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International Protection of ICT Intellectual Property and the Internationalization of ICT R&D

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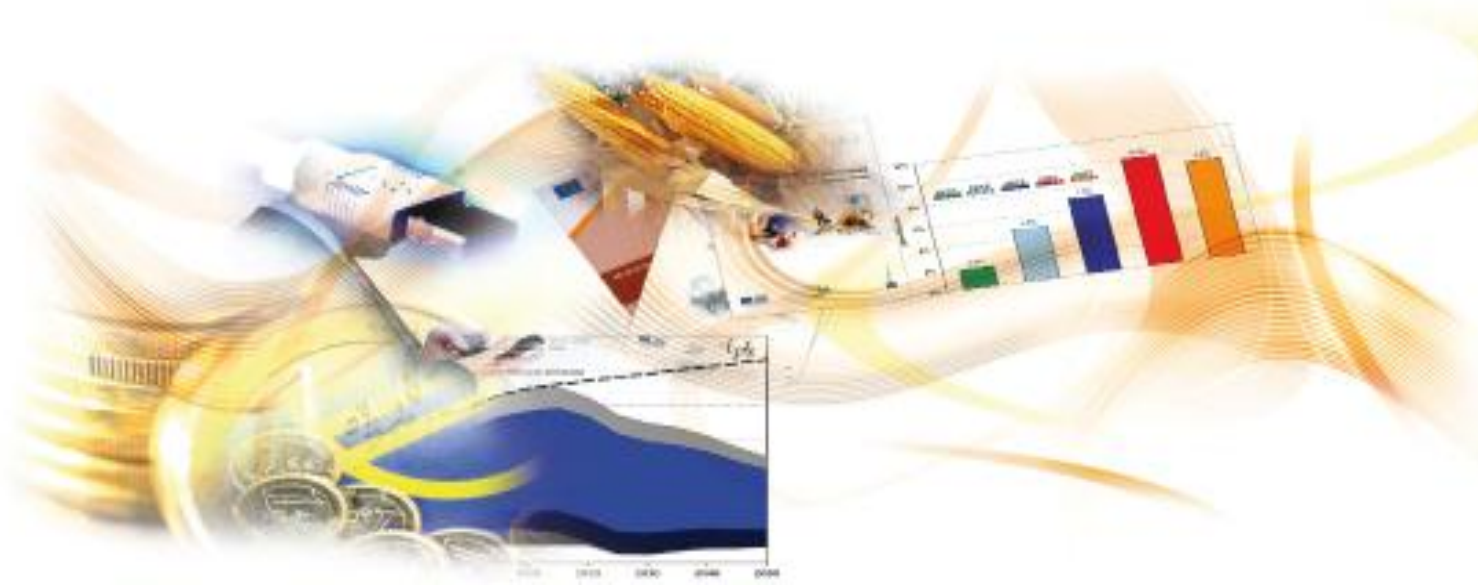

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Executive summary

This report investigates the increasingly internationalised environment of ICT R&D. First, it analyses the issue of international protection of ICT intellectual property by looking at international patent filings. Second, it studies the patterns and dynamics of the ICT R&D internationalisation process.

Regarding the issue of international protection of intellectual property (IP), the analysis in the first part of this report indicates that the number of foreign ICT patent applications is increasing and that multi-country patent portfolios are becoming an intrinsic feature of ICT firms. This process is, however, restricted to a few countries. The top 10 sources of foreign ICT patent filings accounted for over 90% of all the foreign ICT patent applications filed between 1990 and 2011 worldwide. Applicants from Japan, the US and South Korea file the most foreign patent applications. A very high level of concentration can also be observed for the destination of foreign ICT patent filings. The top 10 patent offices account for 94% of all foreign ICT patent filings worldwide. The main destinations of international ICT patent filings are the USPTO, EPO and the Chinese Patent Office.

Although Europe represents an important source of innovation and an attractive technology market, European technology owners are relatively inactive in protecting their IP in foreign markets. In the long term, insufficient protection may impede the competitiveness of EU firms, as they will not be able to claim their rights over their inventions in relevant markets. This, in turn, is likely to undermine their potential to globally capitalise on their innovation efforts.

The analyses reported in the second part of the report indicate that the level and intensity of ICT R&D internationalisation, is also increasing, although there are significant differences between the levels of various forms of technological collaboration between countries. In this context, the emerging roles of Asian countries, such as South Korea, China and India, are of particular interest. On the one hand, these countries are starting to become important producers of technology demanded by other countries, and on the other, they are increasing their demands for technology developed abroad to complement their own technological resources. This process is particularly visible in the interactions between Asia and the US. Today, Asia is the biggest partner of the US in technological collaboration. In contrast, although European inventors are very attractive as a technology development partners for foreign partners, they are less successful in sourcing technology from abroad to complement their own domestic resources.

More information can be found under: http://is.jrc.ec.europa.eu/pages/ISG/PREDICT.html

Table of Contents

Executive summary 1
1. Introduction 3
2. Foreign ICT patent filings 5
2.1. Global trends in foreign ICT patent filings 5
2.2. The sources and destinations of foreign ICT patent filings 7
3. Internationalisation of ICT R&D – patent-based evidence 11
3.1. Overall levels of ICT R&D internationalisation 12
3.2. International ICT co-innovations 14
3.3. International co-ownership of ICT inventions 15
3.4. Cross-border ownership of ICT inventions 17
3.5. Synthesis of the main findings 21
4. Conclusions 23
5. Annex: Data source and methodology 24
References 26

1. Introduction

This report analyses how ICT R&D is taking place across various regions of the world in an increasingly internationalised environment, based on a worldwide analysis of ICT patents. It addresses two points: First, it looks at foreign ICT patent filings, i.e. filing of ICT patents to a patent office outside of the home country or region of the patent applicants. Second, it analyses the dynamics of the ICT R&D internationalisation process, i.e. the process of conducting R&D-related activities in other region than a company's country of origin (Kuemmerle 1997), and of collaborating internationally.

Foreign patent filings constitute an important element of the functioning of the modern ICT industry. A high-tech global technology company, such as Microsoft, earns more than 50% of its revenue in overseas markets (Phelps 2005). A company that seeks protection in a particular market needs to obtain it within the jurisdiction of the corresponding country (De Prato and Nepelski 2012b). Although a home-bias exists, i.e. applicants tend to file for patent protection in their home markets (Dernis and Khan 2004), rapidly growing international commerce is intensifying cross-border competition and forcing firms from technology-intensive sectors such as information and communications technologies (ICT) to protect their inventions in foreign markets. The result is a recent surge in foreign patent filings, which today account for about 50% of total patent filings (WIPO 2011b). This raises some questions about protecting IPR for ICT companies. The most important one is whether a firm protects its invention in the relevant markets.

Concerning the second issue addressed in this report, i.e. internationalisation of R&D, one can observe some important changes in the way ICT R&D is organized globally. After long-standing cooperation in knowledge intensive activities between developed regions, i.e. the EU, the US and Japan (UNCTAD 2005), the process of ICT R&D internationalisation today is marked by the increasing importance of Asian countries, in particular China, India, Taiwan and South Korea (Nepelski and De Prato 2012), due to their growing ICT R&D capacities.[1] This is a natural step, as Asia is starting to become an important producer of technology demanded by other countries, and, at the same time, it is increasing its demand for technology developed abroad to complement its own technological resources, (De Prato and

[1] For the recent developments in Asia's ICT inventive output, please refer to the analysis of ICT R&D performance across the world under: http://is.jrc.ec.europa.eu/pages/ISG/PREDICTperformancemenu.html

Nepelski 2013). However, although Asia is receiving extensive attention as a rising competitor in knowledge intensive activities, it is not really considered to be a source or a destination of technology by other countries. This fact needs to be taken into account by other countries, as their position in the global R&D network influences their innovation capacity (De Prato and Nepelski 2012a).

The rest of the report proceeds as follows: Section 2 analyses the developments and patterns of foreign ICT patent filings. Section 3 includes an analysis of ICT R&D internationalisation, as observed through patent data. In particular, it presents the overall levels of ICT internationalisation (Section 3.1) and the patterns of international collaboration of individual regions in co-inventing (Section 3.2), co-owning inventions (Section 3.3) and cross-border ownership of inventions (Section 3.4). Section 4 offers some conclusions and Section 5 includes a technical annex.

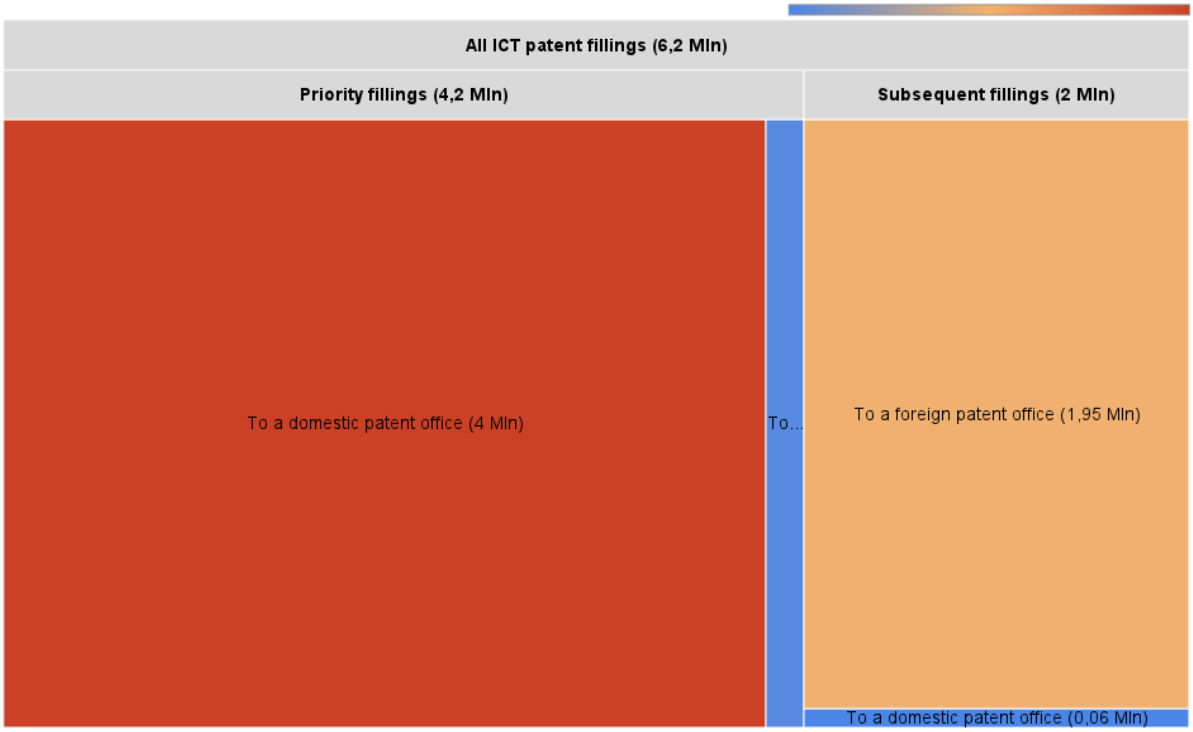
2. Foreign ICT patent filings

This section deals with the issue of foreign patent filings in ICT, i.e. patents filed to a patent office of a different country from the applicant's country of residence. It starts with a general overview of the global trends in foreign ICT patent filings (Section 2.1). Then, it proceeds with a more detailed analysis of the sources and destinations of foreign ICT patent filings (Section 2.2). For methodological details, please refer to Section 5.

2.1. Global trends in foreign ICT patent filings

Figure 1 shows the distribution of ICT patent filings by type, i.e. priority and subsequent, and destination, i.e. to domestic and foreign patent offices. It is based on the total number of ICT patent filings worldwide between 1990 and 2011. According to this information, out of 6.2 million ICT patent applications, two thirds were filed to a domestic patent office and one third to a foreign one. The sheer number of priority patent filings directed to a national patent office confirms the known home-bias, i.e. the phenomenon that applicants tend to file a patent application to their national patent office. Only a very small fraction of priority patent applications, i.e. around 5%, are filed to a foreign patent office. Naturally, the reverse pattern can be observed for subsequent patent applications. Nearly all of them are filed to foreign patent offices.

Figure 1: The distribution of ICT patent filings worldwide by type and destination, total for 1990 - 2011

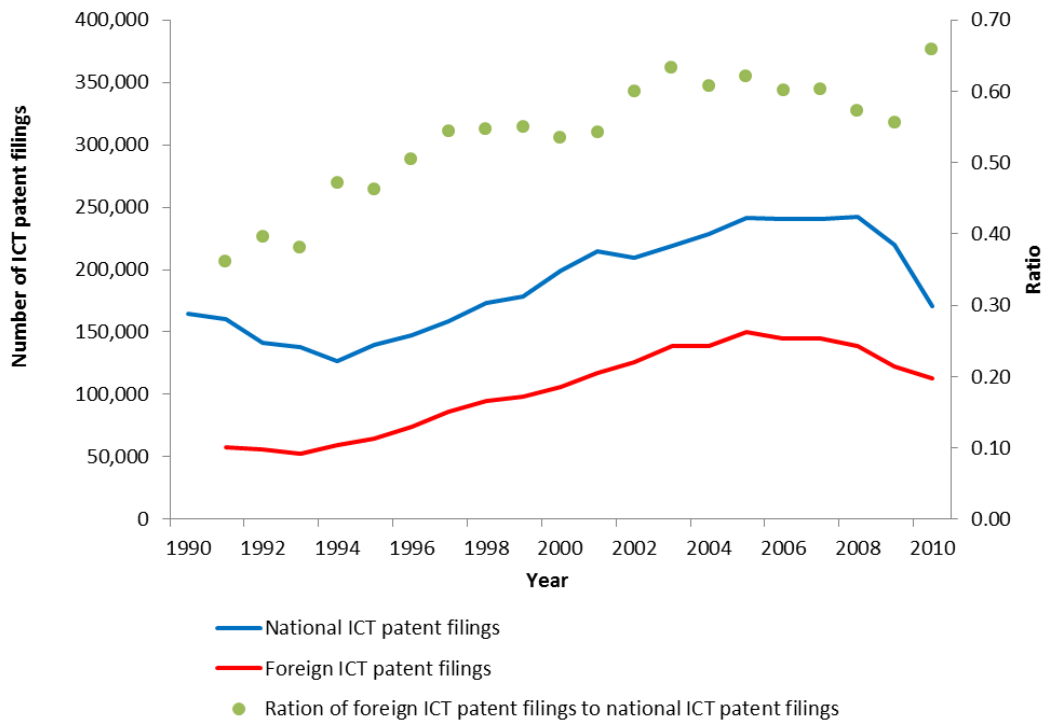


Note: The computation includes all patent applications filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor, the priority date and fractional counts. *Source:* Own calculations based on PATSTAT, 2013.

Figure 2 gives an overview of ICT patent filings trends from 1990 to 2010.[2] It can be observed, that over the entire period, the number of national and foreign ICT patent filings per year increased. However, the growth in foreign ICT patent applications was more sustained, as compared to national ICT patent filings. This is well illustrated by the first half of the 90s, when the number of filings to national patent offices decreased, whereas the number of foreign patent filings continued to grow. In addition, the slow-down in growth of foreign ICT patent filings after the internet hype at the beginning of the 2000s was less pronounced than the progress of national ICT patent filings. As a result, one can observe that the ratio of the foreign to national ICT patent filings has continued to grow. Between 1991 and 2010, it increased from 0.36 to 0.66. All this shows that the protection of ICT-related inventions and technology in foreign markets is becoming increasingly more important over time.

[2] Because we consider priority patent applications filed between 1990 and 2011 and due to a time lag between filing a priority and its follow-up applications, the starting point of observation for subsequent applications is year 1991.

Figure 2: Number of priority ICT patent filings and subsequent foreign ICT patent filings and the ration between them, 1990 - 2010



Note: The computation includes all patent filings filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor, the priority date and fractional counts. *Source:* Own calculations based on PATSTAT, 2013.

2.2. The sources and destinations of foreign ICT patent filings

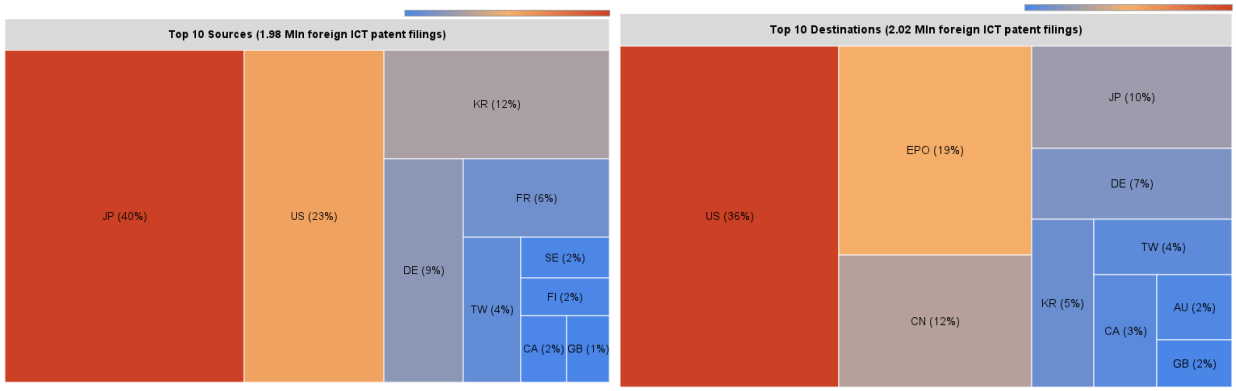
This section presents the main sources and destinations of foreign ICT patent filings. According to the data reported in Table 1, between 1990 and 2011, there were over 2.1 million foreign ICT patent filings. Despite this large number of patent filings, most of them originated from very few countries and were filed to very few patent offices (see Figure 3).

The top 10 sources submitted 1.9 million, or 92%, of all foreign ICT patent applications filed between 1990 and 2011. Among these countries of origin, applicants from just three of them, i.e. Japan, the US and South Korea, accounted for three quarters of all the filings. European countries are also among the major sources of foreign patent filings. The total number of foreign ICT patents filed by applicants residing in Europe accounted for 20% of the foreign ICT patents filed by applicants from the top 10 sources of such filings. These applicants reside in Germany, France, Sweden, Finland or the UK.

A very high level of concentration can also be observed for the destination of foreign ICT

patent filings. The top 10 destinations received 2 million, or 94%, of foreign ICT patent filings submitted between 1990 and 2011. The main destinations of international ICT patent filings include the USPTO (36%), EPO (19%) and the Chinese Patent Office (12%).

Figure 3: Top sources and destinations of foreign ICT patent applications, in %, 1990-2011



Note: The computation includes all patent filings filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor, the priority date and fractional counts. *Source:* Own calculations based on PATSTAT, 2013.

When considering bilateral links (country of applicant – patent office applied to), we can observe a strong concentration of interactions as well. When looking at the top 20 interactions presented in Table 1, we see that the majority of foreign ICT patent filings (70%) originated from only six countries (Japan, South Korea, the US, Taiwan, Germany and France) and were filed to one of eight patent offices (US Patent and Trademark Office (USPTO), European Patent Office (EPO), Chinese, Japanese, South Korean, German, Canadian and Taiwanese Patent Offices). In this group of patent offices, the USPTO, Japanese Patent Office (JPO) and the EPO are together the destinations for nearly 50% of international patent filings (see Table 1).

Japanese applicants account for 33% of international patent filings – an important share. The majority of Japan's international patent filings are submitted to the USPTO, EPO and, interestingly, the Chinese Patent Office. US applicants, who seek for protection mainly in the EPO, Japanese and Chinese patent offices, come second in terms of the number of international ICT patent filings. Patent filings of Korean origins also represent a significant share of international patenting activity. Between 1990 and 2011, South Korean applicants filed nearly 200,000 ICT patent filings to one or more of the nine patent offices considered. This represents almost 10% of all foreign ICT patent filings. In comparison with slightly

over 165 thousand foreign patent filings, European applicants, mainly from Germany and France, represent relatively lower shares.

Table 1: Foreign ICT patent filings by country of applicant and the designated patent office, top 20 country pairs, total number of patent filings in 1990-2011

Rank	Country of applicant	Designated patent office	Total number of ICT patent filings	% in total
1	JAPAN	USPTO	378,374	18%
2	SOUTH KOREA	USPTO	110,500	5%
3	JAPAN	EPO	108,783	5%
4	US	EPO	102,823	5%
5	JAPAN	Chinese PO	102,375	5%
6	US	Japanese PO	95,078	4%
7	TAIWAN	USPTO	60,054	3%
8	JAPAN	S. Korean PO	59,408	3%
9	GERMANY	EPO	55,880	3%
10	JAPAN	German PO	55,505	3%
11	US	Chinese PO	52,204	2%
12	GERMANY	USPTO	50,984	2%
13	SOUTH KOREA	Chinese PO	40,651	2%
14	US	German PO	39,854	2%
15	SOUTH KOREA	Japanese PO	38,222	2%
16	US	Canadian PO	37,025	2%
17	FRANCE	EPO	32,803	2%
18	JAPAN	Taiwanese PO	32,582	2%
19	FRANCE	USPTO	26,296	1%
20	US	S. Korean PO	24,939	1%
Sum of ICT patent filings for 20 top country pairs			1,504,341	70%
Sum of ICT patent filings for all country pairs (2782)			2,150,992	100%

Note: Fractional counting according to the applicant criterion. Sum for 1990-2011. Source: Own calculations based on PATSTAT, 2013.

The differences in international patenting noted above are quite striking, considering the global character of ICT competition. They indicate that applicants from different countries follow different patenting strategies even though they are active in the same industry. The results presented here also reveal the geographical patterns of competition that ICT firms face. In particular, the important role of the USPTO clearly shows that the US is one of the markets where the competition in the ICT sector is the toughest.

Regarding the EU, it can be observed that although Europe represents an attractive technology market, European technology owners are relatively inactive in protecting their IP in foreign markets. This raises the question of whether European inventors sufficiently protect their technologies and how this affects the possibility of exploiting them on a global scale.

3. Internationalisation of ICT R&D – patent-based evidence

This section of the report attempts to track the level of ICT R&D internationalisation. To do this, patent data are used. Regarding R&D internationalisation, patent-based indicators have a long-standing tradition in scientific research (Patel and Pavitt 1991, Patel and Vega 1999, Bas and Sierra 2002, Nepelski and De Prato 2012, Picci 2010, De Prato and Nepelski 2012a). Over the last few last years, JRC-IPTS has also issued reports that use patent-based indicators of internationalisation of the ICT R&D activity (Nepelski et al. 2011).

The methodology of computing patent statistics applied in this report follows the most recent approach in literature (De Rassenfosse et al. 2011; Turlea et al. 2011). Methodological details describing the patent-based indicators of R&D internationalisation that are used in this report are explained in Box 1 and in the Annex (Section 5).

Box 1: Patent-based measures of R&D internationalisation

These measures of internationalisation are based on the presence of inventors and/or applicants residing in different regions of the world among the list of people who file a patent application. An international patent application is defined in the analysis presented here as a patent application in which the people and organizations concerned reside or are located in different countries or regions, e.g. in the US and the EU. It is however important to note that intra-EU patent applications are not considered here as international patents. For example, a patent application which has a German inventor and/or applicant and a French inventor and/or applicant, is not considered here as international. Using this methodology, the following concepts of internationalisation are used in the analysis:

International co-invention: When at least two inventors residing in different countries or regions of the world are listed in the patent application. This concept is used to measure international collaboration between inventors. This measure is defined as a share of a country's inventions with domestic and foreign inventors in the country's total number of inventions.

International co-ownership of inventions: When at least two applicants residing in different countries or regions of the world are listed in the patent application. The measure of international co-ownership of inventions is defined as a share of a country's inventions co-owned by domestic and foreign applicants in the country's total number of inventions.

Cross-border ownership of inventions: When at least one applicant resides in a country or region of the world different from the country or region of the world of residence of at least one inventor listed in the patent applications. Cross-border ownership of patents captures the concept of technology transfer, defined as either a one-time transaction or a long-term collaboration between two parties, in which the acquirer and supplier of technology are involved (Bennett 2002). Depending on the perspective, there are two ways of measuring cross-border ownership of inventions:

- **Foreign ownership of domestic invention**: This measure is defined as the share of a country's inventions owned by applicants residing outside of the country in the country's total number of inventions.
- **Domestic ownership of foreign inventions**: This measure is defined as the share of a country's ownership of foreign inventions (i.e. inventions by inventors residing in foreign countries) in the country's total number of inventions owned.

3.1. Overall levels of ICT R&D internationalisation

In our attempt to measure the level of ICT R&D internationalisation, first we compare the levels of internationalisation across the major world regions,[3] and second, we analyse in detail the patterns of internationalisation in each of the five world regions. Figure 4 shows the levels of ICT R&D internationalisation measures (defined in Box 1) over two decades, from 1990 to 2011.

International co-inventions in ICT: According to Figure 4a, the US have the highest share of international co-inventions. In 2011, the share of international ICT co-inventions reached 3% of the total number of US ICT patent applications. Lower co-inventive activity was observed for the EU and Asia. However, the two regions had very different patterns of international co-invention. Whereas 2% of all EU ICT patent applications were international co-inventions, less than of 1% Asian ICT patent applications were the result of international collaboration. This percentage was even lower for Japan.

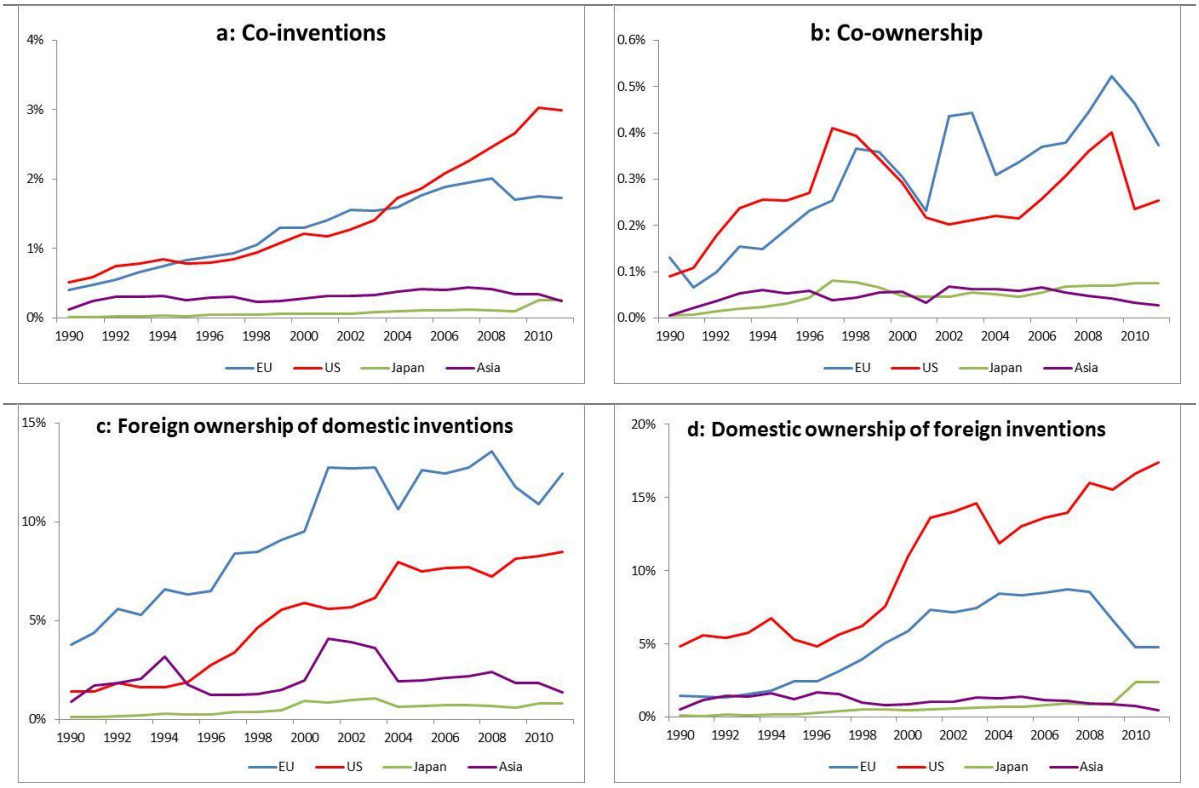
International co-ownership of ICT inventions: Figure 4b shows that the levels of international co-ownership are much lower than those of co-inventions. For all of the regions, the share of internationally co-owned ICT inventions is below 1% of all patent applications. However, the ranking of the regions is different to the one depicted in Figure 4a, i.e. after 2000, the EU had the highest share of international co-ownership of patents, followed by the US, Japan and Asia.

Foreign ownership of domestic ICT inventions: Figure 4c shows the level of foreign ownership of domestic ICT inventions for each region. The EU has the highest share of ICT inventions owned by foreign entities (10%), followed by the US (8%), Asia (1.7%), and Japan (0.5%). Considering that this measure of R&D internationalisation, i.e. foreign ownership of domestic ICT inventions, is a proxy for international technology flow (Bennett, 2002), the above ranking shows the attractiveness of a country/region as a source of technology for foreign entities. Note that this form of internationalisation of ICT R&D plays a more important role than collaboration between inventors or co-ownership of inventions discussed above.

[3] The five world regions include: the EU, US, Japan, Asia and the rest of the world (RoW). In order to account for the differences between Japan and the remaining Asian countries, in this report, Japan is analysed distinctly from the rest of Asia.

Domestic ownership of foreign ICT inventions: Figure 4d shows that the US has the highest share of ownership of foreign inventions. In 2011, over 15% of ICT patent applications owned by US entities covered inventions developed by or with non-US inventors. The EU had significantly lower – and decreasing - levels of ownership of foreign ICT inventions, but it was still far ahead Asia and Japan in this regard. As the previous measure of R&D internationalisation, domestic ownership of foreign inventions can be considered as a proxy for the acquisition of property rights over inventions developed outside of the home country/region and for international technology transfer (Bennett, 2002). Hence, in this context, it shows the intensity of a region in acquiring technology developed abroad.

Figure 4: Shares of international co-inventions, co-ownership, cross-border ownership of inventions in the total number of ICT inventions across world's regions, in %, 1990-2011



Note: Priority patent applications filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor or applicant criterion, the priority date and fractional counts. *Source:* IPTS calculations based on PATSTAT, 2013.

3.2. International ICT co-innovations

Figure 5 represents the development of international co-invention patterns in ICT across the major world regions and their partners for the period between 1990 and 2011. International co-innovation is measured using patent data as a proxy which is good for measuring international knowledge flows and technological collaboration and the organisation of research work by multinational organizations (Guellec and Van Pottelsberghe de la Potterie 2001).

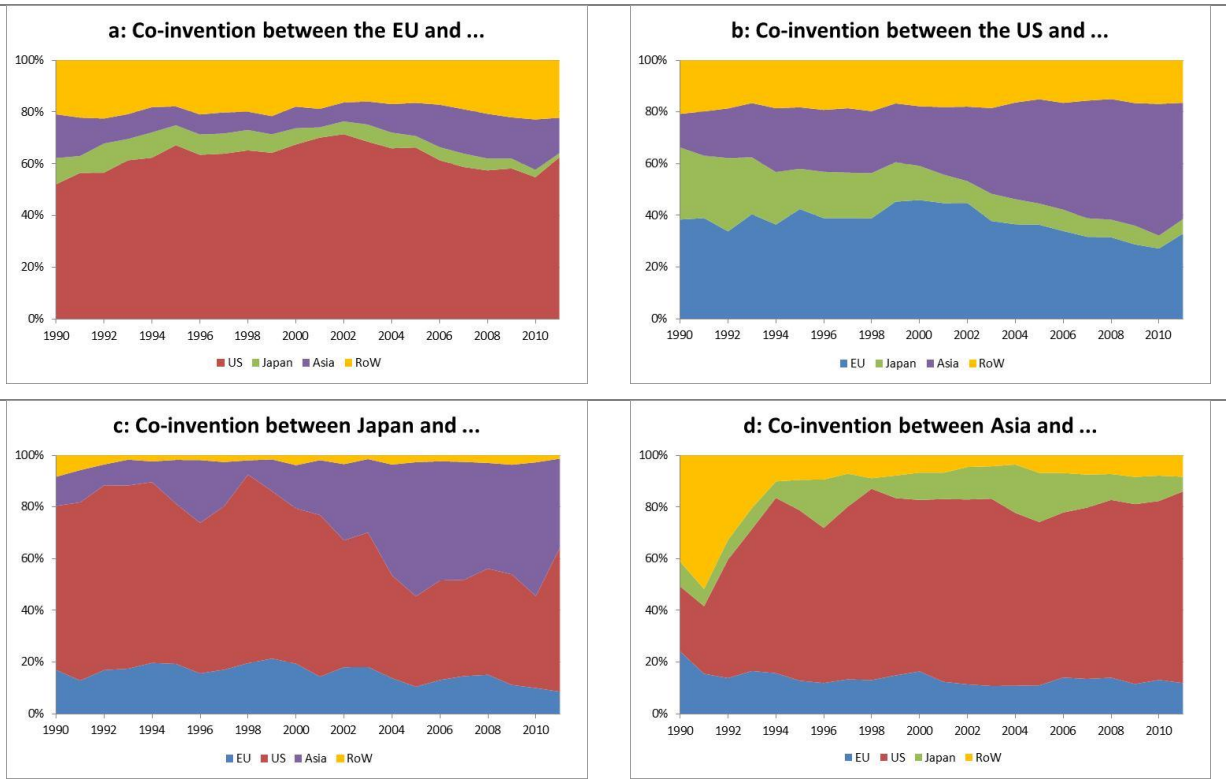
Collaboration partners of the EU: according to the presented information (see Figure 5a), US inventors, followed by their counterparts from the rest of the world (RoW) and from Asia, were the most important partners of inventors from the EU. In total, international co-inventions with EU and US inventors accounted for over 55% of all EU international co-inventions in ICT in 2011. Interestingly, while at the beginning of 90s, Asia played a smaller role than Japan, the situation has changed over the last two decades and Asian partners have gained a considerably more important role as collaborators with EU inventors (18% in 2011), than their Japanese counterparts (3.5%).

Collaboration partners of the US: according to Figure 5b, although EU inventors were the major partners for the US at the beginning of 90s (37%), their leading role has been overtaken by Asian inventors during the last few years. In 2011, Asian inventors' contribution to the US level of international co-invention reached 48%, while EU inventors accounted for only 28%. Asian inventors gained, however, mostly at the expense of the Japanese, whose share in the total number of US international co-inventions decreased from 29% in 1990 to 5.5% in 2011.

Collaboration partners of Japan: according to Figure 5c, in 2011 US inventors were still Japan's major partners in technological collaboration. However, their share in the total number of Japanese international co-inventions decreased from 62% in 1990 to 43% in 2011. In the same period, we see an increase of the number of co-inventions developed by Japanese and Asian inventors. Between 1990 and 2011, the share of Asian-Japanese co-inventions in the total number of Japanese international co-inventions increased from 8% to over 40%. The share of EU-Japanese co-inventions in the total number of Japanese international co-inventions decreased from 25% to 14% in the same period.

Collaboration partners of Asia: according to Figure 5d, US inventors are the main partners of their Asian counterparts. Asian-US co-inventions accounted for over 70% of all Asian international co-inventions. The remaining portion of Asian collaboration was split between the EU (13.5%), Japan (7.6%) and the RoW[4] (8%).

Figure 5: International co-innovations between regions, in %, 1990-2011



Note: Priority patent applications filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor, the priority date and fractional counts. Source: IPTS calculations based on PATSTAT, 2013.

3.3. International co-ownership of ICT inventions

Figure 6 shows the development and patterns of international co-applications in ICT patent applications between applicants from the major world regions in 1990 and 2011. This type of information is a proxy for co-ownership of ICT inventions and, hence, reflects joint intellectual property ownership and rent sharing arrangements between applicants located in different countries (Leten et al. 2013).

Collaboration partners of the EU: Figure 6a shows that applicants based in RoW countries are the most important partners of EU applicants in joint ownership of ICT

[4] Rest of the World include among others such countries as Switzerland, Norway, Canada and Israel.

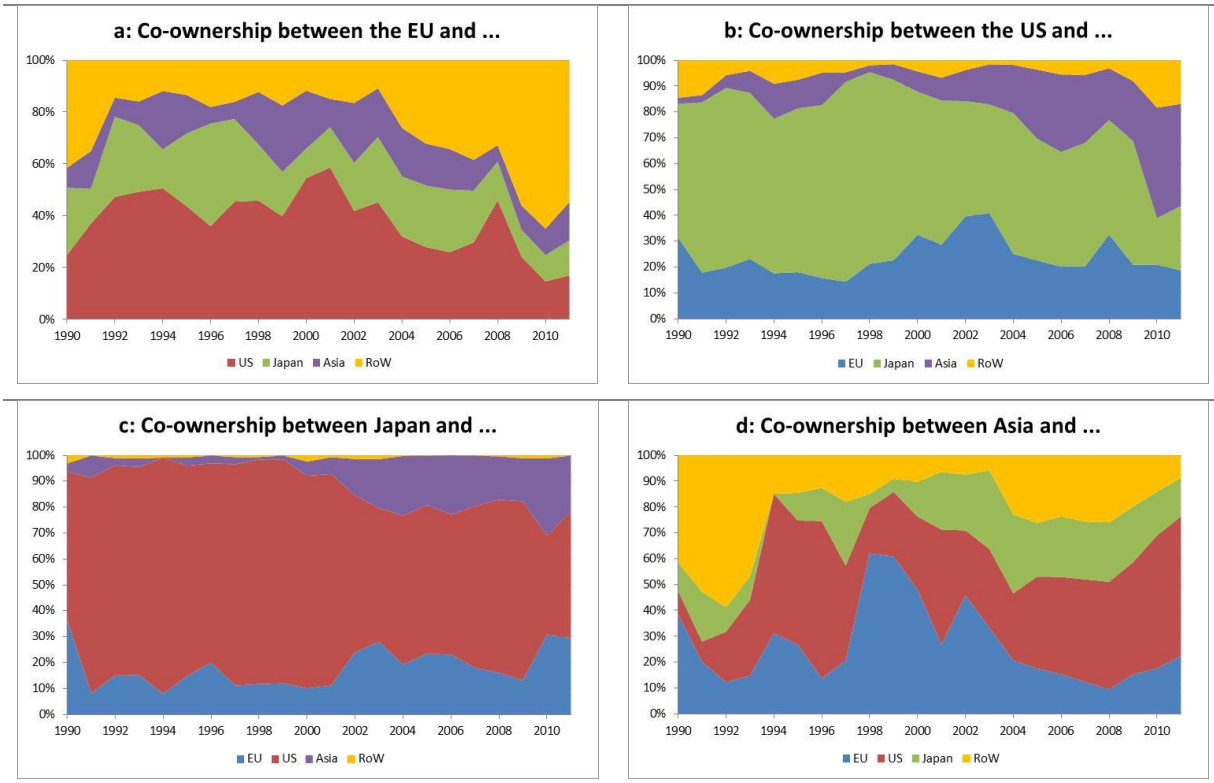
patents. In 2011, international co-ownership between EU and RoW applicants accounted for over 62% of all EU internationally co-owned ICT inventions. US applicants came second with 18% of all EU internationally co-owned patents. In 2011, Japanese and Asian applicants accounted for 11% and 9% of EU international co-ownership.

Collaboration partners of the US: according to Figure 6b, Asian applicants are the most important partners of the US applicants in joint ownership of patents. In 2011, international co-ownership between US and Asian applicants accounted for over 35% of all US internationally co-owned ICT inventions. Considering that this share in 1990 was 2%, it represents an important increase of the importance of Asian applicants in R&D joint-ventures for US applicants. In 2011, with 24% and 22% of all US internationally co-owned patents, EU and Japanese applicants held the second and third position respectively.

Collaboration partners of Japan: according to Figure 6c, US inventors are Japan's major partner in joint ownership of ICT patents. In 2011, they accounted for 42% of all Japanese internationally co-owned patents. In the same year, EU and Asian applicants accounted for 30% and 26% of all Japanese internationally co-owned patents. It is also worth noting, that the importance of Asian applicants for Japanese applicants has increased fourfold in the last decade. Considering the meaning of this measure of R&D internationalisation, it shows the increasingly more important role of Asian in R&D joint-ventures with Japanese entities.

Collaboration partners of Asia: according to Figure 6d, US applicants are the main partners of Asian applicants in joint ownership of ICT patents. In 2011, Asian-US co-ownership accounted for 50% of all Asian international co-ownership. The remaining portion of Asian international co-ownership was split between the EU (17%), Japan (20%) and the RoW (13%). In the considered time period, one can observe an increasing number of R&D joint-ventures between Asian and US and Japanese applicants.

Figure 6: International co-ownership of ICT inventions between regions, in %, 1990-2011



Note: Priority patent applications filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor, the priority date and fractional counts. Source: IPTS calculations based on PATSTAT, 2013.

3.4. Cross-border ownership of ICT inventions

Figure 7 shows the development and patterns of cross-border ownership of ICT patent applications among the major world regions from 1990 to 2011. This information is based on the general levels of cross-border ownership of ICT inventions reported in Figure 4c and 4d and is defined in Box 1. Two perspectives are shown. The first one concerns the foreign ownership of ICT inventions developed by inventors based in a given region. This type of information shows the origin of foreign applicants, i.e. mainly private businesses, that hold property rights over inventions developed by inventors in that region. The second one relates to the applicants from a given region owning patent applications for ICT inventions developed abroad. This type of information is a proxy for international technology transfer. It shows where organisations from one country, i.e. patent applicants, seek and acquire inventions developed by inventors from other countries.

Foreign ownership of EU inventions: Figure 7a shows the distribution of foreign ownership of EU inventions in ICT by the origin of the applicants. According to this

information, the US applicants had the highest share of EU inventions owned by foreign applicants, i.e. 58%, in 2011. The second largest group of applicants were those based in the RoW (21%). Japanese and Asian applicants owned 12% and 8% respectively of EU inventions owned by foreign applicants.

EU ownership of foreign inventions: Figure 7b shows the origin of ICT inventions owned by EU applicants and developed outside of the EU. The US inventions constitute the largest part of the portfolio of foreign inventions owned by EU applicants. In 2011, 44% of all ICT inventions developed outside of the EU and held by EU applicants were US inventions. The next largest shares of EU-owned foreign inventions were developed by inventors based in the RoW and Asia. Each of these regions accounted for 27% of foreign inventions owned by EU applicants. With 3%, Japan came last in this comparison.

Foreign ownership of US inventions: Figure 7c shows the distribution of foreign ownership of US inventions in ICT by the origin of the applicants. According to this information, Asian applicants had the highest share of US inventions owned by foreign applicants, i.e. 32%, in 2011, followed by applicants based in Japan (29%) and the RoW (20%). In 2011, EU-based applicants owned 18% of US inventions owned by foreign applicants.

US ownership of foreign inventions: Figure 7d shows the origin of ICT inventions owned by US applicants and developed outside of the US. Following a rapid increase in the last decade, inventions developed by Asian inventors constituted the largest part of the portfolio of foreign inventions owned by US applicants. In 2011, 51% of all ICT inventions developed outside the US and held by US applicants were inventions of Asian origin. The other half of foreign inventions owned by US applicants was distributed between the EU (31%), the RoW (14%) and Japan (3%).

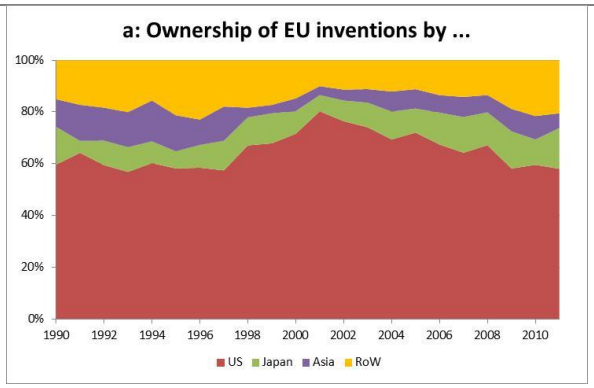
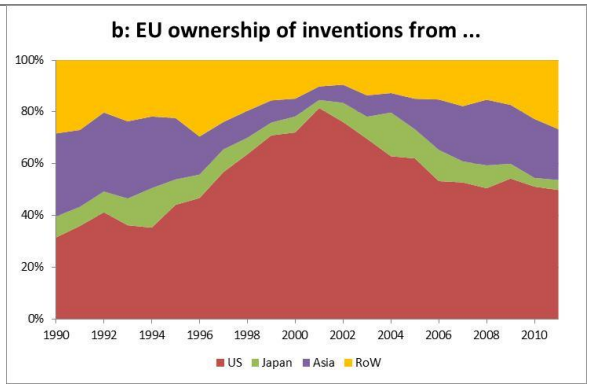
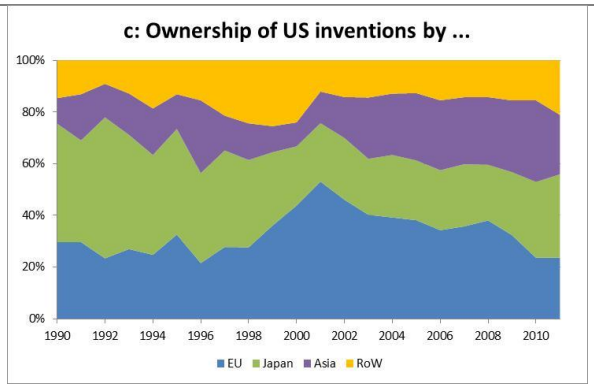
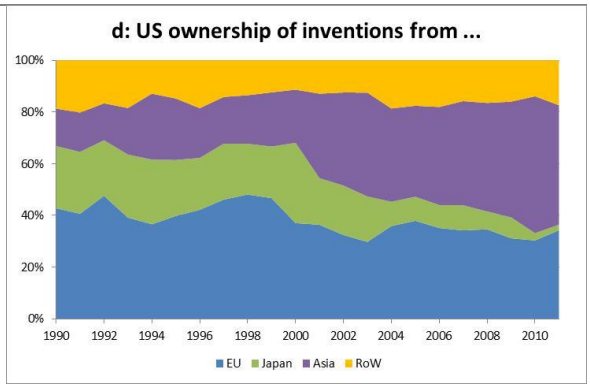
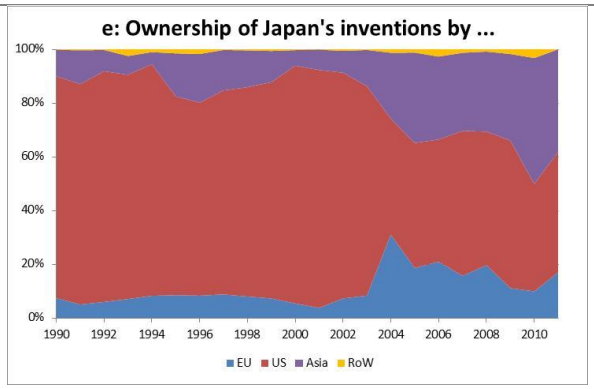
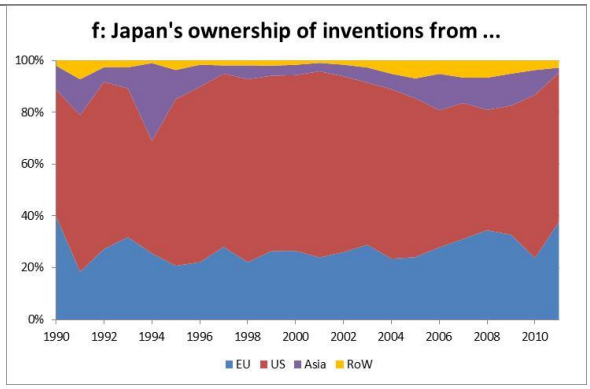
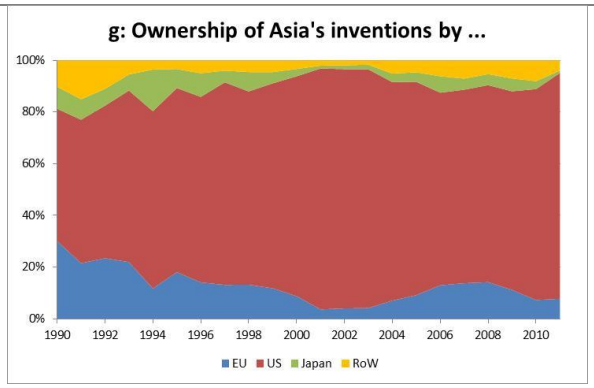
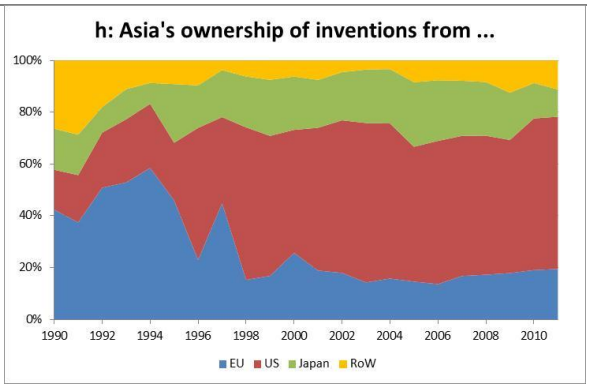
Foreign ownership of Japanese inventions: Figure 7e shows the distribution of foreign ownership of Japanese inventions in ICT by the origin of the applicants. The main foreign owners of Japanese inventions owned by foreign applicants are US applicants. In 2011, they held 52% of inventions developed by Japanese inventors and owned by foreign applicants. Asian applicants, who own 35% of Japanese ICT patent applications, constitute the second largest group in this comparison. EU- and RoW-based applicants hold 7% and 5% of the remaining Japanese patent applications.

Japanese ownership of foreign inventions: Figure 7f illustrates the distribution of international inventions owned by Japanese entities by the origin of inventors. Again, there is a clear dominance of the US. In 2011, 61% of all patent applications for ICT inventions developed outside Japan and held by Japanese applicants were of US origin, followed by those of EU origin (31%). However, inventions of Asian origin (5%) only played a small role in the pool of foreign inventions owned by Japanese applicants.

Foreign ownership of Asian inventions: Figure 7g shows the distribution of foreign ownership of Asian inventions in ICT by the origin of the applicants. US applicants own 86% of Asian inventions owned by foreign applicants. This way, the US is the major foreign destination of ICT technology developed in Asia. The remaining regions, i.e. EU, RoW and Japan, own considerably smaller shares of Asian inventions owned by foreign applicants, i.e. 8%, 5% and 2% respectively.

Asian ownership of foreign inventions: Figure 7f illustrates the distribution of international inventions owned by Asian applicants by the origin of inventors. The distribution of Asian ownership of foreign inventions is more diversified than the foreign ownership of Asian inventions presented above. However, in 2011, US inventions owned by Asian applicants formed the largest part of foreign inventions owned by Asian entities (64%). The second largest source of foreign inventions owned by Asian applicants was the EU (20%). Although Japanese inventions constituted a large share of foreign inventions owned by Asian applicants, this changed over time. By 2011, the share of Japanese inventions owned by Asian applicants dropped to 11% from nearly 20% in 1990. This shows that technology developed in Japan became relatively less attractive for Asian applicants.

Figure 7: Cross-border ownership of ICT inventions, in %, 1990-2011

	Foreign ownership of domestic ICT inventions	Domestic ownership of foreign ICT inventions
EU		
US		
Japan		
Asia		

Note: Priority patent applications filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor, the priority date and fractional counts. Source: IPTS calculations based on PATSTAT, 2013.

3.5. Synthesis of the main findings

Figure 8 presents a comparison of different levels of ICT R&D internationalisation across the world's main regions, based on overall performance according to all four measures between 2000 and 2011. This analysis together with the evidence presented in the previous sections allows us to make the following observations:

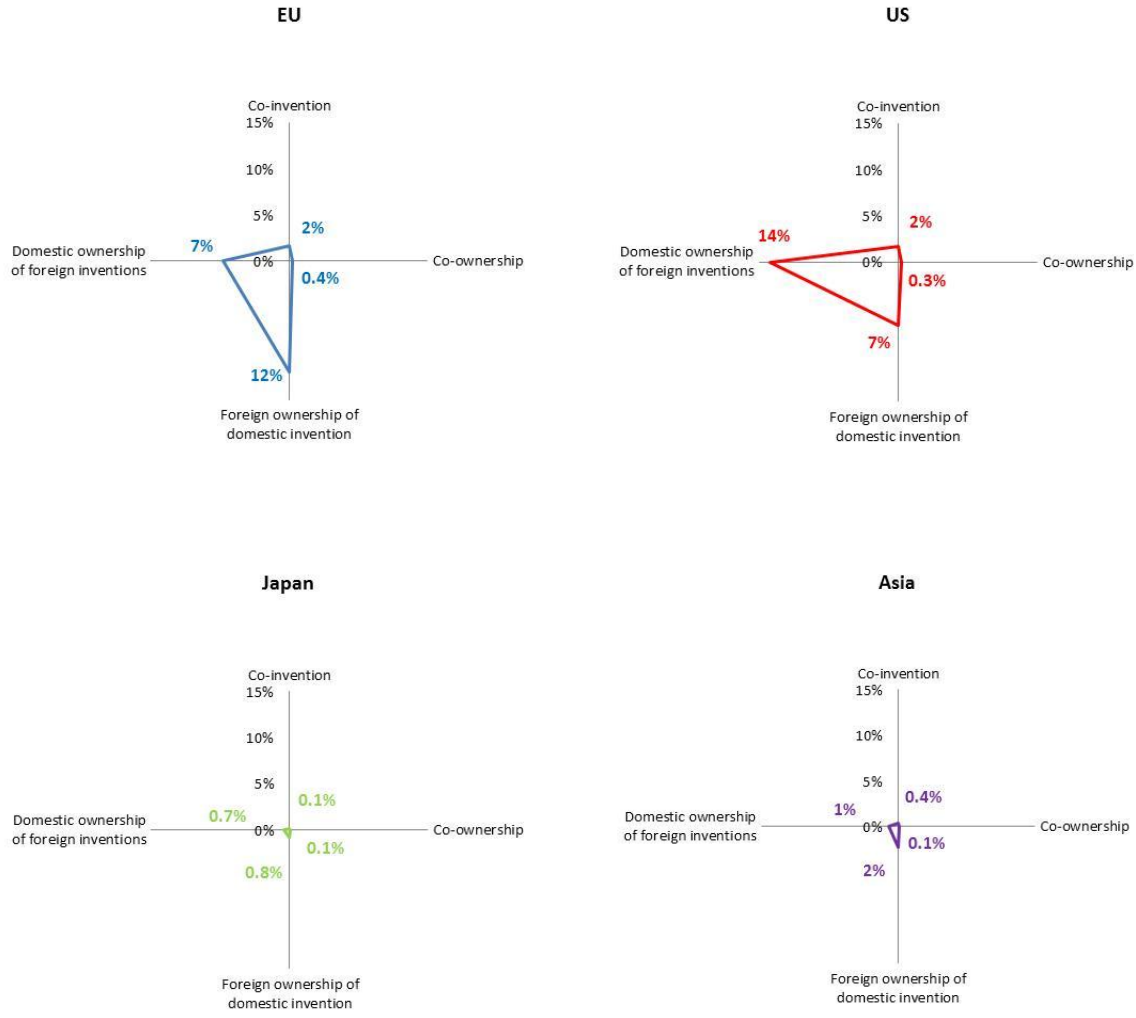
The levels of ICT R&D internationalisation are growing. However, there are significant differences between the levels of various forms of R&D internationalisation. This indicates that while some forms of internationalisation are difficult to implement in practice, e.g. co-ownership of inventions, others are more often observed, e.g. ownership of foreign inventions proxying cross-border technology acquisition.

The EU is very attractive as a technology developer for foreign partners, but it is less successful at sourcing technology from abroad. This is particularly visible in a direct comparison with the US. Although the levels of inventor and applicant collaboration in the US and the EU are similar, there is an important difference in the level of ownership of foreign inventions. US firms own significantly more patents including foreign inventors than EU firms do and, at the same time, more EU inventors file patent applications with foreign firms than US inventors do. In other words, although the degree of inventor collaboration and co-ownership of inventions in both regions are nearly identical, the share of US-owned foreign ICT inventions is significantly higher than the corresponding measure for the EU. Furthermore, this gap has persisted over the last few years, suggesting that it may have structural causes. A possible interpretation is that the US may benefit more from the process of internationalisation of inventive activity by more successfully capturing inventions developed in overseas locations and by having relatively higher levels of collaboration with foreign researchers. When extended to other regions, this observation could suggest that different regions follow different ICT R&D internationalisation 'paths' (Nepelski and De Prato 2012). Alternatively, it may reflect the capabilities of companies to develop and benefit from performing ICT R&D activities on a global level.

The role of Asia as an ICT R&D partner is rapidly increasing. Over the last decade, there have been some important developments in the intensity of ICT R&D internationalisation of Asian countries.

Strong ties between the US and Asia. In particular, since 2000, there has been a steep increase in patent applications with US and Asian inventors, whereas the level of collaboration between EU and Asian researchers and applicants seem to have remained low. Furthermore, as mentioned above, US firms seem to be much more active in applying for patents on inventions developed by Asian inventors than their European counterparts. Moreover, it is equally interesting that Asian firms seem more likely to patent an invention with an American than with a European inventor. Thus, it can be concluded that the US has gained a first-mover advantage in tapping the inventive resources of the Asian region.

Figure 8: A comparison of different levels of ICT R&D internationalisation across the world's regions, % in total for 2000-2011



Note: The figure presents the shares of international co-inventions, co-ownership, cross-border ownership of inventions in the total number of ICT inventions across world's regions. The computation includes all patent applications filed to the EPO, the USPTO and over 80 national patent offices between 1990 and 2011. Invention counts are based on the inventor or applicant criterion, the priority date and fractional counts.
Source: IPTS calculations based on PATSTAT, 2013.

4. Conclusions

The main conclusions of the report can be summarised as follows:

Capitalising globally on innovation requires its global protection. ICT technology is being produced globally. A technology company operating in one country automatically competes with firms from the rest of the world. Mediating the effects of this competition requires the right tools to protect a company's technological assets in the right markets. Either through offensive or defensive use, patent protection is a commonly-used measure to ward off competition and to capitalise on innovation. However, patents are country-specific and are valid within the borders of the issuing country. In order to extend innovation protection to another country, a firm needs to obtain a patent from the national patent office where it seeks protection. It can be observed that the number of foreign patent applications is increasing over time and that multi-country patent portfolios are becoming an intrinsic feature of ICT firms. However, considering the behaviour of European companies, it can be questioned whether they sufficiently protect their inventions and technologies in foreign markets. In the long run, insufficient protection may reduce their competitiveness, as they will not be able to claim rights over their inventions in relevant markets and to capitalise on them.

ICT R&D internationalisation is a two-way street. Firms as well as countries can fully benefit from the process of R&D internationalisation if they recognise that it consists of two directions. First, it is necessary to search for technological assets outside the home location in order to combine them with domestic resources. Second, it is crucial to maintain a domestic R&D base which is attractive for foreign actors. However, we have observed a strong polarization between R&D internationalisation paths that regions follow. For example, the EU is very attractive as a technology developer for foreign partners - a sign of its high level of scientific and technology excellence – but it is less successful at sourcing technology from abroad. Similarly, though many foreign companies participate in Asian R&D activity, Asia has low levels of outward R&D internationalisation. In order to fully benefit from participation in the R&D global network, it is also necessary for firms to seek for knowledge and technology resources outside their home location to complement their domestic assets. On the other hand, international commercialisation of domestic technology helps to increase the return on R&D investments.

5. Annex: Data source and methodology

PATSTAT database: To compute patent-based indicators used in the current study, we used the European Patent Office (EPO) Worldwide Patent Statistical Database (known as the PATSTAT database). This database provides a worldwide coverage of patent applications submitted to around 180 Patent Offices in the world. The present analysis is based on indicators built by extracting and elaborating patent application data from the April 2013 release of the PATSTAT database, taking into account patent applications filed to all Patent Offices included in PATSTAT. The time period covers from 1 January, 1990 to 31 December, 2011.

The PATSTAT data was elaborated through a series of methodological steps. We started with methods consolidated in the literature (De Rassenfosse et al. 2011, Turlea et al. 2011, Picci 2010) to deal with some remaining criticalities, mainly related to the process of exchange of information among patent offices, which affects patent data. First, as the needed variables are intended to provide a measure of the inventive capability of countries, rather than the productivity of patent offices, a subset of 'priority patent applications' was initially taken into account, to avoid double counting and the limitation coming from considering granted patents. The year follows the first filing date. Second, when it comes to identifying the country of residence of applicants (or inventors), several methodological steps are followed to collect missing country information from other records. A detailed description of the methodology can be found in de Rassenfosse, Dernis, Guellec, et al. (2011).

Identifying ICT patents: With regard to the identification of ICT patent application technology classes, we considered the taxonomy of the International Patent Classification (IPC) technology classes proposed by the OECD (OECD 2008b). This taxonomy links four categories of ICTs to groups of technology classes, i.e. Telecommunications, Consumer electronics, Computers and office machinery, Other ICT.[5] The *fractional counts* approach has been applied in cases where applications refer to more than one technology class.

[5] IPC codes for individual groups: Telecommunications: G01S, G08C, G09C, H01P, H01Q, H01S3/ (025, 043, 063, 067, 085, 0933, 0941, 103, 133, 18, 19, 25), H1S5, H03B, H03C, H03D, H03H, H03M, H04B, H04J, H04K, H04L, H04M, H04Q; Consumer electronics: G11B, H03F, H03G, H03J, H04H, H04N, H04R, H04S; Computers and office machinery: B07C, B41J, B41K, G02F, G03G, G05F, G06, G07, G09G, G10L, G11C, H03K, H03L; Other ICT: G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, G01N, G01P,

Assigning patents to countries: As regards assigning patents to countries, there are two common methodologies (OECD 2008a). It is possible to refer to either the declared country of residence of the inventor(s) ('inventor criterion') of a patent, or to that of the applicant(s) ('applicant criterion'). Several applicants could hold rights on a patent application, and they would have legal title to the patent once it is granted. In the same way, several inventors could have taken part in the development process of the invention, and be listed in the patent application. A fractional count is applied in order to assign patents to countries in cases where several inventors (or applicants) with different countries of residence have to be considered for the same application. In general, the choice of the criterion depends on the perspective from which innovative capability is being investigated. Thus, as our analysis focuses on international patenting, we count the number of inventions according to the applicant criterion.

Identifying countries in which an innovation is protected: Each patent application identified in step one has been linked to all subsequent filings, which refer in any way to the first application for protection of the invention. At this point, pairs of countries were formed by linking the country of the applicant who made the priority application on the one hand, and the country of the patent office to which the subsequent applications have been submitted, on the other hand. To each pair of countries, the number of applications was assigned, grouped along with the years of subsequent filings.

G01R, G01V, G01W, G02B6, G05B, G08G, G09B, H01B11, H01J (11/, 13/, 15/, 17/, 19/, 21/, 23/, 25/, 27/, 29/, 31/, 33/, 40/, 41/, 43/, 45/), H01L.

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Abstract
This report looks at foreign ICT patent filings and the dynamics of ICT R&D internationalisation. The number of foreign ICT patent applications is increasing. This process is, however, restricted to a few countries. Applicants from Japan, the US and South Korea file the most foreign patent applications. A very high level of concentration can also be observed for the destination of foreign patent filings. The main destinations of international ICT patent filings are the USPTO, EPO and the Chinese Patent Office. Although Europe represents an important source of innovation and an attractive technology market, European technology owners are relatively inactive in protecting their IP in foreign markets. Considering ICT R&D internationalisation, its level is also increasing. In this context, the emerging roles of Asian countries, such as South Korea, China and India, are of particular interest. Today, Asia is the biggest partner of the US in technological collaboration. In contrast, although European inventors are very attractive as a technology development partners for foreign partners, they are less successful in sourcing technology from abroad to complement and combine with their own domestic resources.

Keywords: international intellectual property rights protection; IPR; internationalisation of R&D; ICT
JEL classification: F23, O30, O57

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