

A CASE FOR NON-GLOBALISATION?

STRATEGIC R&D IN WIRELESS TELECOMMUNICATIONS



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ABSTRACT

The off-shoring of manufacturing has been the most visible ingredient of economic globalisation in recent years. However, the rapid change in the global division of manufacturing has overshadowed another phenomenon, namely the internationalisation of Research and Development (R&D) and inventive activities of firms. In concrete terms this means that researchers and inventors increasingly tend to be located outside the domestic country of origin of companies, as captured in numerous empirical studies. Pressing research questions thus concern the degree to which inventor networks are internationalising, which types of R&D this covers, and how this internationalisation affects the R&D strategies of companies and their home countries. This paper

contributes to these questions by revisiting the “non-globalisation” argument in the specific context of strategically important technologies in a truly global industry

by the face of it, namely the wireless telecommunications industry. In a comparative set-up, the notified essential patents of four leading incumbents are analysed to assess to what degree and how R&D and inventive activity of this technological core of the industry is globalising. Contrary to expectation, results clearly support the case for non-globalisation and suggest that modifications have to be made to sweeping generalisations concerning the internationalisation of R&D. They also raise important issues and new research paths related to the organisation of R&D, locational advantages and the Intellectual Property Rights management of firms.

KEYWORDS

globalisation, R&D, wireless telecommunications, essential patents

1. INTRODUCTION

1.1. BACKGROUND

Heightened international competition implies that globalisation is a topical issue for policymakers and firms alike. Although individuals, firms and countries always have been connected in various ways throughout history, commentators usually claim that globalisation has reached a new phase at the dawn of the 21st century. This is typically considered to be the

outcome of the combined effects of liberalisation of world markets and technological change, especially concerning information and communication technologies (ICT). In short,

globalisation might be defined as “the high and increasing interdependency and interrelatedness among different and geographically dispersed actors” (Archibugi and Iammarino, 2002: 99).

From the viewpoint of firms, foreign direct investment (FDI) and the off-shoring of manufacturing has been the most visible trend of globalisation. However, rapid change in the global division of manufacturing has hence far overshadowed another perhaps even more significant phenomenon, namely the rapid internationalisation also of research and development (R&D)

(UNCTAD, 2005). This means that researchers and inventors generating these inventions increasingly tend to be located outside of firms' domestic countries of origin. Indeed, several studies have recently documented that a growing share of inventions of multinationals involve foreign inventors. This trend appears to be especially clear in the case of technologically leading multinationals originating from smaller countries (see Patel and Vega, 1999; Guellec and van Pottelsberghe de la Potterie, 2001; Hayashi, 2004; and Cantwell and Kosmopoulou, 2004).

The internationalisation of R&D is a multidimensional issue that needs to be analysed from various viewpoints and for which specificities of both the nature of R&D and technologies have to be taken into account. In particular, a seminal – and perhaps long-forgotten – paper by Patel and Pavitt (1991) points out that the actual inventive activities of multinational corporations (MNCs) tend to be significantly less internationalised than the global distribution of the R&D expenditures seem to suggest, with considerable variations across technological sectors. Patel and Pavitt (1991) suggest that this might be due to the fact that country-specific characteristics of national systems of innovation still matter for the core R&D activities of MNCs, highlighting such issues as the importance of physical proximity and tacit knowledge, education, training and basic research. Patel and Vega (1999) provide additional evidence regarding the importance of country-level effects to explain inventive location decisions.

1.2. AIM AND STRUCTURE

Against this general background, this paper analyses the internationalisation of R&D of a set of major firms in core technological fields of the wireless telecommunications industry. It aims to assess the degree to which there is room for the 'case of non-globalisation' in the sense of Patel and Pavitt (1991) referred to above. An analysis of the wireless telecommunications industry from this viewpoint is particularly interesting for three reasons.

First, the wireless telecommunication industry has probably benefited the most from trade liberalisation, deregulation, and technological change, as governments across the globe are developing and upgrading their ICT infrastructures (Zysman and Newman, 2006). Secondly, the industry is also changing its technological core due to the convergence of data and telecommunications and the emergence of the Internet, thus providing

multiple entry points for firms and inventors, also from new geographical locations outside the United States (US) and Europe. Third, due to the significance of standardisation, a system of notification of patents deemed essential to specific standards has been established. This system provides an interesting analytical lens for identifying R&D and inventive activities that lie the closest to the technological core of the industry in a strategic, and perhaps also, in a commercial sense.

The paper should be read as a descriptive and explorative study relating to the collaborative Berkeley University Roundtable on the International Economy and Research Institute of the Finnish Economy (BRIE-ETLA) project, to be both elaborated upon and deepened in subsequent papers to follow. It opens the discussion on globalisation of R&D by considering patents deemed essential from the viewpoint of standardisation in the wireless telecommunications industry in a comparative setting. Its overreaching aim, more precisely, is to address the following two research questions:

- 1. To what extent** are networks of inventors of so-called essential patents of a set of significant MNCs in the wireless telecommunications industry globalised?
- 2. What does the** international composition of inventor networks of essential patents suggest about the organisation of R&D and inventive activity in this particular industry?

The paper is structured as follows. The second section provides a brief conceptual discussion of major interpretations of why R&D is internationalising, combined with some insights into the specificities of the wireless telecommunications industry. The third section discusses the data we use and provides an empirical analysis based on recently collected data for essential patents notified to the European Telecommunications Standards Institute (ETSI). The fifth section synthesises and concludes the paper.

2. THE INTERNATIONALISATION OF R&D

A recent UNCTAD (2005) report offers a comprehensive overview of international trade and investment. According to this report, in considering overseas investment in R&D, three general observations emerge. First, R&D still seems to be the least internationalised of all functions performed by a MNC.

Nonetheless, the second observation is that the degree of internationalisation of R&D is increasing rapidly as suggested by both the popular press and numerous research papers based on data on R&D expenditures, patenting, strategic alliances, etc. (see e.g. Hayashi, 2004, Ali-Yrkkö and Palmberg, 2006). The third observation is that FDI related to R&D is relatively concentrated in a few areas of the world, namely in the highly developed incumbent countries such as the US, Japan and European countries, and mainly occurs across the borders of these countries.

A recent and increasingly significant phenomenon, internationalisation of R&D deserves attention, as the competitiveness of MNCs – as well as the development of regions and countries where they are headquartered and locate their R&D labs – is at stake. In the literature one can find three main explanations for the internationalisation of R&D that also shape research agendas and the policy discussion. The first of these explanations relates to the general international expansion of MNC export activities. As MNCs expand their export activities for existing or new markets, they also need to invest more resources into understanding the specificities of foreign markets in order to adapt their products to different needs and demands. In this case, R&D activities offer support to export expansion, as knowledge generated in the central R&D lab – typically in the home-country – is applied to the foreign market. (Dunning, 1958; Hymer, 1976). Because MNCs’ desire to enter new markets is the main driver of this form of internationalisation, it is often labelled ‘home-based exploiting’ as its priorities are to exploit home-based knowledge advantage through foreign activities (Kuemmerle, 1997).

In his survey of FDI in the US, Kuemmerle (1999) suggests that during a more recent wave of globalisation, a substantive change in the form of R&D internationalisation took place. Today, companies do not go abroad merely to exploit home-based knowledge for foreign markets, but also to learn and explore foreign knowledge which is located in deep pockets overseas. Even though demand is still today recognised as the main driver for FDI, Dunning (1994) recognises that host countries might also be “sources of new knowledge and not only new

markets” as the second explanation for the internationalisation of R&D. Dunning (1998) uses the ‘ownership, localisation, internalisation’ (OLI) framework (these being the three main sources of advantage and motivation of a firm’s FDI activities) to justify the existence of asset seeking FDI driven by access to knowledge intensive factors of production embedded in the locations where the MNC invests. Kuemmerle (1997, 1999) distinguishes this type of FDI in R&D as ‘home-based augmenting’ to contrast it with ‘home-based exploiting’.

Access to and use of cheaper factors of productions for the more labour intensive phases of an R&D project has become a progressively more important third explanation for the internationalisation of R&D. This explanation finds some parallels with internationalisation of manufacturing due to increasing modularisation of products and systems (Brusoni et al., 2001). The regional economics literature is pertinent in this context. This literature suggests

that as the marginal costs of critical factors of production – such as human labour – become more expensive in core regions of the highly industrialised countries, low value added production activities are increasingly transferred to peripheral locations (Vernon, 1960). This phenomenon is self-enforcing as both core and peripheral regions build-up a specialised labour force, intermediaries and supporting industries, as well as tacit know-how related to specific activities (Krugman, 1991).

Even though our empirical analysis does not directly address the cost advantage explanation for the internationalisation of R&D, it is important to acknowledge its possible presence. Global players might decide to relocate the most labour-intensive phases of their R&D effort to regions that are desirable not for the size or growth rate of their market, nor for other cutting-edge R&D activities located in the area, but simply because of the availability of qualified and cheap technical expertise. The development of ICT infrastructures is now making available qualified and cheap human capital located in rapidly developing countries (most notably India, South East Asia, China) and transitional economies (Eastern Europe). This has, in turn, already led to the delocalisation of low-end support service functions. It is very likely that firms that have not already under-

gone a delocalisation of back-office operations will now look at the same locations as possible sites for parts of their R&D operations.

The seminal work by Patel and Pavitt (1991) is possibly the first comprehensive empirical effort to provide evidence of the internationalisation of R&D using patent data, thus sharing some features of the empirical part of this paper. In a series of empirical papers using the inventors of patents' affiliations to identify the location of inventive activity, they show the overwhelming importance of home-based innovative activity for the main MNCs during the period from 1969 to 1986. The conclusions were surprising as they clearly highlighted the importance of 'non-globalisation' of these MNCs' innovative activities. In particular, Patel and Pavitt (1991) suggest that for most cases, these companies "have a long way to go before their technology activities become anywhere nearly as globalised." Only tentative explanations of this need for physical proximity are offered by the two scholars, relating to market uncertainties and characteristics of the local innovation systems, such as proximity to relevant and tacit sources of knowledge or to facilities incorporating and integrating multidisciplinary knowledge.

Despite general evidence for the internationalisation of R&D we do also find further cases for non-globalisation in studies in the tradition of Patel and Pavitt (1991) that distinguish between different types of R&D and inventive activity. Patel (1996) revisits the original argument in considering US companies. He finds non-globalisation to be important when there is a strong emphasis on the role of supply side factors (e.g. R&D infrastructure, education levels, knowledge inputs) in firms' decisions concerning the location of R&D. Further, Patel and Vega (1999) and Le Bas and Sierra (2002) suggest that companies tend to go abroad and tap into technological areas where they already have strength in their homebound R&D.

Bergek and Berggren (2004) also conclude, in an industry specific case study, that innovation is largely homebound and international flows are largely cross-Atlantic for large companies in the electro-technical industry. Significant organisational challenges limit the extent of globalisation of critical R&D activities of Japanese companies, according to Asakawa (2001), whereas Belderbos (2001) suggests that the comparatively weaker internationalisation of the Japanese electronics indus-

try could be due to the fact that these companies started to source their technologies globally relatively late (for further cases on non-globalisation in specific cases see e.g. Kumar, 1996, Morgan, 2004, and Rama, 1999).

Following this line of research on cases for non-globalisation of R&D – and inspired by one of the last remarks in Patel and Pavitt (1991), that "we expect to see greater internationalisation of large firms' technological activities in the future" – this paper contributes by re-assessing the case for non-globalisation in the specific example of strategic R&D in the wireless telecommunication industry as measured by essential notified patents.

3. GLOBALISATION, TECHNOLOGICAL CHANGE AND STANDARDISATION IN TELECOMMUNICATIONS

There appears to be very little to support the case for non-globalisation of R&D and inventive activity in the wireless telecommunications industry. For various reasons, not dwelt upon here, trade liberalisation has been particularly rapid in many high-technology industries, and particularly so in the case of ICT (see here Zysman and Newman, 2006) for a recent overview the industry's development). Apart from trade tariffs of the general kind, regulatory liberalisation has been particularly noteworthy and rapid during the last couple of decades.

Prior to the 1980s, most national telecommunications markets – even in the highly industrialised countries – were characterised by vertically integrated national monopolies in which telecommunications equipment production and demand largely was in the hands of the PTTs. The wave of regulatory liberalisation was set in motion in the early 1980s by the privatisation of British Telecom, NTT in Japan and the break-up of AT&T in the US, although it should be noted that decentralised markets were already in existence especially in Sweden and Finland where wireless telecommunications had taken-off earlier (Davies, 1994).

By the 1990s, the PTTs' vertically integrated monopolies had dissolved, while R&D and innovation increasingly shifted towards the producers of telecommunications equipment. Regulatory liberalisation and the emergence and diffusion of the global system for mobile communication (GSM) also gave

rise to the entry of many new producers and operators. Since the rise of GSM, this trend has strengthened further, especially through the opening of fast-growing markets in Eastern Europe and Asia (China being the most obvious example). The structure of demand has also widened significantly. Today any equipment producer that hopes to join the top-tier players must have a presence in hundreds of markets, and leading firms make their largest share of revenues, by far, outside their home base (Steinbock, 2003).

While trade and regulatory liberalization foremost has globalised demand for telecommunications equipment, technological change in the industry has had pervasive effects on R&D further upstream. One aspect of ongoing convergence – or fusion – between various technology subfields of ICT is that it opens up multiple entry-points for new firms and other players.

We use the term of 'ICT convergence' to refer to the merging of data- and telecommunications technologies which previously, until around the 1980s, were characterised as two separate fields. Consequently, a range of new products, services, applications, markets, policy and regulatory domains are also merging (Bohlin et al., 2000). Above all, the Internet has many important implications for telecommunications incumbents. The increasing popularity of the Internet means that mobile telecommunications applications and services also have to become compatible with the so-

called TCP/IP-standards. This is also evident in a range of standardisation efforts around the fringes of the core next generation standards (such as the 3G standard, UMTS in Europe), examples of which include the WAP forum, GPRS and EDGE standards (Kogut, 2004; Tan et al., 2004).

Standards define the technological interfaces to which firms must comply and thus create new markets. Standards are typically created throughout different types of consortia, clubs or industry groups consisting of carriers, manufacturing firms, standardisation bodies and other stakeholders (Leiponen, 2005). The technologies that the standards define become quite essential for firms to master. As a consequence, standardisation

bodies have set up various schemes to support notification and cross-licensing of intellectual property rights (IPRs) over such essential technologies in order to ensure that no single firm or other stakeholder might block the standardisation process itself. The existence of multiple – and potentially overlapping – technologies and IPRs act as an incentive for firms to invest much effort for managing their IPRs with respect to these various notification schemes (Bekkers, 2001; Bekkers and West, 2006).

Despite heterogeneity in the degree to which firms approach these issues, notification schemes add an important aspect to the globalisation of the telecommunications industry that we capitalise on in this paper. Specifically, these schemes delimit a subset of technologies that are at the core of the industry in a strategic longer-term sense, but that also should have a relatively higher technological and economic value. In the case of the European Telecommunications Standards Institute (ETSI – the European standardisation body), Bekkers (2001) suggests that IPR holders indeed do have strong incentives to lobby for their patents to be notified as essential. Inclusion in a standard opens up various strategy avenues and licensing revenue opportunities for the company. The success of these is ultimately tied to the success of the standard itself.

A possible implication of this is that companies disclose only those patent-based IPRs that they know extremely well, that they are convinced they can enforce and control further downstream in product development projects. During pre-standardisation, each assignee will have to lobby

and convince partners that a license to its IPRs is the most efficient way to solve a technological need, whereas designing around these might either be impossible or only a second-best solution. During this complex negotiation phase, not only the successful market adoption of a standard is on the line, but also the reputation of the IPR assignee. Thus, it seems safe to assume that these IPRs protect proprietary technologies that influence the trend of their technological activities and strategic choices in terms of commercialisation. Framed in this way, the question of the degree to which this part of the R&D activities of companies is globalised or not is an important one in the cur-

rent debate about the internationalisation of R&D and the interpretations thereof.

Apart from the strategic importance of essential patents, there is a debate about whether or not these types of patents might also be more significant in terms of their technological and economic value. A recent paper by Rysman and Simcoe (2006), analyses the notifications schemes of four major international standard setting bodies via looking at the degree to which notified IPRs (patents) score higher in terms of technological content than non-notified ones. Some evidence is provided that such essential patents indeed also have a higher technological and also potentially economic significance. The paper by Rysman and Simcoe (2006) thus also suggests that the data we explore captures technologically and economically more significant R&D of the firms included although we do not wish to push this assumption too far at this stage.

4. EMPIRICAL ANALYSIS

4.1. METHODOLOGICAL CONSIDERATIONS

This section moves on to an empirical analysis exploring to what degree, and how, the technological core of the wireless telecommunications industry is globalising, and the degree to which the case for non-globalisation might still have some rele-

vance in this context in the vein of Patel and Pavitt study (1991). We compare patent data for the development of telecommunications standards, with a control group of similar but ultimately less strategic patents.

ETSI represents an important standard-setting body in the European context and thus functions as a natural point of departure for data gathering. ETSI has set up a notification scheme in which both members and non-members are requested to provide a written statement if their technologies and IPRs (patents) can be deemed essential to the development and inauguration of particular standards (see <http://www.etsi.org/>).

We here use patent data that originally was identified in the ETSI database for essential patents. This data can be accessed via online documentation containing lists of essential patents under various standards commissioned by ETSI. In particular, we consider the four largest assignees of essential ETSI patents, filed at the US Patent and Trademark Office (USPTO) during 1985-2001, and subsequently published before May 2006 (see Table 1). For these patents, we gather information about their technology classes, date of filing and publication, affiliation of inventors, scope of international protection and forward citations.

Table 1. Patents notified as essential at ETSI by companies

Company	Patents	Company	Patents	Company	Patents
Ericsson	241	Digital Theatre Systems	6	Marconi Communications	2
Qualcomm Inc.	143	Nexus Telocation Systems	6	3COM Corporation	1
Motorola	91	Samsung	6	Ensemble	1
Nokia Corporation	78	British Telecom	5	Entrust Ltd.	1
InterDigital Technology	66	Digital Voice Systems	5	France Telecom	1
Philips Electronics	29	Mitsubishi Electric	5	Innovatron	1
Hughes Network Systems	27	Sun Microsystems	5	Intel	1
SIEMENS	19	KPN	3	IPR Licensing	1
Alcatel	18	NEC Corporation	3	Microsoft Corp.	1
AirTouch Communications	15	NTT	3	Tantivy Communications	1
TOSHIBA Corp	14	OKI Electric Industry	3	Vimatix	1
Nortel Networks Ltd.	11	Ascom Management	2	Wi-Lan	1
Lockheed Martin	7	ETRI	2	Total	834
AT&T	6	Inmarsat Ltd.	2		

Source: Study calculations.

In order to assess the case for non-globalisation in the context of strategically important patents at the technological core of this industry we constructed a control group of non-notified patents. In order to define this set of patents we considered all the technology classes assigned to the essential patents. We then collected the complete portfolio of non-notified patents belonging to the same technology classes, assigned during the same period of time to the same four companies and their subsidiaries. With reference to the discussion above, we thus consider this control group of patents as being on average less strategic from the viewpoint of the activities of these firms on European and global markets. This assumption requires some clarification.

Patents are not commodities and their value distribution is often highly skewed as a large majority of patents assigned to companies have little to no intrinsic economic significance. By definition, control group patents have not been notified as essential to ETSI. This, however, does not exclude the possibility that at least some of them are extremely important for the company. We do not gather information about the current use of these patents, and we have no way of predicting their future use. Some of them might indeed protect critical aspects of a commercialised product, or they could be the object of profitable licensing contracts. Our assumption here is merely that on average the strategic relevance of patents is lower in the control group. Moreover, we are confident in claiming that the technological and economic value of patents in the control group is more heterogeneous at the very least. In other words, the event of having been notified with ETSI makes a patent strategically more relevant for the company even though it might not always be so in technological or economic terms.

Furthermore, a comparison of inventive activities of US and non-US companies based on patents filed and issued by USPTO suffers from a significant bias. Usually, when a company files for a patent, initially it seeks protection in its own country, filing a priority application. Subsequently, and only for a subset of patents, the company decides to file for equivalent patents to protect the same invention in each of the countries where the company is seeking to commercialise the related product. A patent assignee has a grace period (one year after filing in the US) to extend the international reach of its patents. However, since filing for international patents is significantly

more expensive, the company has to carefully screen its patents to select which ones deserve international protection. Although IPR strategies vary across firms, it is thus possible to assume that companies are likely to expand the international protection of patents for those inventions that have a higher chance of commercialisation.

While it is reasonable to assume that European companies file a US patent only for inventions that have already undergone this screening process, for US companies, a patent at the USPTO represents the easiest and possibly also the cheapest form of protection. Assuming this is true, when we consider USPTO patents assigned to European companies, we consider only a subset of the entire company portfolio. On the contrary, when we look at USPTO patents assigned to US companies we look at patents before a similar filtering was applied by IPR managers. Hence, in order to make patents filed by European companies comparable with those filed by US companies we look at the composition of the “international patent families” of each single USPTO patent.

A patent family is the collection of all international patents, filed with different national authorities, to extend the reach of protection of the same invention in different countries. We filter out from our analysis all USPTO patents assigned to the two US companies when – within each patent family – we find no equivalent patent or application filed with at least one European patent office. We use the Delphion Patent Family database for this procedure. For the sake of clarity, we will from now on refer to these two sets of patents as the ‘essential patents’ and the ‘control group patents’, stressing again that all the ensuing tables and figures contains data collected at the level of patent families subject to the modification concerning the USPTO patents as discussed above. The distribution across companies is shown in Table 2. Our descriptive analysis and the Chi-Square tests described later on in sections 4.2 and 4.3 refer to this data.

In the ETSI database we counted 1,113 USPTO patent notifications. Since each patent can be notified for more than one standard commissioned by ETSI, ultimately we counted a total of 834 unique, granted USPTO patents. Assigned to the four largest assignees are 64.4%, or 537, of these patents. As this analysis is a comparison of the inventive activities of MNCs,

the choice for these four companies was quite natural. Ericsson, Nokia, Motorola and Qualcomm are the largest assignees of ETSI essential patents. They are also the four most significant players in the wireless telecommunication industry in Europe and the US.

Table 2. Distribution of essential and control groups patents across companies.

	Total Patents (assigned 1985-2005)	Ericsson	Nokia	Motorola	Qualcomm
Essential Patents	537	241	72	85	139
Control Group	4,358	1,752	1,012	1,160	434

Forward patent citations, defined as the number of patents citing a specific patent, are used as a proxy for the usefulness and technological significance of each individual patent. For each patent we consider forward patent citations received in the two years after each patent was granted. Table 3 shows the ratio of two years forward citations for essential and control group patents.

Table 3. Distribution of forward cited essential and control group patents across companies.

Two years forward citations / Patents	Total	Ericsson	Nokia	Motorola	Qualcomm
Essential Patents	4.02	3.31	3.36	3.01	6.21
Control Group	2.31	2.12	2.15	2.47	3.03

Our discussion of a different strategic value of essential and control group patents finds some evidence in the patent citation analysis. Essential patents have an average forward citation rate which is higher than that control group. Essential patents, by definition, are patents whose commercial application and usefulness has been somehow certified through their notification. They are, therefore, more likely to get cited as relevant prior art by subsequent and related patents, than patents in the same technological classes that are not identified as essential ones.

The higher citation rate of patents by Qualcomm stands out. This holds for both essential and control group patents, even when controlling for the age of patents. Qualitative analysis undertaken with industry experts might be necessary to explain this. It seems that Qualcomm is developing technologies of a more generic (or enabling) nature, and as a result plays the double role of competitor and technology providers (in particular for the CDMA and 3G networks). Generic technologies are likely to receive more citations than more application-specific patents, since their range of use is much broader.

4.2. LOCATIONS OF INVENTIVE ACTIVITY ACROSS ALL COMPANIES

Information about the affiliation of inventors on the patent title is used as a proxy of the location where the inventive activity leading to the filing of the patent was performed (for a critical discussion of this definition of location of inventive activity, see e.g. Bergek and Berggren (2004)). The analysis assigns patents to the following three exclusive categories:

- 1. Domestic Patents (DO)** – patents whose inventors are all located in the HQ country of the controlling company: the US for Motorola and Qualcomm, Sweden for Ericsson, and Finland for Nokia;
- 2. Foreign Patents (FO)** – patents whose inventors are all located in countries other than the HQ country of the controlling company; and
- 3. International Collaboration Patents (CO)** – patents that have at least one inventor located in the HQ country and at least one inventor located in another country.

We decided to compare the US with single European countries since European countries are rather different types of entities when compared with US states. Besides the obvious cultural and linguistic differences, Europe is not yet a unique market as some factors of production, such as skilled labour, are not as mobile as in the US. Moreover, in spite of the growing integration between different IPR and legal systems, enforcement of IPR rights and settlement of disputes happens at a country level, with scarce margins to select a particular jurisdiction. In spite of this argument, however, we will briefly consider state level distribution of patents for the two US companies in the sample.

Figure 1 shows the distribution of control group patents. The majority of the patents are domestic. 36% of control group patents have at least one inventor located outside the HQ country of the four companies.

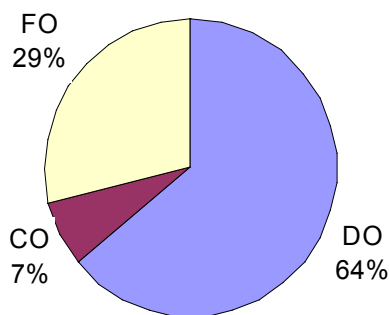


Figure 1. Distribution of control group patents by location of inventive activities

Observing the changing distribution of these patents over time (Figure 2), we note that the four companies substantially increased the numbers of foreign and collaboration patents during the course of the late 1990s. The data indeed shows evidence of an international expansion of inventive activities. While during 1985-1994, 82% of patents were domestic (DO), for 1995-1999, this percentage dropped to 60%. At the same time, the average number of patents applied for per year drastically increased. Hence foreign (FO) and collaboration (CO) patents increased both in absolute and relative numbers. A reverted trend can be detected for the last two years under consideration. A sharp decline in the number of patents began in 2000, and was even more pronounced for FO and CO patents as their share decreased as well.

The sharp decline during the last two years might have been accentuated by a database tailing effect, as we have grouped granted patents by application date. For some of the latest years, patents might still be under review at the USPTO. In spite of this bias, it is well-known that after the euphoria of the late 1990s, some rationalisation of R&D budgets took place in the industry, and this is likely to have impacted differently domestic and foreign R&D activities.

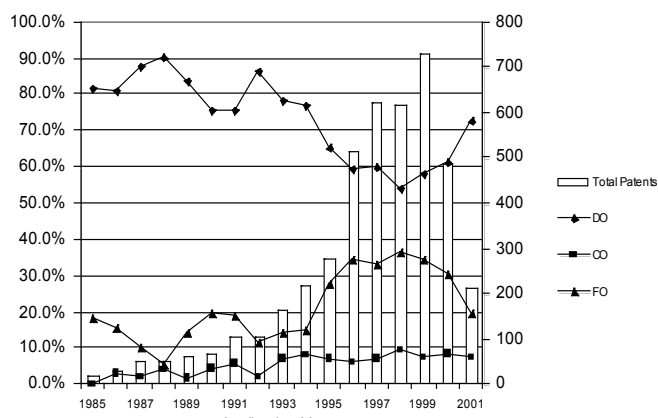


Figure 2. Distribution of control group patents by location of inventive activity (1985-2001)

When we weigh the number of control group patents by the number of forward citations received by each patent for the two years subsequent to publication, the average distribution and trends of DO, FO and CO do not significantly change (Figure 3).

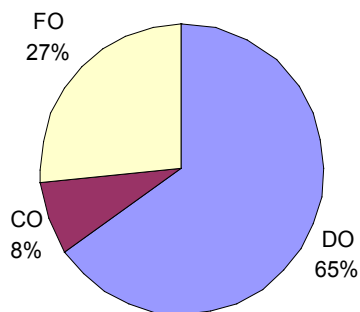


Figure 3. Distribution of forward cited control group patents by location of inventive activity

The DO, FO, CO distribution for essential patents appears as significantly different. Figure 4 shows the concentration of DO essential patents is much higher than the share of DO patents in the control group. The Pearson Chi-Square values for both DO and FO confirm that we have to reject (with 0.01% significance level) the null hypothesis that the international distribution of inventive activity locations is similar for essential and control group patents. 78% of essential patents filed in the period between 1985 and 2001 are the result of inventive activities performed in the HQ countries of the four largest assignees. While the share of CO patents is higher than the share in the control group, the share of FO patents drops to 11%.

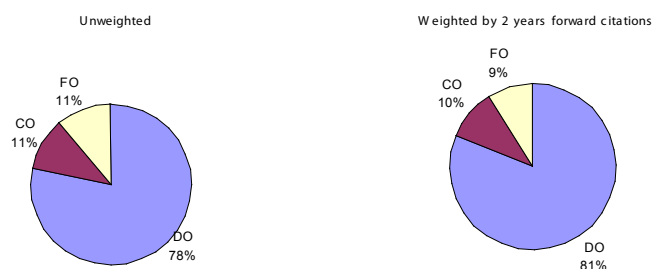


Figure 4. Distribution of essential/cited essential patents by location of inventive activity

When we weigh this data with two years forward citation the difference is even more significant (Figure 4). As for the control group patents, DO patents are slightly more likely do receive citations than FO and CO patents. As a result, the share of DO citations rises to 81% of total forward citations. Therefore, also for patent citations, the Pearson Chi-Square values for both DO and FO confirm that we have to reject (with 0.01% significance level) the null hypothesis that the international distribution of patent citations is similar for essential and control group patents.

The time trend for essential patents shows a similar, but significantly less pronounced trend during the course of the late 1990s (Figure 5).

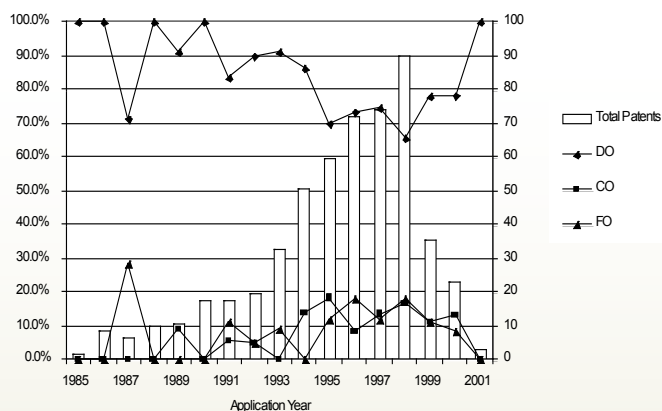


Figure 5. Distribution of essential patents by location of inventive activity (1985-2001)

We now consider the off-shore locations for these inventors. Figure 6 compares the distribution of off-shore sites of FO patents across the essential and control group. We exclude domes-

tic and collaborative patents from this analysis since, by definition, the inventors for these patents are located either in the US or in Europe.

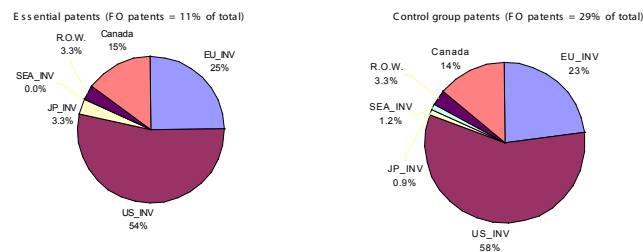


Figure 6. Distribution of inventors of essential/control group patents by US state-level location of inventive activity

The first interesting element is the dominant position of the US as affiliation of inventors, both for essential and control group patents. 58% of off-shore inventive activities of control group patents (and 60% if we weigh this data by two years forward citations) is performed in the US, while 54% of the patents indicated as essentials display a US inventor (the share of two years forward citation is 49%). European countries are the second most common affiliation for both essential and control group patents for all companies.

Canada is also another important affiliation of inventors. The Canadian share across the board is significantly higher than Japan, Asia (SEA) and rest of the world (ROW). Somewhat surprisingly, this latter group of countries/regions altogether merely represent somewhere between 5% and 6% of control group and essential patents. Hence, such emerging countries and regions are substantially absent as affiliations of inventions for ETSI standards according to this analysis.

Unfortunately our data lags behind and cannot reach definite conclusions about the R&D and inventive activities performed in the last three or four years, during which time these countries have been identified in the popular press as the largest recipients of foreign R&D investment. Nonetheless, these observations appear in line with the findings of the UNCTAD report (2005), which describes a distribution of R&D investment that still is highly skewed towards these 'old and incumbent' centres of innovation.

4.3. LOCATIONS OF INVENTIVE ACTIVITY AT THE COMPANY LEVEL

The following figures show that the share of DO patents as higher for essential patents than for the control group is consistent for all four companies in the sample.

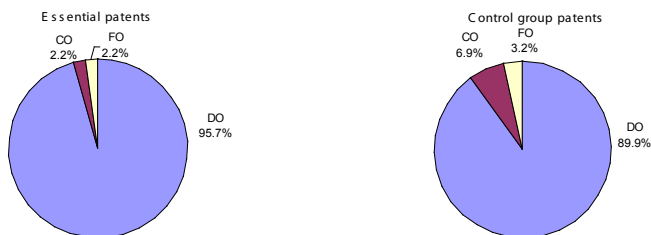


Figure 7. Distribution of essential/control group patents of Qualcomm by location of inventive activity

Qualcomm, the second largest assignee, and the company with the highest average citations per patent ratio, also has the highest share of DO patents. Fewer than 4.5% of essential patents have at least one foreign-located inventor on the title (Figure 7). Essential patents are also more homebound than the control group. The Pearson Chi-Square value for DO confirms that we have to reject (with 0.01% significance level) the null hypothesis that the international distribution of inventive activity locations for Qualcomm is similar for essential and control group patents.

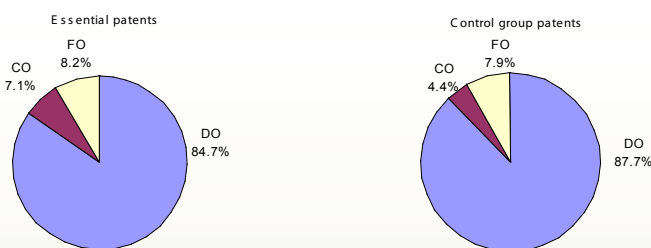


Figure 8. Distribution of essential/control group patents of Motorola by location of inventive activity

Despite the high concentration of DO patents, Motorola has a more similar distribution between essential patents and the control group (Figure 8). Our Chi-Square test fails to reject the null hypothesis of a significant difference across the two groups (with 0.01 significance). The FO share of patents is more-or-less the same, while the CO share varies significantly across

the two groups. For Motorola, however, we are able to find a similar difference in the distribution between essential patents and the control group when we break down the DO patents of these two US firms at the state level (Figure 9). When we move to the state level of analysis the Chi-Square values detect a significant difference.

While this exercise does not make too much difference for Qualcomm (as most of Qualcomm employees are located in San Diego, California), Motorola evidently does R&D in different sites around the US. As a result, inventors of Motorola's control group patents are spread across the US. However, when considering essential patents, only 80.5% of them are located in Illinois where the company HQ is located.



Ericsson, the largest assignee of control group patents in this data, is characterised also by the highest share of FO patents (Figure 10). However, it is important to remember that for both Nokia and Ericsson we also categorised patents whose inventors were affiliated to other European countries as from foreign locations. It is interesting to note that in spite of the fact that for these two companies we are more strict with the identification of DO locations, still the difference across the two patent portfolios is even more pronounced than for the two US companies. For instance, in the case of Ericsson, 63% of all control group patents have at least one inventor located outside Sweden, while only 37% of essential patents are the result of inventive activities performed outside the HQ country.

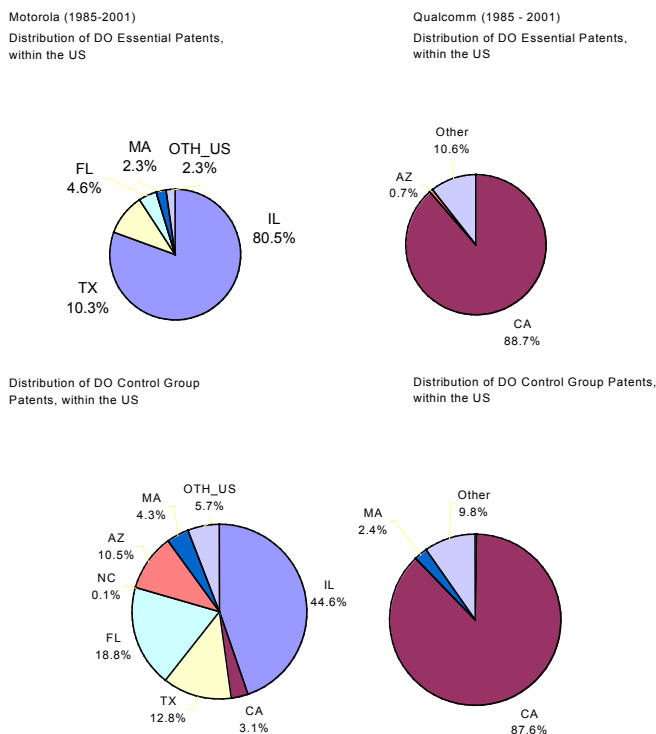


Figure 9. Distribution of essential/control group patents of Motorola and Qualcomm at the US state level by location of inventive activity

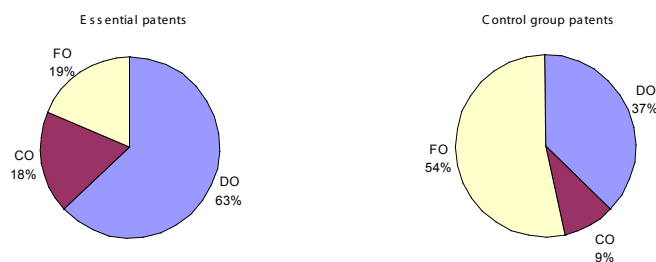


Figure 10. Distribution of essential/control group patents of Ericsson by location of inventive activity

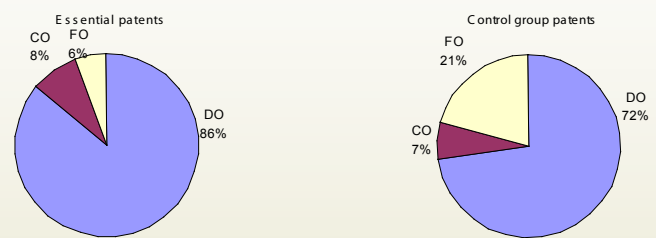


Figure 11. Distribution of the essential/control group patents of Nokia by location of inventive activity

Nokia's inventive activities also vary across the two patent categories (Figure 11). The inventive activities of Nokia are more homebound than those of Ericsson, and also the share of patents with at least one foreign inventive location of essential patents is half the share of control group patents.

5. A SYNTHESISING AND CONCLUDING DISCUSSION

Despite the globalised nature of the wireless telecommunications industry, this paper clearly suggests that R&D and inventive activity relating to the technological core of this industry still is very homebound. We take this as support for the 'case of non-globalisation' made by Patel and Pavitt (1991) some twenty years ago. The observation is based on an analysis of essential patents of four significant companies (Motorola, Qualcomm, Ericsson and Nokia) in the industry set against a benchmark of non-notified control group patents.

Our empirical set-up seeks to control for possible country and firm biases. Nonetheless, it hinges on the assumption that these notified essential patents are strategically, and probably also technologically and economically more significant than their non-notified counterparts in the control group. Further, our observation only concerns the R&D and inventive activity of these firms in relation to standards commissioned by ETSI from whence our data originated. While these are important standards in the development of the industry towards next generation wireless telecommunications technologies, these firms also hold patents of importance to a range of other standards outside ETSI that we have not been able to consider in this paper.

Despite these evident limitations of our analysis, this paper brings forward important questions related to the organisation of R&D and inventive activity in this industry worthy of exploration in subsequent research. A primary question is why non-globalisation appears so significant in the case of the technological core of this industry. We suggests two possible explanations, both of which we will elaborate upon in subsequent work in the next phase of our research. The first relates to location advantages, the second to specificities of IPR management, and the interactions between IPR and R&D functions of firms.

Increasing levels of technological integration and specialisation, the need for access and to be able exploit pockets of knowledge located in various countries, as well as the need to integrate peripheral forms of knowledge with core technologies might suggest that MNCs are acting as connectors of globally dispersed knowledge. Their 'knowledge augmenting' R&D accumulates in the central labs and research centres, often located in their home country where locational advantages relate to accumulated technological capabilities, fluidity of communication and linkages to the innovation systems of the home country, as well as path-dependency in the organisation of the R&D activities of the company (Ali-Yrkkö and Palmberg, 2006). This home-bound R&D is then exploited globally for specific product development projects at foreign locations through closer collaboration with customers (Archibugi and Michie, 1994). Related to this, Cohen and Levinthal (1990) observe that absorption of new knowledge depends on the degree to which it lies close to the existing knowledge base of firms. This could be the first explanation, and one that might hold for many other industries as well.

The second explanation might be more specific as it relates directly to the way in which companies interact with the notification system for essential patents (such as the one set-up by ETSI) and manage their IPRs. As suggested above, a company might be predisposed and capable of lobbying for the inclusion of their patents in an ETSI standard primarily for technologies for which it has matured a deep understanding and a great level of confidence about its possible protection. Not all patents are well-written documents, and it is a quite well-known fact that for industries like telecommunication, many patents are practically useless or not enforceable as they read on claims and technologies which have already been patented, or that have no practical use. In other words, one could argue that R&D projects that are closely monitored by IPR experts are more likely to have a greater impact on standards and downstream revenue streams.

If this second explanation is relevant for the technologies under consideration, then it will be useful in subsequent research to consider IPR management strategies and organisation of companies as an intermediate factor that affects also the location of R&D and inventive activities of a more strategic nature in this industry. While various aspects of an MNC have

been considered to explain the evolution and learning curve of foreign subsidiaries (see among many others: Birkinshaw et al., 2002; Zander and Solvell, 2000; Zanfei, 2000), the importance of international organisation of IPR management has still to be explored. For example, might the home-bound nature of essential patents that we observe be an outcome of the fact that these companies also locate their IPR management functions in the home country and hence also produce patents of higher quality with greater probability of notification there?

Finally, some further interpretations might also be gained by the literature on 'alliance capitalism' which suggests that firms increasingly internationalise their strategic R&D activities and that a new division of labour between global competitors is emerging as a result (see e.g. Dunning and Boyd, 2003; Palmberg and Pajarinen, 2006). Standardisation in the wireless telecommunication industry is the most recent and impressive effort that fits this collaborative capitalism model (Palmberg and Martikainen, 2006). The analysis in this paper also adds some qualifications to this literature on alliance capitalism by suggesting that while the gambling on the development of wireless standards is a global game, firms still bring very local chips to the table. An important distinction should probably also be made with respect to upstream and downstream R&D, for which the latter lies closer to markets and commercialisation, and for which international collaborative alliances thus might play a much bigger role.

While the paper has offered some new insights, it has also highlighted various research paths to undertake in further studies. Our empirical analysis of ETSI patents warrants additional consideration and elaboration. In addition, data on strategic alliances might incur various interesting hypotheses regarding relationships between upstream and downstream R&D in the context of globalisation and this is an empirical extension that we will undertake in the near future. As we only scratch the surface in this paper we feel an important need to complement this data with qualitative interviews covering all four companies included here along one, or both, of the lines of enquiry sketched above.

Finally, one might ask if we make a too strong case for non-globalisation in this paper given that we focus on a particular industry, namely the wireless telecommunications industry.

Aggregate R&D expenditures, alliances and the location of inventive activity indicated by patent data provide compelling evidence that the R&D and inventive activities are indeed internationalising, especially for large firms in highly industrialised countries. What we claim with this specific case of wireless telecommunications, however, is that there are modifications to be made vis-à-vis sweeping findings on the issue, such as those found in the UNCTAD (2005) report, once different types of R&D are distinguished. Thus, a further research path from this paper would be to identify comparatively strategic R&D also in other industries to investigate whether our findings can be generalised beyond the wireless telecommunications industry. ●

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