The 'Home Advantage' Effect and Patent Families: a Comparison of OECD Triadic Patents, the USPTO and the EPO[1]

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Abstract
This paper examines the extent of the 'home advantage' effect in the USPTO and the EPO patent data and in the OECD triadic patent families. By comparing a set of internationalisation indicators for a sample of European, US and Japanese MNEs it finds that, contrary to what is often assumed, this effect is not only present in the USPTO but also in the EPO. OECD triadic patent data, instead, are not biased towards any particular home country. It also finds that, because MNEs do not systematically file their patents with the EPO, the USPTO and the JPO, the OECD triadic patent family dataset excludes many patents, especially those invented in the US and accounted for in the USPTO, though it is mainly only low-value patents that are excluded. Thus OECD triadic patents can be considered a satisfactory alternative to the USPTO and the EPO for measuring R&D internationalisation.

1. Introduction

Patent indicators are extensively used to measure inventive performance, knowledge diffusion, and the internationalisation of innovative activities, but they have a number of weaknesses. One particular limitation that has been widely acknowledged by researchers is the 'home advantage' effect (European Commission, 1997): domestic applicants, proportionate to their innovative activities, tend to file more patents with their home country patent office than foreign applicants do.

This paper addresses the impact of this issue on studies measuring the internationalisation of the innovative activities of US and non-US multinational enterprises (MNEs) and evaluates a number of proposed solutions. Hitherto studies have used patents granted by the US Patent and Trademark Office (USPTO) data although acknowledging (see for example Patel and Vega, 1999), that this data source might, first, underestimate the patenting activities of firms operating outside the US, because of different propensities to protect their inventions in different markets, and, second, overestimate the patenting activities of US-based companies, because of the 'home advantage' effect. More recently others have used patent applications filed with the European Patent Office (EPO) to measure R&D internationalisation under the assumption that they do not suffer from this shortcoming since the EPO is a regional patent office and therefore is not biased towards a particular home country (see for example Le Bas and Sierra, 2002). Another possible way of overcoming the 'home advantage' effect, not yet explored in the R&D internationalisation literature, is to use patent families, i.e. patents that have been filed in various countries to protect the same invention.

Thus this paper examines two distinct, but inter-related questions. First, it assesses the extent of the 'home advantage' effect in the EPO, the USPTO and the OECD triadic patent family dataset by comparing a set of indicators of R&D internationalisation constructed using data for a sample of 131 European, US, and Japanese MNEs in the Fortune 500 list over the period 1989-2000. Second, it investigates to what extent MNEs protect their inventions in all three patent offices (EPO, JPO and USPTO) and what the economic and technological value is of those patents captured by the OECD triadic patent family dataset. Thus it tries to assess to what extent the use of OECD triadic patent families is a satisfactory alternative to the EPO and the USPTO for analysing the internationalisation strategies of MNEs.

In answering these two questions this study adopts a sectoral rather than a firm approach as done in other studies (see for example Bertin and Wyatt, 1988, Grupp and Schmoch, 1999, Schmoch and Schnöring, 1994). The firm approach is able to capture in more detail the patenting behaviour of

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MNEs and how it relates to their international marketing and technological strategies. If the sectoral approach cannot address directly these issues, it does nonetheless allow one to identify the major trends in the patenting strategies of MNEs and assess how they affect the analysis of the R&D internationalisation process based on patent indicators.

The paper is organized as follows. Section 2 discusses in more detail the 'home advantage' effect and proposed solutions. Section 3 describes the data used in this study. Section 4 reports and discusses the results of the comparative analysis of EPO, USPTO, and OECD triadic indicators of R&D internationalisation. Section 5 analyses the proportion of OECD triadic patent families in the sample of EPO and USPTO patents and the characteristics of these OECD triadic patents. The last section summarises and concludes this paper.

2. The home advantage effect

There are many reasons why firms decide to apply for patent protection (Cohen *et al.*, 2000, Levin *et al.*, 1987). The main one is to protect an existing or potential market for their invention. As a result, firms will show different propensities to apply for patent protection in each country depending on their expectations about the extent it can be commercially exploited in that particular market. In general, firms will tend to protect their inventions in the home country of the inventor leading to the so-called 'home advantage' effect (European Commission, 1997): national patent offices receive a disproportionately large number of domestic patent applications (i.e. patent applications from residents) and this can give a misleading indication of domestic inventive activity. A problem then arises if these patent data are used in international comparisons of inventive activities, be it at the country or at the firm level.

A common method that has been used to correct for this potential bias is to base international comparisons on patenting activity in a third country. Patents registered in a common foreign country also have the advantage of having undergone an equal screening process and therefore one can compare patents with similar value. Moreover, since an external patent application is more expensive, the use of patents filed abroad operates as a filter against low value inventions. In following this approach most studies have used patents registered with the USPTO because of the availability of these data and their long time series. However some criticisms have been made of this method (see Pavitt 1985, for a review). The main one is that firms, and therefore countries, will show different propensities to apply for patent protection in the US.

When USPTO patents are used for measuring the internationalisation of inventive activities (Cantwell and Hodson, 1991, Patel and Pavitt, 1991) one should also take into account two other potential problems. First the USPTO may not capture the inventive activity of non-US firms taking place outside the US. A counter-argument (advanced, for example, by Cantwell and Hodson, 1991) is that non-US firms have an interest in protecting their most significant innovations in the USPTO because the US is the largest market for technologically advanced products. Second, USPTO data may present a distorted picture of the degree of R&D internationalisation of US and non-US firms, as a result of the 'home advantage' effect. As Patel and Vega (1999) point out in their study: "using US patent data for US companies and for US subsidiaries of non-US companies means that there will be an over-estimation of the role of domestic R&D for the former and foreign R&D for the latter" (p.148).

One way to overcome these shortcomings is to regroup the total amount of a country or firm's patents into patent families (Faust and Schedl, 1982). A patent family consists of all the patent documents that have been filed in various patent offices in order to protect the same invention in different countries. Once the patents related to the same invention have been consolidated, one can use the priority patent (i.e. the first patent application filed for an invention) of each family as the unit of analysis. International comparison of inventive activities based on patent families has several advantages with respect to that based on patents filed in a single national patent office (Grupp *et al.*, 1996). First it reduces the 'home advantage' effect. Second it includes only patents protecting the most economically important inventions, i.e. those inventions that have expected returns high enough to outweigh the cost of filing a patent in more than one foreign patent office. Third, it eliminates the impact of country-specific rules and regulations in the patent awarding process. Fourth, it limits the patenting bias introduced by strong bilateral trade relationships between countries.

However data on patent families are not easily available;[2] thus some authors have proposed using patents registered with the EPO instead of USPTO data in measuring R&D internationalisation (see for example Le Bas and Sierra, 2002) and in country inventive performance (see for example OST, 2002). In contrast to national patent offices the EPO is not biased towards a particular country and, according to Archibugi (1992), it can be considered a truly international patent system due to the fact that a single application can be potentially extended to all 27 countries that have signed the European patent convention. Thus patent statistics based on EPO data should not be affected by the 'home advantage' effect as much as those built on information from the USPTO or any other national patent office. Indeed EPO patents may be considered as patent families (Dernis and Khan, 2004) since most EPO applications have been filed first in a national patent office and thus they correspond to patent families with at least two patent members. In practice EPO applications are only cost effective if at least four countries are designated for protections (Straus, 1997), thus patent families originating from successful applications tend to have more than two family members.[3]

Although there is some evidence on the degree of 'home advantage' bias in studies using USPTO data to compare countries' inventive performance (see for example Archibugi and Pianta, 1992), little is known to what extent the use of USPTO distorts the analysis of internationalisation of inventive activities and to what extent the use of EPO data reduces the 'home advantage' bias. It is particularly important to address these issues because in measuring R&D internationalisation patent data are often the only detailed and consistent source of information on the degree of innovative activities carried out in different locations. In theory one could replace patent indicators with other science and technology indicators, such as R&D expenditures, but while this is feasible in studies comparing countries' innovative strength[4], it is almost impossible to apply it to the analysis of R&D internationalisation, because financial accounts report only consolidated R&D expenditures with no distinction between different locations of activity.

3. Data

This paper uses three datasets containing patents filed by 131 high-tech European, US and Japanese MNEs listed in the Fortune 500 (for names of the companies see Table A-1 in the appendix): the SPRU Large Firm Database (see Criscuolo and Patel, 2003, for a detailed description) based on USPTO patent data, a similar database developed by Verspagen and Schoenmakers (see Verspagen and Schoenmakers, 2004) on the basis of EPO patent applications obtained from the European Patent Office (Bulletin CD), and the OECD triadic patent family dataset (see Dernis and Khan, 2004), which contains patents filed with the EPO, the USPTO and the Japanese Patent Office (JPO) sharing one or more priority patents. Although this database does not provide information on all the other family members and it excludes patent families with no members in all these three patent offices, the geographical filter used (i.e. which and how many patent offices) in constructing patent families seems suitable for analysing the degree of R&D internationalisation of the firms in the sample.

In both the EPO and the USPTO datasets patents have been consolidated at the level of the firm using the Dun & Bradstreet Linkages database "Who Owns Whom" (1999) which contains group ownership structures as they were in 1998. Thus for each company information is available about their patents granted by the EPO and the USPTO and their equivalent patents in the OECD triadic patent family dataset for the period 1989-2000. Both EPO and USPTO patents have been selected using their application year to these patent offices. Table 1 reports the distribution of these three samples of patents by firms' nationality and by their principal product group, defined as the technology area in which the firm's production is concentrated.

[2] There are three databases with a complete set of all patent family members: Derwent World Patent Index (WPAT), INPADOC, provided by the International Patent Documentation Centre, and the FAMI internal database at the EPO (see Michel and Bettles, 2001).

[3] In a related study it was found that the average family size of EPO patents applied by the MNEs in the sample is almost six members (Criscuolo, 2004).

[4] This solution has been proposed by Soete (1981) in his study of technological determinants of international competitiveness.

Table 1 Distribution of firms in the sample, their USPTO and EPO patents, and their equivalents in the OECD triadic dataset, 1989-2000 by nationality and sector

Sector	Number of firms	US MNEs	EU MNEs	JP MNEs	EPO patents granted	USPTO patents granted	OECD triadic families
Aerospace & Defence	9	7	2	0	3,738	14,996	2,258
Chemicals	13	2	9	2	18,473	36,762	11,427
Electrical & Electronics	14	3	6	5	24,583	62,890	14,820
IT Related	10	6	0	4	11,472	80,263	9,237
Machinery	8	3	3	2	3,257	8,022	1,398
Metals	11	1	4	6	2,754	6,402	1,605
Mining & Petroleum	15	7	6	2	5,720	16,464	3,235
Motor Vehicles & Parts	21	4	8	9	14,009	40,445	5,868
Pharmaceuticals	12	7	5	0	7,090	24,592	4,654
Photography	6	3	0	3	11,413	45,093	9,076
Telecommunications	12	4	7	1	7,145	28,933	4,240
Overall	**131**	**47**	**50**	**34**	**109,654**	**364,862**	**67,818**

4. Assessing the degree of 'home advantage' effect

Using these datasets it is possible to calculate some internationalisation indicators to show the extent of the 'home advantage' effect of the USPTO and the EPO patent systems and compare the results with those computed on the basis of OECD triadic families. In deriving these indicators a fractional count method is used to count EPO and OECD triadic patents.[5] In contrast, for USPTO patents the country of residence of the first inventor has been used to attribute the patent to a particular location. Different counting methods have been applied because, while in the USPTO the order of the inventors is a reflection of their contribution to the development of the patented invention, in the EPO and the OECD the order of the inventors does not follow this rule.

Table 2 Comparing the internationalisation of EU MNEs across patent datasets (% of total patents owned by these firms)

	Share of pats invented in:								
	home country†			US			other EU countries*		
	EPO	USPTO	OECD	EPO	USPTO	OECD	EPO	USPTO	OECD
Sector	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aerospace & Defence	90.9	92.9	94.1	0.3	0.2	0.4	7.6	5.4	2.6
Chemicals	74.9	63.4	74.3	9.7	23.9	10.8	13.6	10.4	13.0
Electrical/Electronics	74.2	52.6	74.0	6.9	23.1	7.8	17.9	20.6	17.0
Machinery	81.2	76.7	78.0	4.2	14.5	7.7	13.5	7.2	12.4
Metals	84.1	74.6	83.6	3.9	18.5	5.0	11.0	6.2	10.2
Mining & Petroleum	66.1	45.8	66.0	20.7	45.5	24.1	11.4	6.6	8.5
Motor Vehicles & Parts	89.5	89.7	90.3	1.9	5.5	2.3	8.0	4.0	6.9
Pharmaceuticals	47.9	38.4	49.0	20.2	38.7	20.1	29.6	20.3	28.8
Telecommunications	67.1	59.3	69.1	7.2	20.5	8.0	25.1	17.1	22.5
Overall	**74.8**	**59.9**	**73.1**	**8.4**	**24.1**	**10.4**	**15.5**	**13.4**	**15.0**

†For EU MNEs the home country is the country where the company has its headquarters.
*This share calculates the patenting activity of these firms within the EU but outside their home country.

Table 2 presents the shares of patents granted to European MNEs invented, respectively, in the home country of the multinational, in the US and in other European countries in the total number of EPO

[5] This takes account of patents with multiple applicants: if a patent has m applicants, of which m_b are from firm B or one of its subsidiaries, and n inventors, of which n_a are from country A, then the number of patents originating from country A and assigned to firm B is equal to $1/(n_a m_b)$.

patent granted to each group of firms alongside the corresponding shares computed using USPTO patents and OECD triadic patent families.[6] Thus column 1 in Table 2 shows that 90 per cent of EPO patents granted to European MNEs in aerospace & defence have been invented in the home country of the multinational, whereas according to USPTO patents and OECD triadic patent families this share is almost 93 and 94 per cent, respectively. Similar shares for US MNEs and Japanese MNEs are shown in Tables 3 and 4.

Table 3 Comparing the internationalisation of US MNEs across patent datasets (% of total patents owned by these firms)

	Share of pats invented in the:					
	home country			**EU**		
	EPO	**USPTO**	**OECD**	**EPO**	**USPTO**	**OECD**
Sector	(1)	(2)	(3)	(4)	(5)	(6)
Aerospace & Defence	85.9	95.3	88.2	12.0	3.2	9.7
Chemicals	84.2	90.8	88.7	11.8	5.7	7.5
Electrical/Electronics	75.9	91.8	82.1	15.5	5.3	8.9
IT Related	78.1	89.1	79.6	16.4	5.6	14.5
Machinery	67.4	91.3	84.9	30.3	7.5	14.0
Metals	65.4	96.1	82.5	30.4	2.8	15.9
Mining & Petroleum	86.5	93.4	89.0	10.5	3.6	8.1
Motor Vehicles & Parts	57.7	91.2	70.8	41.1	5.5	27.3
Pharmaceuticals	76.4	85.4	78.4	18.3	10.7	16.6
Photography & Photocopy	89.1	90.3	90.8	8.0	5.4	6.1
Telecommunications	92.1	96.1	94.7	6.0	1.6	3.7
Overall	**81.2**	**91.2**	**85.5**	**14.9**	**5.2**	**10.4**

Table 4 Comparing the internationalisation of JP MNEs across patent datasets (% of total patents owned by these firms)

	Share of pats invented in the:								
	home country			**US**			**EU**		
	EPO	**USPTO**	**OECD**	**EPO**	**USPTO**	**OECD**	**EPO**	**USPTO**	**OECD**
Sector	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Chemicals	98.1	98.4	98.5	0.4	1.3	1.2	1.5	0.0	0.2
Electrical/Electronics	96.2	94.4	97.5	1.8	4.3	1.0	1.8	1.2	1.4
IT Related	97.3	97.4	98.2	1.3	2.1	1.0	1.1	0.4	0.6
Machinery	99.2	99.1	99.5	0.2	0.9	0.5	0.6	0.0	n.a.
Metals	97.5	95.7	98.0	0.8	3.9	1.5	1.6	0.4	0.5
Mining & Petroleum	99.6	99.7	100.0	0.1	0.1	n.a.	0.3	0.3	n.a.
Motor Vehicles & Parts	99.0	99.0	99.7	0.7	0.8	0.0	0.2	0.1	0.2
Photography & Photocopy	97.3	97.2	97.5	1.3	1.8	1.2	1.2	0.6	1.1
Telecommunications	99.7	99.6	100.0	n.a.	0.4	n.a.	0.3	0.0	n.a.
Overall	**97.2**	**96.9**	**98.0**	**1.3**	**2.4**	**0.9**	**1.2**	**0.5**	**0.8**

n.a. indicate cases where the number of observations is too low

As discussed in the introduction, one would expect to find a 'home advantage' effect in the USPTO-based indicators, while share calculated on the basis of EPO and OECD triadic patents should not suffer, at least not to the same extent, from the same shortcoming. This implies that USPTO figures should show greater patenting activity by US MNEs in the US and by US affiliates of foreign companies with respect to the figures based on EPO and OECD data. However both the EPO and

[6] This implies that, for instance, the sum of the shares in columns (1), (4) and (7) does not equal 100 because patents invented outside these three locations are not taken into account.

USPTO should capture to the same extent the home country patent activity of Japanese MNEs since patents filed with these patent offices are foreign patent applications.

The figures reported in Tables 2 and 3 show that not only the USPTO but also the EPO appears to overestimate the home country patenting activity of its domestic firms. According to the EPO, the home country share of European MNEs patents across all sectors is 74.8 per cent on average but this drops to 59.9 per cent when calculated on the basis of USPTO data (see columns 1 and 2 in Table 2). For US MNEs the USPTO-based home country share is equal to 91.2 per cent while the same share amounts to 81.2 per cent on the basis of EPO patents (see columns 2 and 1 in Table 3). This effect is particularly significant for European MNEs in mining & petroleum and electrical & electronics where there is a difference of respectively 20.3 and 21.6 percentage points between the home country shares based on EPO data and the ones computed using USPTO data.

The 'home advantage' effect is even more pronounced when one examines the share of patents filed by US subsidiaries of European MNEs (see columns 4 and 5 in Table 2): across all sectors, with the exception of the aerospace & defence, the share of USPTO patents attributable to US affiliates is significantly larger than the EPO-based shares. Similarly the share of EPO patents granted to European affiliates of US MNEs is 14.9 per cent, while the share of USPTO patents granted to these firms is only 5.2 per cent (see column 4 and 5 in Table 3).

The presence of a 'home advantage' effect also emerges from the shares of patents owned by Japanese MNEs reported in Table 4. While both the USPTO and EPO data provide a similar picture of the home country patenting activities of these firms, the same cannot be said for the patenting performance of Japanese subsidiaries in the US and in Europe. In particular, the share of patents invented in Europe on the basis of USPTO patents is more than two times smaller than the one derived using EPO data.

Thus three main conclusions can be drawn from the analysis of the USPTO and EPO shares presented so far. First, both the EPO and the USPTO show evidence of a 'home advantage' effect. While this result confirms the a priori expectation for the USPTO, it does contradict the assumption about the international nature of the EPO patent system. As argued by Dernis and Khan (2004) the condition imposed on the members of an EPO family, i.e. patent applications within at least two patent offices (the EPO and the national patent office), is not stringent enough to eliminate completely the 'home advantage' effect.

Second, this effect is especially significant if one tries to measure the patenting activity of foreign affiliates. This implies that if one uses EPO patent data to analyse the internationalisation strategies of MNEs, one will underestimate the R&D activities of European and Japanese MNEs originating from US locations, while by using USPTO patents one will underestimate the inventive efforts carried out in European affiliates of US and Japanese MNEs. This finding can be explained in part by recent international mergers and acquisitions, the effect of which is not completely captured by these datasets.[7] However in most instances the discrepancy between EPO and USPTO figures reflects different international patenting strategies which, as reported by Schmoch and Schnöring (1994) and by Bertin and Wyatt (1988), are connected not only to their decisions concerning market penetration, export, licensing and technological alliances, but also to technological conditions.[8]

The technological element may play a relevant role in explaining the different findings for domestic and foreign firms. Foreign subsidiaries tend to focus on developing incremental innovations with the aim of adapting products to local markets conditions. This implies that what has been invented by these units cannot be exploited in other contexts and need not be protected in other jurisdictions.

Third, despite the presence of a 'home advantage' effect, the relative level of internationalisation across countries appears to be consistent in the EPO and the USPTO: European

[7] For example, BP acquired two large American companies before 1998: Standard Oil Company and Amoco. The patenting activities of these two firms account for 95.5 per cent of BP's USPTO patents invented in the US, introducing an upwards bias to BP's share in the US and a corresponding downward bias to its home country share in the mining & petroleum figures.

[8] This technological explanation could, for example, accounts for the high difference between the share of USPTO patents granted to Shell and invented in the US (47%) and the corresponding EPO figure (31%). Indeed most of Shell's innovations discovered in the US, especially in drilling, cannot be applied in Europe where most of Shell's oil extraction takes place off-shore.

companies are the most engaged in undertaking R&D activities outside their home countries, whereas US and Japanese companies show a much weaker propensity to perform their R&D activities abroad.

OECD triadic patent families

If the USPTO and the EPO appear to overestimate the patenting activities of their national firms, the OECD triadic patent family dataset does not seem to be biased towards any particular home country. Indeed the shares shown in Tables 2, 3 and 4 calculated on the basis of OECD triadic patent families attenuate the difference between the EPO and USPTO-based figures, which confirms the assumption that the use of triadic patent families reduces, if not eliminates, the 'home advantage' effect and thus they appear to be a better source of information for measuring the R&D internationalisation strategies of MNES.

Although the OECD triadic patent family dataset does not seem affected by a 'home advantage' effect, it is worth investigating to what extent this database is able to capture the inventive activities of these firms taking place in different locations, that is, to what extent firms file their patents with all three patent offices (EPO, USPTO and JPO). It is often assumed that non-US MNEs will protect their inventions in the USPTO regardless of where they have been invented. However the findings of the previous section have already provided some evidence that this claim may not apply systematically.

One way to shed light on this issue is to calculate the proportion of OECD triadic patent families in the total number of each of USPTO patents granted and EPO patent applications. These shares should indicate to what extent the OECD triadic patent family database is able to measure the R&D internationalisation of these firms. Very small shares in these tables would indicate that the R&D activities of these firms performed in different locations are not completely captured by the OECD dataset.

Table 5 reports the sectoral and geographical distribution of these shares for the sample of USPTO patents granted. Columns (1) to (3) show the shares of OECD triadic patents owned by European MNEs and invented, respectively, in the MNE's home country, in the US and in other European countries in the total number of USPTO patents originating from these locations. Columns (4) and (5) present the shares for the sample of USPTO patents granted to US MNEs and invented in, respectively, the US and in the EU. Columns (7) to (9) report similar shares for the sample of USPTO patents filed by Japanese MNEs. Thus, for example, Table 5 shows that 85 per cent of USPTO patents granted to European chemical MNEs have also been extended for protection in the EPO and the JPO.

Table 5 Sectoral and geographical distribution of shares of OECD triadic patents in the sample of USPTO patents (% total patents)

	EU MNEs			**US MNEs**		**JP MNEs**		
	share of pats invented in the:			**share of pats invented in the:**		**share of pats invented in the:**		
Sector	**home country** (1)	**US** (2)	**other EU countries** (3)	**home country** (4)	**EU** (5)	**home country** (6)	**US** (7)	**EU** (8)
Aerospace & Defence	42.1	n.a.	11.1	26.1	27.5	-	-	-
Chemicals	85.6	61.6	87.8	65.2	65.8	62.1	61.8	43.6
Electrical/Electronics	68.9	42.6	77.9	34.5	36.3	40.6	40.2	27.7
IT Related	-	-	-	31.2	33	32	31.9	27.6
Machinery	39.1	33.2	60.9	19.3	20	55.2	54.8	5.9
Metals	75.9	29	60.6	23.4	25.1	56.6	55.6	29.1
Mining & Petroleum	77.6	44.2	78.4	39.8	41.3	81.4	81.3	n.a.
Motor Vehicles & Parts	45.3	33.8	58.7	21.3	22.8	32.2	32.1	16.7
Pharmaceuticals	89.4	74.4	89.5	63.9	65.7	-	-	-
Photography & Photocopy	-	-	-	53.4	53.6	35.9	36.3	40.5
Telecommunications	68.6	31.4	55.9	34.2	34.3	66.1	65.8	n.a.
Overall	**70.5**	**52.9**	**78.2**	**38.2**	**39.6**	**37.6**	**29.3**	**39.6**

n.a. indicate cases where the number of observations is too low

An interesting trend to note from the figures in Table 5 is the low share of USPTO patents granted to US and Japanese MNEs that have equivalents in the EPO and the JPO. This is particularly the case for those patents invented in the US (see columns 4 to 7) and granted to these firms and implies that, if USPTO data better reflect their inventive performance in this location, the OECD triadic patent family dataset is only able to capture a small proportion of their US-performed R&D activities.

These low shares are in contrast to the figures for European MNEs (see columns 1 to 3): the share of OECD triadic patents among USPTO patents granted to these firms and invented in the EU, either in their home countries or in other EU countries, is more than 70 per cent. This suggests that when European MNEs decide to extend their USPTO patents abroad they apply to both the EPO and the JPO. A smaller proportion, though still significant, of USPTO patents owned by these firms and invented in the US have equivalents in the JPO and the EPO (52 per cent), although the share for European chemicals and pharmaceuticals MNEs is much higher (61 and 74 per cent, respectively).
For US MNEs this could be due to the fact that the USPTO is their national patent office and thus a large proportion of patents will not be filed with other patent offices since they are not valuable enough (as will be shown later in this paper). The finding for Japanese MNEs' USPTO patents could be the result of their special focus on the US market which could imply that the invention protected by the USPTO is not going to be exploited in other markets. This trend can also be explained both by the increase in the cost of patenting in the USPTO over time, which may have discouraged applicants also to seek patent protection elsewhere, and by the existence of different patentability standards across patent offices, which may have lead US applicants to seek protection for inventions at home but not in other countries where those inventions are not considered patentable (Hingley and Park, 2003). However it is interesting to point out that US MNEs operating in the chemical, pharmaceutical and photography & photocopy sectors appear to file their USPTO patents also with the EPO and the JPO, a possible indication of their international R&D strategies. This strategy appears also to be followed by Japanese MNEs in chemicals, mining & petroleum, and telecommunications.

Table 6 Sectoral and geographical distribution of shares of OECD triadic patents in the sample of EPO patents (% total patents)

	EU MNEs			**US MNEs**		**JP MNEs**		
	share of pats invented in the:			**share of pats invented in the:**		**share of pats invented in the:**		
	home country	**US**	**other EU countries**	**home country**	**EU**	**home country**	**US**	**EU**
Sector	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Aerospace & Defence	37.2	n.a.	12.5	79.0	61.3	-	-	-
Chemicals	71.6	79.0	72.4	86.4	68.1	89.9	94.7	n.a.
Electrical/Electronics	55.2	70.7	51.0	88.0	50.2	92.3	87.3	80.1
IT Related				88.5	77.4	93.6	87.0	50.6
Machinery	40.8	79.2	44.8	59.3	35.4	85.9	n.a.	n.a.
Metals	54.1	73.1	50.7	87.9	40.0	86.9	88.9	87.5
Mining & Petroleum	63.7	72.9	56.4	75.2	66.5	86.8	n.a.	n.a.
Motor Vehicles & parts	41.3	48.7	38.2	59.7	42.0	91.2	75.0	36.8
Pharmaceuticals	85.1	87.9	84.1	84.1	76.7	-	-	-
Photography & Photocopy	-	-	-	91.8	74.7	94.9	95.4	79.4
Telecommunications	61.5	63.3	51.0	88.2	68.4	96.8	n.a.	n.a.
Overall	**58.4**	**75.3**	**59.2**	**84.4**	**62.5**	**92.5**	**88.7**	**66.9**

Table 6 presents the corresponding shares for the sample of EPO patents. It shows that there is a relatively high number of OECD triadic patents among EPO patents invented in the EU: across all firms around 60 per cent of the inventive activity performed in the EU and captured by the EPO is also measured by the OECD triadic patent family dataset. The lower share of triadic patent families among EPO patents granted to EU MNEs and invented in the EU is consistent with the fact that the EPO is like a national patent office for these firms. However it is interesting to point out that this share is higher than the corresponding USPTO figure for US MNEs (see column 4 in Table 5). This is consistent with the claim that the EPO is an 'international' patent office with less 'home advantage'

effect and thus that patent granted by this office might have already gone through the scrutiny of a national patent office and that their value justifies the higher cost of filing with the EPO. The sectoral trends identified in Table 5 also emerge from the figures in Table 6, namely that MNEs in the chemical and pharmaceutical sectors appear to have adopted a more international patenting strategy, while firms in motor vehicles & parts and machinery show the opposite patenting behaviour.
Thus if it is true that the set of OECD triadic patents excludes many patents, it is worth testing whether what is excluded are patents with little economic and technological value. As was pointed out earlier in the paper, a limitation of patent indicators based on national patent offices is that they include many patents with little or no value (a problem known as the high skewness of the distribution of patent value) (Pakes and Schankerman, 1984, Scherer, 1965) while patent families should capture more valuable innovations.

One way of testing this hypothesis is to calculate the number of citations received by those EPO and USPTO patents which are not part of an OECD triadic patent family and compared this with the citations received by OECD triadic patents. Patent citations have been shown to be correlated with the value of innovations (Trajtenberg, 1990) and the total number of citations received by patents has been used in other studies as an indicator of their relative importance (Lanjouw and Schankerman, 1999, Trajtenberg *et al.*, 1997). Table 7 reports the average number of citations received within each patent system and within a time lag of 4 years by USPTO and EPO patents invented, respectively, in the EU and the US. Table A2 and A3 in the appendix present the same statistic with patents regrouped into technological fields according to the classification in Hall *et al*. (2001) and in OST (2002), respectively. As expected, OECD triadic patents receive on average a higher number of citations than those patents not filed in the other two patent offices do and this result is consistent across technology classes. Thus OECD triadic patents seem to protect inventions with a relative higher economic and technological value.

Table 7 Assessing the economic and technological value of OECD triadic patents

	Average number of citations received by:			
	USPTO pats invented in the US		**EPO pats invented in the EU**	
	OECD triadic patents		OECD triadic patents	
Pats filed by	*no*	*yes*	*no*	*yes*
EU MNEs	1.804	2.023	0.519	0.837
JP MNEs	2.824	3.804	0.558	1.192
US MNEs	2.645	3.593	0.574	0.875
Overall	**2.566**	**3.333**	**0.524**	**0.844**

5. Conclusion

This paper aimed to examine the extent of the 'home advantage' effect in EPO, USPTO, and OECD triadic patent data. By comparing a set of internationalisation indicators for a sample of European, US and Japanese MNEs it was found that, contrary to what it has been assumed so far, there is evidence of a 'home advantage' effect in both the USPTO and the EPO that affects especially the measurement of foreign subsidiaries' patenting activity, while indicators based on OECD triadic patents do not appear to be biased towards any particular home country. However, despite the 'home advantage effect', both the EPO and the USPTO data provide a similar picture of the relative level of R&D internationalisation across countries.

To assess the validity of the OECD triadic patent family dataset as an alternative source of information for measuring R&D internationalisation this study analysed to what extent MNEs file their USPTO (EPO) patents with both the EPO (USPTO) and the JPO. Three important points emerge from this analysis. First, even these large firms with multinational operations and extensive financial resources are very selective in their decision to apply for protection in more than one patent office. Second, the OECD triadic patent family database does not capture much of the US-performed R&D activity of US and Japanese MNEs, which is instead measured by the USPTO, though it is better able to capture the inventive activities of all firms taking place in the EU and which are instead accounted for in the EPO. This analysis revealed as well that there is a relatively higher number of OECD triadic patents in the total number of EPO patents granted to European MNEs and invented in the EU with respect to that in total number of USPTO patents granted to US MNEs and invented in US. This

partially confirms the claim that the EPO is an 'international' patent office with less of a 'home advantage' effect. Third, USPTO and EPO patents with equivalents in the OECD triadic patent family dataset appear to be more valuable than those that are not extended for protection in the other two major patent offices. This suggests that the OECD is a satisfactory alternative to the EPO and the USPTO for measuring the internationalisation of inventive activities.

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