The rate and motives of the internationalisation of large firm R&D (1994-2005): Toward a turning point?

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Abstract

This paper addresses the internationalisation of R&D of large multinational firms by analysing their patents from the mid-1990s to the mid-2000s. It highlights three major results. Firstly it does not reveal any significant increase of the global rate of R&D internationalisation, which remains at around 23%. This means that the national base remains prevalent in their technology production. Secondly it shows striking different regional trends: (i) a relative retraction of European firms that still remain more internationalised (30%) and have re-focused R&D in European countries, (ii) a continuing increase of the internationalisation of US firms (17%) and a very important loss of attractiveness of the US as a destination for R&D investments by non-US firms; and (iii) a rapid rise (but still limited) of Asian firm R&D internationalisation. Thirdly, These movements did not promote, as anticipated, the role of technology-based motives (asset augmenting strategies) in the internationalisation of large firms R&D: Technology-based motives remain the most important of driver but the gap with market-based considerations has narrowed.

Keywords: multinational firms; global firms; R&D; technology; patents; internationalisation

1- Introduction: setting the scene and research questions

Policymakers have shown a continuing interest in the internationalisation of R&D activities of firms (UNCTAD, 2005; OECD, 2005). Because of the strong link between innovation and corporate R&D, policy concerns in developed countries focus on the potential loss of jobs and economic benefits as well as on the potential depletion of the local knowledge base due to the internationalisation of R&D (Moncada-Paternò-Castello and al., 2011). The increased attraction of Asian countries (in particular China and India) as R&D locations, the so-called "R&D offshoring" (d'Agostino and al., 2013), have led to a growing concern among policy makers with regards to the perceived hollowing-out of the national innovation system (Narula and Zanfei, 2005).

These concerns have triggered empirical research into the drivers and the consequences of the internationalisation of corporate invention in recent years (see among others Florida and Kenney, 1994; Frost, 2001; Ambos, 2005; Abramosvsky and al., 2008; Sachwald, 2008). Today, the dominant view is that this activity is *increasingly internationalised* (see for instance Iammarino and McCann, 2013). This is clearly expressed by Moncada-Paternò-Castello and al. (2011), "The globalisation of R&D activities has continued its *growth path* as companies are *increasingly* trying to capture knowledge and market opportunities internationally." This view is different from the basic idea developed by Patel and Pavitt (1991), who considered technological activity as "an important case of non-globalisation". More recently, Dunning and Lundan (2009) and Patel (2011) emphasised *the continuing reliance of firms on the home country as a base for innovation.* This tension has generated a number of studies that attempted to measure the degree of internationalisation of R&D activities of large firms. Some of these studies are based on surveys (UNCTAD 2005; Doz, 2006), but the two largest draw on patents as a marker of firm technological activities (Patel and Vega, 1999; Le Bas and Sierra, 2002). These studies, conducted at the turn of

the century, deal with the situation from the mid-1990s. Both studies conclude that R&D internationalisation is growing but remains weak. Building on these works, the first objective of this paper is to look at more recent data to see if the supposedly fast globalisation movement of large firms has translated into a corresponding growth of internationalisation of technology-based activities.

The two questions this paper addresses are: 1. Can we confirm the general dominant view assuming a growing trend in the internationalisation of technology creation? 2. Does the "home-base-augmenting" strategy still dominate as observed in the 1990s? For both interrogations, we shall consider whether these trends are generalised or whether we observe differences depending, for instance, upon the origins of firms. The paper is organised as follows. The next section presents the contrasting results exposed in the literature dealing with *firm R&D internationalisation*. Section 3 discusses the interest of using patents as a data source, then presents the unique dataset employed in this research and exposes the methodology used for measuring R&D internationalisation. Section 4 presents the findings with regards to the overall level and dynamics of multinational corporation (MNC) R&D internationalisation, showing diverging trends between firms from different continents. Similarly, section 5 explores the issue of the *locational strategies* of MNCs concerning R&D and their evolutions. The final section reflects upon our two main results: we are still facing an overall case of weak internationalisation, but levels and trajectories differ widely between continents, with Europe being a special case of internal diverging dynamics. Secondly there is a clear evolution towards motives that are more linked to market penetration (aiming at exploiting the home knowledge base) even if the search for new capabilities remains prevalent (with the objective of augmenting the home knowledge base). Once more these results show a strong spatial differentiation.

2. Framing Firm R&D internationalisation: a review of the literature

Before analysing the recent trends of R&D internationalisation in large firms we review the literature along two lines: the degree (the volume) of firm R&D internationalisation and the choice of the location abroad where R&D is carried out.

2.1- The decision to invest in R&D abroad and the degree of R&D internationalisation

The motivations for locating R&D activities abroad have fed a significant body of literature. Its analysis shows that there are two main reasons that explain why firms internationalise their technological activities: 1) the adaptation of products and processes to foreign conditions, a quasi-compulsory rule for penetrating markets abroad; and 2) the acquisition of knowledge and expertise from foreign R&D centres and universities (Kuemmerle, 1999; Belitz, 2010; Erken and al., 2010; Franck and al., 2003; Gersbach and al., 2011). There is a long tradition emphasising that firms invest in R&D activity abroad mainly for organising the adaptation of their products to the local markets. In this tradition, the main driver of R&D internationalisation is technology adaptation. It corresponds to Vernon's hypothesis related to the international product life cycle (Vernon, 1966). Today, the dominant view states that the international localisation of innovation activities responds mainly to the need to gain access to local competencies and knowledge in order to produce innovations on an international basis (Narula and Zanfei, 2005). This corresponds to the "knowledge seeking" motivation of MNC foreign direct investments (FDI) pictured in particular by Cantwell (1989) and Dunning (1981)[1]. It implies that firms must be embedded in local research networks and/or search for a close geographic proximity with foreign knowledge producers in order to acquire new knowledge including tacit knowledge (Jacquier-Roux and Paraponaris, 2011).

The increasing importance of the globalisation of R&D by MNCs is related to the growing importance of the network firm. The reduction of transaction costs has enabled the outsourcing of

[1] See the contributions by Chen and al. (2012, 2013) for other references.

multiple functions (Iammarino and McCann, 2013). It has given rise to the "end of distance conjecture" and the "flat world vision" (Friedman, 2005). The idea that the offshoring of R&D activities might have no limits stems from this perspective on globalisation. By contrast, another perspective considers that the world is not becoming flatter but more curved (McCann, 2008), spiky (Florida, 2005), lumpy or uneven (Iammarino and McCann, 2013).

In the eclectic paradigm formulated by Dunning (1988) the internationalisation of R&D activities can be seen as the *internalisation* of cross-border activities. Instead of acting on the market, the firm places its operations under its own direct control in order to gain competitive advantage. However, the decision to internalise activities is a trade-off linked to the level of transaction costs. Narula and Zanfei (2005) have proposed to analyse the drivers of both the concentration of R&D at home and the dispersion of R&D abroad as two opposing forces. R&D investment abroad can be interpreted as a dispersal of resources driven by the search for technological opportunities that match the firm benefits. But such conduct involves the costs of searching, networking, absorbing and integrating knowledge created in foreign locations. This costly strategy is constrained by resource limitations. The key message delivered by the two authors is that R&D investment abroad must not always be considered as effective. An important point is that one cannot take for granted an ever-increasing growth of internationalisation of the R&D activities of MNCs. Belderdos and al. (2008) demonstrate that there cannot be a systematic behaviour in favour of foreign R&D investment, and, as a consequence, that R&D investment abroad is not always profitable.

Empirical studies converge in identifying a slowly growing level of internationalisation of R&D. For instance the UNCTAD survey (2005), looking at evolutions between 1994 and 2002 on a small set of 66 large firms, points out that a growing share of MNC R&D is performed abroad. Roberts (2001), with a panel of 400 largest R&D-performing companies in North America, Western Europe and Japan, found a significant increase of R&D spending abroad, whose share rose from 15% in 1995 to 22% in 2001. The survey conducted by Doz (2006) pointed out that the number of R&D

sites located in the home country has steadily decreased since 1975 from 55% to 32% in 2000. Similarly Le Bas and Sierra (2002), studying a sample of 350 large firms, found that the share of international patenting has increased from 15.8% in the period 1988-1990 to 19.5% in the period 1994-1996. Similar results were found by Patel and Vega (1999). More recently Patel (2011) considered a sample of 963 technology active MNCs to characterise technology internationalisation dynamics between 1991 and 2006 using patents applied for at the European Patent Office. The data confirm a small but increasing trend (+2.5%) of R&D internationalisation but show regional differences: stronger for US firms (+4.7%), average for Japanese firms (+2.5%) and lower for European firms.

However there is also anecdotal evidence that points to possible limitations in technology internationalisation by large firms. The UNCTAD report (2005) interestingly notes that the international share of R&D expenditures of the largest Swedish MNCs stagnates at 43% after a regular period of growth. The Pro Inno survey (Pro Inno Europe, 2007) points out that R&D offshoring is expected to increase less than total R&D spending. Gammeltoft (2006) further hypothesised that the growth in R&D internationalisation may have come to an end. His own interpretation of this quantitative stagnation is that firms are now focussing on the organisational consolidation of existing complex international R&D structures.

Looking at this empirical evidence, which is mostly based on trends witnessed in the early and mid-1990s, drives us to our first question: does the situation 10 years later corroborate the scarce elements of knowledge that point to a stabilisation of the internationalisation of R&D activities and does it reveal significant regional variations in terms of internationalisation levels and dynamics?

2.2- The location decision

In order to follow the strategic locational choices made by firms, with respect to their R&D abroad, Soete (1987), Patel and Pavitt (1987) and Cantwell (1989) have jointly proposed a method based upon the analysis of firm patent portfolios. Using Revealed Technological Advantage (RTA)

indexes the method compares the firm relative strength in a given technology in its home country, and the relative strength of host countries in the same technology[2]. Combining the two indexes allows the categorisation of the R&D internationalisation strategy of one firm or group of firms according to four types: i) Home-base-augmenting (HBA) strategy corresponds to situations where firms and recipient countries are both over-specialised (the firm in its home country, and the recipient country compared to the overall world), ii) Home-base-exploiting (HBE) strategy is a situation where the firm is over-specialised but the recipient country is not, iii) Technology-seeking (TS) strategy is a case where the firm is under-specialised in its home country and invests in over-specialised countries; and iv) Market-seeking (MS) strategy corresponds to situations where both the firm and the recipient country are under-specialised.

This method has been mobilised in two wide empirical studies that converge in showing that the most important strategies are the two first, with HBA-motivated patenting surpassing HBE-motivated patenting (Patel and Vega, 1999; Le Bas and Sierra, 2002). Le Bas (2006) further showed that there is no effect of the level of technological internationalisation on the choice of strategy. *These studies also indicate a growing share over time of HBA-based strategies*. The relevance of home-base-augmenting motivations for internationalisation has not changed according to Picci and Savorelli (2012). But the two authors did not find evidence that home-base-augmenting motives have become more important in recent years. Other recent studies (for instance Nachum and Song, 2011) argue that firms take advantage of the location-specific assets driving them to build synergistic portfolios of knowledge. Thus we might find specific combinations of different options, depending upon locations. These findings justify studying the recent evolution of motivations for R&D internationalisation. Do we witness an evolving balance? And are there different mixes associated with different levels of internationalisation?

3 Methodology

[2] The definition and calculation of RTA are detailed in Le Bas and Sierra (2002)

In this section we present the reasons why we chose patents as a data source for characterising R&D and the principles that have guided the set up of a new large firm patent dataset. The details of the building of the dataset are presented in the appendix.

3.1- Patents as markers of industrial R&D

There are few data sets accounting for R&D internationalisation, as most countries do not publish data on the share of R&D undertaken by foreign firms according to the nationality of the firm, with the notable exception of the US (Patel, 2011). Moreover confidentiality issues often hinder the use of R&D expenditures data at firm level. As a consequence, most researches on R&D internationalisation rely on patent data (Debackere and al., 2004; Guellec and al., 2004).

The measure of firm technological activities based on patent data presents many advantages (Griliches, 1990; Patel and Vega, 1999). Patenting provides a good indicator of firm innovative capacity. A patent application signals the detection by an economic actor of the potential value of a technical invention. Patents are easy to access, often available in long time series, display rich information (place and date of applications, information on inventors and applicants) and are classified in categories according to technology fields. The detailed information on individuals and organisations can be matched across various databases and makes patents a rich data source for investigating the internationalisation patterns of technology activities. In this study, information on inventors enables the mapping of firm technological activity at geographical level, i.e. the identification of the places where the novelty creation occurred. Patent data also has well-known drawbacks. Since they do not necessarily reflect innovation activity, we will therefore restrict our analyses to technological development (i.e. invention)[3] and avoid erroneous conclusions regarding the global innovation process. A second limitation is that patents account only for codified knowledge creation, leaving out all kinds of tacit forms of knowledge. Finally, comparing technological activities across countries should be done with care, since the patentability

[3] See OECD Patent Statistics Manual, Paris, 2009.

requirements can differ widely between patent offices. Nevertheless patents properly reflect technological performance of firms, sectors or countries, revealing patterns consistent with those pictured by the R&D statistics (Hagedoorn and Clood, 2003; de Rassenfosse and van Pottelsberghe, 2008; Patel, 2011).

3.2- The Patstat database and the worldwide patent indicator based on priority patents

This research uses the Patstat database (October 2011 version) which offers a complete coverage of patenting activities from more than 180 patent offices and has made possible the design of a new patent marker: the worldwide patent indicator (de Rassenfosse and al., 2013) based on priority patent applications.

This indicator presents several advantages compared with indicators based on data emanating from a restricted number of large patent offices (EPO, WIPO, USPTO) or a combination of them (triadic patent families). De Rassenfosse and al. (2013) showed that compared with indicators based on patents applied for at USPTO or at EPO, indicators based on priority patents "*capture different dimensions of inventive activity*". They also overcome the strong national bias, which hampers indicators based on data from one single patent office. This feature is important for our study as we aim at analysing the inventive resources used by corporations all over the world. Second, counting all priority patents has the advantage of covering more inventions than counts based only on patents extended internationally through the Patent Cooperation Treaty (PCT) or on the very selective "triadic families". It makes the worldwide indicator well adapted to the investigation of the whole inventive activity of large firms with no threshold on the value of the invention. Third, the dates that are compiled (the application date of priority patents) are closer to the novelty creation event than the dates of later eventual extensions applied for in one or the other large patent office (whether USPTO or EPO). This provides a more precise view on the dynamics of transformation of corporate inventive patterns.

This worldwide indicator suffers from an institutional bias as it treats equally patents originating from offices where the rules for patenting show essential differences[4]. The main consequence is the very large share of Japanese and Korean patents in the world total. This bias will be dealt with in two ways. First we will compute and analyse figures including and excluding these two over-represented Asian countries. Second, we will mainly analyse, within countries, the distribution of patents either according to the locations of inventors or according to the strategies reflected in the patents including foreign inventors. This focus on percentages computed at national level enables to avoid the bulk impact of this institutional bias[5].

3.3- The large firm database

This research exploits a new database that identifies the priority patents applied for by the largest industrial firms in the world. It has been built in three steps, presented in detail in the appendix. First, a set of 2800 large industrial R&D performers has been produced by complementing the list of 2000 firms identified in the 2009 edition of the IPTS "Industrial R&D Investment Scoreboard" with a series of Chinese and Indian corporations (identified in the Compustat database as active in industrial R&D) and with top patent applicants from WIPO, EPO and USPTO rankings. Second, relying on the Orbis database edited by Bureau van Dijk Electronic Publishing, we have identified the subsidiaries included in the consolidated perimeter of these industrial groups. Third, the names of the firms and their subsidiaries have been looked for as potential applicant names in the Patstat database.

For this research, we have restricted the set of firms to those that have applied for at least five priority patents in both three years periods 1994-1996 and 2003-2005. This leads to a corpus of 946

[4] Cost of application, inventive level required or even the possibility to patent some types of inventions

[5] Another possibility would have been to follow the approach developed by de Rassenfosse and al. (2013). Mobilising the fact that the average number of claims of Asian patents compared to EU or US patents is three times lower, they suggest to correct Asian patents by a factor of 3. After careful consideration, we decided that this would not improve the analysis thanks to the strategy we have adopted.

firms that have applied for 882 895 priority patents between 2003 and 2005 (representing 49.4% of total priority patents taken worldwide during this period).

3.4- Geography and firm perimeter

Geographical information concerns the national origin of corporations and the places where inventions occurred. It has been identified according respectively to the corporations' headquarters location and to the personal addresses of inventors. When more than one country appears in inventors' addresses in a given patent, a fraction is attributed to each country (fractional counting). Geographical information is treated in two ways. It is first computed at national level for identifying foreign inventions (i.e. patents including an inventor's address located in a different country than the headquarters country) and the corresponding strategies they reveal regarding technological specialisation. Then, the results are analysed either at national level for large countries or at an aggregated or regional level when such a grouping is required either for increasing the size (and therefore the statistical robustness) of the corresponding population of firms and patents or for highlighting analogous behaviours among neighbouring countries. In a similar way, results can also be aggregated by location of inventors (appearing in large firm patents) in order to investigate countries or continents in which R&D activity is carried out by foreign large firms. This study uses a single delineation of firm perimeter defined at the end of the period of analysis. Corporations' boundaries are based on a lone outlining of subsidiaries established in 2008. This single "static" definition gives an accurate representation of the last period under study. But it bears a clear drawback: it does not take into account the mergers and acquisitions that have occurred during the period nor the partial sales that have happened. Section 4 will show the estimates that drive us to consider that the bias thus introduced remains secondary to the trends observed; mergers and acquisitions having a limited impact on net inventive activities. In any case, this delineation gives a fair account of the geographical basis through which the portfolio of inventive activities has been

accumulated. We shall speak of a "quasi-indicator of dynamics" as we shall compile data for the 1994-1996 period according to a corporate delineation established in 2008.

3.5- Descriptive data

The 946 firms are roughly equally distributed between the US (34%), Asia (27.2%, 23.2% for Japan only) and Europe (35.7%) (see Figure 2 in appendix 1). However priority patents are completely biased towards Asian firms (they account for 78% of all patents for the 2003-2005 period). During the same period, US firms' world share of priority patents was 11.5% and European firms' 9.8%. German firms account for 26% of European firms but represent 60% of the patents applied for by European firms. The corresponding figures are: 15% and 16% for French firms; 39% and 21% for firms from smaller countries (a group made of Nordic countries, the Netherlands, Belgium, Switzerland and Austria) and 17% and 5% for British firms. The distributions of patents according to the country of the firm or the country of residence of inventors show similar levels but reveal a more limited contribution of small European countries and a higher contribution of Europe (in particular Germany) when considering the inventor's location instead of firm location.

4. The degree of internationalisation: an overall stabilisation

Using the inventor's country as a proxy for the location where the technological activity related to the invention occurred, we analyse the degree of internationalisation as the share of corporate patents with inventors located outside of the country of the firm headquarters (using a fractional count). The nationality of the firm is the country of the firm headquarters and all the subsidiaries of the firm will take the nationality corresponding to the headquarters location, even if the applicant of the patent is located elsewhere (e.g. subsidiaries located in a country that is not the country of the headquarters). Other works on MNC R&D internationalisation have made different choices. Picci (2010) or Thomson (2013) measure internationalisation from the countries of the patent applicant and inventor. In their work, the nationality of a subsidiary of the MNCs is defined according to the

country of the applicant while in our approach it is the country of the MNC headquarters. This methodological difference can significantly influence the measure of the internationalisation of MNCs in particular in the case of highly globalized ones. In this section we shall characterize the situation in 2003-2005 both regarding the level of internationalisation and the location (section 4.1) before analysing trends over the decade (section 4.2).

4.1- Main characteristics of firm R&D internationalisation in 2003-2005

4.1.1- The level of internationalisation

The overall rate of internationalisation computed on the total number of patents appears very low, 7.2% for 2003-2005. This rate is largely dependent upon Japan and Korea, the two largest priority patent producers whose firms, moreover, are the least internationalised in terms of inventive activity. Excluding these two countries increases the rate of internationalisation to 22.6% in 2003-2005 (Table 1)[6]. The internationalisation rates for corporations from Europe and Northern America reach respectively 30.4% and 17.3%.

Table 1 - Internationalisation of firm inventions by continent or country of firms in 1994-1996 and 2003-2005

Country of firm	Patent share (%)		Internationalisation rate (%)		
	2003 - 2005	1994 - 1996	2003 - 2005	1994 - 1996	Evolution (%) 1994 -1996 to 2003 -2005

[6] When calculated for patents from the European Patent Office only (as Le Bas and Sierra did) and not for all priority patents (as done elsewhere in this research), the internationalisation rate for our set of firms reaches 23.4%.

United States	11.8	11.7	17.3	9.8	76.7
Europe	10.2	8.4	30.4	40.7	-25.3
Asia	77.9	79.7	2.5	0.7	260.8
Total	100.0	100.0	7.2	5.2	37.1
Total without Japan and Korea	24.4	20.6	22.6	23.0	-1.7

This global analysis however incorporates very different situations depending upon the location of firms. Levels of internationalisation differ widely with Japanese firms at one end (with an internationalisation rate around 1% overall), small European countries (around 65% together) and the UK (nearly 80%) at the other. Emerging Asian countries (mostly Korea, 7%), Germany (13.8%) and the US (17.3%), France (around 30%) are in between (Table 2).

Table 2 - Internationalisation in European and Asian firm inventions in 1994-1996 and 2003-2005

Country of firm	**Patent share by continent (%)**		**Internationalisation rate (%)**		
	2003 - 2005	**1994 - 1996**	**2003 - 2005**	**1994 - 1996**	**Evolution (%) 1994 -1996 to 2003 -2005**
Germany	57.4	44.5	13.8	15.8	-12.8
France	16.0	19.6	34.1	48.0	-29.0
United Kingdom	4.7	9.0	79.9	88.1	-9.3
Small countries	20.4	24.5	64.4	62.0	2.3
Europe	**100.0**	**100.0**	**30.4**	**40.7**	**-25.3**
Japan	80.5	93.3	1.3	0.6	123.1
Emerging countries	19.2	6.4	7.3	2.4	210.5
Asia	**100.0**	**100.0**	**2.5**	**0.7**	**260.8**

4.1.2- Where do firms locate their foreign R&D investments?

The dataset enables focus not only on firm location, but also on recipient location, i.e. countries or continents in which R&D activity is carried out by (foreign) firms. To better understand the logics behind such situations we have made a distinction between proximity investments (international continental patents) and distant investments (intercontinental patents) (Table 3). US and European firms are quite similar in their overall patenting effort (102 000 vs. 90 500 patents in 2003-2005), in their respective engagements in Asia that remain secondary - even if the level for US firms (4.7% of all inventions) is twice higher than for European firms - and in their mutual engagements in the other continent (US firms in Europe and European firms in the US) that nears 10%. But what radically differs, are the proximity or continental relationships: they are 10 times stronger for European firms than for US firms (17.5% against 1.6% of their total patenting effort). This forms the core of the difference in the role of the country of origin of the firms (what we call the home base): though it is dominant for the two groups of firms it represents only two thirds of total inventive activities for European firms (69.6%) and over four fifths for US firms (82.4%).

Table 3 - Geographical patenting patterns by firms in United States, Europe and Asia in 2003-2005

	US firms	**European firms**	**Asian firms**
Share of domestic patents (%)	82.4	69.6	97.5
Share of international patents (%)	17.6	30.1	2.5
Share of international continental patents (%)	1.6	17.5	1.3
Share of intercontinental patents (%) with:			
US inventor	-	**10.0**	0.7

European inventor	**10.9**	-	0.4
Asian inventor	4.7	2.3	-
Other	0.4	0.6	0.1
Total	100.0	100.0	100.0
Total number of patents	101 918	90 525	688 017

The very low level of internationalisation of Asian firms does not enable to adopt a similar approach. However, focusing on international patents enables the comparison of absolute and relative levels of use of international resources. There the image changes significantly: US and Asian firms have similar international portfolios (around 18 000 international patents) while European firms have 1.5 time more patents (Table 4). European and Asian firms have in common to massively call on countries of their own continent (more than 50% for European and Asian firms vs. 8% for US firms) and place far more importance on investments in North America than in the other continent. US firms on the contrary invest heavily in the two other continents (90% together), with Europe being twice as important as Asia.

Table 4 – Continental structure of international patenting by European, US and Asian firms in 2003-2005

	US firms	**European firms**	**Asian firms**
Share of international patents (%) with:			
North American inventor	8.0	34.3	29.8
European inventor	**62.9**	**57.6**	16.7
Asian inventor	27.1	7.4	**53.2**
Other	2.0	0.7	0.3
Total	100.0	100.0	100.0

Total number of international patents	17 677	27 489	17 461

While different patterns of internationalisation are evidenced, the first key element remains in the mid-2000s the lasting dependence vis-à-vis the national sources of technology.

4.2- What trends in the internationalisation of R&D over the decade?

4.2.1- No deepening of the global internationalisation rate

After excluding Japan and Korea, the corporate R&D internationalisation rate (22.6%) in 2003-2005 is not significantly different from the rates found 10 years before by Patel and Vega (20%) and Le Bas and Sierra (19.5%). In order to improve the comparison of the internationalisation level we have computed with that obtained by Le Bas and Sierra (2002), we calculated the rate with our dataset selecting - as they did - only patents from the European Patent Office. This increased the internationalisation rate to 23.4%. To better analyse this difference (23.4% against 19.5%), we restricted our firm data set to those present in both studies and recomputed the internationalisation rate for 1994-1996 both with our firm delineation and with theirs. Based on our delineation, we arrive at 21.9% while we found 20.4% using the delineation made by Le Bas and Sierra (2002). The difference between the two figures (1.5 percentage point) provides a proxy for the weight of mergers and acquisitions, showing their overall limited effect. This leads us to conclude that the delineation we propose provides a reliable "quasi-indicator of dynamics", and that we can thus compare the two periods of time. This "quasi-indicator" shows with our total population of corporations that the rate of internationalisation was slightly higher in 1994-1996 (23%) than in 2003-2005 (22.6%). This drives to a first important conclusion: there has not been any deepening in the internationalisation over the decade, contrary to what anecdotal evidence linked to case studies tended to show. We thus consider this period as a period of global stabilisation or, to follow

Gammeltoft (2006), as a period of organisational consolidation. This stabilisation means that, when existing, home inventive resources remain by far the main source of technological knowledge and that the core strategy for firms is to exploit domestic resources when available.

4.2.2- Very contrasted situations and opposite dynamics by continent firms

The global picture of corporate R&D internationalisation in 2003-2005 juxtaposes very different behaviours, depending on the continental origin of the firms. US firms, compared with one decade before, have doubled their level of internationalisation through an expansion in the two other continents. Asian firms witness a limited relative growth resulting mainly from investments in Asia. European firms, by far still the most internationalised, have strongly diminished their level of internationalisation and refocused their foreign R&D operations in Europe. The following paragraphs present these diverging trajectories.

The rate of internationalisation of Asian firms remains very low in 2003-2005 (2.5%) even if it has increased very significantly (Table 1). This situation stems from the very limited rise of the internationalisation of Japanese firms (from 0.6% in 1994-1996 to 1.3% in 2003-2005), while in "emerging" countries the corporate internationalisation rate more than doubled, reaching in 2003-2005 the world average (7.3%). The Asian growth originates mainly from Korean and Taiwanese firms, which contribute respectively for 53% and 16% of the total growth in international patents by Asian firms (Chinese and Indian firms still remain marginal players).

US firms have shown a regular and sustained increase of their international patenting effort (from 9.7% to 17.3%, i.e. +77%) even if their rate remains far below that of European firms.

Conversely, European firms, while displaying a high level of internationalisation (30.4% in 2003-2005), have seen their rate strongly decrease since the previous period (40.7% in 1994-1996, a fall

of more than 10 percentage points)[7]. The observed overall European trend is also a combination of contrasting trends. The rate of internationalisation for firms from small countries has remained stable (around 60%, Table 2), demonstrating once more the well-known fact that the smaller the home base, the greater the need for internationalisation. The overall European decrease is borne mostly by firms from large countries, Germany (-12%), United Kingdom (-10%) and France (-30%). If the French situation can be explained by the drastic transformation of a few firms (namely Alcatel-Lucent and Sanofi-Aventis), it is more difficult to explain the behaviour of large German firms that contribute to 58% of the total patenting by large European firms in 2003-2005 and to 83% of the total increase in patenting by these firms over the period. The global decrease of the internationalisation of German firms results from the decline of distant R&D investments by one third observed in the German firms that were the most internationalised in 1994-1996[8]. Moreover, the growing share of traditionally weakly internationalised sectors (such as car manufacturers) among the German corporate applicants also contributed to reduce the overall internationalisation[9]. The reasons of this German contraction would require further in depth analysis since available research on German firms mostly focuses on the role of the mid-sized firms (the famous "Mittelstand"), but has never highlighted the very domestic approach of large German firms in sourcing technology.

4.2.3- New patterns of internationalisation of R&D

In a further step, we examine whether the modifications of trends in the internationalisation of R&D have changed the patterns of internationalisation i.e. the respective attractiveness of continents when considering both the locations of firms and of inventors. To this end we compare the

[7] Even if we take into account the effects of the 3 major firms, which have radically changed of configuration during the period through mergers and acquisitions (2 French firms, Alcatel-Lucent and Sanofi-Aventis, and one British firm, Vodafone), the overall decrease remains (from 35.5% in 1994-1996 to 28.8% in 2003-2005).

[8] Such trends are observed in various sectors such as Chemicals (BASF, Bayer, Linde), General industries (J.M. Voith), Household goods (Henkel), Car equipment manufacturing (ZF Friedrichshafen), Metal industry (Thyssenkrupp), Industrial machining (Knorr-Bremse).

[9] The contribution of car manufacturers to German corporate patenting has progressed from 11% to 15% over the decade. Their internationalisation rate was around 8% in 2003-2005.

contribution of continents considered either as the origin of R&D international firm investments (identified through the patent applicants) or as the destination of the R&D international firm investments (identified through the location of inventors appearing in international patents). In 2003-2005, Europe is the dominant actor in the internationalisation of firm R&D investments. The old continent is the first location of origin of international investments (43.3% of the foreign investments) and also became, by far, the most attractive place as destination for international R&D firm investments (45.7% of the foreign investments) (Table 5). Comparatively, a share in the range of 20% to 30% came from the US (27.5%) or Asia (28.9%), or went to the US (21.8%) or to Asia (28.3%).

In the mid-1990s Europe already dominated, being the first place where international investment originated from (65.9%) and both Europe and US performed at the same level as attractors for investments from other continents (with respective shares of 42.1% and 46.4%). A decade later, the *strong growth of Asia,* both as the origin (28.9%) and destination (28.3%) of R&D international investments drives to a different pattern, detrimental to Europe (in matters of origin of investment) and to the US (in matters of destination of investment). The US, as recipient of international investments, witnessed a drastic reduction of their share, from 46.4% to 21.8% over the decade.

The lasting relative attractiveness of Europe for foreign firms and the striking loss of attractiveness of the US for non-US firms over the decade are very important results that have not been highlighted before.

Table 5: Host continents and origin continents of firm international patenting in 2003-2005 and 1994-1996

Country or continent	**Share of international patents (%)**	
	according to the location of firms	**according to the location of inventors**

	2003-2005	1994-1996	2003-2005	1994-1996
United States	27.5	23.0	21.8	46.4
Europe	43.3	65.9	45.7	42.1
Asia	28.9	10.7	28.3	7.0
Total	100.0	100.0	100.0	100.0

In terms of overall dynamics, it is thus worth noting that behind an apparent stabilisation of the R&D level of internationalisation lies a combination of different continental trends. Asian firms exhibit a lasting quasi-exclusive reliance on national sources of invention. While US firms have undergone a progressive movement of internationalisation, European firms have increased their reliance on national sources (nearly 70%) and concentrated their technology efforts within Europe.

We propose an organisational explanation for the diverging trends between US and European firms. Assuming that the European Union is now an effective economic space for European firms the global (i.e. summing national and continental contribution) reliance on their continent for US and European firms are quite similar (respectively 84% and 87%). This high level of proximity R&D investments enables firms both to benefit from surrounding skills and opportunities and to lower the possible high costs of distant internationalisation. This follows evidence given by Picci (2010) on the negative effect of distance on internationalisation. This raises a key question: are we witnessing a transition, or can we make the hypothesis that institutional and organisational complexities drive the development of a "plateau" for long-distance reliance concerning technology sourcing?

Section 5. Locational strategies of MNCs: a turning point in the growth of home-base-augmenting strategies?

Does the overall stabilisation of internationalisation of R&D observed go along with a stabilisation of rationales for investment abroad? Or do we witness, as with the (different) continental dynamics, an evolving balance of motivations to internationalise? As previously done by Patel and Vega (1999) and Le Bas and Sierra (2002) we use Revealed Technological Advantage (RTA) indexes to classify firm internationalisation strategies in four types ("home-base-augmenting", "home-base-exploiting", "technology-seeking" and "market-seeking")[10].

5.1- Internationalisation locational strategies: the situation in 2003-2005

As shown in previous studies we have found that strategies corresponding to situations where the firm is more specialised than its home country (home-base-exploiting and home-base-augmenting) are prevalent in our overall population, gathering 82% of firms' international inventions (Table 6). The home base remains thus critical, which means that our results do not sustain the assertion of Doz and al. (2001) when they suggested that firms were becoming "metanational"[11]. Both strategies are quite balanced, even if HBA strategies are slightly more important: 42.5% against 39.4%. Only one invention in ten corresponds to firms that look for a technology in a foreign specialised country while they are not specialised in their home country. Finally, 'pure' market-seeking strategies (MS) remain quite rare (8.3%).

Table 6 - Firm rationales for internationalisation in 2003-2005 and 1994-1996

Country or continent of firm	Locational strategies (%)							
	HBA motivations		HBE motivations		TS motivations		MS motivations	
	2003 -2005	1994 -1996	2003 2005	1994 -1996	2003 -2005	1994 -1996	2003 -2005	1994 -1996
United States	51.1	49.5	30.9	31.7	9.3	10.9	8.6	7.9
Europe	40.9	44.0	37.6	35.2	11.7	11.4	7.8	8.4
Asia	35.8	25.3	50.0	42.7	6.4	14.9	7.8	17.2
Total	42.5	43.3	39.4	35.7	9.8	11.7	8.3	9.3

[10] Dalum and al. (1998) have suggested another algebraic expression for RTA, the symmetric RTA. The first exploration made with our data shows that the use of this different expression does not really change the findings.
[11] Metanational large firms "do not derive their competitive advantage from their home country or from a set of national subsidiaries" according to Doz and al. (2001).

Total without Japan and Korea	43.8	45.7	36.9	35.0	10.9	11.1	8.4	8.2

Again we find significant differences between continents. US and Asian firms widely differ: for US firms, the balance is clearly in favour of looking for complementary technologies (51% HBA against 31% HBE) while Asian firms is clearly prefer exploiting home assets (50% HBE against 36% HBA).

The situation of European firms, and in particular of German firms, reflects the average world situation even though firms from the UK, France and the group of small countries exhibit different behaviours (Table 7). "Technology-augmenting motivations" are quite similar between firms from the UK (52.5%) and small countries (47.9%). French firms exhibit a specific profile with "assets exploitation motivations" (HBE) well above continental average (42.7% vs. 37.6%), and the share of firms relying on foreign inventions in technologies where they have no domestic specialisation (TS and MS) is far greater than the continental average (30% vs. 20%). The comparison of the behaviour of European firms shows first that there is no clear relation between the degree of internationalisation of the country and a given pattern of strategic motivations, and second that firms from small countries, despite the fact that they do not have at their disposal a large domestic base, do not rely far more on "home-base-augmenting" strategies than firms from larger countries.

Table 7 - European firm rationales for internationalisation in 2003-2005 and 1994-1996

Country of firm	Locational strategies (%)							
	HBA motivations		HBE motivations		TS motivations		MS motivations	
	2003 -2005	1994 -1996	2003 -2005	1994 -1996	2003 -2005	1994 -1996	2003 -2005	1994 -1996
Germany	41.2	37.6	36.8	41.5	12.9	12.0	9.1	8.9
France	27.7	40.8	42.7	34.0	17.1	11.8	12.5	13.3
United Kingdom	52.5	65.2	37.5	29.5	2.9	2.0	7.1	3.3
Small countries	47.9	43.2	35.6	37.3	12.1	13.6	4.4	5.8

5.2- Towards a new trend in R&D investment motivations?

Our results for 2003-2005 are largely in line with those described both by Patel and Vega (1999) and Le Bas and Sierra (2002). Changes that have occurred have thus been slow and reduced. Even if limited, we consider these results meaningful. When excluding Japan and Korea, the comparison of the overall situation in 2003-2005 with the one monitored one decade before (using our quasi-indicator), shows a slight but significant decrease of the overall weight of the HBA motivations (from 45.7% to 43.8%) associated with a slight increase of the share of HBE motivations (from 35.0% to 36.9%). When considering the data for all the firms (i.e. including Japanese and Korean firms) the decline of HBA strategies is less pronounced but the rise of HBE ones is more pronounced (above 4 percentage points).

This is in clear contrast with the conclusions derived from the literature review that allow anticipating a continued growth of home-base-augmenting motivations. There is thus no visible movement towards an increasing search for complementary competences. Even if a longer time frame is needed to confirm this trend, we might face a new equilibrium between the two dominant motivations.

Once more we observe different continental dynamics. US firms with more than a quarter of their international patenting in Asia, follow their own pattern increasing their overall share of HBA motivation by 1.6 points between 1994-1996 and 2003-2005, while reducing by 1 percentage point the share of HBE motivated patents. In Asia, we witness a similar but far stronger increase of HBA-motivated patents, with still HBE-motivated patents remaining more important, showing an important relative growth (from 42.7% to 50%). This underlines the changing positions of Asian firms that have aligned with the rest of the world and invest more and more in technologies where they are overspecialised in their home country (85.8% of HBA or HBE patents in 2003-2005 against 67.9% one decade before). Again, European firms are at the core of the evolutions, and this

trend is massively borne by French and UK firms with, for both countries, a reduction of the share of HBA motivated patents counter-balanced by a similar increase of HBE motivated patents.

To further characterise the underlying locational strategies, we now focus on recipient continents and analyse the strategies that correspond to the patents from foreign firms. Table 8 shows that Europe is the preferred location for foreign firms both for technology driven and market driven strategies (HBA driven patents have a world share of 51% and HBE driven patents a world share of 37.5%). This leading role for technology driven strategies interestingly stands true for all major European countries (Table 9). A second critical result lies in the important role taken by Asian countries: they become in 2003-2005 the second most important continent for both types of home base strategies. This highlights the reduced role played by the USA as a location for foreign technological activity with, further more, a far greater emphasis of home base exploiting compared to home base augmenting strategies. These results contradict much of the anecdotal evidence gathered on the basis of selected (and often limited) case studies[12]. However they are in line with NSF (NSF, 2014) results that show that foreign investments by multinational firms have been at a plateau between 2000 and 2008 (between 13 and 15% with 13.9% in 2008) and that these results concerning investment take into account a rapidly increasing share of 'non manufacturing' firms (from 16% of the total in 1998 to 31% in 2005) which we expect to be less prone to patent. As we consider the dataset as quite robust, we think that further research using other approaches should be developed to deepen the present results and to test how much they are linked to the shifts observed in the industrial structure of the US economy.

Table 8 – R&D internationalised by host continents and type of locational strategies (2003-2005)

[12] Furthermore, many of the papers we have examined have focused more on new technological firms than on the largest European firms.

Country or continent of inventors	Locational strategies (%)			
	HBA motivations		HBE motivations	
	2003-2005	1994-1996	2003-2005	1994-1996
United States	15.1	44.6	27.1	48.5
Europe	51.5	42.8	37.5	40.2
Asia	27.8	9.2	31.6	5.5
Total	100.0	100.0	100.0	100.0

Table 9 - Host key countries of firm international patenting 2003-2005

	Internationalisation R&D strategies (%)		
Country of inventors	**HBA motivations**	**HBE motivations**	**Total**
United States	29.6	49.2	100.0
China	36.6	53.3	100.0
Japan	45.9	37.8	100.0
Germany	46.7	35.6	100.0
United Kingdom	51.2	27.9	100.0
France	50.7	26.9	100.0

To sum up, this research brings three unexpected results. Firstly, European attractiveness regarding foreign corporate R&D investments over the decade has been steady, and this is based on the reinforced technological attractiveness of European countries. In contrast, the decline of the US as an attractive place for technology sourcing for our sample of large MNCs is a real surprise, and this regression is not only relative but also absolute. It is even more striking to see that "technology-based" motivations have declined more than "market-based" motivations. A third surprising result

is the growth of Asia as an inventor location for international patenting, mostly borne by the growing attractiveness of China for firms from other Asian countries.

6- Conclusion

By developing a new dataset of the patent portfolios of large firms, our objective was to contribute to the debate on the internationalisation of their R&D activity. The literature mainly based on developments that took place in the 1990s has postulated two main trends: 1) a *growing* internationalisation, 2) increasingly justified by *knowledge augmenting motives* rather than for exploiting the knowledge of the home base. Our results tend to contradict these postulates.

Overall the levels of internationalisation in 2003-2005 remain very similar to those observed by studies conducted one decade ago: 7% at world level and just over 20% excluding Asian countries. Our proxy-measure of technology dynamics shows that (Asian countries excluded) the overall rate of R&D internationalisation reveals a slight decrease; a striking result vis-à-vis the state of the art known to date.

This stems from a combination of three diverging continental trends. The level of internationalisation of US firms has almost doubled but it still remains below the observed world average when excluding Asian countries. The growth in patenting by Asian firms has been impressive but it still does not translate in any significant increase in their degree of internationalisation, which remains low (less than 3%), and furthermore centred on Asia. Thirdly, European firms that were at the core of R&D internationalisation processes during the previous decade, have witnessed a movement of 'organisational consolidation' (as emphasised by Gammeltoft, 2006): most have re-centred their inventive activities on their home country and refocused their international activities in other European countries.

Similarly the fact that the level of internationalisation has not significantly changed does not entail a stability in the patterns of internationalisation: the relative share of recipient countries of

international patenting by large firms has widely changed: the US as a host country has seen its role halved (to 22%) in one decade while Europe remained as attractive (45%). The difference (some 20%) is linked to the emergence of China as a major inventors' location for international patents mostly for firms from its own continent.

Altogether, when looking at "intercontinental" inventive activities, these contradicting trends between European and US firms drive to an interesting convergence: both groups of firms now stand at around 15%. This raises one conclusion and one question. The conclusion: our findings give more relevance to the trade-off (home country centralisation/foreign country dissipation) pictured in section 2. It may be that at a certain level of R&D internationalisation factors now play a role in favour of "home" country re-centralisation, a situation that is further reinforced if we consider the European Union as a "quasi-home country" for European firms. For instance, academics have put forward the importance of transaction costs (Iammarino and McCann, 2013) and the idea that less efficient knowledge transfers within multi-national firms are gaining importance (Sanna-Randaccio and Veugelers, 2001). And the question: could this figure of 15% represent a type of plateau, beyond which, as suggested by Gammeltoft (2006), organisational issues become too complex to be efficiently managed? Clearly, further analysis is required on more recent trends.

As far as the different firm strategies regarding international patents are concerned we do not confirm the trends witnessed previously nor the postulates made about the growing role of HBA motivations and a retraction of the HBE ones. Technology-based motives (asset augmenting strategies) are still the most important motives, but they only slightly overcome R&D internationalisation motivated by market-based considerations (HBE). When using our quasi-indicator of dynamics, we witness over the period a slight decrease of HBA motives and more importantly a significant and unexpected increase of HBE motives. These trends hold when we exclude Asian firms. These results *strongly confirm the importance of the home base technology for*

firms: firms go abroad for augmenting or exploiting their home base, not for acquiring new bits of knowledge outside the technologies they master at home.

Once more there are striking regional differences that lie behind this overall quasi-stability; but they concern more the geographical areas that host the inventors of international patents than the firms origin. More than half of firm R&D foreign investments in Europe stem from technology motives (HBA), while the share is only around 30% for the US and China, where clearly market motives (HBE) prevail. For the US this is a radical reversal compared to the situation one decade earlier, when technology motives were as important as market motives. It is important to verify if these trends observed before the financial crisis still hold.

Two results are very critical to this work, and require further consideration and testing: one deals with the very specific international technological profile of large German firms (as raised in the conclusion of section 4.2.2) and the changing attractiveness of the US as a recipient country for international technological investments (as highlighted in the conclusion of section 5.2). We hope they will generate new work to confirm and deepen our understanding of these phenomena.

All in all, we consider that this quantitative and systematic analysis allows us to underline caveats on generalisations previously made from case study analyses and by quantitative analyses done one decade ago: neither has there been a strong growth in the internationalisation of inventive activities, nor is internationalisation driven mostly by home-base-augmenting motives. One important result is that these results derive from a combination of very different continental dynamics in terms of the dominant strategies by firms headquartered in these continents, in terms of attractiveness for firms from other continents and in terms of the balance of technology investments the different continents attract.

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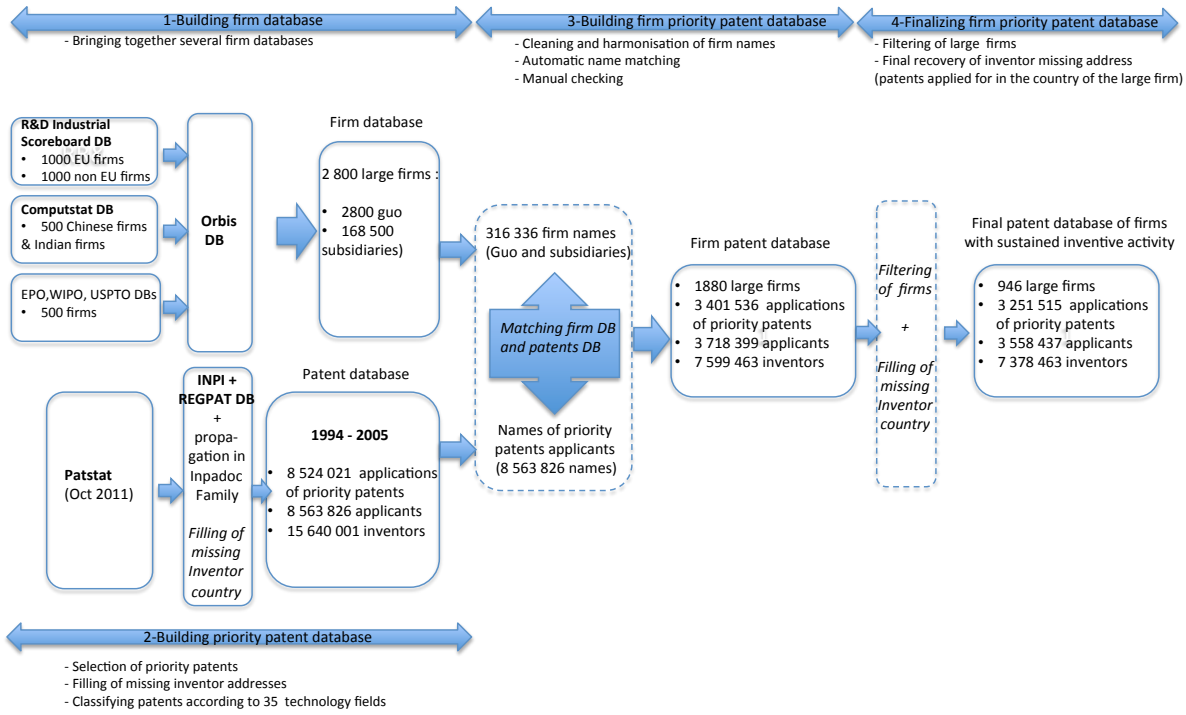
Appendix: Building and characterisation of the large firm database

Our large firm priority patent database was built combining several existing databases. Figure 1 gives an overview of the four main steps leading to the creation of the firm patent dataset used in this research work.

Figure 1 – Overview of the building of the firm patent database



Our first data source is the "Industrial R&D Investment Scoreboard" (2008 edition) that lists the 2000 industrial companies (1000 based within the European Union, 1000 outside) with the highest annual R&D investments. This initial set was complemented with 500 Indian and Chinese firms declaring R&D investments between 1999 and 2009 in the Computstat database and with the 500 most important firms as assignees of WIPO[13], EPO and USPTO patents. Then using the Orbis

database edited by Bureau van Dijk Electronic Publishing we defined the *global ultimate owner* (GUO) for each of the firms and identified all subsidiaries in which one of the GUOs had more than 50.01% of shares. We ended with a list of 2800 GUO and 168 500 different subsidiaries. Using the data cleaning and harmonizing methodology developed by Magerman et al. (2006), we prepared a list of cleaned GUO and subsidiaries names that was further enriched by adding firm acronyms, firm old names and standardized names from the Patstat database. The final list of firm names contained 316 676 different names. The final issue was to define the home country of the firms. Following the practice of the "Industrial R&D Investment Scoreboard", the home country of the firm (GUO and all its subsidiaries) was defined according to the location of the GUO headquarters.

We used the Patstat database version October 2011 provided by EPO and selected all priority patents (appln_kind ='A' or 'W') applied for from 1994 to 2005 without any patent office restriction. It contained 8 524 021 priority patents, 8 563 826 applicants and 15 640 001 inventors. In the initial dataset only 7 429 485 patents reported a piece of information on inventors and 5 862 294 inventors among the 15 640 001 inventors (and 4 765 672 among 8 563 826 applicants) had a residence country. The recovery of missing information of the inventor residence country was carried out following two successive steps: first, by matching the Patstat database with two additional databases from INPI (the French patent office) and from OECD (REGPAT); second, by retrieving country information displayed in other patents from the same Inpadoc family. Both steps allowed to assign 1 561 486 new residence country to inventors. Complementary information retrieved from the database was the application filing year and IPC categories. Patent technological classification in 35 technology fields was realized according to the WIPO classification.

The search for firm names in the names of patent applicants was carried out using very strict rules in order to limit the retrieval of false positives (the volume of firm patents may thus be slightly underestimated). The 316 676 firm names were matched with all the applicants standardized names

[13] World Intellectual Property Organisation, the international organisation that deals with all geographical patent extensions.

of priority patent applications in the Patstat database. Basically matching the firm database and the patent database was carried out in two ways: matching both name (exact spelling and proxy) and firm country of our firm list with Patstat applicant standard name and applicant country when this latter information was present in the Patstat database and only exact firm spelling of our firm list when the applicant country information was missing. Manual checking was carried out to discard falsely retrieved patents. 1880 large firms of our initial set of 2800 large firms had applied for at least one priority patent from 1993 to 2005. The total number of priority patent applications was 3 401 536. They involved 7 378 463 inventors. Information of their residence country was still missing for almost 70% of the inventors (98% of them were inventors of patents applied by Japanese large firms).

Lastly for patent applications with no information on inventor residence country we hypothesized that when a patent was applied for in the country of the firm headquarters the residence country of the inventor is this very country (i.e. of the firm headquarters). This step filled almost exclusively the country of residence of inventors for Japanese large firms that applied for priority patents at JPO (98%). To test the validity of such a large recovery of country information for Japanese inventors we have also investigated the situation of priority patents of Japanese firms where the inventors were known to be located in Japan. We found that 99.7% of the patents from Japanese firms with inventors located in Japan applied for their priority patents in Japan. Therefore our massive recovery of missing residence country in Japan is consistent with what was found initially in Patstat. Attribution of patents to inventor countries was calculated using a fractional counting on the residence country of the inventors. Attribution of patents to large firms was calculated using a fractional counting of the number of large firms as applicants[14].

[14] A patent with three inventors, one located in France, one located in Germany and one with no residence country is counted as 0.5 for France and 0.5 for Germany. A patent shared by two large firms is counted as 0.5 for each firm.

As a final step, we restricted our large firm patent dataset to firms that applied for at least 5 priority patents in the 1994-1996 period of time and in the 2003-2005 period of time. We ended with 946 firms, 706 524 priority patents for 1994-1996 and 882 895 priority patents for 2003.

They covered more than 60% the word priority patents in 1994-1996 but only half of them in 2003-2005. Discarding patents of Japanese inventors, the firm share dropped to approximately 30% of the world priority patents and remained stable over time. Japan displays a quite unique situation where more than 90% of the inventions originate from large firms (however decreasing due to the action of a law similar to the Bayh-Dole Act in 1999). This share stands between 30% and 40% in North America and between 20% and 30% in European countries. It has significantly declined between the two periods in the United States (possibly due to the increasing contribution of start-up to US overall patents) but has progressed in European countries.

North America where 35% of the large firms are located only account for less than 12% of the firm patents (either taking into account North American firms or North American inventors) (Figure 2). Similarly European firms that represent 35.7% of the total firms only totalize around 10% of the patents and 60% of the European patents originate from German firms. Asian firms only account for 27% of the total firms but contribute to more than 2/3 of the firm patents. Japan firms have the lion share with more than 60% of the total large firm patents. The distribution of patents according to the country of the firm or the country of residence of inventors shows similar trends (over representation of patents originating from Asian firms or inventors, similar contribution of North America and Europe).

Figure 2 – Distribution of firms and patents according to firm headquarters location or residence of patent inventors

Country	Firm share (%)	Patent share by firm country 2003 -2005 (%)	Patent share by inventor country 2003 -2005 (%)
North America	35.2	11.8	11.6
United State	34.0	11.5	11.2
Europe	35.7	9.8	10.3
Germany	9.2	5.9	6.4
France	5.3	1.6	1.7
United Kingdom	6.2	0.5	0.6
Italy	1.2	0.1	0.2
Small countries	13.8	2.1	1.4
Asia	27.2	78.0	77.7
Japan	23.2	62.0	61.4
Emerging countries	3.3	15.9	16.1

Country	Firm share (%)	Patent share by firm country 2003 -2005 (%)	Patent share by inventor country 2003 -2005 (%)
Switzerland	2.9	0.47	0.24
Netherlands	2.5	0.43	0.17
Belgium	1.3	0.06	0.12
Austria	0.5	0.04	0.17
Luxembourg	0.1	0.10	0.01
Liechenstein	0.1	0.20	0.0
Sweden	2.9	0.51	0.31
Finland	1.9	0.41	0.32
Denmark	1.2	0.05	0.06
Norway	0.5	0.04	0.05

Country	Firm share (%)	Patent share by firm country 2003 -2005 (%)	Patent share by inventor country 2003 -2005 (%)
Korea	1.5	13.66	12.97
Taiwan	1.2	0.98	0.74
China	0.4	1.28	2.35
Singapour	0.1	0.01	0.05
Hong Kong	0.1	0.01	0.01