playing field among OECD and non-OECD countries as it would be impossible to prevent non-OECD businesses from accessing this information.

[10] This ranking is applicable only to the year 2000, which is the reference year for this study.

The R&D status quo is simply not an option in the long run. This study has shown that R&D expenditure is the input with the greatest impact on triadic patenting and consequently innovation. As aforementioned, non-OECD countries are pursuing innovation to a greater degree. Their investments in R&D, in particular, are outpacing Canadian investments. Even within its peer group, Canada has much to fear as these countries continue to increase innovation to ensure their economies remain strong.

In the end, only three alternatives remain. If one were to initiate the following recommendations in the year 2006, implementation would begin just as the tolerance for the status quo begins to wane. Taken together, these policies are expected to facilitate increased outward FDI and R&D spending and consequently increased international patent filing.

## 10.1 Recommendation 1

To increase the amount of outward foreign direct investment, a further expansion of bilateral investment treaties with a new emphasis on emerging and developing economies is advisable. The strength of this option relates to the dual purpose it serves: BITs increase outward FDI and expand trade by reducing barriers to markets. As such, the business community and other stakeholders are likely to view this policy option favourably. A complementary benefit is the potential for improved diplomatic relations. The pursuit of BITs rates high for effectiveness and is a politically acceptable option with low government costs.

## 10.2 Recommendation 2

To increase R&D spending, particularly in the private sector, a reduction in foreign ownership restrictions in telecommunications is advisable. The analysis of this alternative found that political factors may prevent government from initiating discussion on commercial aviation. In the case of telecommunications, however, a policy window may open sooner. In order to pursue this option, the government would be compelled to limit the reduction in foreign ownership restrictions to distribution service, not content. In this way, the government would avoid the Canadian content debate and allow greater foreign financing of distribution activities, which is the area that makes up the bulk of R&D expenditures in telecommunications. As a result, Canadian telecommunications companies could make the choice to conduct greater R&D at home and reduce reliance on foreign R&D.

## 10.3 Recommendation 3

Canada is in a unique position. Despite increasing R&D expenditures, "international data from the last 10 years convey that Canada has always ranked among the lower-performing countries in R&D (Barrett et al., 2005, p. 38). Accountable governments should periodically evaluate policies for effectiveness and determine if initiatives should expand or be altered in any way. To gain a better understanding of the challenges facing Canada with respect to R&D output as well as the ways Canada can become more productive and innovative, it is highly recommended that the federal government initiate and fund a commission on R&D and innovation in Canada. To be effective, the commission must attract high profile and reputable commissioners, researchers, and policy analysts; and be undertaken in partnership with businesses of all sizes, business associations, research institutions, NGOs, provincial and large municipal governments, and influential leaders representing these sectors. Without the political will and buy-in this alternative could be destined for failure. As such, an influential champion is necessary to drive the process and pursue serious consideration among decision-makers, and ideally implementation, of the recommendations.

## 10.4 Recommendation 4

Evaluation is a crucial, yet often neglected phase in the policy cycle. It allows policymakers to track and explain the impacts policies have and, more importantly, to distinguish success from failure in achieving policy goals. Canada's experience in R&D spending reinforces the need for evaluation. Accordingly, it is recommended that government departments responsible for the implementation of the recommended policies evaluate their effectiveness. Evaluation will determine whether to expand, continue or cease activities associated with the alternatives. Potential qualitative and quantitative measurements include:

- quarterly and annual increases or decreases in R&D expenditures and OFDI
- annual increases or decreases in triadic patent family filing
- annual review of the number of BITs signed and in force
- annual review of Canadian OFDI in countries that have signed BITs with Canada
- evaluation of the implementation of commission recommendations
- government R&D expenditure reviews
- surveys of impacted stakeholders

- general review of administrative efficiency
- monitoring of other countries' related policies

# 11 Conclusion

The importance of innovation in the twenty-first century cannot be underestimated. Innovation has become a driving force for economic growth and has led to improvements in the standard of living for many worldwide. Canada continues to maintain its international patenting ranking among the best in the world; nonetheless, its ability to remain competitive is dependent upon the commitment of political leaders and stakeholders to keep sufficient focus on innovation.

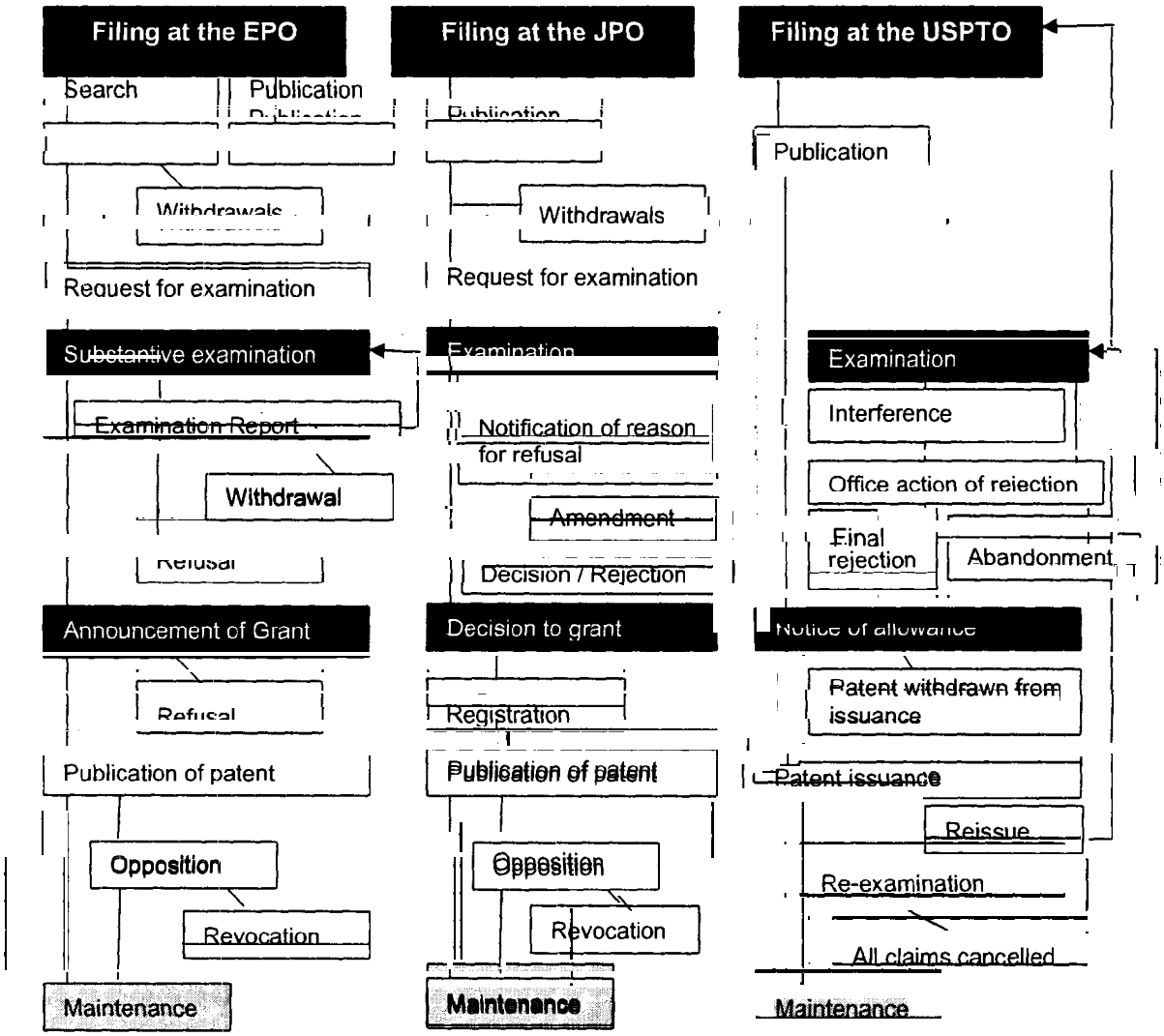
Understanding why and how countries can increase their innovative capacity was the purpose of this study. The regression results reveal that high-income country status and population size do matter. Moreover, increasing R&D expenditures and outward FDI are the best ways for countries to improve their international patent filings and consequently expand their capacity to innovate. In addition, it was discovered that R&D expenditures do not necessitate quality. Accordingly, the ability to extract value from R&D is critical. By analysing the widest selection of countries possible, the empirical model was able to generalise how Canada could increase its international patent filings with a view to increasing innovation. Through analysis, it became clear that generalisations are not sufficient to develop policies. Instead, policies and implementation mechanisms must be specific to the circumstances of the country in question.

Government's role is to improve the innovation environment and provide appropriate incentives. Still, it is up to individuals and businesses to seize opportunities and transform them into value. In this respect, the pursuit of greater trade liberalisation in the form of BITs and a reduction in foreign ownership restrictions are expected to lead to increased international patenting. In addition, an in-depth study of Canada's R&D situation is advised to provide recommendations on the policy mechanisms required to increase efficient R&D spending over the longer-term. Looking to the future, a concentrated focus on innovation and corresponding input indicators will allow Canada to remain competitive, protect the high standard of living, and generally improve the well-being of all Canadians.

# Appendices

# Appendix A: Patent Procedures

*Figure 6: Patent Procedures at the Triadic Patent Offices*




*Source: OECD Compendium of Patent Statistics, © OECD, 2004, https://www.oecd.org/dataoecd/60/24/8208325.pdf, by permission.*

*Table 7: List of Triadic Patenting Countries and Supplementary Data Sources*

| COUNTRY | MISSING DATA | SUPPLEMENTARY DATA SOURCES | HIGH INCOME |
|---|---|---|---|
| Argentina | N/A | ▪ Foreign Students reference year: 2000/2001 | No |
| Armenia | N/A | ▪ Foreign Students reference year: 2002/2003<br>▪ Tert. Ed. reference year: 2000/2001 | No |
| Australia | N/A | ▪ GERD reference year: 1996 | Yes |
| Austria | N/A | ▪ FDI reference year: 2001 | Yes |
| Belgium | N/A | ▪ FDI reference year: 2001 | Yes |
| Brazil | N/A | ▪ Foreign Students source: (OECD)<br>▪ Foreign Students reference year: 2003<br>▪ GERD reference year: 1996 | No |
| Bulgaria | N/A | ▪ Tert. Ed. reference year: 1998/1999 | No |
| Canada | N/A | N/A | Yes |
| Cayman Islands | Foreign Students, Tert. Ed., GERD | N/A | Yes |
| China (Mainland) | N/A | ▪ Population data source: China Population and Information Research Center<br>▪ Foreign Students data source: People's Daily Online<br>▪ FDI reference year: 2001 | No |
| Chinese Taipei | Tert. Ed, GERD | N/A | No |
| Croatia | N/A | ▪ Foreign Students reference year: 2000/2001<br>▪ Tert. Ed. reference year: 2002/2003 | No |
| Cuba | N/A | N/A | No |
| Czech Republic | N/A | N/A | No |
| Denmark | N/A | N/A | Yes |
| Egypt | Foreign Students, Tert. Ed. | N/A | No |
| Estonia | N/A | ▪ GERD reference year: 1996 | No |
| Finland | N/A | N/A | Yes |

| COUNTRY | MISSING DATA | SUPPLEMENTARY DATA SOURCES | HIGH INCOME |
|---|---|---|---|
| France | N/A | N/A | Yes |
| Georgia | Foreign Students, Tert. Ed. | N/A | No |
| Germany | N/A | N/A | Yes |
| Greece | N/A | ▪ Foreign Students reference year: 2001/2002 | Yes |
| Hong Kong - China | N/A | ▪ Foreign Students reference year: 2000/2001<br>▪ Tert. Ed. reference year: 2000/2001<br>▪ GERD reference year: 1998<br>▪ FDI reference year: 2001 | Yes |
| Hungary | N/A | N/A | No |
| Iceland | N/A | ▪ Tert. Ed. reference year: 2000/2001 | Yes |
| India | N/A | N/A | No |
| Indonesia | GERD | N/A | No |
| Iran | GERD | N/A | No |
| Ireland | N/A | N/A | Yes |
| Israel | Foreign Students | N/A | Yes |
| Italy | N/A | N/A | Yes |
| Japan | N/A | N/A | Yes |
| Kenya | GERD, Foreign Students | N/A | No |
| Korea | N/A | N/A | Yes |
| Latvia | N/A | ▪ Tert. Ed. reference year: 2000/2001 | No |
| Liechtenstein | Tert. Ed, Outward FDI, GERD | N/A | Yes |
| Lithuania | Foreign Students | N/A | No |
| Luxembourg | Foreign Students, Tert. Ed., Outward FDI | N/A | Yes |
| Malaysia | N/A | ▪ Tert. Ed. reference year: 2000/2001<br>▪ GERD reference year: 1996<br>▪ FDI reference year: 2001 | No |

| COUNTRY | MISSING DATA | SUPPLEMENTARY DATA SOURCES | HIGH INCOME |
|---|---|---|---|
| Mexico | N/A | ▪ FDI Source: IMF, Balance of Payments Tapes, August 2003 | No |
| Monaco | Foreign Students, Tert. Ed., Outward FDI, GERD | N/A | Yes |
| Morocco | GERD | N/A | No |
| Netherlands | N/A | N/A | Yes |
| New Zealand | N/A | ▪ Tert. Ed. reference year: 2000/2001 | Yes |
| Norway | N/A | N/A | Yes |
| Philippines | GERD | N/A | No |
| Poland | N/A | N/A | No |
| Portugal | N/A | N/A | Yes |
| Russian Federation | N/A | ▪ Foreign Students reference year: 2000/2001<br>▪ Tert. Ed. reference year: 2001/2002 | No |
| Saudi Arabia | GERD | N/A | Yes |
| Singapore | N/A | ▪ Foreign Students reference year:2002<br>▪ Foreign students data source: International Education Journal<br>▪ Tert. Ed. reference year: 2000/2001 | Yes |
| Slovak Republic | N/A | N/A | No |
| Slovenia | Foreign Students | N/A | Yes |
| South Africa | N/A | ▪ Foreign Students reference year: 1998/1999<br>▪ GERD reference year: 1998 | No |
| Spain | N/A | N/A | Yes |
| Sweden | N/A | N/A | Yes |
| Switzerland | N/A | ▪ GERD reference year: 1996 | Yes |
| Thailand | N/A | ▪ Foreign Students reference year: 2000/2001 | No |
| Tunisia | N/A | ▪ Tert. Ed. reference year: 1998/1999 | No |
| Turkey | N/A | ▪ Tert. Ed. reference year: 2000/2001 | No |
| Ukraine | N/A | ▪ Foreign Students reference year: 2000/2001<br>▪ Tert. Ed. reference year: 2000/2001 | No |
| United Arab Emirates | Foreign Students, GERD | N/A | Yes |

| COUNTRY | MISSING DATA | SUPPLEMENTARY DATA SOURCES | HIGH INCOME |
|---|---|---|---|
| United Kingdom | N/A | N/A | Yes |
| United States | N/A | ▪ Foreign Students reference year: 2000/2001<br>▪ Tert. Ed. reference year: 1998/1999 | Yes |
| Venezuela | Foreign Students, Tert. Ed. | N/A | No |

*Note: Shaded rows reflect countries removed from the study based on lack of available data.*
*Tert. Ed. stands for tertiary education expenditure, as a percentage of a country's total education budget.*

# Appendix C: Regression Results

*Table 8: Simple Correlations of Variables in Triadic Patenting Model*

| | Ln Patent Families | Tert. Ed. (% Total) | GERD (% GDP) | High Income | Ln Pop (millions) | Ln Foreign Student (millions) | Ln OFDI (millions) |
|---|---|---|---|---|---|---|---|
| **Ln Patent Families** | 1.000 | .208 | .798 | .683 | .389 | .702 | .789 |
| **Tert. Ed.** (% of Total) | | 1.000 | .202 | .345 | -.068 | .140 | .338 |
| **GERD** (% GDP) | | | 1.000 | .703 | -.003 | .481 | .638 |
| **High Income** | | | | 1.000 | -.187 | .430 | .785 |
| **Ln pop millions** (millions) | | | | | 1.000 | .484 | .182 |
| **Ln Foreign Students** (millions) | | | | | | 1.000 | .582 |
| **Ln Outward FDI** (millions) | | | | | | | 1.000 |

*Notes: correlations less than 0.8 indicate no correlation among variables.*

*Table 9: Model Summary*

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .941(a) | .886 | .869 | .99346 | 1.948 |

*Table 10: Degrees of Freedom*

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **Regression** | 306.998 | 6 | 51.166 | 51.842 | .000(a) |
| **Residual** | 39.479 | 40 | .987 | | |
| **Total** | 346.476 | 46 | | | |

*Table 11: Residual Statistics*

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| **Predicted Value** | -1.0134 | 8.6258 | 3.1641 | 2.58338 | 47 |
| **Residual** | -2.77672 | 1.81811 | .00000 | .92641 | 47 |
| **Std. Predicted Value** | -1.617 | 2.114 | .000 | 1.000 | 47 |
| **Std. Residual** | -2.795 | 1.830 | .000 | .933 | 47 |

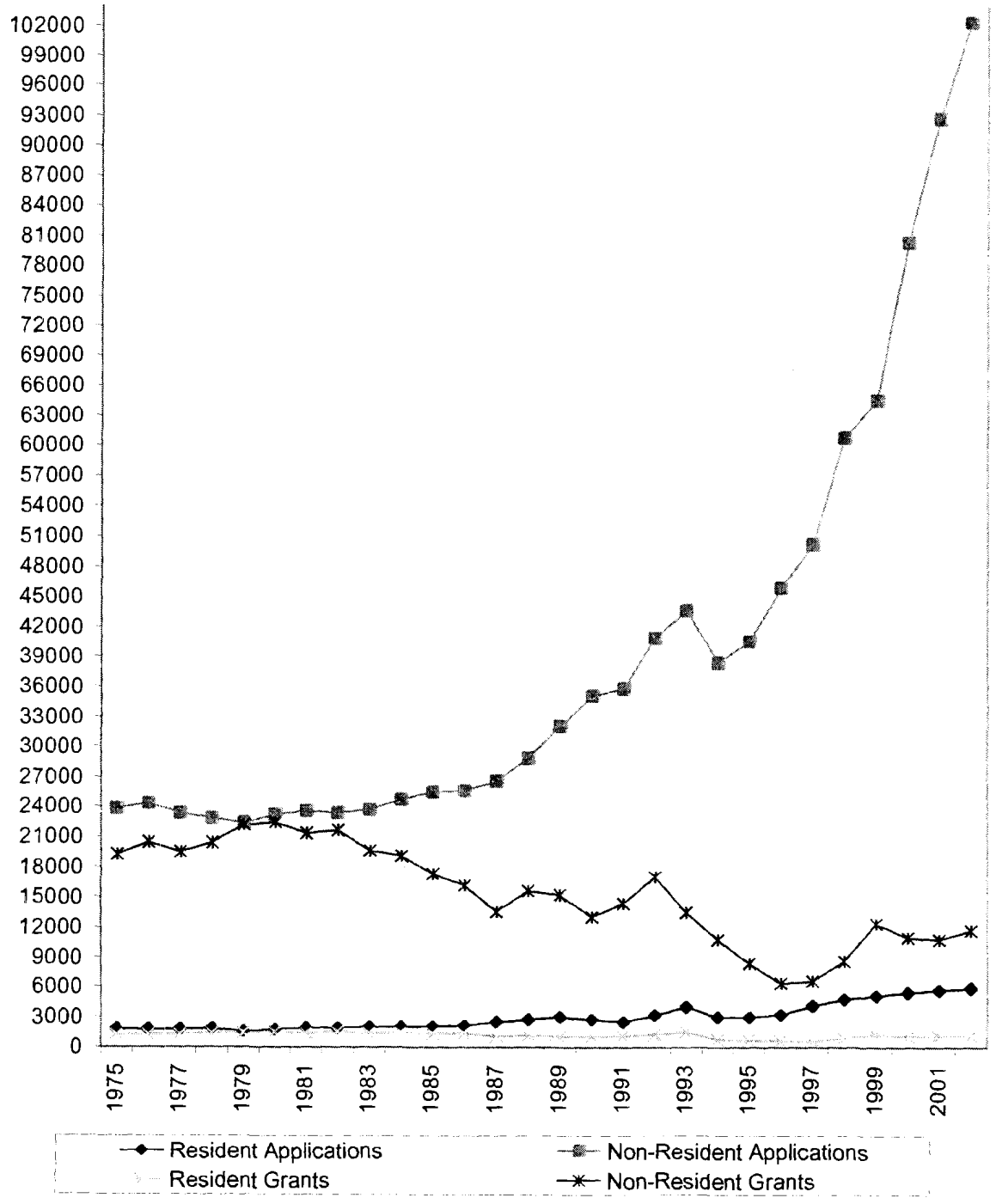
*Table 12: Collinearity Statistics*

| | Tolerance | VIF |
|---|---|---|
| **Ln Population** (millions) | .491 | 2.038 |
| **Ln Foreign Students** | .456 | 2.192 |
| **Tertiary Education Spending** (% of total education expenditure) | .859 | 1.165 |
| **Ln Outward FDI*** | .259 | 3.863 |
| **GERD** (% GDP) | .460 | 2.172 |
| **High Income** | .217 | 4.613 |

*Notes: VIF scores less than five signify no multicollinearity among the variables entered in this model.*

# Appendix D: Annual Patenting In Canada

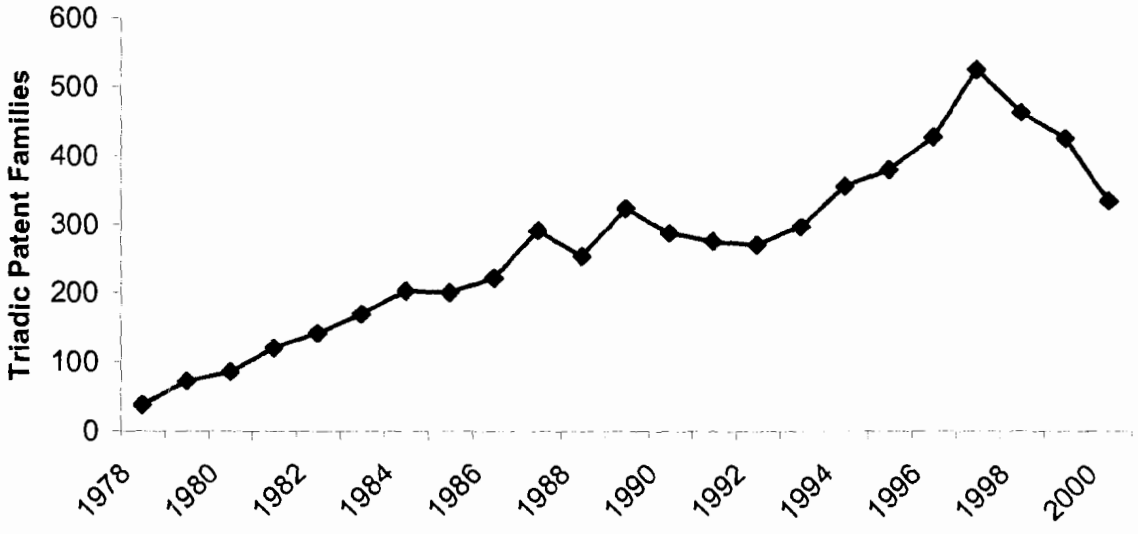
*Figure 7: Annual Patenting in Canada*
*Resident and Non-resident Applications and Grants (1975-2001)*




*Source: World Intellectual Property Organization Industrial Property Statistics*
*Notes: Data reflects all patents filed in Canada, not triadic patent families filed.*

# Appendix E: Canadian International Patents Filed

*Figure 8: Canadian Triadic Patent Family Filings (1978-2000) (attributed to Canadian inventors)*




*Source: OECD, Triadic Patent Families Database*

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