INTERNATIONAL PATENT SYSTEM: AN EMPIRICAL ANALYSIS

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∗ The opinions and views expressed herein are solely those of the authors and should not be attributed to WIPO or their employers.

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Introduction

The restructuring of the patent system world wide that the Agreement on TRIPs has brought about also brought into sharp focus the need to look at the dynamics of patenting activity in various countries. In this context, it was particularly important to recognise that patenting activity has evolved over a period of time and given this fact the phenomena had to be examined over an extended period of time.

Several studies have been conducted in the past that provide an analysis of cross-country patenting activity. These studies have tried to explain either domestic or foreign patenting activity using macro-economic variables. The interesting feature of this literature is that all but one of these studies has been done in the period prior to 1985. Yet another aspect of the available literature on the issue at hand is that developing countries have not been included in any of these barring a singular exception.

This, in other words, indicates that a comprehensive analysis of patenting activity, as it has taken place across countries, has not been attempted thus far. This lacuna is particularly galling in the context of the current discussion on the post-TRIPs patent system, one that has constantly underlined the need for countries to take advantage of the emerging regime.

The present study is an attempt to address the above-mentioned gap in the literature. There are two salient points of this study. The first is that the study takes into consideration a set of countries that is larger than has been done in the past. The countries included in the study cover the entire development spectrum. The second feature of this study is that the analysis uses time series data, spanning 24 years.

The study has several parts. The first provides a brief survey of literature, which helps in putting the study in perspective. The two following sections discuss the methodological issues and explain the data set that has been used. The criteria for selective of the countries that have been included have been spelt out length.

The trends in patenting activity observed across countries have been analysed in the next section. This section presents the data both for applications as well as grants as have been recorded in the Industrial Property Statistics of the WIPO.

The final section provides an econometric analysis of development and patents using a limited set of macro-economic variables. This exercise had to be limited in scope because comparable data set for countries included in the study were not available.

This exercise should be seen as the first attempt at a more comprehensive understanding of the patenting activity across countries. More than anything else, the study helps in identifying the data limitations that exist and which need to be addressed if an adequate understanding of dynamics of the patent system across countries is to be had.

Review of Literature

In this section, we will review some of the major studies on the Economics of the Patent System, which try to explain either domestic or foreign patenting behaviour or both in an inter-country comparative framework. A feature of these studies that have been discussed in this section is that they deal with the developed countries.

Domestic patenting Behaviour

Vayrynen [1977] estimates Spearman's rank-order correlation coefficients for 10 African countries between patents granted (both domestic and foreign) per capita and GDP (as a measure of the market size) and GDP per-capita (as a measure of development) both for 1971. The correlation coefficient he obtains is 0.90 for patents and GDP and 0.85 for patents and GDP per-capita.

Schiffel and Kitti [1978] try to explain domestic patent applications (Source: WIPO's December issue of *Industrial Property*) in Canada, France, West Germany, Japan and the United States by R&D expenditures lagged by two years. The data covered the period 1963-74 for all countries except Japan for which the data covered the period 1967-74. The results showed that for Canada and Japan the R&D coefficient was positive and significant, for West Germany, it was negative and significant and for France and the United States, it was not significant. The authors try to explain these results by saying that R&D is difficult to measure.

Soete [1981] explains domestic patenting in 19 OECD countries (Source: *Industrial Property Statistics*]. The dependent variable is the log of domestic patent applications per capita averaged for the years 1976-78 and the independent variable is R&D per capita in the business enterprise sector for the year 1975. He finds that the R&D in the business enterprise sector is positive and significant in explaining domestic patents.[1]

Watanabe [1985] estimates correlation coefficients between log of resident patent applications (Source: *Industrial Property Statistics*) percapita and log of gross domestic manufacturing product per capita (for 53 countries, 16 of which are developed) and log of

[1] He also uses log of patents granted percapita and obtains the same results.

GNP per capita (for 60 countries, 21 of which are developed) for the year 1979 and shows a positive and significant relationship.

Foreign Patenting Behaviour

Schiffel and Kitti [1978] try to explain foreign patenting activity in the United States by applicants from Canada, France, West Germany, Japan, Netherlands, Sweden, Switzerland and the United Kingdom (Source: *Industrial Property Statistics*). The independent variables are exports to the US by countries to which the foreign applicants belong and patents taken by the residents in the same set of countries, or domestic patents. The period covered by this study is 1965-74 for all countries except the Netherlands in which case the period is 1965-73. The domestic patents variable is positive and significant for Switzerland, and negative and significant for the Netherlands. For all other countries, it is not significant. The exports variable is positive and significant for all countries except for the Netherlands.

In the same paper, Schiffel and Kitti have attempted to explain foreign patenting activity in Japan by Canada, France, West Germany, Netherlands, Sweden, Switzerland, the United Kingdom and the United States (Source: *Industrial Property Statistics*). The independent variables as in the earlier case are, exports to Japan by countries to which the foreign applicant belongs and domestic patents in the same set of countries. The period covered for this exercise is identical to that considered for the earlier case. In the case of Japan, domestic patents as an explanatory variable are found to be positive and significant for Canada and Switzerland, and negative and significant for West Germany and Sweden. For all other countries, it is not significant. The exports variable is positive and significant for Canada, Sweden and Switzerland, and not significant for all the other countries.

The paper by Bosworth [1980] explains foreign patenting by the United States in 50 countries[2] for the year 1974 (Source: *Industrial Property Statistics*). The explanatory variables are gross domestic product and gross domestic product percapita of the 50 countries in which inventors belonging to the US have obtained patents as also exports

[2] Bosworth does not identify the countries.

and foreign investment[3] originating in the United States to each of the above mentioned countries. The log-linear results show that all the independent variables are positive and significant buy only exports and foreign direct investment variables are significant at one percent level of significance.

Soete [1981] tries to explain patenting behaviour of foreign applicants from 17 OECD countries in France, West Germany, Japan, the United Kingdom and the United States. The dependent variable is the patents granted averaged for the years 1976-78 and the independent variable is the R&D expenditures of the business enterprise sector for the year 1975. The interesting feature of this study is that domestic R&D expenditure undertaken by each of the 17 countries was used to explain foreign patenting activity in that country. The log-linear results of regression between foreign patent percapita and business enterprise R&D percapita show that business enterprise R&D is positive and significant for all the countries.

Bosworth [1984] tries to explain UK patenting activity abroad. He uses cross-section data (source UK Patent Office) for 50 countries[4] for the year 1974. The explanatory variables are GDP, GDP per capita, exports of UK to the countries concerned and size of operations of multinational enterprises (proxied by the number of UK subsidiaries in each country). The log-linear regression shows that all the independent variables are positive and significant.

In the same paper, Bosworth also tries to explain foreign patenting activity (Source: *Industrial Property Statistics*) in the UK. He uses cross-section data for 22 countries for the year 1974. The explanatory variables are imports into UK from the countries included in the sample, size of operations of multinational enterprises from that country (proxied by the number of subsidiaries from the originating country) and domestic patenting in the originating country. The log-linear regression shows that the size of operations of multinational enterprises and domestic patenting activity of the country are positive and significant while imports from that country is not significant in explaining foreign patenting activity in the UK.

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[3] The number of foreign firms was used as a proxy.

[4] Bosworth does not identify the contries.

Eaton and Kortum [1996] try to explain the flow of patent applications among 19 OECD countries for the year 1988. The explanatory variables are, human capital (average years of schooling), imports of one country from another country relative to one's GNP, the ratio of R&D scientists and engineers to total labour force, relative productivity of one country to the concerned country. The log-linear equation explaining ratio of patent applications and total labour force shows that human capital, intensity of R&D scientists and engineers employment and relative productivities are positive and significant, while import intensity if not significant. This equation also contains four variables to account for strength of the patent system. They find that while countries providing strong patent protection attract more foreign patents, patent strength and domestic patents are not so related.

Methodological Issues

Limitations of the Patent data

Patents have long been considered as a key output of R&D activity. Technology studies, which have a paucity of data to measure technological capability, rely on patent data. But at the outset let us enumerate some of the problems that are encountered while using patent data.

These problems could be grouped under three broad headings relevant for our study:

1. Patents as indicators of inventive activity
2. International comparability of patent data
3. Use of patent applications data

Patents as indicators of inventive activity

There are at least two sets of problems that need to be taken into account while using patents as indicators of inventive activity. The first is the fact that not all patentable inventions are patented. The second problem arises from the quality of patent data. Mansfield [1986] estimates that while in the pharmaceutical, oil and machinery industries, more than 80 percent of patentable inventions are patented, it is only 60 percent in case of primary metals and automobile industries. This not only shows that some patentable inventions are not patented but also points out to inter-industry differences in patenting. The inter-industry differences in propensity to patent arise from the fact that while some industries such as pharmaceuticals depend on patent protection as an appropriation mechanism the others do not. Taylor and Silberston [1973] showed that fine chemical industry in general and pharmaceutical industry in particular depends on the patent system. Ease of imitation is one of the reasons for this. Industries such as aircraft industry depend much less on the patent system; while they spend heavily on R&D, their output of patents is very small.

There are considerable differences in quality among patents within a country. While some patents are important, most of the others are not.

In an inter-country comparative perspective the differences in the quality of patents from one country to the other might result from such factors as the capabilities of patent offices and the differences in the interpretation of patentability criteria viz., novelty, non-obviousness and industrial applicability by different patent offices.

This point can be illustrated by the fact that a significant proportion of patents whose validity is challenged are held to be invalid by courts. One reason given is that the patent offices, do not have the resources to do a through examination of each and every patent, whereas a court is obliged to conduct a through examination of a patent in order to determine its validity (Engel [1985]).

There have been attempts to quantify differences in quality of patents through the use of number of claims, renewal information and citations. The most successful of these attempts were the patent renewal models. Many countries have a requirement that for the patent to be effective it has to be renewed periodically. The main reason for this is to weed out economically useless patents from being in force. Hence, we can assume that a patent, which has been renewed through its lifetime, is more valuable than the one, which was allowed to lapse. This information has been used to model patent renewal by Pakes [1986] and Schankerman and Pakes [1986]. Using the patent renewal information and patent fee schedules Schankerman and Pakes [1986] have shown that the distribution of private value of patents is highly skewed, while a few patents are very valuable a large majority of patents do not have any value.

Firm level differences in propensity to patent arise from the strategic perspectives of these firms towards R&D and patenting. Finally, these inter-industry and inter-firm propensities could change over time.

International comparability of patent data

Patent data may not be comparable among countries because of differences in patent laws. There are vast differences in patent laws of different countries. A country's patent law will certainly influence the patent output of that country. It could hence be argued that patent data across countries are not comparable. Further, these differences in patent laws would be accentuated by differences in practices of the patent offices in interpreting these laws and ultimately the enforcement of these provisions.

The differences in patent laws could arise because of differences in various provisions concerning patent protection. The more important among these are patentability criteria, coverage, duration, compulsory licensing and definitions of residents. Moreover, these laws could change over time, but changes in patent laws are not very frequent.

The generally accepted patentability criteria are novelty (new), non-obviousness (inventive step) and industrial applicability (usefulness). But, for example, in India the Indian Patents Act, 1970 had only novelty and industrial applicability as criteria of patentability and not non-obviousness. In addition, there are differences in the manner in which patent laws define novelty, which is taken either as novel in the world or in the country. Some countries have only a patent registration system where there are only requirements of form to be fulfilled and no substantive examination of the patent takes place. Some of the former colonies have or had a dependent patent system linked to the former colonial power, for example, Hong Kong and Singapore. Australia, Germany and Japan and the Netherlands followed a "deferred examination system" where substantive examination takes place only if specific request has been made within a specified period, which can be up to seven years from the date of application (UNCTAD [1975] p.7). All these differences in patent laws have the potential to influence patent applications and hence patent data.

Historically, there have been substantial differences in the patentable subject matter as between countries. Countries have excluded specific sectors from the ambit of patenting. Among the sectors that have been excluded are: pharmaceutical product patents, pharmaceutical process patents, food products, food processes, chemical products, methods of treatment of human or animal body, cosmetics, fertilizers, mixture of metals and alloys, agricultural machines and anti-contaminants. The other explicit exclusions found in some countries include, animal varieties, plant varieties, biological processes for producing animal or plant varieties, microorganisms and substances obtained by microbiological processes. Computer programs and nuclear inventions have also been excluded by certain countries (WIPO [1988]).

The duration of patent protection is another important source of differences in patent laws of countries. The patent term could vary among countries; it could be

different for different sectors within a country and the date from which the terms starts could vary from country to country, while some countries give a 20-year patent term some countries provide a patent term of 10 years. For example, the Indian Patent Act, 1970 provides a patent term of 14 years from the date application for all inventions except for pharmaceutical and food inventions. Under the Indian Act, pharmaceutical and food inventions have a term of five years from the date of grant or seven years from the date of application, whichever is shorter. The date on which the term of the patent starts varies among countries. The most important are, the date of application and the date of grant.

There could be important differences in the way the compulsory licensing provisions are incorporated in different patent laws. Compulsory licenses can be granted to counter non-working of the patent in the country of grant. Other grounds for grant of compulsory licenses can be public interest, including those relating to public health. Non-working of a patent, which is the ground for the grant of compulsory licenses that is recognized by the Paris Convention, is also considered as an abuse of patent rights. While many countries in the world have compulsory licensing provisions in their patent law to check possible abuses of patent monopoly, the United States is the only country, which uses anti-trust provisions to the same effect. Many developed[5] countries, which had strong compulsory licensing provisions in the past, diluted them in later years as they attained technological capability. Developing countries, which inherited colonial patent laws, reformed their patent systems in the late 1960s and early 1970s, an important component of which was to have compulsory licensing provisions. As of late 1980s, while developed countries had less stringent compulsory licensing provisions many developed countries had strong compulsory licensing provisions. The presence of a strong compulsory licensing provision could discourage inventors from seeking patent protection, for instance, Scherer [1977] in a survey of US firms finds that anti-trust decrees involving compulsory licenses discourage research and development and also increases secrecy.

[5] Through out this paper we consider high-income economies identified as such by World Bank [1993] to be developed countries. High-income economies have GNP per capita of $7620 or more in 1990, World Bank [1993].

Generally, the scope of patent rights covers making, selling and using the patented product. There are significant differences among countries in incorporating importation as a right of the patent holder. While some counties explicitly include importation as a right of the patent holder, other countries do not explicitly mention it.

Finally, there are differences in how a country defines residents and non-residents. While in the US "the concept of residence is determined by the place of residence of the first-named inventor rather than that of the applicant", in Japan it is "the concept of residence is determined by the nationality of the applicant rather than the country of residence of the applicant". All the other countries go by the residence of the applicant rather than by nationality.

The practices of the patent offices in interpreting the various provisions of the patent law could differ. One reason for this may be the subjective element, which normally surrounds these provisions. Another reason could be the differences in capabilities of patent offices. Many patent offices in developing countries may not have the human or material resources, which are required to implement a patent law satisfactorily. The practices of patent offices might have an effect on the number of patent applications.

There are considerable quality differences among patents in different countries. We could expect those inventions and hence patents granted in a developing country could be of less quality in general than those coming from a developed country. Another reason why the quality of patents coming from developing countries could be low is that the patent offices of developing countries might not have the resources to undertake a thorough examination of patent applications. A worldwide search for prior art could be beyond the reach of patent offices from developing countries both in terms of facilities as well as monetary resources. We would illustrate this point with the experience of Australia. The *Industrial Property Statistics* gives patent applications classified into 32 IPC technical units (a technical unit is between a sub-section and a class). Technical unit 32 is titled "Others (unclassified)". For Australian domestic patents a large proportion falls under this category. This is way above the average for other countries. The next largest figure is from France which has 550 domestic patents classified under Technical Unit 32 for the year 1994 making up only 4.39 percent of domestic patents. During the

period 1994-98 Australia did not grant even one patent under classification Technical Unit 32. The table below gives the information.

Table 1: Australian domestic patents classified as Technical Unit 32

Year	Total domestic patents	Domestic patents classified as "Others (unclassified)" Technical Unit 32	Percentage
1994	8511	7035	82.7
1995	8197	6888	84.0
1996	8108	6886	84.9
1997	7754	6567	84.7
1998	7744	6460	83.4

Source: *Industrial Property Statistics*

We interpret the classification of a majority of Australian domestic patents as unclassified technical unit as reflecting the quality of Australian domestic patents. This gets reflected in the very low percentage of grants Australian domestic patents, which we will discuss later.

There are differences in the enforcement of patent rights across countries. While many countries have only civil remedies in the case of infringement, a few countries have criminal provisions. The courts play an important part in enforcement of patent rights and their practices differ among countries.

Apart from differences in patent law, their interpretation by different Patent Offices and the capability of Patent Offices, there is another peculiar source of differences in patent counts which makes inter-country comparison difficult is the number of claims allowed for each patent. Japanese patent counts seem to be exaggerated because of practice of granting one patent for each claim, while in case of other countries' patents contain multiple claims.

Use of patent applications data

Patent grant data is a more direct measure of inventions than patent applications, because patent applications go through an examination at the patent offices and only those applications, which fulfill the patentability[6] criteria, are granted patents. But we propose to use applications data for our analysis. The reason for this is that while

[6] Generally, the primary criteria of patentability are novel (new), industrial applicability (useful) and non-obviousness (inventive step). The secondary criterion is enabling disclosure.

applications have a time dimension to it, grant data does not have. This can be explained by the fact that while the patent applicants decide the date of application, the practices of the patent office decide the date of grant[7]. This problem becomes more acute with the differences in patent office practices between developed and developing countries. While applications for a year belong to that particular year, grants for a particular year contain applications made in different years. We regard the time dimension as contained in the applications data to be crucial for our analysis; hence, we will use applications data.[8] The ideal data set will be grant data arranged according to date of application, but such data is not available.

The major flaw with using applications data is that only some of the applications are granted patents. And this grant rate may be different in different countries and may change over time. We assume that these differences are not major. We will report on grant rates in different countries in a subsequent section.

[7] See Griliches [1989] for a discussion on how the resources available to the patent office determine the grants. Some time these grants do not follow the trends in applications.

[8] Eaton and Kortum [1999] say "We report on applications than grants because they are much more comparable across countries", (p.542).

Database for the Study

The source of data on patenting is the World Intellectual Property Organization's annual compilation *Industrial Property Statistics*. We have collected data on patent applications and grants for residents and non-residents for the period 1975-98. The choice of 1975 as the initial year for the study was driven by the consideration that patent laws were changing in many countries.

The total patent figure as reported by the *Industrial Property Statistics* includes patents, inventors' certificates, patents of importation, patents of introduction, revalidation patents, precautionary patents and petty patents. For some countries, the data included provisional as well as complete specifications.

A total of 151 countries and OAPI (Organisation Africaine de la Propriete Intellectuelle), representing the regional arrangement among states of West Africa, have reported at least once during this period. This number includes countries belonging to former socialist bloc and those that have emerged after their breakup.

The patent data in *Industrial Property Statistics* is based on voluntary reporting by countries, if a country reports, it is included otherwise it is omitted. There is no mechanism to address the problem of non-reporting by countries. If one is trying to build up a long time series there are quite a few 'non-reporting' observations. There is endemic non-reporting by a number of developing countries. The extent to which countries provide patent data may be taken as an indicator of how important they felt the patent system to be. Some countries report only total applications without giving a break up of domestic and foreign applications. Only 20 countries have given data for each year and also the breakup between residents and non-residents during the entire period under study. Ireland and Italy are developed countries, which either do not report or give no breakup between residents and non-residents for some years.

After analysing the data compiled, we have decided to drop different sets of countries from detailed analysis. The set of countries and the reasons for their removal are discussed below.

Small Economies

There are 21 countries, which have a population of less than one million, which have reported their patenting activities to *Industrial Property Statistics* at least once during 1975-98. The reason for dropping these countries from detailed analysis is that we expect small economies i.e., those that have a population of less than one million, to have sub-optimal resources to exploit the patent system fully. This reason is reinforced by the number of zero domestic patents these countries report over time and also the number of years in which these countries do not report. These countries are Bahamas, Bahrain, Barbados, Belize, Brunei Darussalam, Cyprus, Fiji, Grenada, Guyana, Iceland, Kiribati, Luxembourg, Macau, Malta, Monaco, St. Lucia, St. Vincent and the Grenadines, Samoa, Seychelles, Solomon Islands and Swaziland.

Least Developed Countries

UNCTAD [1995] identifies 48 countries as least developed countries (LDCs). These countries thus have too few resources to spend on either efficient patent systems or any meaningful R&D. These countries therefore have either too few domestic patent applications (most of them zero) or they do not report most of the time. There are 20 LDCs, which have reported to *Industrial Property Statistics* at least once during this time. These countries are Angola, Bangladesh, Burundi, Ethiopia, Gambia, Haiti, Lesotho, Liberia, Madagascar, Malawi, Nepal, Rwanda, Sierra Leone, Somalia, Sudan, Tanzania, Uganda, Yemen, Zaire and Zambia.

In June 2001 the World Trade Organization (WTO) and the World Intellectual Property Organization (WIPO) launched an initiative "to help least developed countries (LDCs) maximise the benefits of intellectual property protection", WTO [2001]. In this context, let us examine the experience of the LDCs with the patent system.

As many as 15 of the 20 LDCs in our database are members of the Paris Convention and nine countries are members of the Patent Cooperation Treaty (PCT). Nine of these 20 countries are members of African Regional Industrial Property Organization (ARIPO).

The LDCs have a high incidence of non-reportage. Besides, they also report zero patents in quite a few years. Out of the total observations of 480 (20 countries and 24 years), of domestic patent applications as many as 273 observations are not reported

making up 57 percent of the total. The total number of observations reported zero patent applications are 100 making up 21 percent of the total. The problems with the data relating to these countries are indicative of the fact that these countries do not have functioning patent systems. They report zero domestic patenting when there is a positive number to be reported in foreign patent applications. Hence, we can assume that many of the non-reporting cases are actually zero domestic patents. There are fourteen countries, which either do not report or report zero domestic patent applications in more than twenty years of the twenty-four years covered by our study. These are Angola, Burundi, Ethiopia, Gambia, Lesotho, Liberia, Madagascar, Rwanda, Sierra Leone, Somalia, Sudan, Tanzania, Uganda and Yemen.

Malawi is one country, which never missed reporting. The Gambia national patent office never reported even once. The average number of domestic patent applications (for reported years) for Bangladesh is 37, for Zaire, it is eight and for Zambia it is three. Bangladesh is the most active among the LDCs as far as domestic patent applications are concerned.

Nine member countries of ARIPO belong to LDCs. This regional patent system seems to generate domestic patents. Up to 1997, only one domestic patent application was reported through ARIPO. But in 1998 as many as 36 domestic patents were reported as being applied through ARIPO in six countries.

Next, we will discuss the foreign patent applications scenario in LDCs. The number of foreign patent applications received by the national patent offices was declining, as increasing number of countries have joined PCT or the regional patent organization, ARIPO. The number of foreign patent applications was very low. The only countries with more than 50 as the average (reported) foreign patent applications are Bangladesh (106), Zaire (84) and Zambia (87).

For members of PCT the numbers of designations increase exponentially. While the average for PCT member countries was 334 in 1985, it rose to 33607 in 1998. Such an increase in designations was not translating to more foreign patent applications being received by the national patent offices. It would hence be surmised that these designations do not reflect the intentions of the patent applicants to actually seek a patent. There is a

convergence of foreign patent applications through PCT like in the case of EPC foreign patent applications.

For the member countries of ARIPO who are also members of PCT, the foreign applicants seem to prefer applying for patents in member countries through PCT. This is reflected by the fact that applications have gone up for member countries from 4207 in 1994 to 34153 in 1998. The number of foreign applications reaching ARIPO directly seems to be very low. On an average, they went up from eight in 1985 to only 65 in 1998.

On the whole, the domestic patenting performance of LDCs seems to be very low. These countries, which have some acute problems of poverty, malnutrition, education and health, may not have resources to spend on R&D, which might result in patents. Only after these problems are solved does it makes sense for these countries to spend on R&D. What seems to be interesting is that the foreign patent applicant seems to be least interested in least developed countries. If the patentee is looking for making profits out of his invention, the LDCs do not seem to matter. If the problem of developing countries is a large number of foreign patents (see section on Proportion of Domestic Patents in Total Patents), the problem with LDCs seem to be too few foreign patents.

In these circumstances, unless the basic problems of these countries such as poverty, malnutrition, education and health are solved these countries may not benefit much from the patent system.

OAPI

We have excluded OAPI members from our analysis because our focus is on inter-country comparison. Unlike other regional patent systems such as European Patent Convention (EPC) and African Regional Intellectual Property Organization (ARIPO), OAPI is a unitary system, with one patent law applicable in member countries and one patent office. The other reason for excluding the OAPI members is that 10 out of the 15 member countries of OAPI are LDCs. The member countries of OAPI are Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Mali, Mauritania, Senegal and Togo. Guinea-Bissau and Mali have reported separately for some years.

However, we may briefly mention the situation in OAPI countries. The member countries of OAPI have a unified patent system. The average number of domestic applications during 1975-98 was 24. The average number of foreign applications was 232 during the same period. The designations in PCT applications of OAPI as the designated regional patent organization rose from 398 in 1985 to 34692 in 1998. On the whole, OAPI seems to exhibit the characteristics of the other LDCs in their experience with the patent system.

Re-registration countries

We have excluded countries, which have a dependent patent system. Countries which have a re-registration system merely register patents, which are granted in some other designated country. While this system is not burdensome for foreign patentees, who just re-register those patents, which were granted elsewhere. It puts particular burden on domestic patent applicants. Domestic patentees who want to get patent protection for their inventions in their home country have to apply for a patent in a foreign country and once it is granted have to register that patent in their home country. Hence, re-registration system discourages domestic inventors in applying for a domestic patent. The domestic patent counts would be larger if there were an independent patent system rather than a re-registration system. The countries are, Hong Kong, which had a re-registration system till 1998, and Singapore, which had a re-registration system till 1995. The argument that re-registration discourages domestic applicants can be illustrated by the proportion of domestic patent applications in total patent applications. This proportion is 1.79 percent for Hong Kong and 0.88 percent for Singapore for the years 1975-98.

Former Socialist Countries

The main reason for excluding these countries from our analysis is that they had an 'inventor certificate' system when they were socialist countries. Patents and 'inventor certificates' counts are not comparable because the law, which governs them, is fundamentally different. For example while patents grant monopoly rights, 'inventor certificates' do not do so. An 'inventor certificate' holder does not have control over the use of his invention but has a right over royalties resulting from its use. Hence, the

problem of using the data for former socialist countries in a cross-country analysis. There are 34 such countries and these are Albania, Bulgaria, Cuba, Czechoslovakia, Czech, Slovakia, East Germany, Hungary, North Korea, Mongolia, Poland, Romania, Soviet Union, Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Viet Nam, Yugoslavia, Bosnia & Herzegovina, Croatia, Macedonia TFYR and Slovenia.

Countries which have reported for less than 12 years

There are 11 countries, which have not reported their patenting activities in more than eleven years out of twenty-four years, which our database covers. We have decided to remove them from further analysis. Their non-reporting shows that the patent system is not working efficiently. This non-reporting for such a long time will also make estimating missing observations a more erroneous task. These countries are Dominican Republic, Jordan, Kuwait, Libya, Namibia, Nicaragua, Nigeria, Paraguay, Saudi Arabia, Syria and United Arab Emirates.

Countries with zero Resident Patent Applications for More than 11 years

There are three countries with zero resident patent applications for than 11 years of the 24 years we are covering. Zero resident patent applications for such a long period of time shows that the patent system may not be working efficiently. These countries are Botswana, Ghana and Kenya.

Countries with zero Patent Grants for More than 11 years

There are two countries with zero patent grants in more than 11 years of the 24 years we are covering. No patent grants for such a long time signify a non-functioning patent system. These countries are Algeria and Indonesia.

Japan

The count of patent applications in Japan is not comparable with patent counts in other countries. While the practice of patent offices in all the other countries is to grant one patent with multiple claims, Japan has followed the practice of granting a patent to cover only one claim. Hence, the patent counts from Japan are inflated. "Okada [1992]

finds that Japanese patents granted to foreigners contain on average 4.9 times as many inventive claims as those granted to Japanese inventors" (referred to in Eaton and Kortum [1996, p.262]. Following them, we would also divide Japanese domestic patent applications by 4.9 to make them comparable to other countries. With these modified patent counts Japan was placed third between 1975-79 and second between 1980-98 in the overall domestic patent ranking, it overtook Germany in 1980.

Change in Coverage since 1985

One of the major problems in constructing and using this database is the change in coverage since 1985. Before 1985, the *Industrial Property Statistics* used to give only data reported by the concerned National Patent Office. This comprised patent applications filed directly at the National Patent Offices. Since 1985 the *Industrial Property Statistics* started reporting data from the Patent Cooperation Treaty (PCT) (which came into force in 1978) applications.

Apart from this, data pertaining to applications received by European Patent Office (EPO) (which came into force in 1977) were reported since 1985. Data on applications received by the African Regional Industrial Property Organization (ARIPO) (which came into effect in 1978) were reported in *Industrial Property Statistics* since 1994, only one member country of ARIPO viz., Zimbabwe remains in our sample. OAPI (which came into force in 1964) and the later Eurasian Patent Organization (EAPO) (which came into force in 1996) do not create a problem for us because we have excluded them from our sample. There is a perceptible jump from 1984 to 1985 because of the change in the way the data are reported.

This is especially true of the patent applications submitted to the EPO. The member countries of the European Patent Convention (EPC) in 1985 were Austria, Belgium, France, Germany, Italy, Netherlands, Sweden, Switzerland and the United Kingdom. Once the EPC came into effect in 1977 there was a shift towards applying for a patent to the EPO rather than national patent offices. While this shift took place after an interval in the case of domestic applications, in case of foreign patent applications the shift was almost immediate. In Belgium, the Netherlands and Switzerland domestic applications under EPC constituted 35.4, 41.89 and 34.35 percent of the total domestic

patent applications respectively during 1985-98. These countries being small countries the inventors shifted to EPC much more quickly than other member countries. While the national patent offices in Belgium and Switzerland report a sharp decline in domestic applications received by these offices, this does not take place in the Netherlands. For other countries, domestic patent applications received by national patent offices did not decline so rapidly during 1979-84. The number of domestic patent applications under EPC constituted much less proportion of total domestic applications. Hence, there is underreporting of domestic patent applications for those countries, which were EPC members before 1984.

This is even more true in the case of foreign patent applications. Foreign patent applicants just stopped approaching the national patent offices. They directly approach the EPO. The change is apparent as soon as a country becomes a member of EPC. Here the number of foreign patent applications being received by national patent offices shows a perceptible decline since 1979. Except for Germany and the United Kingdom, the proportion of foreign patents through the EPO is more than 90 percent. For Germany, it is 79.1 percent and for the United Kingdom, it is 80.3 percent. As far as foreign patent applications in EPC countries are concerned, there is significant underreporting because the *Industrial Property Statistics* did not cover it prior to 1985.

Problems with the PCT Data

The *Industrial Property Statistics* gives two sets of figures for a Patent Cooperation Treaty (PCT) member for applications and grants. One set of figures refer to applications received directly by the National Patent Office (N) and the other set of figures "P: Designations in international applications filed under the Patent Cooperation Treaty …".

The moot point is how many of these designations actually come before the National Patent Offices. The PCT requires that an applicant pay for the first six countries and nothing for any more country designations. This encourages PCT applicants to designate all the PCT member countries as designated countries. This results in patent designations, which can be termed as 'frivolous'. This can be illustrated by the example of North Korea.

North Korea joined the PCT in 1980 and stopped reporting its patenting activity since 1993. The PCT applications, which designate North Korea, were 1041 in 1987 reached a figure of 33918 in 1998. However, there were no grants reported since 1993. Why are PCT applicants designating North Korea when there is no possibility of getting a patent granted there? This example shows that many PCT designations could be 'frivolous'.

This may be true of many least developed countries, which were found to have attracted very large number of designations in the PCT applications. The following least developed countries attracted more than 10,000 designations in PCT applications in the year 1998. Malawi (67751), Sudan (67713), Uganda (67603), Lesotho (67485), Gambia (60267), Madagascar (34941), Liberia (34862), Sierra Leone (33154) and Guinea-Bissau (15568). Very few of these applications may reach national patent offices, which can be seen from the case of Trinidad and Tobago. Trinidad and Tobago joined the PCT in 1994. The number of PCT applications, which designated Trinidad and Tobago as a country, for various years are given below.

1994: 7200; 1995: 15468; 1996: 20723; 1997: 26168; 1998: 34969

The number of PCT applications, which reached Trinidad and Tobago Patent Office for this period, is given below.

1994: 0; 1995: 17; 1996: 31; 1997: 76; 1998: 90; 1999: 78; 2000: 133

To find out how many PCT designations with Trinidad and Tobago eventually reach Trinidad and Tobago Patent Office, we have done the following exercise to give a rough idea. Total PCT applications with Trinidad and Tobago as a designated country for the years 1994-98 were 104,951. Total PCT applications, which reached Trinidad and Tobago Patent Office for the years 1994-00, were 425. Hence as few as 0.40 percent of PCT applications with Trinidad and Tobago designations reached Trinidad and Tobago Patent Office. If we take PCT applications with Trinidad and Tobago as a designated country for the years 1994-97 only (69559) and actual PCT applications reaching Trinidad and Tobago Patent Office for the years 1994-00 (425) then the percentage is higher at 0.61. In any case, the number may not be much higher than one percent, which is very low.

The patent application figures reported by the National Patent Offices of respective countries for inclusion in the *Industrial Property Statistics* contain PCT applications, which were received by them. Hence, there is an element of double counting. We feel the quality of data in the *Industrial Property Statistics* can be improved if PCT designations are reported separately rather than as part of the patent applications and grants table. The explanatory notes to the table, which state that the PCT applications are only designations it is giving a wrong picture. The *Industrial Property Statistics 1998* in its 'Notes applicable to individual countries or organizations' with regard to Israel says "The (N) figures include international applications filed under the Patent Cooperation Treaty which entered the national phase in 1998". This note also figures in the notes pertaining to Luxembourg, Sweden, UK and USA. This is misleading because this is true for all the PCT member countries.

Finally, some comments on the way PCT works.

1) It seems most useful for marginal inventions. This can be used by individual or small firms to test whether their invention is worth patenting.
2) The extra time period offered by PCT applications (20 or 30 months if international preliminary examination is requested gives more time for large corporations to decide in which countries to apply. This time period is much more than the one-year given by the Paris Convention.
3) To reduce non-serious designations there should be a fee for all designated countries.
4) WIPO should follow what is happening to PCT applications in designated countries and report the data. They collect data for PCT applications, which were, granted patents but not for applications.

We have decided to remove all PCT designation data given in *Industrial Property Statistics*.

We have observed that while a country joining the PCT will not have an immediate or even medium term impact on domestic patent applications, the impact on foreign patent applications is immediate. Once a country joins the PCT, there will be a sudden drop in the number of foreign patent applications received by the national patent offices. With a lag of about one to two years the number of foreign patent applications received by the national patent offices increase. When a country joins the PCT foreign

patent applicants, have an easy way of applying in that country by designating that country in a PCT application. As it is easy and cost effective to apply in this way, foreign patent applicants shift to PCT route instead of approaching the national patent office. It also gives them 24 months to 36 months to decide whether to approach the national patent office. This is the reason why foreign patent applications received by national patent offices increases with a lag after joining PCT. On the other hand, domestic patent applicants do not seem to shift to PCT procedure immediately on a county joining PCT. They continue to approach the national patent offices and only shift to PCT slowly.

Estimation of Missing Data

Non-reporting or partial reporting of patent data is a critical problem for the analysis of the kind that has been attempted in this study. As only a single Patent Office deals with patent matters in a country one would expect it to have aggregate patent data. One would also expect that the national patent offices report their activities to the *Industrial Property Statistics* for data purposes. It would come as a surprise that many countries fail to report their patent activities regularly to the *Industrial Property Statistics*. Some countries do not report a break up of resident and non-resident patent activities. Out of the 56 countries in our sample, 30 countries have not reported for at least one year and two countries did not give a breakup between residents and non-residents for at least one year. Five countries did not report and did not give a breakup between residents and non-residents at least for one year. We have fitted a trend equation for available data and then estimated for the missing years. For no break up between residents and non-residents we have used the average proportions for the nearest available years. The error in estimation will be less in the case of no break-up being given for residents and non-residents. But the error in estimation will be higher in the case of non-reporting. In case of a country, which has experienced major fluctuations in applications or grants over time the error will be more. Out of the total 1316 observations in our database, the non-reporting observations were 158 (12.0 percent) and no-breakup between residents and non-residents were 16 (1.2 percent) making a total of 174 (13.2 percent). The countries for which we had to estimate the missing data are: Argentina, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, El

Salvador, Greece, Guatemala, Honduras, India, Iran, Iraq, Ireland, Italy, Jamaica, Japan, South Korea, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, South Africa, Sri Lanka, Thailand, Trinidad & Tobago, Tunisia, Turkey, Uruguay, Venezuela and Zimbabwe.

Incomplete Data

Four countries have data missing in the earlier part of the period considered for the study. These are: China (1975-84); Malaysia (1975-84); Thailand (1975-78) and Zimbabwe (1975-78). While China adopted a patent system only in 1984, Malaysia had a re-registration system till 1983. Thailand enacted a patent law only in 1979 and Zimbabwe did not report between 1975-78. This makes our data set an unbalanced panel data.

The Final Data Set

The data set used for the analysis in this study contains 56 countries. 52 countries have complete data (for all the 24 years) and four countries have incomplete data (for less than 24 years). Out of 56 countries in the data set, 20 developed countries and 36 developing countries. These countries are Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, China, Colombia, Costa Rica, Denmark, Ecuador, Egypt, El Salvador, Finland, France, Germany[9], Greece, Guatemala, Honduras, India, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, South Korea, Malaysia, Mauritius, Mexico, Morocco, Netherlands, New Zealand, Norway, Pakistan, Panama, Peru, Philippines, Portugal, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad & Tobago, Tunisia, Turkey, United Kingdom, United States of America, Uruguay, Venezuela and Zimbabwe.

[9] For the period 1975-91 Germany refers to West Germany and for the period 1992-98 it refers to unified Germany.

A Statistical Profile of the International Patent System

In this section the nature of patenting activity across the set of countries included in the study over the period 1975-98 would be explored. Domestic and foreign patenting activity in these countries would be analysed with a view to report the broad tendencies that were observed.

Domestic Patenting

Domestic patenting can be regarded as a better indicator of local inventive activity. From an analytical standpoint, the use of domestic patenting data seems more appropriate because it does not involve any double counting unlike foreign applications. However, it must also be added that counting only domestic patents might understate patenting activity of countries like Canada, in which inventors are more inclined to apply for patents abroad. The following table gives the data of Canadian domestic applications and Canadian applications in the US for the years 1994-98[10].

Table 2: Canadian domestic patents as percentage of Canadian patents in the US

Year	Canadian patents in the US	Canadian patents in Canada	Canadian domestic patents as percentage of Canadian patents in the US
1994	4574	2480	54.22
1995	5108	2431	47.59
1996	4888	2583	52.84
1997	5091	3344	65.68
1998	6094	3809	62.50

Source: *Industrial Property Statistics*

The table shows that Canadians are patenting only a portion of their patentable inventions in their own country and that they are more keen to seek patents in the US. The above-mentioned phenomenon has been a feature of Canadian patenting activity. An observation made in a study conducted more than two decades ago brings home this point. Schiffel and Kitti [1978] note that "Canada is particularly interesting since for the

[10] Canada has another interesting problem. There is a great difference in the figures provided by Canada for resident and non-resident patent applications for the years 1975-81 as given in WIPO [1983] and the annual *Industrial Property Statistics* for these years.

last four years more patent applications have been filed by Canadians in the US than by Canadians in Canada" (pp.330). While some Canadians may be applying for patents in the US and not in Canada, one reason for this phenomenon may be the way the US Patent Office classifies nationals and non-nationals. While other countries make a distinction between residents and non-residents irrespective of their nationality, the US Patent Office classifies inventors on the basis of nationality of the first inventor. Hence, some of the Canadians applying for patents only in the US and not Canada may be residing in the US. But this will not account for the large difference in Canadian domestic applications and applications in the US. According to Grupp and Schmoch [1999] "such countries being located in the neighborhood of a very large and attractive market for technology (as is also the case of Switzerland in relation to Germany, for South Korea in relation to Japan and for Belgium" (pp.383). We found that in relation to Switzerland, South Korea and Belgium countries for the years 1994-98 domestic patents are higher than foreign patents from these countries in Germany, Japan and France respectively.

Total domestic patent applications in the 56 countries in our sample, which were 201,875 in 1975, rose to 435,508 in 1998, the yearly average being 278,933 applications for the period as a whole (see Figure 1). The compound annual growth rate was 3.8 percent per annum. The share of developed countries in total domestic applications during 1975-98 was 88.10 percent, that of developing countries 11.9 percent.

There are considerable differences in the share of different countries within these groups. Japan and the US accounted for 48.1 percent of the total patent applications for the period 1975-98.

The share of developing countries in total applications rose from 6.1 in 1975 to 18.4 percent in 1998. This rise in the share of developing countries in recent years was due to the high increases registered by China and South Korea. These two countries accounted for 80.5 percent of total patent applications in developing countries in the terminal year of the study viz., 1998. Without these two countries, the share of developing countries in total patent applications comes down from 5.5 in 1975 to 3.6 in 1998.

There are only six countries, which had on the average more than 10,000 domestic patent applications per annum during 1975-98. These are France, Germany, Japan, South Korea, UK and USA. Of the 17 countries, which have more than 1000 domestic patent

applications per annum, only five are developing countries. These are Argentina, Brazil, China, India and South Africa. Apart from these, all the other countries are developed countries.

Of the 14 countries, which have on the average less than a 1000 domestic patent applications and more than 100 domestic patent applications per annum only three countries viz., Ireland, Israel and Norway are developed countries. The remaining 19 countries have on the average less than 100 domestic patents per annum. Mauritius comes last with only two domestic patents per annum. Hence, it is clear from the above analysis that while a few developed countries can have low average domestic patent applications, very few developing countries can have high domestic patent applications. The average patent figure shows clearly the disparities in domestic patent applications as between countries, which is an indicator of their comparative technological capabilities.

The imbalances in domestic patent applications across countries can be seen in yet another way. Of the domestic patent applications in all the 56 countries in our sample, the top five countries accounted for 76.9 percent, while the top ten countries accounted for 90.2 percent in 1998. The bottom twenty countries accounted for 0.16 percent of the total domestic patent applications.[11]

Foreign Patenting

Foreign patenting across countries could be motivated by two factors. First, it could be seen as attempts by the innovators to patent their inventions in countries that are most likely to imitate their inventions. Secondly, it could represent an interest on the part of the inventors to transfer their technologies to different countries. Any analysis of foreign patenting will have to face the problem of double counting. While all the domestic applications will not result in foreign patent applications, some patent applications will be applied in more than one country. Some important patent applications may be filed in a number of countries. This has to be taken into account while doing any analysis of foreign patenting.

[11] For the year 1975 our sample has 52 countries (China, Malaysia, Thailand and Zimbabwe do not have data for earlier years). The top five countries accounted for 76.9 percent while the top tent countries

Total foreign patents, by the 56 countries in our sample, which were 323,204 in 1975 rose to 942,620 in 1998, showing an annual compound growth rate of 4.5 percent. Developed countries accounted for 86.2 percent of foreign patents during 1975-98. Developing countries accounted for the remaining 13.8 percent.

There were considerable fluctuations in total foreign applications made during the period. The 1975-84 period saw a sharp decline. The reason for this might be the European Patent Convention, foreign patentees have started using EPC route for filing patent applications instead of approaching the national patent offices. The *Industrial Property Statistics* started reporting the EPC applications only from 1985. There was a sudden increase in 1985 to the tune of about 200,000 applications. EPC countries saw an increase of about 195,000 patent applications from 1984 to 1985, accounting for about 95 percent of the increase over the previous year. After a steady increase during 1985 to 1990, foreign patent applications saw a decline again during the period of 1990 and 1996. During the years 1997 and 1998 a huge increase in the number of foreign patent applications was recorded, in fact the year 1997 saw an increase of about 256,000 foreign patent applications over the previous year while 1998 saw an increase of about 203,000 foreign patent applications. Most of the increase in the foreign patent applications came from the EPC countries. While the EPC countries saw an increase of about 252,000 foreign patent applications in 1997 over 1996 (a share of 95 percent), it was about 178,000 in 1998 (a share of 79.5 percent) over the previous year. Hence, much of the remarkable increase in foreign patent applications goes to the EPC countries, because of the ease of applying for an EPC patent.

There are fourteen countries, all of them developed countries[12], which attracted on an average, more than 10,000 foreign patent applications between 1975 and 1998. There are nineteen countries, which attracted more than 1000 but less than 10000 foreign patent applications per annum of which six are developed countries. Of the remaining 23 countries, which received less than 1000 foreign patent applications per annum, none of them was a developed country. The destination of foreign patent applications between countries thus shows skewedness in favour of the developed countries.

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accounted for 88.2 percent of domestic patent applications. The bottom twenty countries accounted for 0.34 percent of domestic patent applications. We can see that concentration increased during this period.

[12] Eleven of them were members of EPC by 1998.

Proportion of Domestic Patents in Total Patents

The proportion of domestic patent applications to total patent applications can be taken as an indicator of the relative significance of local technological capabilities of a country. While domestic patents come from one single country, foreign patent applications come from rest of the world; hence we could assume that foreign patent applications would outweigh domestic patent applications. The other factor is that all domestic patent applications do not end up as foreign patent applications. For example, out of total domestic patent applications in the US only 1.12 percent were applied for in India during 1972-87. The figure is 1.26 for UK and 0.89 for Germany (Rao [2002]).

We have taken the average proportion of domestic patents in total patents for the period 1975-98. Of the twenty developed countries in our sample in only three of these more than 50 percent of total patents came from domestic applicants. These are Japan (66.72), the US (57.54) and Germany (54.33). Eight countries have domestic patent applications accounting for more than 25 percent but less than 50 percent of total patent applications. Among these are United Kingdom (37.42) and France (31.78). There are nine countries whose domestic patent applications accounted for less than 25 percent of total patent applications. These are Austria, Belgium, Canada, Denmark, Ireland, Italy, the Netherlands, Norway and Spain. As many as seven of these countries are members of EPC. With the ease of applying for an EPC patent there was a surge in foreign patent applications in EPC member countries. This could be one reason why these countries displayed a low proportion of domestic patent applications in total patent applications. In the case of Belgium, the lowest proportion of domestic patents in total patents at 9.50 percent was observed. While the average number of domestic applications in Belgium was 1,000 during 1975-98, the average number of foreign patent applications was 16,000. Belgium being a member of EPC attracts a large number of foreign patent applications.

Of the 36 developing countries in our sample, only two countries have domestic patent applications accounting for more than 50 percent of total patent applications. These are Iraq (56.21) and China (53.36). Iraq is a special case because the steep decline in foreign patenting increased the share of domestic patent applications to more than 50 percent. The case of China is interesting: the country was generating more domestic patent applications than the foreign patent applications it was attracting. Seven countries had more

than 25 percent and less than 50 percent of total patents being accounted for by domestic patents. South Korea (43.69) and India (32.04) are in this group. There are 27 countries in which for less than 25 percent of total patent applications came from domestic patentees. Of these in six countries, domestic applications were less than ten percent of total patent applications. These are Jamaica, Malaysia, Pakistan, Philippines, Portugal and Thailand.

One of the main problems faced by developing countries is the high proportion of foreign patents in total patents. From the above analysis, it is clear that while in a majority of developing countries the ratio of domestic patents to total patents was low, some developed countries shared this characteristic. The average proportion of domestic patent applications in the total was 29.08 percent for developed countries and 20.89 percent in developing countries. For some of the members of EPC the increase in foreign patenting activity after they joined EPC might have brought down the proportion of domestic patent applications out of total patent applications. The fact that many developed countries also had low proportion of domestic patents should not distract from the fact that developing countries face acute problem with dominance of foreign patenting activity and also very low domestic patenting activity.

Grant Ratio

Countries, which have substantive examination requirements for patentability, grant only a proportion of patent applications. In this sub section, we will analyse the grant ratio for different countries. In the United States 65 percent of patent applications were granted patents during the 1970s (Griliches [1990] p.1663). It was 83 percent in the UK during 1950-76, 93 percent in France during 1951-79, and 35 percent in Germany during 1952-78 (Schankerman and Pakes [1986] p.1056). In Finland, it was it was 41 percent during 1974-79 and in Norway 44 percent during 1974-79 (Pakes and Simpson [1989] p.381)[13]. There is a lag between applications and grants and it depends upon the practices of the national patent offices and the number of applications. According to Griliches [1989 p.295) the United States Patent Office issued 95.1 percent of patents eventually issued within four years for the application years 1966-80. The Indian Patent Office on the average took 4.3 years (from the date of application) to grant patents for the application years 1972-87 (Rao

[13] The figures covers both domestic and foreign patents.

[2002]). Hence, we estimate the proportion of grants with a four-year lag. The application years will be 1975-94 and the corresponding grant years will be 1979-98.

Domestic Applications: Countries in our sample can be divided into four groups based on the ratio of grants to applications (hereafter the grant ratio). There are four countries, in which the grant ratio was more than 90 percent. The countries in this group are Trinidad and Tobago, Morocco, Tunisia, and Sri Lanka. These countries have a system of registration of patent specifications hence, they do not do substantive examination of patent specifications resulting in high grant ratio.

The second group of countries grants patents on less than 75 percent but more than 50 percent of domestic patent applications. There are thirteen countries in this group. Prominent countries in this group are South Korea and United States with a grant ratio of 70.6 and 64.2 percent respectively. France grants patents to 74.3 percent of its domestic patent applications.

The third group of countries is the most numerous with 29 countries, in which grant ratio was between 25 and 50 percent of domestic patent applications. Germany is the most interesting country with a grant ratio of only 42.3 percent. Differed examination could be one of the reasons why the grant ratio is low in Germany. Japan had a comparatively a low ratio grant of 27.5 percent of domestic patent applications. Wineberg [1988] says that in Japan domestic inventors apply for a patent early in the R&D process, as there is no requirement to show "reduction of the invention to practice". Apart from this, Japanese apply for a patent to claim priority and many of the applicants do not request for an examination (Wineberg [1988], pp.16). This puts Japan in the group of countries, which grant the lowest percentage of domestic patent applications. India is also in this group with 38.4 percent of domestic patent applications being granted patents.

The last group consists of ten countries, which granted patents to less than twenty five percent of domestic patent applications. Australia, China and United Kingdom are the surprising entries in this group of countries. Australia grants only 14.2 percent of domestic patent applications just above Egypt, the last country at 11.5 percent. China grants 24.2 percent of domestic patent applications while United Kingdom grants 23.3 percent.

Thus, almost 70 percent of the countries included in the sample gave patents 50 percent or less of the total applications made. While some of the more industrialized

countries have recorded better grants to patent applications ratios, the leading developing countries have lower grants ratios.

Foreign Applications: Foreign patent applications had a higher grant percentage as compared to domestic patent applications. One plausible reason for this could be that while domestic patent applications come before patent offices for the first time, foreign patent applications might have already been submitted, if not granted, by the time they reach patent offices in foreign countries. Because only a low proportion of domestic patents reach foreign patent offices these might have been chosen with care by the applicants. Hence, they have more chances of being granted patents by foreign patent offices.

There are seven countries, in which more than 90 percent of foreign patent applications were granted patents. Apart from the four we have identified as patent registration countries, the other three countries are Australia, Switzerland and Venezuela.

In twelve countries, the percentage of foreign patent applications getting patent rights is between 75 and 90 percent. France and the United Kingdom with 87.6 and 80.9 percent respectively figure in this group.

The most numerous group of countries at 29 are those countries in which between 50 and 75 percent of foreign patent applications are granted patents. Germany grants patents to 72.4 percent of foreign patent applications. While United States grants 70.6 percent, South Korea grants 61.6 percent of patents to foreign patent applications. India also figures in this group with 56.7 percent of grants for foreign applications.

Interestingly China and Japan figure in the group of countries, which grant less than 50 percent but more than 25 percent of foreign patent applications. While China grants 46.5 percent of foreign patent applications, it is only 42.9 in Japan, higher than the percentage of domestic patents granted at 27.5. The last set of countries, which grant less than 25 percent of foreign patent applications are Jamaica and Costa Rica.

Growth of Patent Applications

In this sub-section, we will analyse the trends in patent applications, both domestic and foreign patent applications during the period 1975-98. For this purpose, we have calculated the compound annual growth rates.

Domestic Patents: Of the 56 countries in our sample 39 countries experienced a positive growth rate in domestic patent applications while 17 countries showed a decline in their domestic patent applications in the period 1975-98.

Of the 20 developed countries in our sample, four countries experienced a decline in their domestic patent applications. These countries are Austria, Sweden, Switzerland and United Kingdom. In Austria, the domestic patent applications were remarkably stagnant over the twenty-four year period, showing a decline of 0.4 percent. Sweden witnessed a decline in domestic patent applications during the period 1975 to 1990, from 4042 in 1975 the fell to 3340 in 1990. During the 1990s, there was a positive trend in domestic patenting. Switzerland's domestic patent applications fell drastically during the period 1975-84. After witnessing a sharp increase in 1985 at 4372 domestic patent applications were stagnant till 1998 reaching a figure of only 4342. Generally, we did not see any drastic impact of the EPC on domestic patent applications, but in the case of Switzerland, we feel that EPC might have had an impact on domestic patent applications. Swiss domestic patent applicants seem to have preferred approaching the EPO rather than Swiss national patent office. The decline during 1975-84 might be the result of the EPC applications not being reported in the *Industrial Property Statistics*. But overall, one can see that domestic patent applications in Switzerland are stagnant for a long time.

The United Kingdom experienced noticeable fluctuations in its domestic patent applications during this period. The domestic patent applications, which were 20842 in 1975, fell to 19043 in 1984. During 1985-89, it witnessed a positive trend in domestic patent applications. But the period 1990 to 1996 experienced a sharp decline. Domestic patent applications, which were 21649 in 1990, fell to 19479 in 1996. There was, however, a reversal of the trend in the following years. These fluctuations in domestic patenting resulted in a decline of 0.03 percent during 1975-98. Of the developed countries, which showed a positive growth rate, Japan's domestic patent applications grew at 4.85 percent per annum. There are two distinct periods during 1975-98, which describe Japan's domestic patenting activity. The first was 1975-87 and the second 1988-98. During 1975-87, domestic patent applications in Japan increased at the rate of 8.26 percent per annum. The second period 1988-98 period witnessed virtual stagnation in Japan's domestic patent applications growing at only 1.01 percent per annum. The United States, which

experienced increase in domestic patenting of a somewhat lesser magnitude as compared to Japan, US domestic patent applications showed a growth rate of 3.46 percent per annum during 1975-98. Two distinct phases are observed in respect of the United States' domestic patenting activity. In the phase, 1975-83 domestic patent applications in the US declined by 0.68 percent per annum. The second period of 1984-98 saw a growth rate of 5.67 percent per annum in US domestic patent applications. The growth rates in domestic patent applications of the other major countries viz., Germany and France were 2.83 percent 1.93 percent per annum respectively.

What comes out clearly from the above analysis of growth trends in domestic patent applications in the five largest domestic patenting countries is the following. The time period 1975-98 could be divided into two phases. The first phase roughly covers the period 1975-84 and the second 1985-98. In the first phase France, United Kingdom and United States of America (1975-83) witnessed a decline in their domestic patent applications of the magnitude of 0.88, 0.81 and 0.68 respectively. Germany witnessed a growth rate of only 0.36. In the second phase these countries except United Kingdom witnessed positive growth rates in their domestic patent applications, which were 1.22 percent, 2.66 percent and 5.74 percent respectively for France, Germany and Japan respectively. United Kingdom continued to experience a decline. The experience of Japan on the other hand has been exactly the opposite. During the first phase covering 1975-87, the growth rate in domestic applications was 8.26 percent, the growth in the second phase covering1988-98 was 1.01 percent per annum. What could be the reasons for this? We speculate that the macro economic performance of these countries during these phases is responsible for this.

Of the 36 countries developing countries in our sample as many as thirteen countries experienced a decline in their domestic patent applications during the period 1975-98. These countries are Argentina, Costa Rica, Ecuador, El Salvador, Greece, Guatemala, Honduras, Jamaica, Mexico, Pakistan, Peru, Uruguay and Venezuela. Of these thirteen countries, eleven belong to the Latin American region. The macro economic turmoil faced by these countries during the period under study seems to have had a severe effect on their domestic patenting performance. The other two countries, which witnessed a decline in their domestic patent applications during this period, were Greece and Pakistan. Greece witnessed one of the most dramatic declines in domestic patent applications with an 8.68

percent annual decline. The domestic patent applications, which were 1664 in 1975, fell to 170 in 1998. This period can be divided into two segments. Between 1975 and 1987, there was a relatively small decline, 1664 applications to 1548 applications. The decline from 1987 to 1988 was very sharp when the number of domestic patent applications fell to 378. This decline continued till 1998. Pakistan witnessed a decline of 1.75 percent in its domestic patent applications during the period under consideration.

Among the developing countries, which showed a growth rate of more than ten percent in their domestic patent applications, are China, Egypt, Iraq, South Korea, Malaysia and Thailand. Of the countries, which showed more than 10 percent growth per annum, South Korea and China are interesting cases. South Korea whose domestic patent applications were 1,326 in 1975 rose up to 50,596 domestic patent applications in 1998, an increase of 22.59 percent per annum. China introduced a modern patent system in 1984. Domestic patent applications, which were 4,065 in 1985, went up to 13,726 in 1998. These two countries will be discussed in depth later.

There are twelve countries, which show a growth rate of more than one percent and less than ten percent per annum. India with 1.95 percent is in this group. Apart from this, the countries with a growth rate between zero and one number five.

Foreign Patents: While 34 countries out of the 56 countries in our sample showed a positive growth rate in foreign patent applications, as many as 22 countries showed a decline in foreign patent applications during the period 1975-98.

Among 20 developed countries in our sample, four countries experienced a decline in their foreign patent applications during 1975-98. These are Australia, Canada, Japan and Norway. In all these countries, the decline was particularly sharp during the 1990s. Australia witnessed a stagnation of foreign patent applications at around 10000 for the period 1975-90. Between 1990 and 1998, the number of foreign patent applications fell from 10502 to 5847. The fall in foreign patent applications in Australia was 2.52 per annum. In Canada, foreign patent applications grew between 1975 (25237 applications) and 1989 (32060 applications). But they fell sharply thereafter. In 1998, foreign patent applications were 11338, which was less than half of that in 1975. As a result, Canada witnessed a decline of 2.82 percent per annum in its foreign applications for the period 1975-98. In Japan, foreign patent applications were stagnant between 1975 (24703

applications) and 1992 (24699 applications), but fell between 1992 and 1998 (21280 applications). It is surprising that Japan being a large economy attracted relatively smaller number of foreign patent applications and also that they were either stagnant are falling while foreign patenting is growing in other countries. The number of foreign patent applications in Japan fell by 0.62 percent between 1975 and 1998. The observed tendencies in foreign patenting activity in Japan can be ascribed to the procedures followed by the Japanese Patent Office. Wineberg [1988] cites the practice of the Japanese system in having opposition proceedings at various stages of the grant of a patent as a barrier for foreigners applying for patents in Japan. Norway also experienced a sharp fall in foreign patent applications. Foreign patent applications fell from 4122 in 1992 to 2083 in 1993 and continued falling till they reached a level of 1534 applications in 1998. In Norway, the foreign patent application fell by 2.17 percent per annum. Among the developed countries that experienced increases in foreign patenting were the members of EPC. The tendencies observed in case of these countries would be dealt with in detail in a later section. Three of the leading countries in terms of patenting activity, viz., the United States, France and Germany witnessed impressive growth in foreign patenting. The United Sates witnessed a growth rate of 4.55 percent per annum. France had a growth rate of 4.36 percent per annum, UK 3.93 percent per annum and Germany 3.42 percent per annum.

Of the 36 developing countries in our sample, as many as 22 countries experienced a decline in their foreign patent applications. These countries are Bolivia, Brazil, Costa Rica, Egypt, El Salvador, Guatemala, Iran, Iraq, Jamaica, Mauritius, Morocco, Panama, South Africa, Sri Lanka, Trinidad & Tobago, Tunisia, Venezuela and Zimbabwe. Nine of these countries are from Latin America. As was with their domestic patent applications the macro economic turmoil these countries faced during the period under study, might have had an adverse impact on foreign patent applications.

Six developing countries experienced a growth rate of more than ten percent per annum in their foreign patent applications during the period 1975-98. These countries are China, Greece, South Korea, Malaysia, Portugal and Thailand. Of these countries, the China (11.2 percent) and South Korea (10.9 percent) recorded the highest increases in foreign patenting. Foreign patent applications in China increased from 4493 in 1985 to 12,102 in 1997 and 22,234 in 1998. Similarly, foreign patent applications in South Korea

went up from 1588 in 1975 to 16,457 in 1997 and 24,637 in 1998. As we have noted in the previous sub-section these are the countries, which have shown remarkable performance as far as their domestic patent applications are concerned. In the case of Greece and Portugal, the increase in foreign patent applications was solely because of their membership of the EPC. There are nine countries, which have had a growth rate of between one and ten percent. India is in this group with a growth rate of 5.6 percent. All the three countries, which experienced a growth rate of zero to less than one in their foreign patent applications, are from Latin America.

European Patent Convention

Here we will discuss the experiences of countries, which joined the European Patent Convention after 1985. These countries are Denmark, Finland, Greece, Ireland, Portugal and Spain. The reason for this choice is because we have breakup of the patent applications received by the national patent offices and the EPO right from the start of their membership. The availability of this data would enable us to examine the impact of these countries joining EPC on production of domestic patent applications. We would also examine the impact of the membership of EPC on foreign patent applications. As we have seen most of the increase in foreign patent applications worldwide is coming from new members of EPC. This analysis may shed some light as to what is likely to happen when developing countries join the Patent Cooperation Treaty (PCT).

Denmark (1990), Finland (1996), Greece (1986), Ireland (1992), Portugal (1992) and Spain (1990) have data prior to and after joining the EPC. We had to exclude Finland because it did not have enough observations and Greece because of a continuous and precipitous fall in domestic patent applications much before joining the EPC. We did Chow test to see whether there is a structural break in domestic patent applications and foreign patent applications after a country joined the EPC.

Table 3: Structural break in domestic and foreign patent applications: Chow test

Country	Domestic applications	Foreign applications
Denmark	**3.24	*5.28

Ireland	1.39	*24.37
Portugal	0.78	*18.80
Spain	1.82	1.49

* Significant at 1% level, ** significant at 5% level

It is interesting to note from the above table that the entry into EPC did not have any major impact on domestic patent applications in Ireland, Portugal and Spain, while there was an impact on the domestic patent applications of Denmark. While Denmark had the technological capability to take advantage of joining EPC and hence increase its domestic patent applications, the other countries did not have the technological capability and hence could not take advantage of joining the EPC[14]. Technological capability will have an impact on patent output rather than ease of patent application procedure. Ease of patent applications procedure will have a modest impact on patent output.

On the other hand, all the countries except Spain show a structural break in foreign patent applications after joining EPC. The ease of applications procedure which membership of EPC affords foreign patent applicants had an immediate impact on the number of foreign patent applications. Spain on the other hand saw a peak in foreign patent applications in 1989 before it joined the EPC. It joined the EPC in 1990 actually saw a fall in foreign patent applications (received both at the national patent office and the EPO) till 1996.

What lessons can be drawn from the experiences of these countries, which joined after 1985 for countries joining PCT? The ease of applying for foreign patents through PCT will only give a marginal benefit for the countries joining PCT. A PCT application is not a worldwide patent application, after an initial period the applicant has to approach the national patent offices for grant of a patent. Only those countries, which have a technological capability and produce patents, which are important worldwide, will derive any benefit from joining PCT and applying through it. This technological capability comes from elsewhere than by joining PCT alone.

[14] Fagerberg [1988] identifies Denmark in a cluster of countries with 'high levels of productivity and relatively low levels of measured technological activity'. He identifies Ireland and Spain in a cluster of countries with ' Low levels of productivity and patenting but their R&D efforts vary considerably (Semi-Industrialised countries)'.

Convergence of Number of Foreign Patent Applications: Here we will analyse the behavior of foreign patent applicant at the EPO. We have the foreign patenting data coming through the EPO since 1985. Figure 2 depicts the number of foreign patent applications received by the EPO with particular country designations. The trends in these foreign patent applications figure are interesting. There was a steady increase in foreign patent applications from 1985 to 1990 when it reached a peak. After 1990, there was a decline till 1996 with the exception of 1992. The trends in almost all the countries are the same but the levels are different. During this period the foreign applicants still seems to have chosen the countries in which their EPC patent will be valid, taking economic reasons into account. The convergence of patent counts started in 1997 and reached a culmination in 1998 where the foreign patent application figures for all the countries was around 46000. The only exception was Germany where the foreign patent applicants seemed to approach the national patent office instead of going to the EPC, with Germany as a designated country. The interesting thing about this convergence is that countries such as Finland and Portugal, which joined the EPC later, were also a part of this. The impact of this convergence in the number of foreign patent applications will be apparent only after some time.

We can already see similar impact on PCT countries as has happened in the case of EPC countries. The number of designations is increasing in all the PCT member countries. But unlike EPC the number of foreign patent applications, reaching the national patent offices did not show much change.

ASEAN Countries

The countries of Association of South East Asian Nations (ASEAN) have achieved a remarkable performance in economic growth till the crisis in 1997. In this sub-section, we will briefly analyse their patenting performance. ASEAN has ten members, which are Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. Of these, Brunei Darussalam, Cambodia, Laos and Myanmar never reported to *Industrial Property Statistics* for the period 1975-98. Vietnam had an 'inventors' certificate' system till 1997. As discussed earlier Singapore had a re-registration system till 1995. The case of Indonesia is interesting. Indonesia joined the Paris Convention in 1950. It did not have a patent system till 1989. Between 1970 and 1998 on

the average, it received 44 domestic patent applications and 1332 foreign patent applications. It did not report a single patent grant till 1994. How could Indonesia be a member of the Paris convention with out any patent law in force? According to WIPO [1984], Indonesia announced provisional measures in anticipation of the introduction of a patent law. These provisional measures stated that patents might be provisionally filed. But any grant had to wait the enactment of a patent law, which came about only in 1989.

That leaves us with Malaysia, Philippines and Thailand. Malaysia had a re-registration system between 1951 and 1983. For Malaysia, patent data is available only from 1985. For Thailand, it is available only from 1979 when it enacted its first patent law. The average number of domestic applications was 121 for Malaysia (1985-98), 125 for Philippines (1975-98) and 161 for Thailand (1979-98). The average number of foreign patent applications was 2678 for Malaysia, 1907 for Philippines and 1812 for Thailand.

For countries, which have such a high growth path and foreign direct investment these figures seem to be rather, low. On the average number of domestic patent applications for the period 1975-98 Thailand, Malaysia and Philippines occupy 32nd, 35th and 36th position respectively. Comparatively India was in the 19th position. On the average number of foreign patent applications during the same period Thailand, Malaysia and Philippines occupy 29th, 31st and 32nd position respectively. Comparatively, India was in the 27th position.

Although we cannot come to any strong conclusions on such aggregate figures, we speculate that the foreign direct investment and technology transfer to these countries was not patent based. Patents, either domestic or foreign did not play any significant role in their growth performance.

China and South Korea

China and South Korea stand out as outstanding examples of good performance in domestic patenting. They deserve a special mention. We will make some comments on their patenting performance in this section.

South Korea had its first patent law in 1961. It joined the Paris convention in 1980 and the PCT in 1984. South Korea's domestic patenting performance especially in the 1990s has been nothing but spectacular. South Korea's domestic patent applications, which

were 1326 in 1975 rose to 50596 in 1998. The compound annual growth was 22.6 percent. The average number of domestic patent applications for this period was 15850.

There are four distinct phases in the emergence of South Korea as a major patenting country. In the first phase between 1975 and 1984, the average number of domestic patent applications was 1367. In the second phase between 1985-90, this number increased to 5500. In the third phase (1990 to 1995), this number again rose to 19800. Finally, it culminated by reaching the figure of 63626 between 1995-98. In the process, it surpassed France in 1992, the United Kingdom in 1993 and Germany in 1995 in the number of domestic patent applications. While it occupied 18th position in the number of domestic patent applications in the year 1975, it rose to 4th in 1998. The average proportion of domestic patent applications to total applications for the period 1975-98 was a very credible 43.7. The grant percentage of domestic patents was very high at 70.6 percent. La Croix and Kawaura [1996] while discussing the amendments carried out in 1981 to the Korean Patent Act, 1961 say "multiple claims for related inventions could be contained in a single application" (pp.112). This means that South Korea like Japan insisted on one patent for each claim before 1981. Did the amendment in 1981 apply to foreign inventors only or domestic inventors too? Does the rise in the domestic patent applications in South Korea the result of splitting of patents?

Major amendments were carried out to the Korea patent law of 1961, in 1986 under pressure from the United States.[15] Is there any linkage between this change in the patent law and the performance of the domestic patent applications? Mansfield [1989] says, "When countries like Korea, Brazil and Taiwan become increasingly industrialized, and as their industries become more innovative, their attitudes toward patents are likely to change" (pp.408). While it is important that as a country gets more industrialized (or acquires more technological capability) it would prefer having a stronger patent system, the important question is how did it acquire its initial technological capability under a 'weak' patent regime. As La Croix and Kawaura [1996] say the changes made to the patent act in 1986 were the result of the pressure from the US unlike the change in Japan, which came from within. Did South Korea take advantage of the advent of a 'strong' patent system and improve its domestic patenting performance? Does this offer a lesson to other developing

[15] For a history of the changes in the patent law in South Korea see La Croix and Kawaura [1996].

countries? Are other developing countries in a situation to take advantage of 'strong' TRIPs-consistent patent systems, which will be in place shortly?

The other developing country, which had performed credibly on the domestic patenting scene, is China. China introduced a patent system in 1984 with technical help from Germany. It joined the Paris convention in 1985 and the PCT in 1994. The domestic patent applications from China, which were 4065 in 1985 rose to 13726 in 1998. They showed a compound annual growth rate of 12.0 percent. Domestic patent applications accounted for 53.3 percent of total applications. But the grant percentage of domestic patents is very low at 24.2 percent.

Development and Patenting Activity

In this section, we will analyze the relationship between selected macro-economic variables and patents. This is the first such large scale study to explain the patenting behavior of countries through macro-economic variables.

One of the most contentious issues in the discussions on the international patent system in various fora has been whether countries at different stages of development benefit from the patent system in the same way (Pretnar [1953]). The developing countries argued that their stage of technological development, which is a manifestation of their overall development, requires a 'lesser' level of patent protection than that afforded in the now developed countries. They also pointed out to the fact that developed countries in their stages of technological development experimented with the patent system in various ways and it was only after they achieved technological development that they tend to have a 'strong' patent system. This argument, which by its very nature is a post-colonial phenomenon, culminated in many developing countries to 'reform' their patent systems in the late 1960s and early 1970s. These developments at the national level were sought to be given an international recognition when developing countries asked for the revision of the Paris convention. This revision process resulted in a failure (Rao [1989a]). On the other hand the developed countries, which were successful in introducing the so-called ‘Trade Related Aspects of Intellectual Property Rights’, in General Agreement on Tariffs and Trade, succeeded in including an Agreement on TRIPs as part of the World Trade Organization (WTO). During these GATT negotiations on TRIPs developed countries argued that 'lesser' level of patent protection in developing countries is not only distorting trade but also acting as a disincentive for investment in R&D in developing countries (Rao [1989b]). While the developing country argument is based on the premise that technological diffusion is comparatively more important than generation of technology, the developed countries argue that generation of technology is more important than diffusion. This differences in perceptions arises because, developing countries are consumers of technology, while developed countries are generators of technology.

It is admittedly difficult to empirically verify the hypothesis about stages of development and what kind of a patent system should countries have, our attempt here is to see how a country's patenting is influenced by major macro variables. The major problem with this will be the fact that the low domestic patenting performance of developing countries may arise from two sources. One the low technological capability and the other the 'weak' patent system that most of these countries have. There is no way to differentiate between these two effects. We assume that technological capability dominates the strength of the patent system in determining the number of patent applications.

The Model

We will analyze the determinants of domestic and foreign patenting separately. Hence, we will give our analytical framework for these separately below.

Domestic Patenting: The macro economic variables, which we use for explaining the intensity of domestic patenting activity are: GDP per capita and foreign trade intensity.

The rationale and the hypothesis regarding the two macro economic variables chosen for explaining domestic patenting activity is given below:

GDP Per Capita: We use GDP per capita as a proxy to measure the level of development. We hypothesize that there is a positive relationship between the level of development and domestic patenting intensity. The higher the level of development the higher will be the patent output per 1000 population. With a higher level of development, a country's capacity to invest in Research and Development (R&D) goes up and will have a positive impact on patent output.

Foreign trade intensity: Foreign trade intensity is exports plus imports as a percentage of GDP. We have taken foreign trade intensity as a proxy to measure the openness of the economy. We hypothesize that the higher foreign trade intensity the higher the domestic patent output. The trade intensity will indicate the integration of an economy into the world economy, and the higher intensity means that the economy is fully integrated and hence will have a better allocation of resources from a global point of view.

We estimate the following equation

$$DP_{it} = \alpha + \beta_1 GDPPC_{it} + \beta_2 EXIM_{it} + u$$

Where DP is domestic patenting, GDPPC is Gross Domestic Product per capita and EXIM is exports and imports as percentage of GDP. The i and t subscripts refer to individual countries and time periods respectively.

Foreign Patenting: The decision to patent in a foreign country is an important one for a patentee. As it is expensive to take patents in a foreign country, s/he has to carefully select those countries in which s/he has to take patents. For a patentee from a developed country (these are the countries from which foreign patents originate) the first consideration will be to patent in those countries, which have the technological capability to imitate his/her invention. Hence, the first reaction is defensive. Most countries in this list will be developed countries. Some developing countries, which have the technological capability, can also figure in the list. Depending on the importance of the invention a patentee may take patent in a number of countries. In this scenario, least developed countries will not figure what ever may be the importance of the invention for a particular country.

The macro economic variables through which we will explain foreign patenting intensity are: GDP per-capita, foreign trade intensity and Net Foreign Direct Investment intensity.

The rationale and the hypothesis regarding these three macro economic variables chosen for explaining foreign patenting activity is given below:

GDP Per Capita: We use GDP per capita as a proxy to measure the level of development. We hypothesize that there is a positive relationship between the level of development and foreign patenting intensity. The higher the level of development the higher will be the foreign patent intensity. Foreign patentees while deciding about the countries in which to take patents choose those countries, which are more developed than which are less developed. A more developed country will mean a better market for the patented product or the product made by the patented process.

Foreign Trade Intensity: We have taken the combined export and import intensity as a proxy to measure the openness of the economy. We hypothesize that the higher the foreign trade intensity the higher the foreign patent activity. The trade intensity will

indicate the integration of an economy into the world economy, and the higher intensity means that the economy is fully integrated making it an important destination for foreign patents.

FDI intensity: We hypothesise a positive relationship between FDI and foreign patenting. First, the FDI which is determined by a number of factors (including maybe the strength of the patent protection) moves to a country. A country in which a firm has invested may figure in the list of countries in which it intends to take patents. Here it is the FDI, which determines foreign patenting activity.

We estimate the following equation

$$\mathbf{FP_{it}} = \alpha + \beta_1 \mathbf{GDPPC_{it}} + \beta_2 \mathbf{EXIMit} + \beta_3 \mathbf{FDI_{it}} + \boldsymbol{u}$$

Where FP is foreign patent applications per 1000 population, GDPPC is Gross Domestic Product per capita, EXIM is exports and imports as a percentage of GDP and FDI is the net FDI as a percentage of GDP. The i and t subscripts refer to individual countries and time periods respectively.

We expect developed and developing countries to behave differently in their domestic as well as foreign patenting. Hence, we will estimate the equations separately for these two groups of countries. There are 20 developed countries and 35 developing countries in our sample.

The source of the data for the macro economic variables mentioned above is the World Bank's annual publication *World Development Indicators*. The GDP percapita is in 1995 constant $. While Iraq is present in the patent based sample, the WDI does not report data for the past several years, hence we dropped Iraq from our analysis. The other problem was with Germany. Its unification in 1991 creates a break in its time series data on macro economic variables. We have taken the patent figures only for West Germany, East Germany was excluded because it had a system of inventors certificates. While the macro economic data pertains to West Germany from 1975 to 1991, the data pertains to unified Germany for the later years.

We have 55 countries in our sample and 1292 observations. Our sample is unbalanced panel data, the time period covered is 24 years, except for China, Malaysia, Thailand and Zimbabwe. While China and Malaysia have 14-year data, Thailand and

Zimbabwe have 20-year data. As the sample database is a panel, we use fixed effects model. This will take into account the individual specific fixed effects.

The Results

Domestic Patents: The following table gives the fixed effects estimate of the domestic patent equation.

Table 4: Fixed Effects Estimate of Domestic Patent Equation

(Dependent Variable: DP_{it}/$Population_{it}$)

Variable	Full Sample	Developed Countries	Developing Countries
GDPpc	0.00001486 (14.692)	0.00001011 (14.231)	0.00007559 (12.871)
EXIM/GDP	-0.00043123 (-2.145)	-0.00076608 (-2.563)	-0.00109741 (-4.921)
Adj. R^2	0.85	0.92	0.57
No. of Observations	1292	480	812

Figures in the parenthesis are t-values.

The above results show that for the full sample 85 percent of variation in domestic patent applications is explained by variation in GDP percapita and foreign trade intensity variables. While both the explanatory variables are significant, GDP percapita is positive and foreign trade intensity is negative. GDP percapita as a measure of development has a significant and positive impact on domestic patent applications. It means that when GDP percapita goes up domestic patent applications also go up. The negative sign of foreign trade intensity is interesting. It means that while foreign trade intensity goes up the domestic patent applications come down. Open economies tend to produce less number of domestic patent applications than closed economies as measured by intensity of foreign trade.

While the overall results are the same as the full sample, for the equations estimated separately for developed and developing countries, there are some interesting differences. While for the developed countries, domestic patent applications equation the variation in the dependent variable explained by independent variables is 92 percent for

the developing country equation it is only 57 percent. The GDP percapita is positive and foreign trade intensity is negative for both sets of countries. It is interesting to note that the coefficient of GDP percapita for developed countries is smaller than that of coefficient of GDP percapita of developing countries. This could be interpreted to mean that while an increase in GDP percapita would result in an increase in domestic patent applications it does not do so proportionately.

Countries with low per capita income can be expected to have low output of domestic patent applications. Countries with higher GDP percapita are in a position to allocate more resources to Research and Development efforts and this results in more output of domestic patent applications.

The negative relationship between domestic patent applications and openness index as measured by foreign trade intensity is a more interesting result. It implies that countries, which are more open, tend to produce less domestic patent applications. One reason for this could be that countries especially developing countries, which were found to be relatively more open, tend to depend on foreign technology and hence do not allocate sufficient resources for R&D effort. A comparison of coefficients of developed and developing country equations shows that a one percent increase in foreign trade intensity will decrease domestic patent intensity more in developing countries than in developed countries.

Foreign Patents: The following table gives the fixed effects estimate of the foreign patent equation.

Table 5: Fixed Effects Estimate of Foreign Patent Equation

(Dependent Variable: FP_{it}/$Population_{it}$)

Variable	Full Sample	Developed Countries	Developing Countries
GDPpc	0.00012054	0.00005546	0.00015177
	(13.914)	(4.199)	(12.552)
EXIM/GDP	0.09294102	0.41423747	-0.00429536
	(7.410)	(11.666)	(-0.765)
Net FDI/GDP	0.00352963	0.02033801	-0.00059613
	(2.020)	(3.840)	(-0.765)

Adj. R^2	0.57	0.57	0.42
No. of Observations	1292	480	812

Figures in the parenthesis are t-values.

The above results show that for the full sample 57 percent of variation in foreign patent applications is explained by variation in GDP percapita, foreign trade intensity and FDI intensity variables. All the three independent variables are positive and significant. Countries with higher GDP percapita will attract more foreign patents than those countries, which have lower GDP percapita. Foreign patentees choose those countries, which are more developed as the destination for their patents. This could be explained by the fact that those countries with higher GDP percapita are a more attractive market than those, which have lesser GDP percapita. The foreign trade intensity variable is also positive and significant, implying that those countries, which have a higher intensity of foreign trade, attract more foreign patents. Hence, countries, which have a more open economy, are destinations of foreign patenting. The FDI intensity variable is also positive and significant. This means that countries, which are destinations of FDI, are also destinations of foreign patents. Countries in which firms have already invested might be high on the list of countries in which patents could be taken.

The equations estimating foreign patent applications in developed and developing countries have interesting differences. While for developed countries the three independent variables explain 57 percent of variation in foreign patent applications, for developing countries they explain only 42 percent of the variation in foreign patent applications. For developed countries, all the three independent variables are positive and significant, while for developing countries only the GDP percapita variable is positive and significant. For developing countries, the foreign trade intensity and the FDI intensity variables are not significant. This is an interesting result. For developing countries, foreign trade and FDI do not explain foreign patenting activity. It means that openness of the economy as measured by their foreign trade intensity is not related to foreign patenting. Foreign patentees do not show any marked preference to those developing countries, which are more open. In the same manner, FDI and foreign patenting are not related as far as developing countries are concerned. Developing countries, which are the destination of foreign investment, do not seem to be destinations

for foreign patenting. One reason for this could be that the foreign direct investment is not patent related. The fact that these three independent variables are positive and significant for developed countries mean that foreign patentees react differently to developed and developing countries in their patenting decisions.

Summary and Conclusions

This study had two main objectives. The first was to carry out a cross-country comparison of patenting activity, spanning the period 1975-98. The second was to relate the observed patterns in patenting to the economic characteristics of the selected countries.

The choice of the initial year was guided by the fact that patent laws in many countries were changing during the 1970s and it was therefore our intention to capture the changes that the patent laws had caused to the patenting activity in various countries.

The source of our data on patents is the *Industrial Property Statistics*. We collected resident and non-resident patent applications and grants for the period 1975-98. A total of 151 countries and OAPI have reported at least once during this period. After a preliminary analysis of the data, we have decided to remove various country grouping from our sample. These are small economies, least developed countries, former socialist countries, re-registration countries, countries that did not report for more than 12 years, countries that reported zero domestic patents for more than 11 years, countries that did not report grant for more than 11 years. The sample consists of 56 countries out of which 36 countries are developing countries.

We did a review of literature of all the studies, which try to explain either domestic or foreign patenting at country level through macro economic variables. In the literature, domestic patenting has been explained only through R&D expenditure while in our study we try to explain domestic patenting through macro economic variables. In the literature, foreign patenting has been explained through macro economic variables. But these studies only explain the foreign patenting activity in or by developed countries. In our study, we try to explain foreign patenting in a country through macro variables. Our study is also broad based and covers a period of 24 years.

We also discuss the pros and cons of using patent data as an economic indicator. We discuss this in three broad heads of patents as indicators of technological change, problems in using patent data across countries and using applications data instead of grant data.

In our section on Statistical Profile of the International Patent System, we tried to provide some very basic quantitative information on the international patent system,

which has been done for the first time. This section includes trends in the aggregate domestic and foreign patenting in the countries included in our sample, ownership pattern according to developed and developing countries, proportion of domestic patents to total patents, grant ratio and growth of patent applications in individual countries. We also discuss the structural break in domestic patenting in newer countries of EPC and domestic and foreign patenting in ASEAN. We also discuss domestic patenting in China and South Korea, which have experienced remarkable performance.

Aggregate domestic patenting in the countries in our sample is heavily concentrated in developed countries. The share of developed countries in total domestic applications during 1975-98 was 88 percent, that of developing countries 12 percent. There are considerable differences in the share of different countries within these groups. Japan and the US accounted for 48 percent of the total patent applications for the period 1975-98. The share of developing countries in total applications rose from 6 in 1975 to 18 percent in 1998. Of the domestic patent applications in all the 56 countries in our sample, the top five countries accounted for 77 percent, while the top ten countries accounted for 90 percent in 1998. The bottom twenty countries accounted for just 0.16 percent of the total domestic patent applications.

Likewise, most of the foreign patenting is done in developed countries. Developed countries accounted for nearly 86 percent of foreign patents during 1975-98. Developing countries accounted for the remaining 14 percent.

The average proportion of domestic patent applications in the total applications was about 29 percent for developed countries and just less than 21 percent in developing countries.

We also found that South American countries, which had macro economic problems in the 1980s, have shown a remarkable decline in domestic and foreign patenting.

Chow test to see whether there was a structural break in domestic patenting in the newer members of EPC has shown that this happened in the case of only Denmark and not in Ireland, Portugal and Spain. A look at ASEAN countries has shown that their domestic and foreign patenting does not reflect their growth performance.

In the section on development and patents, we tried to find the relationship between domestic patenting activity and the macro-economic variables of the sample countries. Lack of comparable data for a number of key variables like R&D expenditure and the degree of industrialization achieved by the countries, posed severe limitation on this part of the analysis. From the available data, two sets of variables were included. These were GDP per capita and Exports plus imports as percentage of GDP (as a measure of openness). We also try to find the determinants of foreign patenting liking it up with GDP percapita and Exports plus imports as percentage of GDP (as a measure of openness) and foreign direct investment as percentage of GDP. We find that while domestic patenting and GDP percapita are positively related, openness and domestic patenting are negatively related. On the other hand, while GDP percapita is positively related to patenting both openness and FDI while positive and significant for developed countries is not significant in the case of developing countries.

As was stated at the outset, the present study represents the first step towards a better understanding of patenting behaviour of countries spread across the development spectrum. This analysis can be refined by supplementing the data that we have used, particularly for the econometric analysis that looks at the relationship between development and patenting activity.

Table 6: Domestic Patents: Descriptive Statistics

Countries	Mean	Coefficient of variation	% of domestic patents	Grant percentage	Compound annual growth rate
Argentina	1070	0.299	24.91	49.3	-3.56
Australia	6665	0.209	43.39	14.2	2.86
Austria	2347	0.054	21.50	52.5	-0.40
Belgium	1040	0.178	9.50	74.2	1.55
Bolivia	18	0.363	16.84	38.0	0.75
Brazil	2208	0.135	32.64	23.0	1.64
Canada	2392	0.247	10.72	51.0	2.82
Chile	157	0.291	16.89	29.9	0.58
China	8274	0.448	53.26	24.2	11.98
Colombia	76	0.356	11.34	53.4	2.48
Costa Rica	22	0.357	29.90	22.8	-0.12
Denmark	1114	0.199	13.28	55.2	2.49
Ecuador	20	0.417	13.36	25.1	-5.59
Egypt	208	0.739	22.43	11.5	11.69
El Salvador	15	0.524	18.46	34.1	-2.88
Finland	1828	0.233	33.21	43.9	3.33
France	13368	0.144	31.78	74.3	1.83
Germany West	38680	0.213	54.33	42.3	2.83
Greece	919	0.552	23.69	66.5	-7.61
Guatemala	26	1.031	15.66	22.1	-11.91
Honduras	11	1.160	15.72	59.2	-2.83
India	1258	0.248	32.04	38.4	1.95
Iran	203	0.341	43.43	26.3	4.30
Iraq	113	0.815	56.21	27.4	10.30
Ireland	642	0.329	13.83	24.4	4.99
Israel	947	0.385	27.38	35.6	5.23
Italy	6420	0.402	23.46	44.1	2.52
Jamaica	7	0.382	8.78	29.4	-0.40
Japan	53485	0.064	66.72	27.5	4.85
Korea South	15850	1.469	43.69	70.6	22.59
Malaysia	121	0.568	4.46	26.2	21.90
Mauritius	2	0.914	13.94	35.7	1.09
Mexico	595	0.283	11.97	28.7	-0.20
Morocco	51	0.569	15.25	98.4	7.95
Netherlands	2869	0.315	17.96	39.6	4.25
New Zealand	1088	0.166	30.46	21.6	0.40
Norway	922	0.181	22.15	33.1	2.19
Pakistan	25	0.213	4.60	51.7	-1.75
Panama	13	0.464	13.68	59.1	3.81
Peru	53	0.483	14.71	37.3	-4.52
Philippines	125	0.210	6.62	32.4	0.70
Portugal	88	0.170	3.36	47.5	0.29
South Africa	4442	0.294	45.81	44.3	4.41
Spain	1989	0.146	12.43	66.3	1.52
Sri Lanka	35	0.551	28.60	92.0	4.66
Sweden	3990	0.084	26.43	45.5	-0.32
Switzerland	4475	0.130	28.04	49.8	-0.47
Thailand	161	1.201	9.04	20.2	19.57
Trinidad & Tobago	13	0.440	12.76	98.6	4.70
Tunisia	27	0.404	15.83	98.4	4.48
Turkey	156	0.363	19.11	33.9	3.66
United Kingdom	20690	0.051	37.42	23.3	-0.03
USA	80799	0.285	57.54	64.2	3.46
Uruguay	47	0.599	21.39	30.5	-5.37
Venezuela	262	0.510	13.89	46.5	-2.19
Zimbabwe	46	0.197	17.89	43.1	0.94

Table 7: Foreign Patents: Descriptive Statistics

Country	Mean	Coefficient of variation	Grant percentage	Compound annual growth rate
Argentina	3301	0.234	50.8	1.77
Australia	8789	0.211	94.0	-2.52
Austria	13918	0.752	88.2	8.60
Belgium	16098	0.654	80.5	7.16
Bolivia	91	0.384	55.3	-3.61
Brazil	4885	0.310	64.4	-3.56
Canada	21991	0.259	62.7	-2.82
Chile	836	0.433	56.9	4.48
China	7502	0.666	46.5	11.23
Colombia	663	0.513	73.1	4.28
Costa Rica	59	0.504	12.4	-6.65
Denmark	10183	0.988	52.8	7.70
Ecuador	166	0.499	59.7	1.29
Egypt	668	0.228	43.5	-0.28
El Salvador	70	0.401	54.1	-2.41
Finland	6226	1.640	49.1	5.52
France	32361	0.395	87.6	4.36
Germany West	33792	0.323	72.4	3.42
Greece	8789	1.218	68.0	15.22
Guatemala	115	0.340	65.5	-2.32
Honduras	58	0.835	57.6	0.95
India	3002	0.624	56.7	5.61
Iran	539	1.373	35.7	-11.24
Iraq	80	0.711	47.4	-12.25
Ireland	6767	1.527	56.9	9.86
Israel	2450	0.190	64.3	1.13
Italy	25603	0.489	86.0	5.72
Jamaica	71	0.221	24.5	-1.77
Japan	24740	0.083	42.9	-0.62
Korea South	9119	0.633	61.6	10.91
Malaysia	2678	0.587	74.3	17.23
Mauritius	12	0.467	60.8	-2.79
Mexico	4687	0.345	56.0	0.48
Morocco	288	0.185	93.8	-1.26
Netherlands	18313	0.613	85.8	7.46
New Zealand	2708	0.343	86.6	0.31
Norway	3557	0.292	53.2	-2.17
Pakistan	536	0.182	87.5	2.21
Panama	84	0.254	63.6	-0.82
Peru	331	0.404	78.2	0.55
Philippines	1907	0.339	52.7	4.46
Portugal	6686	1.612	69.4	13.75
South Africa	5068	0.094	81.1	-0.34
Spain	17289	0.592	72.0	6.87
Sri Lanka	86	0.299	98.2	-1.70
Sweden	16554	0.661	89.5	7.54
Switzerland	15925	0.641	91.7	6.93
Thailand	1812	0.904	25.3	24.09
Trinidad & Tobago	96	0.260	91.7	-2.35
Tunisia	159	0.299	97.3	-3.99
Turkey	714	0.427	70.0	3.64
UK	38034	0.355	80.9	3.93
USA	60354	0.314	70.6	4.55
Uruguay	179	0.464	59.1	1.30
Venezuela	1626	0.208	92.2	-1.32
Zimbabwe	214	0.154	79.4	-1.27

Figure 1: Trends in World Patenting

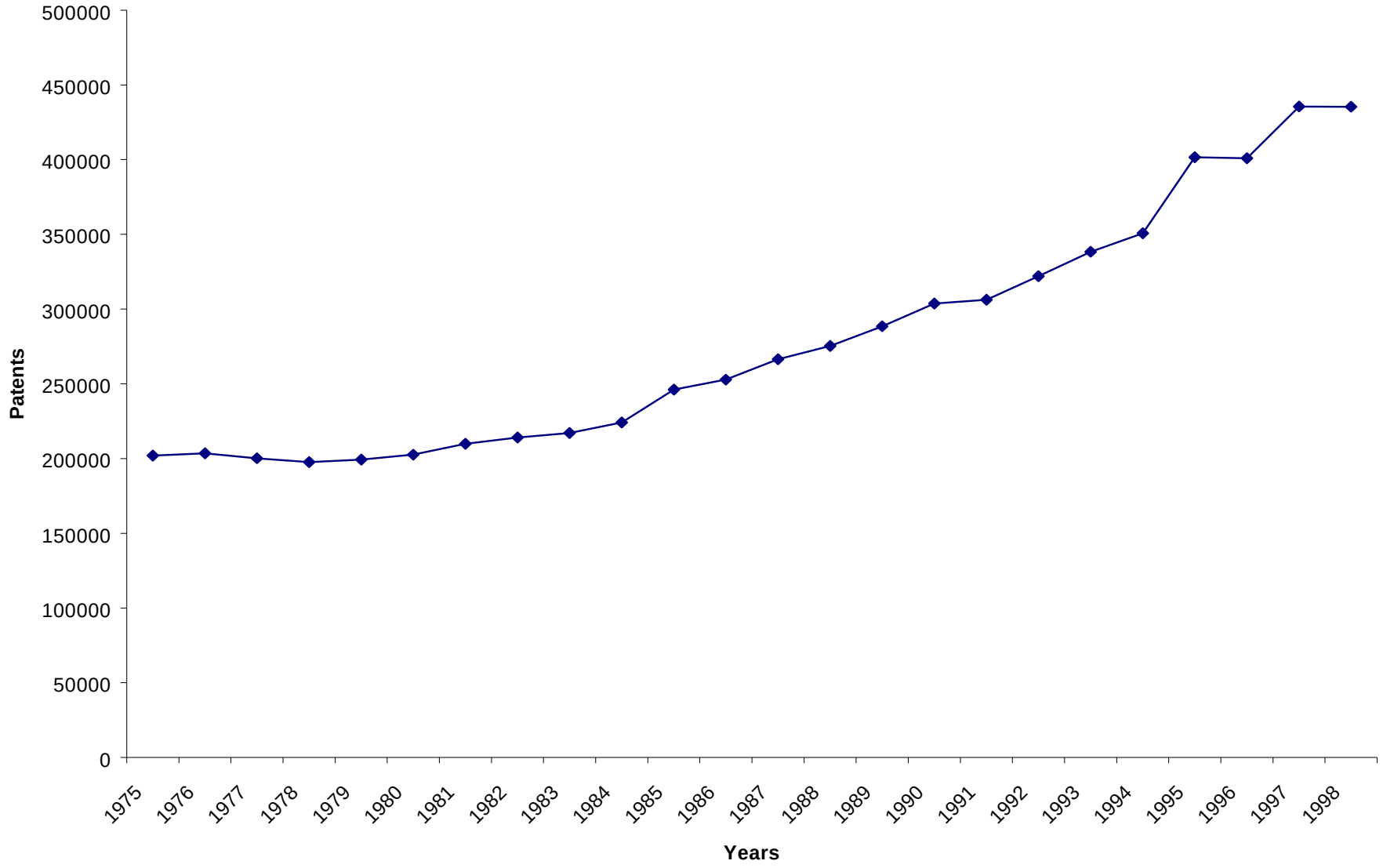
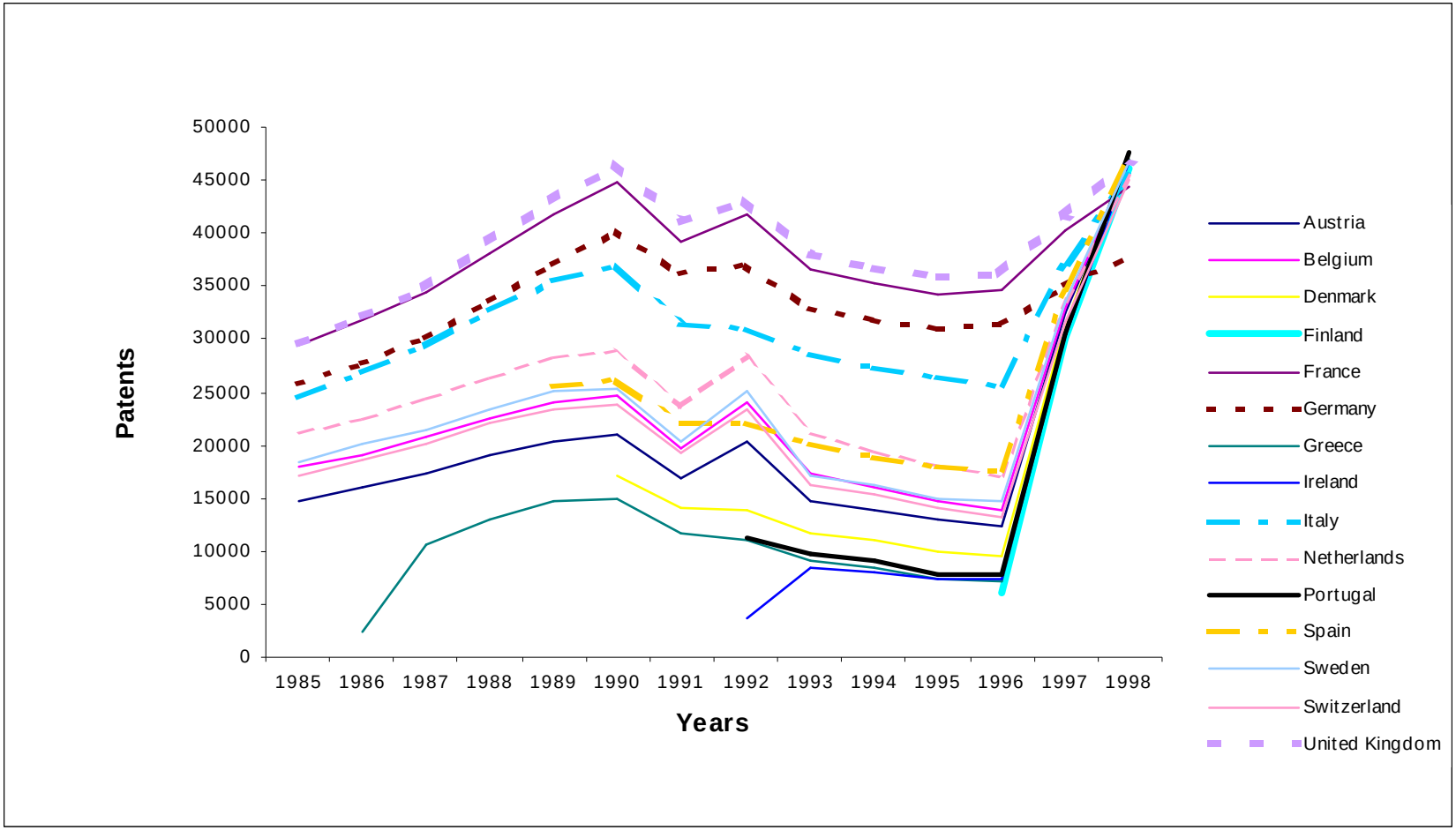


Figure 2: Foreign Patent Applications through EPO



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