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CIFRA: Challenging the ICT Patent Framework for Responsible Innovation

D2.2: Empirical Evidence on ICT patents between 1990 and 2012

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PREFACE

Social Sciences and Humanities (SSH) do not usually take a preeminent role in technical research projects. Sister projects arise as part of Horizon 2020 Framework Programme as a way to address this historical constraint and to allow SSH make a meaningful contribution to the shaping of the research agenda. To this regard, Sister projects are created to go beside the mainstream research in order to challenge existing biases in the research agendas and trying out more daring alternatives through the widening of imaginaries and by taking into account the SSH perspective.

CIFRA, as a Sister project, does not take the current status quo in the ICT patent ecosystem for granted, but on the contrary, explores the impact that potential new framings could have in ICT innovation and the value they could provide to the society.

Moreover, CIFRA project has addressed the ICT Patent ecosystem from the perspective of the Responsible Research and Innovation (RRI), thus with the aim of determining the way it can be better aligned with the values, needs and expectations of society.

1 INTRODUCTION

Based on surveys carried out in 1994 with R&D laboratories of about 1500 firms in manufacturing industries, Cohen et al. (2000) reported that companies relied most heavily on secrecy and lead times, and to a much lesser extent on patenting. Since then patent propensity has exploded. Indeed, the number of patent applications has increased steadily across the last 10 years in all major jurisdictions. For instance, from 2006 until 2015, patent applications at the USPTO and EPO increased by 50% and 20% reaching 589000 and 160000, respectively (although patent applications have stagnated in Europe in the last five years). The growth of applications at the Chinese Patent Office is even more dramatic with over 1 million patents filed in 2015 and nearly 300000 granted.

The information and communication technologies (ICT) sector displays even more pronounced propensities toward patenting. Based on data covering 13 OECD economies, Fink et al. (2013) show that patenting propensities in ICT continued to climb during the 2000s. Fink et al. (2013) also show that the relative increase in patent filings in ICT is partly due to an extremely fast growth in filings on digital communication technologies. Eberhardt et al. (2016) attribute most of the surge in patenting activity at the Chinese Patent Office to the filings of a small number of firms that operate in the ICT sector.

While a naïve interpretation of these trends might conclude that the ICT sector is healthy and innovative, a proliferation of patent rights might have some deleterious consequences. Take, for instance, smartphones that require licenses of hundreds or even thousands of patents that, in most cases, have fuzzy boundaries (Biddle, White and Woods, 2010). This creates a complex interdependency scenario in which exclusion rights involving a scarce resource, such as those arising from patents, hinders the availability of technology (Heller, 1998). In fact, patents become powerful tools to stop the implementation of the technology instead of promoting it. This has brought in an escalation in the filings and the legal costs of patent enforcement, often associated with 'Patent Wars', as well as other strategic reactions like moving to countries with weaker intellectual property rights regimes (Paik and Zhu, 2016).

Another important consequence is associated with the proliferation of patent applications and the fragmentation of the patent landscape. Overloaded with patent applications, patent offices might relax their quality checks and/or delay their granting decisions. Lower quality patents and longer patent lags make the patent landscape even more complex for companies and thus contribute to additional fragmentation and uncertainty, as property rights are not clear to the different players. Longer lags have also important implications for those companies that want to license their intellectual property. Gans, Hsu and Stern (2008) show that the probability of achieving a cooperative licensing agreement significantly increases in the aftermath of a patent allowance, as the allowance removes the uncertainty regarding the intellectual property that is negotiated. Farre-Mensa et al. (2016) find that each year delay in reviewing a firm's first patent application that is eventually approved reduces the firm's employment and sales growth over the five years following approval by 21 and 28 percentage points, respectively.

In this paper, we explore the correlation between measures associated with excessive patent fragmentation/proliferation and patent lags (from application to grant) in the ICT industry during the period 1990-2012. Our results are not to be interpreted as causal effects of firm characteristics on patent delays, but rather as descriptive evidence of correlations between patent applicants' characteristics and the time from patent applications to patent grant.

Among the different intellectual property rights, the CIFRA project chose to focus on patents because patents are particularly relevant in ICT. Moreover, as explained above, their use has increased dramatically in the last few years. We acknowledge upfront that findings might not be generalizable to other IPRs or industrial contexts.

The rest of the paper is structured as follows.

Section 2 provides a literature review of the main drawbacks associated with excessive patenting in ICT. Section 3 describes our data. Section 4 presents descriptive statistics and provides an overview of the trends of patenting within the ICT industry. Section 5 explores more in detail the correlation between patent lags and several measures of fragmentation and patent proliferation. Section 6 offers some conclusive remarks.

2 Drawbacks of Excessive Patenting

2.1 Fragmentation of IPRs

The ICT industry is characterized by an overall increase in the level of technological complexity and the convergence of different technological domains (Gauch and Blind, 2015). In addition, the need for interoperability and interconnectivity of different technologies and devices to combine them into single products and services creates demand for technological standards that promote compatibility (David and Greenstein, 1990). This has created a proliferation of patents and a fragmentation of the patent landscape, with increased incentives to patent strategically (Berger et al., 2012, Kang and Bekkers, 2015). This trend has produced a number of different problems including patent thickets, patent wars and underinvestment in innovation.

Patent thickets arise when different patent owners hold complementary patents (Shapiro 2001). This kind of situation is problematic because it can create the conditions for which companies may block each other's use of the technology protected by the intricate set of patent claims. When technologies are particularly complex, like in the ICT sector, the likelihood that firms will experience patent thickets is higher (Von Graevenitz, Wagner, and Harhoff, 2011). Patent thickets are associated with increased transaction costs for companies. Patent thickets have far-reaching consequences. Cockburn and MacGarvie (2011) show that the presence of patent thickets (as proxied by patent density in a market) is negatively associated with the choice of entry to a given product market. A recent study of the impact of patent thickets in the UK (Hall, Helmers and von Graevenitz, 2017) shows that they raise entry costs, which leads to less entry into technologies regardless of a firm's size.

Patent wars are likely to erupt whenever the expected payoff from offensive actions aimed at dominating the technological field exceeds the expected payoff from cooperation with other industry players (Somaya, 2003). Such behaviors are mostly witnessed in industries built around platforms or standards (e.g. the smartphone industry), where one or few major players quickly become dominant (Shapiro and Varian, 1999; Zhu and Iansiti, 2012). In industries presenting such high strategic stakes, cooperation mechanisms are likely to break down in the early stages of industry development (Lanjouw and Lerner, 2001) and patent owners are more likely to aggressively defend their patent rights against competitors.

The fragmentation of the patent landscape that characterizes the ICT industry is especially problematic because of its detrimental effects on the incentives for developing innovations. Thumm (2005) finds evidence that the presence of blocking patents at times impedes the development of medical tests. Likewise Arundel and Patel (2003) report that 16% of the firms included in their study declared that they had to abandon research projects because of patents held by competitors. Based on a large-scale survey conducted with inventors in USA, Europe and Japan, Torrisi et al. (2016) report that about 40% of patents remained unused by their owners, and about 67% of patent applications were filed to block other patents. Even when fragmentation does not oblige companies to abandon R&D projects, it frequently forces them to engage in some sort of copying mechanism, such as taking legal actions to limit the IP held by others or acquiring additional IP rights (Mueller, et al., 2013).

2.2 LITIGATION COSTS: LACK OF FREEDOM TO OPERATE

Patent litigation is a topic of extreme relevance for scholars, industry players and policy makers. According to a PWC report (2016), the total number of patent litigations in the US has been growing since 1991 at a 6.7% Compounded Annual Growth Rate to a total of more than 5600 cases in 2015. The growth rate is higher than the corresponding growth rate in patents granted, which over the same time-span has been equal to 4.9%. Not surprisingly, this trend has produced an increase in the amount of time it takes to judicial courts to process patent cases. According to the same report, the median time-to-trial for the period 1996-2000 was less than a year, while the figure for the 2011-2015 period is more than two and a half years. Beyond the US, patent litigation has been increasing in the rest of the world, with at least 250 cases of patent litigation being reported in the past 5 years.[1] In countries with patent-owner friendly systems, like Germany and China, infringement of a patent, and the validity of a patent need to be determined at two different courts. Furthermore, patent owners have high win rates in these countries, so patent litigation cases may continue to rise.

Patent litigations represent a heavy financial burden for firms and do not create any value for the society. Bessen and Meurer (2008) estimated that on average firms spend in patent litigation an amount equal to 14% of their total budget for research and development. Moreover, to prevent potentially destructive legal lawsuits, firms are at times forced to take drastic and costly actions. For example, the multi-billion dollar acquisition of Motorola by Google was mainly conducted to avoid lawsuits from Apple and Microsoft. The value of Motorola for Google in fact stemmed from the possibility of using the patent portfolio of Motorola to sue back Apple and Microsoft in case this would have been necessary. A recent paper by Mezzanotti (2016) shows that patent litigation reduces investment in innovation by lowering the returns from R&D and by exacerbating financing constraints.

With millions of active patents and hundreds of thousands new patents filed for every year, it is difficult for any single firm to keep up with the state-of-the-art, especially in fast moving industries (Lemley and Feldman, 2016). These authors note that the majority of patent lawsuits are now filed by non-practicing entities. According to a recent study using event study method to look at cumulative abnormal returns around the time when non-practicing entities file for patent lawsuits, non-practicing entities may have caused the loss of half a trillion dollars in market value between 1990-2008 period (Bessen et al., 2011). Moreover, this represents a huge loss in R&D incentives and in social welfare as only a small amount of money transferred from the sued parties ends up in the non-practicing entity.

2.3 High (legal) uncertainties regarding prior art and granting

More recently economic and legal scholars have begun to look at patents in a probabilistic sense (Lemley and Shapiro, 2005; Shapiro, 2003). According to this view patents do not confer to their holders the right to exclude others from the unauthorized use of the innovation, but rather a right to *try* to exclude by asserting the patent in court.

Part of the reasons behind this increase in uncertainty can be traced back to the process through which patents are granted. The USPTO, for example, requires the patent applicants to disclose the relevant prior art of which he/she is aware of, but not to conduct an exhaustive search of all the prior patents that are related to the invention. As a result, the USPTO is frequently criticized for missing relevant prior art and thus improperly issuing patents (e.g. Lemley, 2001). As patent proliferation has become an issue over the last years,

[1] The Rise of Non-Practicing Entity (NPE) Cases Outside the United States. Accessed on 02/04/2017. Available at: http://www.darts-ip.com/the-rise-of-non-practicing-entity-npe-cases-outside-the-united-states/

patent offices around the world have been focusing on quality. As way of example, the so-called EPO "Raising the bar on patent quality" program (EPO annual report, 2007) aimed at achieving better patent applications from the onset.[2]

Furthermore, the problem of high legal uncertainty is complicated by three tendencies. The first is the expansion of the patentable subject matters over time (Gallini, 2002; Kortum and Lerner, 1999). In the United States for instance, the Federal Circuit Court of Appeals included software to the list of patentable inventions in the 1980s and 1990s, and business methods in 1998. The second is the relaxation of the principle that an invention must be non-obvious and contribute non-trivially to prior knowledge in order to be granted a patent (Merges, 1992). For some technology areas this principle has been relaxed to a point where a large number of patents of dubious validity has been granted (Barton, 2003; Jaffe, 2000) thereby increasing the chance that a given invention will infringe one or more existing patents and hence, lead to litigation. The third is a general propensity of inventors to file patent applications in areas of technology that historically have not been patentable (Lerner, 2002).[3]

2.4 PATENT DELAYS

Patent delay indicates the time that elapsed between the date in which a patent is filed (an application) and the date in which the patent is granted by the patent office. Detailed evidence of how patent delays have changed across years and how they vary across subject matters and jurisdictions is not available. However, a few studies have shown that patent delays are an increasingly important phenomenon. There is also scattered evidence about the determinants of patent delays. There is evidence showing that well-documented applications and those referred to patents with higher value are approved faster by the EPO and are withdrawn more slowly by the applicant (Harhoff and Wagner, 2009). Based on a longitudinal study of patents on genetically modified crops in the US, Regibeau and Rockett (2010) find that examination delay decreases as the patent office examines more patent applications in a technology class, and that the review delay is shorter for more important patent applications (i.e. patents that receive more citations) when the date of filing is controlled for.

Delays in patent allowance have far-reaching consequences, as the intellectual property rights associated with a patent are not tradable before the patent is granted. Delayed patent allowances have been associated with a lower probability to license the patented technology, reduced employment by firms and reduced sales growth (Gans, Hsu and Stern 2008; Farre-Mensa et al. 2016).

[2] https://www.epo.org/about-us/annual-reports-statistics/annual-report/2007/focus.html

[3] Recently, a new phenomenon has appeared in patent strategies: the extensive use of divisional applications and continuations (Link: https://www.epo.org/news-issues/news/2013/20131018.html). These applications benefit from early priority dates that can effectively target alleged infringing products, long after these products have been introduced in the market. Many advocated that patents should not be allowed to be drafted ex post. To that end, the EPO unsuccessfully attempted to limit the time that divisional could be filed. So, the practice of allowing products to flood the market, target the future patent to the already known product has not been limited yet.

2.5 Patent Quality

A report by the OECD (Science, Technology and Industry Scoreboard 2011) finds that patent quality has declined by an average of around 20 percent between the 1990s and 2000s, a pattern seen in nearly all countries studied. Patents of low quality should not be granted by the patent offices as they protect trivial innovations, offer very uncertain claims, infringe other patents, cover non-patentable subject matter, etc.

Empirically, it is difficult to measure patent quality and, in most cases, patent quality has been equated to patent value. The latter has been measured with patent citations (Trajtenberg, 1990), the number of countries where the patent is applied for, how long a patent is renewed for (Lanjouw et al., 1998), the number of claims in the patent application (Tong and Frame, 1994), an index made up of number of claims, forward citations to the patent, backward citations in the patent application, and family size (Lanjouw and Schankerman, 2004). A more recent assessment of patent quality indicators across countries and technology fields, compares three composite indicators based on an equal weighting but different combinations of indices on patent scope, patent family size, patent grant lags, backward citations, citations to non-patent literature, claims, forward citations, breakthrough inventions, generality, originality, radicalness and patent renewal (Squicciarini et al., 2013). These efforts underscore the fact that measuring patent quality has been a consistent challenge for scholars working on innovation strategy.

3 Data

The data used in this study is based on the European Patent Office (EPO) data of the CRIOS-PatStat database. Researchers at the Invernizzi Center for Research on Organization and Strategy of Bocconi University use the raw data from Worldwide Patent Statistical Database (PatStat) released by EPO, and process the data to associate patent applications with other information on inventors. This cleaning activity consists of the disambiguation of inventors and applicants, as well the normalization and reclassification of technology classes, which allow for easier statistical analyses. A description of the history, disambiguation procedures, and the access rules to the separate tables of the data used in putting together the CRIOS-PatStat database can be found in Coffano and Tarasconi (2014).

The current version of the database allows tracing patent applications made by companies over time and has data on patent applications between 1978 to 2014. However, patent offices are subject to large patent application backlogs, with 888,000 patents waiting to be examined at United States Patent and Trademark Office (USPTO), compared to 340,000 patent applications waiting to be examined at the EPO as of 2008 (Mejer and de la Potterie, 2011).[4] Besides the backlog issue for patents that are still under examination within the

[4] While discussing the reason for these backlogs based on descriptive evidence, these authors suggest that the larger backlog at USPTO is due to very low patent application filing fees and a weak rigor in the examination process, whereas the reason for the backlog in EPO, the data source for this study, is a strategic filing behavior by inventors. According to this, applicants at the EPO aim to delay the grant date, in an effort to postpone high fees associated with translation, multiple validation and annual renewal fees based on which of the 35 national patent offices under EPO that applicants want their patent to be validated (Mejer and de la Potterie, 2011).

span of our database, we also need to consider the beginning of an overall increase in patenting activity in late 1980s.[5] Hence, we restrict our analyses to start from 1990, and considering patent backlogs, as well as the evidence we provide below showing long periods between application and patent grant, we restrict our sample to the end of 2012 for most of our analyses.

Some drawbacks of this dataset are explained below. First, the parsing, cleaning and matching processes in disambiguation of inventor names and applicant addresses carry some cases of mismatches across tables, due to name similarities, and address similarities, as well as multiplicity of addresses for distinct applicants. Second, in the underlying PatStat data, IPC concordances are not reported for a large portion of the original patent applications (about 20% in 2010/10 Patstat data). This issue propagates into the data we use. Another caveat is that after the latest update to the database, the patent application is associated with the last inventor/applicant of the patent. Finally, for the International Patent Classification (IPC) correspondences, we use the CLMN variable providing the IPC code in a fixed format, which allows capturing IPC classes in a more reliable manner, but it is specific to the database we are using[6]. This classification is not up-to-date with the IPC-NACE 2 concordance[7].

The ICT industry does not map directly to technology classes as they appear in patent documents. To extract patents that belong to ICT we need to rely on a concordance scheme which relates industries to relevant technological classes. To do so, we followed Palmberg and Martikainen (2006). They identify a set of technology classes that belong to the ICT industry. Indeed, their study was motivated by the goal of understanding the largest ICT operators' technology diversification, across the broader ICT technology landscape. The "traditional" telecom category lists technologies that are backward compatible with the ISDN standard and circuit switching, whereas internet related telecom classes are technology classes with TCP/IP compatibility and packet-switching compatibility. Applications category relates to both traditional and internet-based telecom technology classes, and lays the foundations of the new generation smart phone technologies. We also include some "other" technology classes that feature technologies that span crucial patents to continue operating in ICT industry, using the most recent IPC v8 -NACE Rev 2 version (2014).

Specifically, the IPC concordance used in determining which patent classes belong to which technology classes in our industry of interest, i.e. ICT industry, was based on the following table:

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[5] There is evidence suggesting that in many industries across different countries, patenting activity started to increase from mid-1980s, such as in semiconductors industry (Hall and Ziedonis, 2001), along with an increase in patenting activity concentrated on electrical, electronics, computing, and scientific instruments industries (Hall, 2004), and overall in the United States (Kortum and Lerner, 1999), as well as in China (Hu and Jefferson, 2009).

[6] The original table of the Patstat database for the CLMN variable is tls209_ipc_class_symbol.

[7] The most recent IPC v8 -NACE Rev 2 version is available here: https://circabc.europa.eu/sd/a/d1475596-1568-408a-9191-426629047e31/2014-10-16-Final%20IPC_NACE2_2014.pdf

Table 1: IPC concordance

Technology Categories	**Four-digit IPC Classes**
Traditional Telecom	
- Transmission - Switching - Voice Applications and Equipment	- H04B, H01Q, H01P, H04J, G01R - H04Q, H01H - H04M, H94R, G10L
Internet Related Telecom	
- Data and Internet Applications - Encrypting and Security - User Authentication and Access Control	- G06F, H04L, G06N - H04K - G09F
Applications	
- Pictorial Communication - Positioning - Games - Electronic Payment - Codecs and Algorithms - Machine to Machine - Photography - Mechanical Technologies	- H04N - G01S - A63F - G07G - H03M, H03L - G08C - G03B - B23K, B29C, G06N, H05K, H01B, H01R, H02B, H02G
Others	
- Impedance Networks - Pulse Technique - Broadcast Communication - Wireless Communication Networks - Recognition of Data - Image Data Processing	- H03H - H03K - H04H - H04W - G06K - G06T

Based on this classification, we use the four-digit technology class to search for patent applications in our database. There is variation across 5-digit technology classes within those 4 digit classes that we do not employ for the purposes of our analysis. Our universe of patents is solely based at the 4-digit technology class of the IPC class normalization of our database. Upon discussions of this scheme with practitioners from the industry, we also decided to demonstrate what happens when we take H04H and H04W classes out of the "Others" category.

Finally, our data only reflects trends at the EU level and we do not know if these findings are generalizable to other jurisdictions.

4 DESCRIPTIVE EVIDENCE

4.1 AGGREGATE TRENDS IN ICT

According to our dataset, the number of patent filings increased from less than 10,000 per year in 1990 to over 33,000 in 2012. (See Figure 1). The growth rate of patent filings for the period under scrutiny is 5.6%. A more revealing statistic is how the growth of ICT patent filings compares to the general trend in patent filings. We know that patent applications have increased in all jurisdictions, at least until the early 2010s. Thus, the growth rate of ICT patent filings, while compelling, might simply reflect a general trend. Figure 2 addresses this question. It shows that the share of ICT patent filings over the total number of patent filings at the EPO has increased during the period under scrutiny, moving from around 15% in 1990 to over 20% in 2012. We interpret this trend as an increasing relevance of ICT sector in the overall economy as well as an increasing patent propensity in that sector, rather than reflecting an overall increase in patenting across all fields. In our database, we observe a total of 3,130,489 patents filed in all technology classes, of which 582,664 belong to ICT patent classes as per Table 1. This figure is comparable to what Ozcan and Greenstein (2013) have found for the USPTO. They report that the 550,000 patents granted in the ICT equipment industry during the period 1976-2010 correspond to roughly 14% of all patenting activity in the United States. In our data, the share is higher but we also cover more recent years where ICT has exploded in terms of patenting.

Figure 1: ICT patent filings at the EPO – 1990-2012

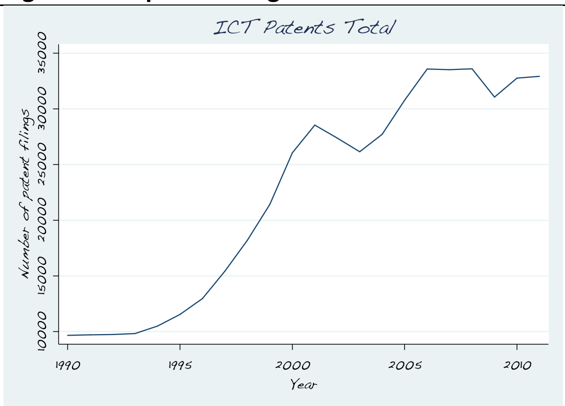
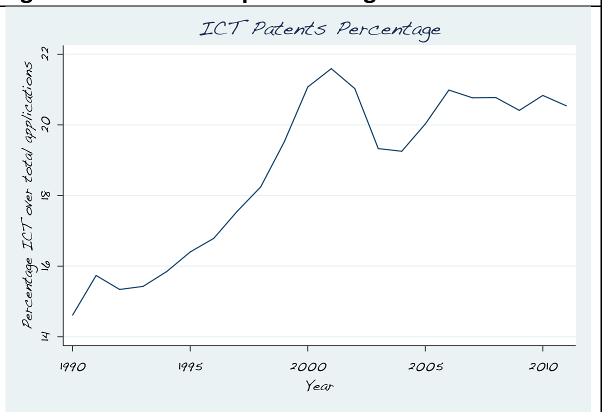


Figure 2: Share of ICT patent filings EPO – 1990-2012



4.2 MAIN PATENTEES IN ICT

Table 2 reports the top 20 ICT patent assignees during the period 1990-2012. All of these companies have filed more than 4,000 patents in the study period. The top 5 companies (Siemens, Samsung, Philipps, Qualcomm and IBM) have filed collectively over 56,000 patents, which correspond to about 9.8% of all patent filings in ICT. Interestingly, the top assignees have changed over the years. Table 3 compares the top 5 assignees during the period 1996-2000 with top 5 assignees during period 2006-2010. As can be seen, Siemens, Philips, Matsushita, Nokia and Lucent have been replaced by Qualcomm, Samsung, Ericsson, Huawei and LG. The new list suggests that over this timespan, Asian firms have become important players in the ICT sector. Also interesting to investigate is the evolution of the share of the total ICT patents that the top patent assignees received. In 1996-2000 period the top 5 assignees received a total of 11,408 patents out of 94,072 ICT patents. In the 2006-2010 period instead, the top 5 assignees received 20,758 patents out of the total 164,524 ICT patents assigned during the same period. This represent a slight increase in the share of patents received by the top 5 assignees in comparison to the total ICT world, from 12.1% to 12.6%.

Table 2: Top 20 ICT patentees at the EPO – 1990-2012

Firm	Number of patents
SIEMENS	15786
SAMSUNG	11629
PHILIPS	10278
QUALCOMM	9721
IBM	9382
ERICSSON	9246
SONY	9229
NOKIA	8408
NEC	7782
FUJITSU	7620
MATSUSHITA ELECTRIC	7211
MICROSOFT	5632
CANON	5555
LG ELECTRONICS	5253
HUAWEI TECHNOLOGIES	4962
THOMSON LICENSING	4664
BLACKBERRY	4303
TOSHIBA	4261
ROBERT BOSCH	4240

Table 3: Top 5 ICT patentees – 1996-2000 vs 2006-2010

Firm	Number of patents
Top patentees 1996-2000	
SIEMENS	3122
PHILIPS ELECTRONICS	2391
MATSUSHITA ELECTRIC INDUSTRIAL	2176
NOKIA	1928

LUCENT TECHNOLOGIES	1791
Top patentees 2006-2010	
QUALCOMM	5155
SAMSUNG	5047
ERICSSON	4630
HUAWEI TECHNOLOGIES	3144
LG ELECTRONICS	2782

In order to take a closer look at the emergence of new leaders in the patenting landscape of the ICT industry, we also analyze the increase and decrease in the patent applications by individual companies. For this, we take the total of patents applied for by all companies between 1996-2000, and compare these totals to those for the period 2006-2010. Figure 3 and Figure 4 contain the results of this analysis.

Figure 3: Increase in patenting from 1996-2000 to 2006-2010

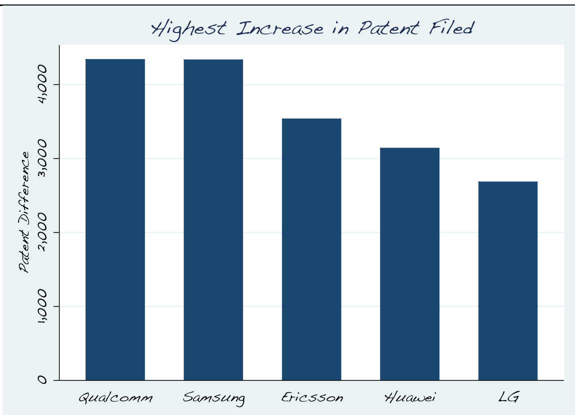
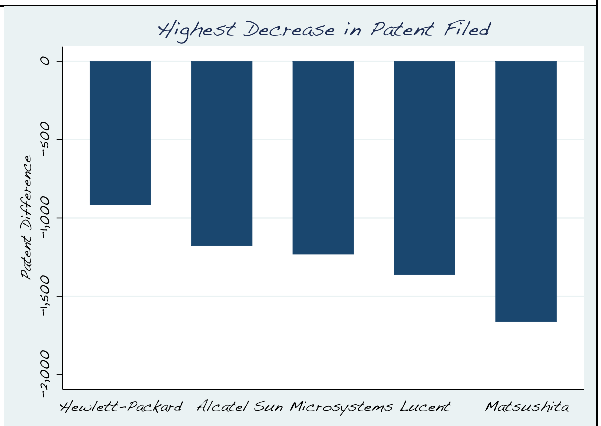


Figure 4: Decrease in patenting from 1996-2000 to 2006-2010



It is interesting to note that the five firms with the highest growth in patenting activity are also the ones with the highest amount of patent applications in 2006-2010 (Table 3). However, Matsushita Electric Industrial and Lucent Technologies are the only two companies that are among the companies with the largest drop in patent applications although being among the most active in patenting in 1996-2000. This also hints at some variation across different parts of the patenting landscape within the ICT industry, which we look at next.

4.3 Patent Classes with the Highest Growth Rates

In this section, we would like to draw attention to the concentration of patenting activity in different technology classes. Above we made a distinction between traditional and internet related telecom based on backward compatibility standards of TCP/IP for internet based telecom, and ISDN and circuit switching standards for traditional telecom (Palmberg and Martikainen, 2006). We start by looking across these larger technology categories and we then move to take a closer look into separate technology classes within those larger categories.

Figure 5a: Patent Applications in Macro Categories

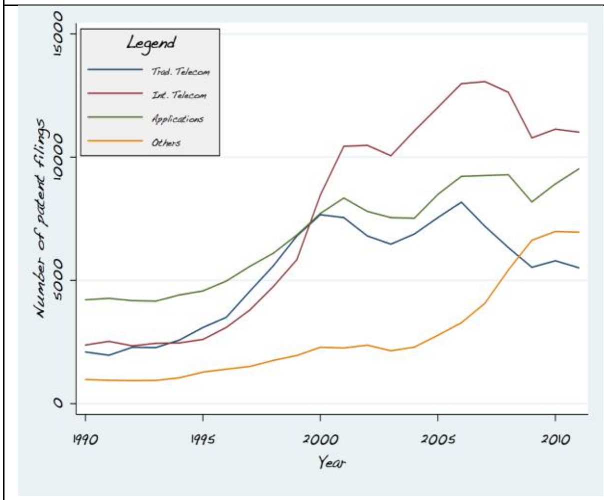
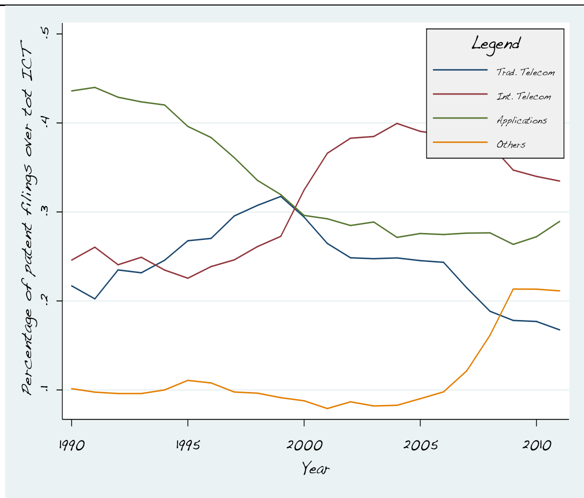


Figure 5b: Share of Macro Categories in total ICT patents applications



The first thing to note is that the behavior of our data seems to confirm that the categorization of ICT patent technology classes in terms of traditional telecom, internet telecom, applications and others is meaningful. Figure 5a reports the total level of patenting activity of the macro categories; figure 5b categories exhibit a generally increasing trend starting from 1995. Starting from year 1998, there is a surge in patenting in internet related telecom technology classes. The divergence in patenting activity in traditional and internet telecom is clear especially from year 2000 onwards. Patenting activity in traditional telecom patent classes decline slightly in the early 2000s and the same happens in the internet related classes in the years of the tech bubble bust, but in this latter case the decline it is soon followed by a strong increase in activity. Patenting in the category "Others" starts to rise from mid 2000s onwards. The high level of patenting activity in the applications technology category in the early period arises from the more general applicability of some of the technology classes within it, like "photography" and 8 classes of "mechanical technologies", as per Table 1.

In order to better understand the jump in the "others" category, we take out H04H - Broadband Communications and H04W – Wireless Communications, and repeat our analysis. Once these two technology classes are taken out of "Others", the remaining technology classes within that category show an almost linear trend over the study period as can be seen in Figure 6a. Indeed, the jump in patent applications that we observe in "Others" category emanates from the rise of patenting activity in these two relatively nascent technology fields. These two technology classes make up a very small part of ICT patents in the earlier part of our study, as can be seen in Figure 6b below, but this is followed by a large increase to almost 15% in the later part of the study.

Figure 6a: Patent Applications in Macro Categories with H04H and H04W Separated

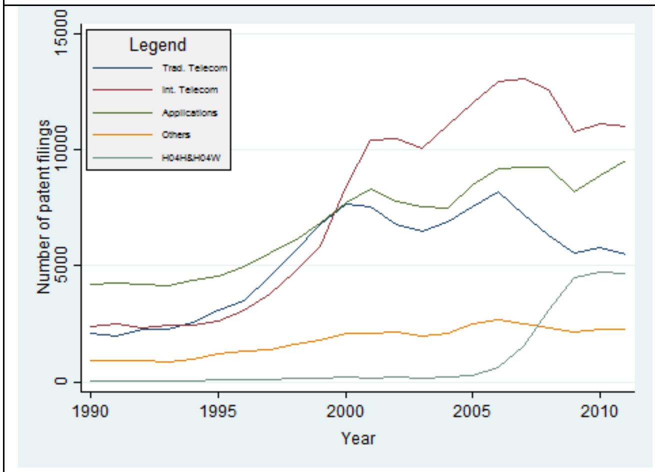


Figure 6b: Share of Macro Categories and H04H-H04W in total ICT patents applications

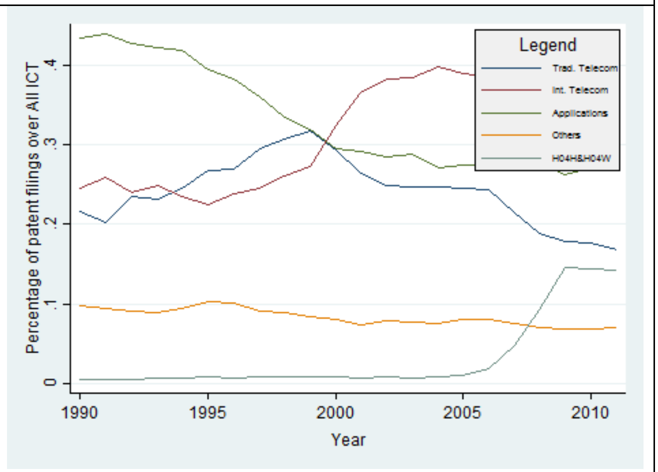


Figure 6c: Share of Macro Categories in Total ICT Applications in 1995 and 2012

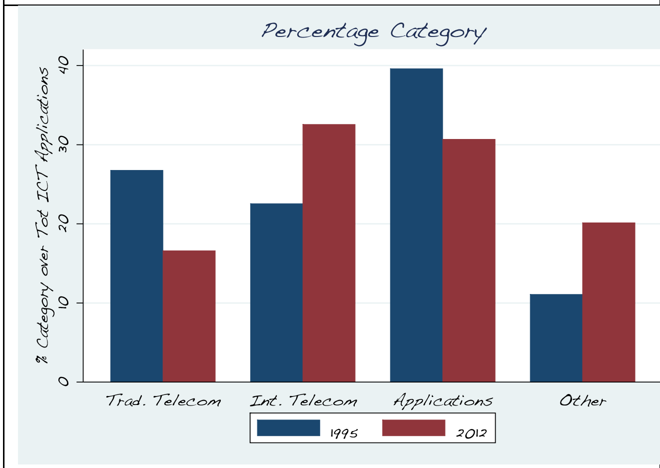
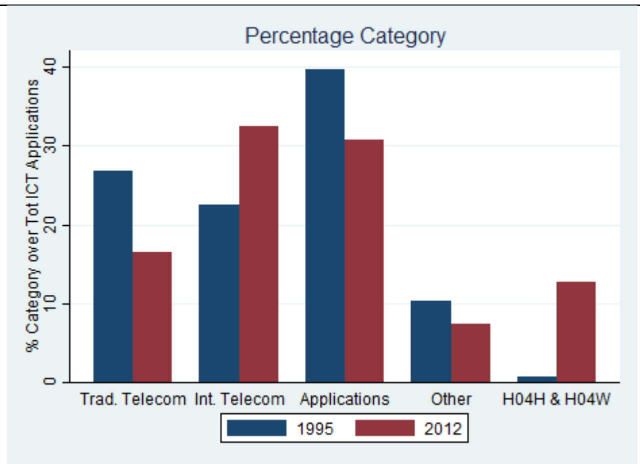


Figure 6d: Share of Macro Categories and H04H-H04W in Total ICT patents applications in 1995 and 2012



In Figure 6c, we report two slices out of Figures 5b to contrast the changes in the categories from the earlier part of our sample to the later part. In Figure 6d we take out the H04W and H04H categories out of the "Other" category and repeat the exercise. Indeed, H04W and H04H had a very small presence in the database in the earlier part of the study period.

For the period 1990-2012, we look at the three technology classes with the highest number of patent applications among ICT technology classes. In table 4, we observe that three of the thirty-seven technology classes that we look into, make up almost 40% of 582,664 patent filings within ICT. Electric digital data processing (G06F) is a central technology field where ICT firms patent heavily. Within this class, about 14.1% of patent applications have been filed by the top 5 assignees. Transmission of digital information (H04L) is another IPC class code within the larger category of data and internet applications under internet related telecom technology field. The top 5 firms for patent applications in this class represent 18.8% of all patent applications in the class. The concentration of patenting activity in these two subclasses within an internet related telecom technology field indicates the growing importance of patenting activity in new generation technologies, especially in the aftermath of the introduction of TCP/IP protocol and data transmission requirements for ICT firms. Pictorial communications (H04N) is the subclass of Applications technology category with the highest patenting activity, and the firms in the top 5 of patent applications for Pictorial Communications patents make up about 25.4% of all patent applications in the class. Firms with the highest patenting activity in all three fields are large incumbents. Siemens AG appears in top 5 within both electric digital data processing and transmission of digital information, while Philips NV appears both in electric digital data processing and pictorial communication. All of these firms also appear on the list of top 20 firms with the most patenting activity.

Table 4: Top patentees in different patent classes, 1990-2012

Firm	Firm patents	Patent Class Total
	G06F - Electric Digital Data Processing	
IBM	4689	99648
MICROSOFT	3649	99648
PHILIPS	1949	99648
SIEMENS	1927	99648
FUJITSU	1869	99648
	H04L - Transmission of Digital Information	
ERICSSON	4010	69386
QUALCOMM	2572	69386
SIEMENS	2384	69386
HUAWEI	2218	69386
NOKIA	1885	69386
	H04N - Pictorial Communication	
SONY	3468	51508
SAMSUNG	2667	51508
PHILIPS	2435	51508

CANON	2301	51508
THOMSON	2216	51508

The introduction of third generation telephones and the technologies that are necessary to support them should most probably be the reason for the increase in patenting activity in data and internet applications subfield. Taking a closer look at our data, we indeed observe a drastic increase in patenting activity in the second half of our study period. Figure 7 reports the 10 patent classes with the highest level of patenting activity in the period 1990-2000 and their corresponding level of patenting activity in the period 2001-2012. Figure 8 does the same for the second part of the study period.

Figure 7: Evolution of patenting from 1990-2000 to 2001-2010 for the main ICT classes in 1990-2000

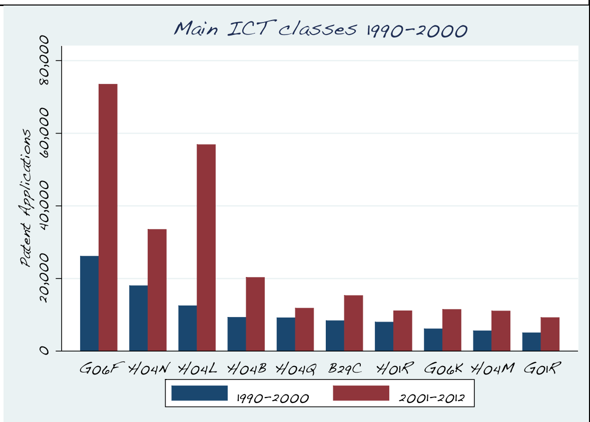
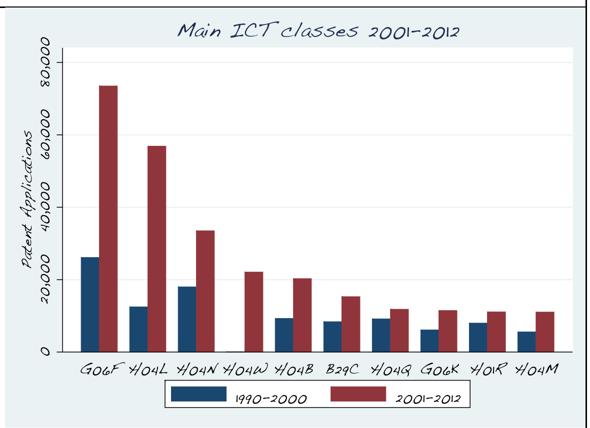
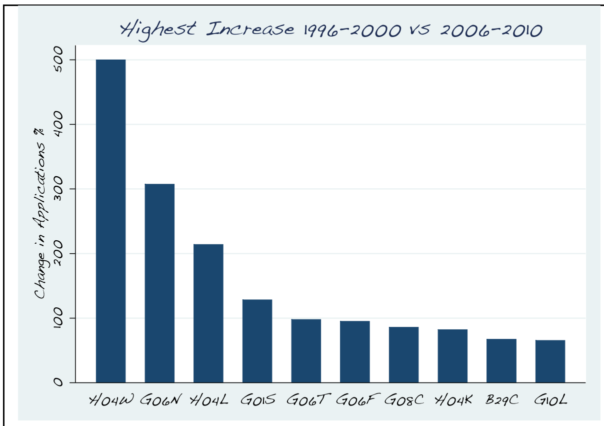


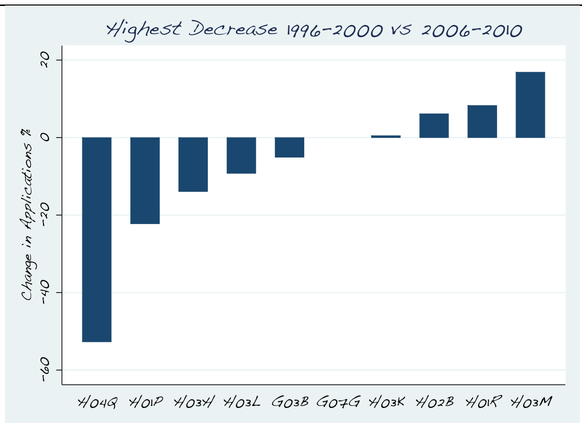
Figure 8: Evolution of patenting from 1990-2000 to 2001-2010 for the main ICT classes in 2001-2012



Patent applications in GO6F and H04L demonstrate a big jump across the two time periods, in line with the above interpretation of the emergence of internet technologies on portable telecommunications devices. Interestingly, both G06F and H04L are already very important in the 1990-2000 period, with G06F being the leading technology class, and H04L coming in third, only after H04N. In the second part of our study period, these two technology subclasses emerge clearly at the epicenter of the patenting landscape, but other fields also show increased patenting activity. H04W, Wireless Communication Networks, appears in the chart as the technology class with the fourth highest patenting activity, although it does not appear in the earlier period.

Figure 9: % Increase in patenting from 1996-2000 to 2006-2010	Figure 10: % Decrease in patenting from 1996-2000 to 2006-2010





The above interpretation of the general trend in patenting activity is also reflected in a breakdown of the 37 classes in terms of those showing the largest increase and decrease in patenting. Figure 9 lists the 10 patent classes with the highest increase in patenting activity calculated by comparing the period 1996-2000 to the period 2006-2010. Figure 10 does the same for the 10 patent classes with the highest decrease (or lowest increase). Four of the five internet related telecom technology classes are among the 10 technology classes with highest increase, whereas among the 5 technology classes with decreasing patent applications, two classes, H04Q and H01P, are related to traditional telecom technologies.

Based on the trends we have described so far, we note that some patent classes are consistently more important in the ICT industry. Table 5 lists the names of these classes, and in what follows, when looking at other trends, we pay special attention to these patent classes, which we henceforth refer to as the main ICT technology classes.

Table 5 – Main ICT Technology Classes

G06F	Electric Digital Data Processing
H04N	Pictorial Communication (e.g. Television)
H04L	Transmission of Digital Information
H04B	Transmission (transmission of information carrying signals)
H04Q	Selecting
B29C	Shaping or Joining of Plastics…
H01R	Electrically-Conductive Connections…
G06K	Recognition of Data; Presentation of Data; Record Carriers; Handling Record Carriers
H04M	Telephonic Communication
H04W	Wireless Communication Networks

4.4 Concentration of Patentees across Patent Classes

Besides the variation of patenting activity across technology classes, the concentration of the number of patentees also changes across patent classes. As already noted in some of the tables above, some technology classes have a larger amount of the patenting activity carried out by a smaller number of firms. Delving into this, we look at patentee concentration within the four macro categories.

Figure 11a: Concentration of Patenting Activity 4 Main ICT Categories

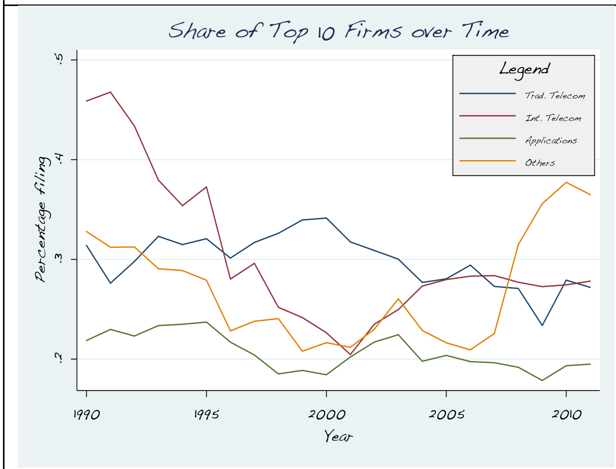


Figure 11b: Concentration of Patenting Activity 4 Main ICT Categories with H04H and H04W Separated

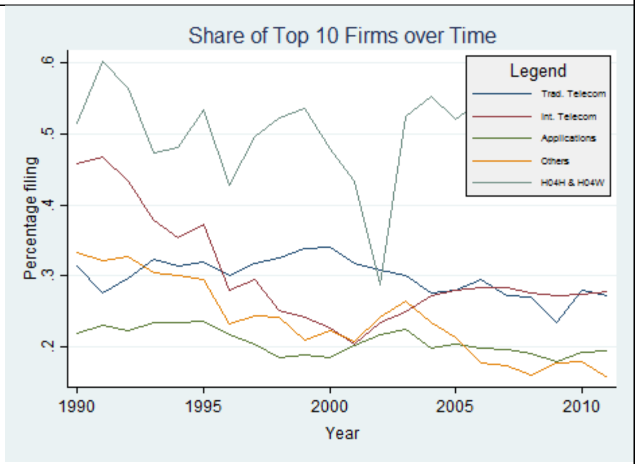


Figure 11a shows the changing levels of concentration for each macro category over time. Patenting activity in internet telecom starts off highly concentrated within the hands of the top 10 firms, but the patenting activity in that category is then picked up by other firms as well, and becomes diluted. Traditional telecom demonstrates a persistent level of concentration of patenting activity over the period of our study. Applications technology classes are subject to lower concentration at generally around 20% of patenting activity carried out by the top 10 patenting firms over our study period. Others category shows a trend similar to internet telecom, with patenting activity dominated by the top firms in the first years of our study. This activity then dissipates, but again becomes consolidated towards the end of the study period, whereby it has the largest concentration among the four main categories.

After observing the concentration of patent activity in our 4 main categories, we repeat the exercise we carried out in Figures 5b and 6b, and take a look at what happens when we treat H04H and H04W as a separate category, instead of within the broad category of "Others". We interpret Figure 11b as supporting our earlier observation that these two are nascent technology classes, since these two technology classes present radical changes in the concentration of patenting activity, with new actors showing up in the patenting scene for these classes, but quickly moving out to give the big jump we observe in the top unbroken-line. The growing number of patent applications does not bring the concentration ratio to the levels of the other main categories within our observation period, a trait we interpret as indicative of the emergent nature of these technologies, and the dominance of few players with large commitments and investments in these technology classes of broadband communications and wireless communication networks. When H04H and H04W are taken out, the rest of the “Others” category presents a decline in the concentration of patenting activity.

In order to understand the underlying dynamics of the concentration of patenting activity, we also look at the classes with highest concentration in Figure 12. Electronic payment, G07G, demonstrates the highest concentration, with a technology class of emerging importance, Wireless Communications Networks (H04W) following closely behind. Photography, G03B, also demonstrates very high concentration of patenting activity. Switchgear for distribution of electrical power (H02B), and games (A63F), also demonstrate high concentration. Next, for these five classes, we also look at whether the concentration of patenting activity persists over time or is driven by some consolidation at the beginning of the study period or towards the end, hinting at possible consolidation of innovative potential in some key actors. Note, however that there was very little patenting activity in the first half of our study period for H04W, Wireless Communication Networks, a technology that rose to central importance in the second half of the study period.

Figure 12: Patent Classes with higher concentration of patenting activity

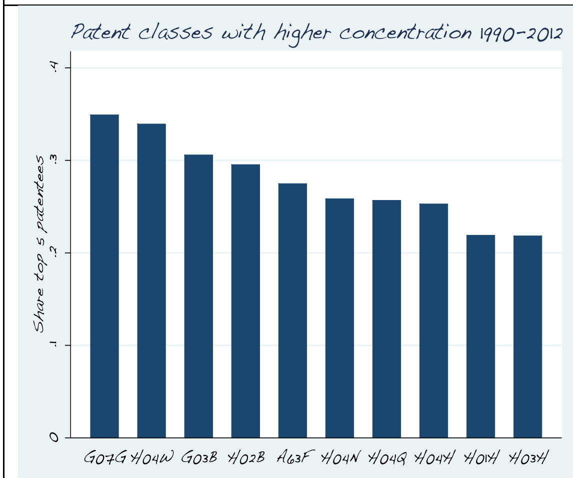
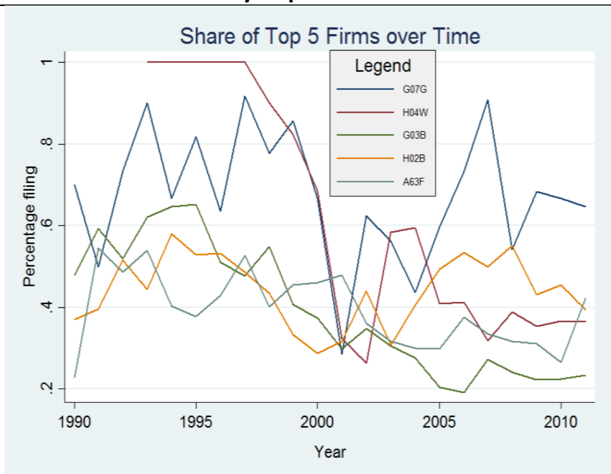
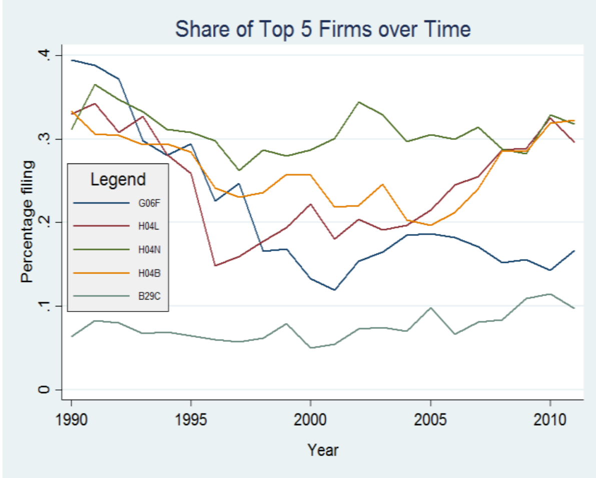


Figure 13: Concentration of Patenting Activity in Classes with High Concentration– Share of Patenting by Top 5 Firms



As can be seen from Figure 13, most of these patent classes demonstrate very high concentration until 2001, a point in which some patent classes experience a sharp decline in concentration. After 2001 the concentration for the most concentrated patent classes remains below 50% for the majority of the remaining timeframe. An exception is the electronic payment class (G07G) in our main category of “Applications” which has more than 60% of the patenting activity done by the top 5 firms at the end of our study period.

Figure 14: Concentration in Main Patent Classes	**Figure 15: Concentration in Main Patent Classes**



In Figure 14, we present the concentration of patenting activity for the main ICT patent classes as indicated in Table 5. We note that B29C has the lowest concentration, whereas H04W has the highest concentration. The patenting activity in H04W is relatively more concentrated than those of the other classes, but all the main ICT technology classes with the exception of B29C – Shaping or Joining of Plastics, have at least 10% of the patenting activity in that class carried out by the top 5 patentees. We then trace the concentration of patenting activity for five of these main technology classes (G06F, H04L, H04N, H04B, B29C) over time, to see if there are visible time trends. Indeed in Figure 15, we can see a general downward trend in concentration in all classes except B29C. B29C has traditionally a lower concentration than the other four technology classes, and the share of the top 5 patentees in this class only peaks 10% by the end of the timeframe. Three of these classes had their concentration first plateau at around 20% of the patenting carried out by top 5 firms, upon which H04B and H04L climbed up to a similar concentration level as H04N. The concentration in these five classes is generally below those of higher concentration classes (Figure 12).

4.5 FRAGMENTATION

In this section we examine the level of fragmentation of the ownership rights in the ICT domain by using two proxies: The number of citation of prior art (other patents) contained in each patent application, and the number of different owners to which the patents cited in the application belong. The assumption is that the higher is the number of patents cited in the application and the higher is the number of owners to which the cited patents belong, the more fragmented the patent field is. Patent applicants in this case will have a harder time developing innovations without infringing rights held by others. Citations based measures have been used to operationalize fragmentation in innovation strategy literature before (Ziedonis, 2004).

Figure 16a lists the average number of citations contained in applications for patents in ICT technology categories. The general trend is positive across virtually all main categories. Besides the overall increase in patent citations, the “others” category features a jump around year 2001, but then fits back into the general trend. While traditional telecom and applications show some decline in citations in late 1990s, the internet telecom category shows a more monotonical increase up to 2004. Around about year 2005 all patents have decreasing amount of citations. This is probably due to the timespan of our database. If less controversial patents (low number of citations, low number of owners of patents cited) are granted faster, then they enter the database earlier than the rest of the applications. Another explanation could be a change in the patenting strategy of applicants, which significantly affects applicants' patent portfolios (Blind et al., 2009). There is evidence suggesting a positive link between the number of citations made in patents, with the number of litigation cases (Lim, 2014; Pwc Litigation Study, 2016). If patent applicants have internalized this information they might be purposefully reduce the number of citations in patents. In section 5, we test for the first of these two explanations. The differences between 1995-2005, as well as the similar trends across the other years require further and more fine-grained analysis.

Figure 16a: Number of Citations per Patent Application

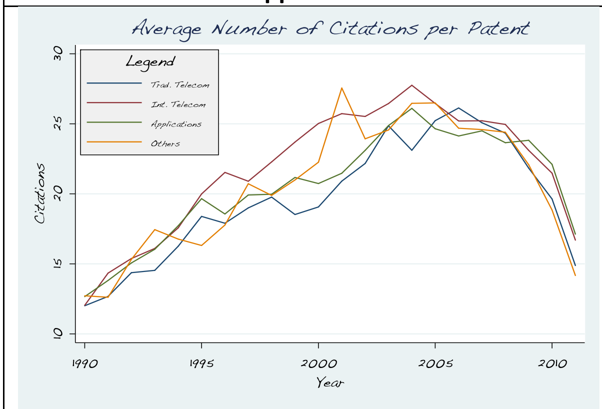
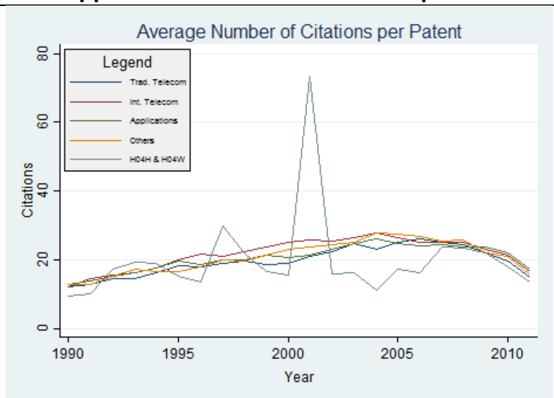


Figure 16b: Number of Citations per Patent Application with H04W-H04H Separated



In order to take a closer look at the curious nature of the jump in the applications category, we take out the two classes of H04H and H04W out of "Others" category and take a look at the citations in patent applications once again. It seems that not only these two technology classes (i.e. Broadband Communications and Wireless Communication Networks) are nascent and characterized by high concentration of patenting activity in few actors, but also these patent applications have very large numbers of citations compared to other main categories, thereby explaining the jump in Figure 16a. Once H04H and H04W are taken out, the remaining four main categories broadly fit the same similar trend, as was observed in Figure 16a as well.

In Figure 17, we report patent classes with the most citations. Patents in two patent classes, H04K – Encrypting and securing, and A63F – Games, make more than 30 citations on average but all the patent classes listed exceed the 20 citations per patent application threshold.

Although at this level of detail we observe the technology classes with patents that have the most citations on average, looking into time trends within these classes may help to understand the fragmentation issue better. For this purpose, Figure 18 plots the top 5 most citing technology classes over time. Here we take a closer look at H04K, A63F, G06K, G06F and G10L. The big “jump” in patent citations by H04K is due to the extremely low number of patent applications in that class in that year (17 in total) and to the presence of huge outlier, a patent from First Data Corp containing 1609 citations.

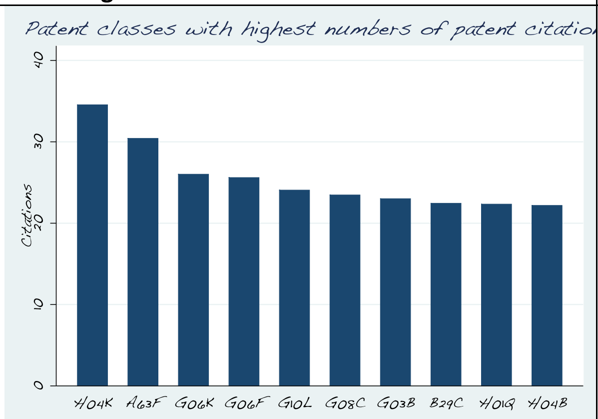
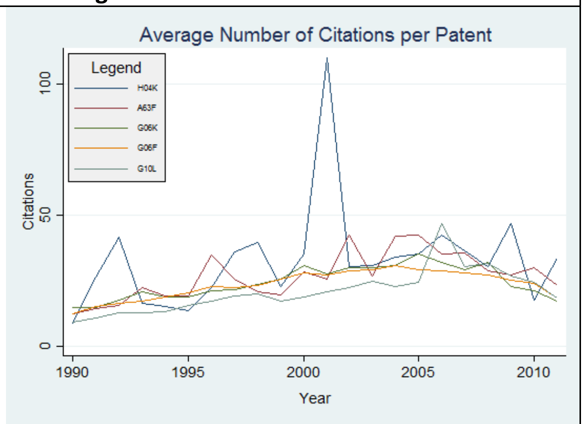
<table>
<tr><th>Figure 17: Classes with Most Citations</th><th>Figure 18: Classes with most citations</th></tr>
<tr><td>
</td><td>
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Figure 19: Average number of Citations in Most Important Classes	Figure 20: Trend in Citations in Most Important Classes

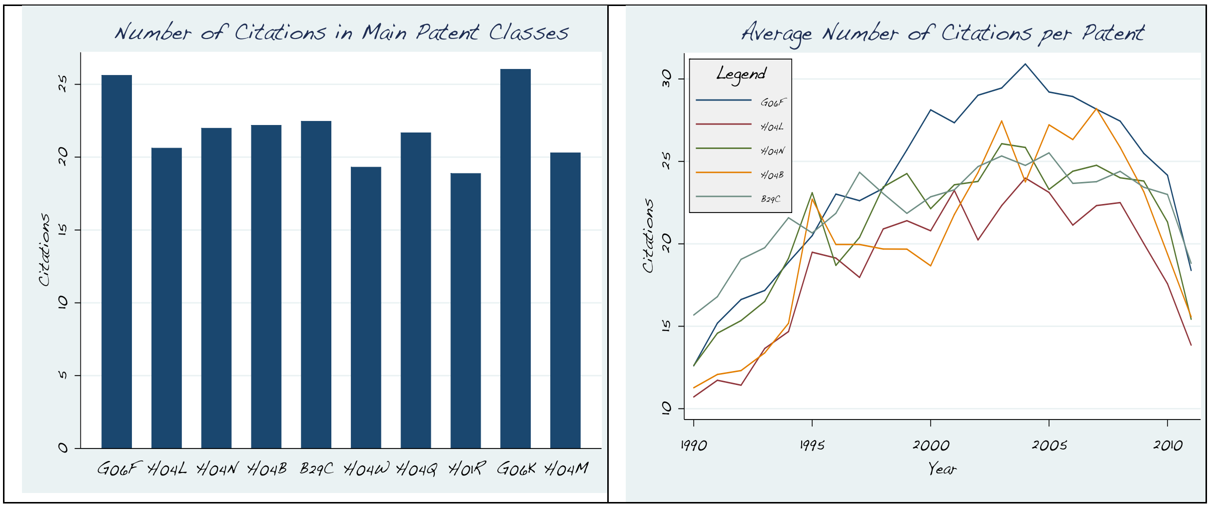
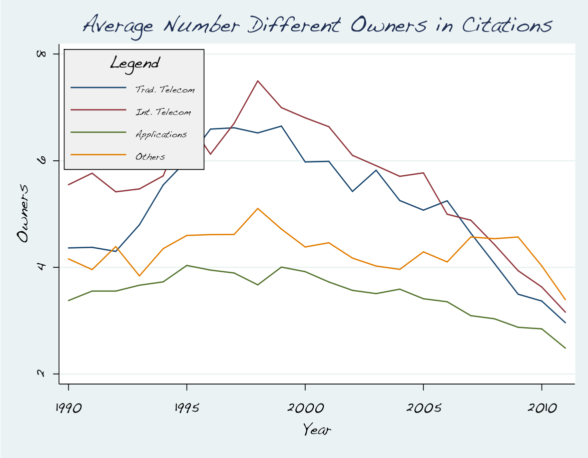


Figure 19 shows the patent citations made by applicants in the patent technology classes that are deemed to be the most important during our study period, based on our earlier analyses (see Figure 7 and Figure 8). Thus, here we draw attention to the patent citations made by applicants in those main patent classes. The classes with the most patent applications, and the highest increase in patent citations, also feature four of the most citing technology classes, namely G06K, G06F, B29C, H04B. Next, we take a closer look at the five most important classes over time (figure 20). For the most part of the period of study, the patent citations are on similar trends, with a general increase to above 20 citations in patent applications on average, from late 1990s onwards. Among the five most important technology classes, G06F – Data and Internet Applications is the only class reaches a peak of more than 30 citations made per patent application.

Although informative about the fragmentation of the knowledge within patent classes and the influence of earlier patents on later patents, patent citations may be made to the patents of the applicant (self-citations), or they can be made to patents owned by very few companies. If that is the case, an increasing amount of citations, would not necessarily imply a fragmentation of knowledge and intellectual property rights within the field. In order to understand whether this is the case, we also look at the average number of owners of the cited patents. In other words, we look at how many different owners the patents cited in patent applications belong.

As can be seen in Figure 21, the overall trend is decreasing from 2005 onwards, and as such, reflects the same trend as in Figure 16a. In figure 21, we refer to the four main technology categories, and observe that traditional and internet telecom have consistently had a higher dispersion of ownership in the technology cited than the two remaining categories. Indeed, traditional telecom and internet telecom have also been on similar trends starting from mid-1990s. We interpret this as evidence that these two main classes involved more complex property rights. We further interpret the slightly more complex ownership of citations of internet telecom patents, as compared to traditional telecom as well as to the other two main categories, as evidence that patents in internet telecom are subject to the highest level of fragmentation.

Figure 21: Dispersion of Ownership in Citations



In Figure 22 we plot the classes with the highest number of owners in their citations. H04K and H04Q are clear outliers, with citations to 8 different owners on average made in patent applications in these classes. For the top 5 technology classes in that plot, we also demonstrate the change in the average number of owners of cited patents over time in figure 23. Besides a general trend of increases up to 1997, and then decreasing until the end of the study period, H04K is the only technology class showing a slightly different pattern of patent citations to patents with an increasing number of firms at first, and then decreasing, only to make a big jump in late 1990s. Overall, the patent classes making the most citations to other patents, cite patents that belong to more than 5 owners.

Figure 22: Classes with most different owners cited

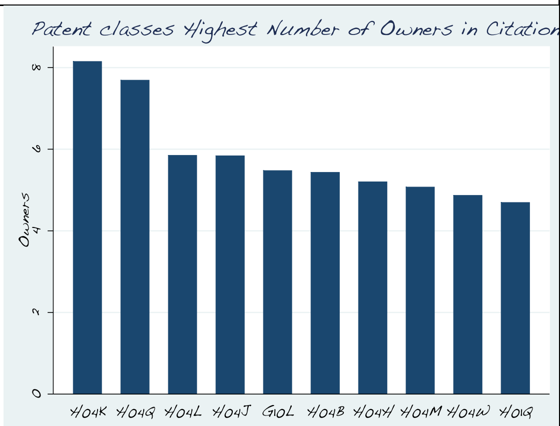
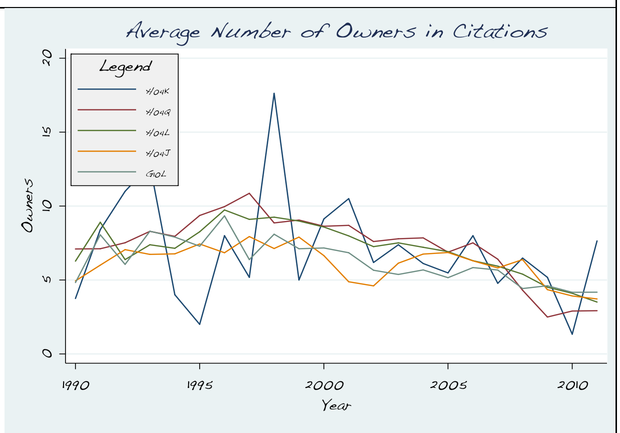


Figure 23: Classes with most different owners cited



We also look at the number of owners of the cited patents in the technology classes that we deem to be the most important, due to the concentration and increase of patenting activity in those classes over the study period, in Figure 24. Compared to the technology classes citing patents with the highest number of owners in Figure 22, it seems that the most important five classes have a higher concentration of ownership in citations made. This is despite the fact that these five classes cite about as many patents (about 20 citations per patent application on average) as the classes with the highest dispersion of ownership (see Figure 19). We interpret this as evidence that the patent classes deemed to be the most important have less fragmentation compared to other technology classes. This is because, patent applications in these technology classes cite about as many patents, but these patents belong to a much smaller number of firms.

Figure 24: Average Number of Owners Cited in Most Important Classes

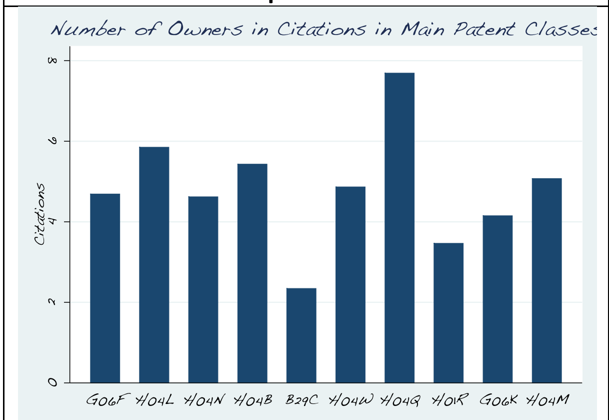
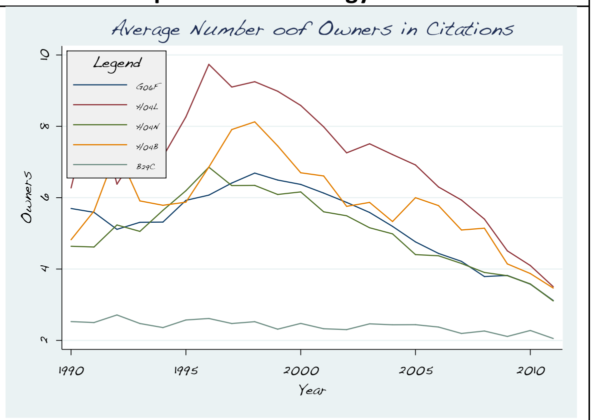


Figure 25: Average Number of Owners Cited in Important Technology Classes



In Figure 25, we also trace the average number of owners cited in the most important technology classes. The most striking case is B29C as the technology cited in applications in this class belongs to a very low number of different owners. On the contrary patent applications in H04L cites patents with more owners. Patent applications in the other three most important classes have an average of 4-7 different owners in their citations throughout the study period.

4.6 Patent Delays

In this section, we consider another issue that has generated attention by scholars working on innovation strategy in our sample. For 212,168 applications with application dates, grant dates, and ICT classes available, we look at the average time from application to grant for applications for patents granted in different years (Figure 26), and patents granted in different technology classes (Figure 27).

Figure 26: Average Time to grant for ICT patents granted in years 1980-2014

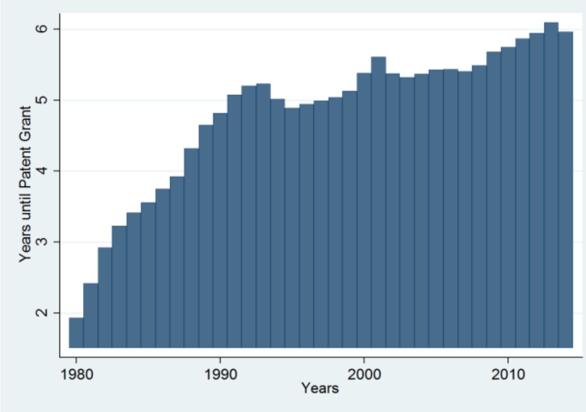
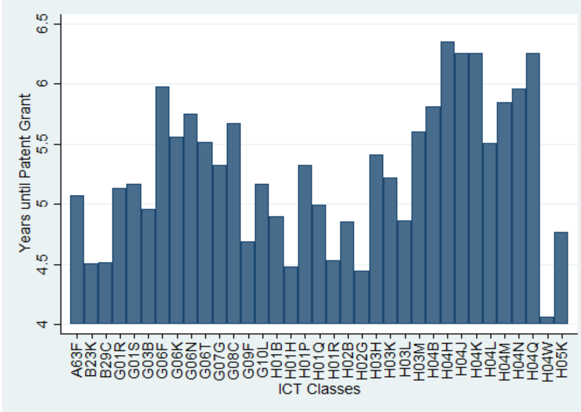


Figure 27: Average Time to Grant for Patents Granted in ICT Technology Classes



Overall we see a general increase in the time to grant, with the increase picking up in late 80s, and with a renewed increase starting from early 2000s. Patents granted in 2013 had on average a lag of more than 6 years. For patent classes with patent application date and patent grant date available, we observe quite a bit of variation across their time to grant. Applicants of patents for H04Q - Selecting (switches and relay for signals), H04J – Multiplex Communication, Jamming of/Secret Communication - H04K and H04H – Broadcast Communication had to wait longer than 6 years on average to receive their patents.

4.7 Patent Quality

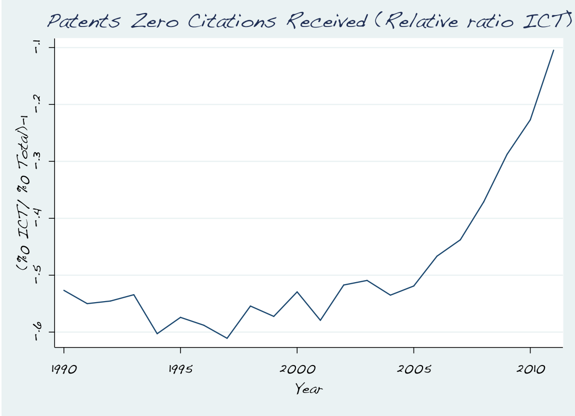
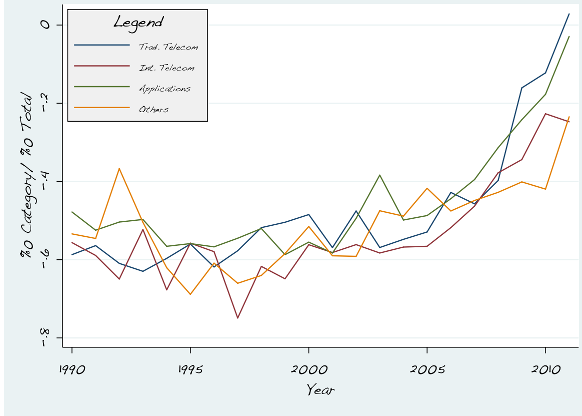
In this section we report the trend in patent quality between 1990 and 2012 for both the total ICT sector (Figure 28 & 30) and for the macro categories ICT (Figure 29 & 31). Following previous literature (e.g. Trajtenberg, 1990; Neuhäusler et al., 2015) we evaluate patent quality using the forward citations received by the patents. In particular, we calculate two proxies that allow us to evaluate patent quality in the ICT sector in relative terms, by comparing it to the patent quality of the entire utility patent universe. The choice of this approach is dictated by the timespan of the sample, the truncation of the database in 2014, and the descriptive nature of the analysis that does not allow for the inclusion of year controls[8].

Our first proxy is the share of granted ICT patents that receive zero citations in comparison to the same share for the utility patent universe[9]. Figure 29 and 30 contain the results of this analysis. Figure 29 shows that relative patent quality has been higher in the ICT sector even though it has deteriorated significantly in recent years. Up until 2005 in fact, the share of ICT patents receiving zero citation has been 50% lower than the corresponding share for the entire patent universe. Nevertheless the situation has changed considerably since then

[8] Looking at the citations received by patents in the ICT world in the absolute term would lead to misleading conclusions, as patent granted in later years have less time for being cited. The result of the analysis would therefore show an artificial decrease in the level of quality. On the contrary the only assumption behind our approach is that the timing of the citation for patents in ICT and the timing of citations for patents in the rest of the utility categories is similar.

[9] (% of ICT patents with 0 citations/ % of utility patents with 0 citations) - 1

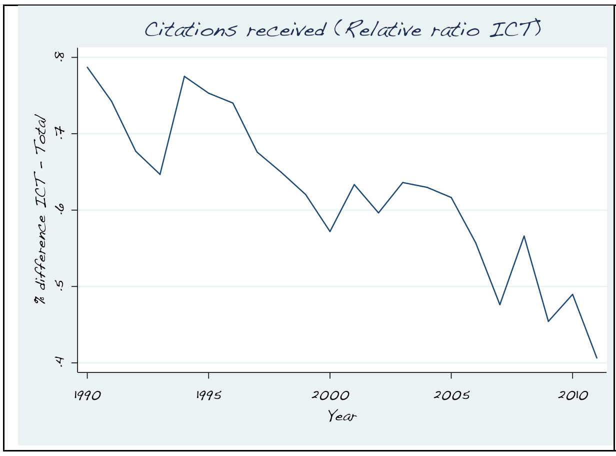
and by 2012 the same share is only 10% lower. Figure 29 shows that the trend is shared by the four macro categories. There doesn't seem to be any significant difference in terms of average level of quality between them.

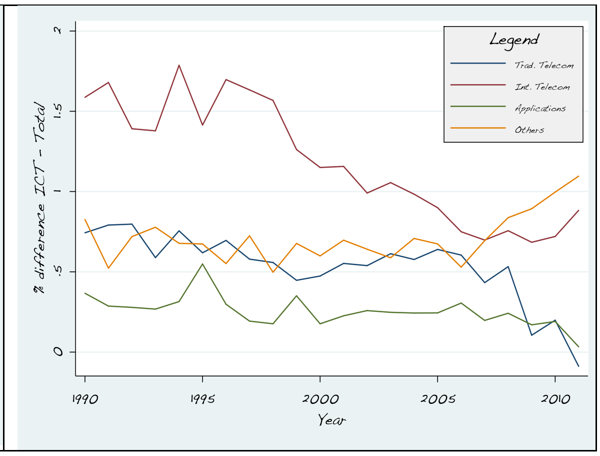
Figure 28: Share of patents with 0 citations 1990-2012 relative comparison ICT-total patent universe	**Figure 29: Share of patents with 0 citations 1990-2012 relative comparison macro cat.-tot. patent**
	

Our second proxy is the number of citations received by ICT patents relative to the number of citations received by the average utility patent[10]. Figure 30 and 31 report the result of the analyses. Consistent with the results previously obtained, figure 30 shows that ICT patents have lost ground in terms of quality in comparison to the average utility patent. In 1995 in fact ICT patents received 75% more citations than the average patent. By contrast in 2012 ICT patents receive only 40% more citations. Figure 31 reports the trend for the macro categories. It is possible to see that the sharpest decline has been suffered by the internet telecom category that passes from receiving 150% more citation in 1995 to receiving 80% more citations in 2012. Also the traditional telecom category, while stable for most of the timeframe, experienced a decline toward the end and by 2012 is less cited than average utility patents. The only category exhibiting an increase in citations is the residual category "other" which experienced an increase in citations received starting from 2007.

Figure 30: Citations per patent 1990-2012 relative comparison ICT-total patent universe	**Figure 31: Citations per patent 1990-2012 relative comparison macro categories-total patent universe**

[10] (Citations per patent ICT/ Citations per patent all utility) - 1





An important disclaimer is due at this point. We do not observe directly patent quality. We proxy quality with some measures that have been used in the literature, but they are far from being a perfect characterization of the underlying construct. So, our conclusions about patent quality should be interpreted with caution.

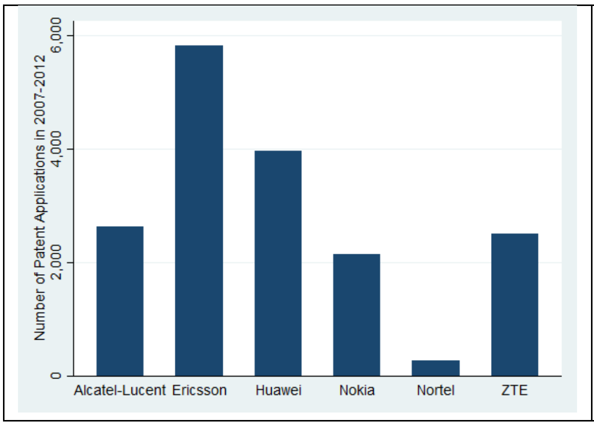
4.8 Consolidation in ICT

Our interpretation of the above analyses suggests that ICT sector has demonstrated a growing level of fragmentation from 1990s, until the end of late 2010s. More recent years of our patent database suffers from problems outlined in the previous sections, mainly patent applications take a long time to process, and the rights associated with patents become increasingly complicated over time. Industry insiders suggest that this is also paralleled by a consolidation of firm ownership[11]. In order to take a look at this phenomenon, we trace the ICT patents of 6 of the important network equipment makers, after the emergence of smartphones. For each of the six firms, we first check the number of patents they had in that year, after getting rid of multiple observations for the same entity within our database. Throughout the 2007-2012, Alcatel-Lucent has a growing patent portfolio, while Ericsson has a persistently dominant position in ICT patents. Huawei and Nokia have a big presence in patenting activity, although Nokia shows some relative decline starting from 2011, a trend also observed for ZTE. Nortel Networks falls from the patenting scene by late 2010, and the reason is indeed that the company filed for bankruptcy in early 2009, and later started selling its patents in large deals.[12]

Figure 32: Patents of ICT Vendors 2007-2012	**Figure 33: Patent counts of vendors, time trend**

[11] "Can Nordic rivals stop the Chinese juggernaut?"Kochhar R., TelecomsTech. Accessed, April 3,2017. Available: https://www.telecomstechnews.com/news/2016/aug/23/opinion-can-nordic-rivals-stop-chinese-juggernaut/

[12] "Nortel $4.5-Billion Patent Sale to Apple, Microsoft, Others Approved", Brickley, P. WSJ. 2011. Accessed, April 3, 2017. Available at: https://www.wsj.com/articles/SB10001424052702303812104576440161959082234



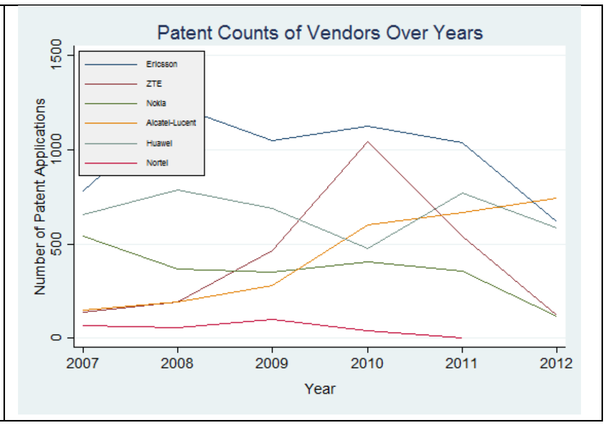


Table 6. Patent Stocks and Ranking of Patent Stocks within ICT for 2007-2012

	Alcatel-Lucent		Ericsson		Huawei	
Year	Patents	ICT Rank	Patents	ICT Rank	Patents	ICT Rank
2007	152	35	780	3	658	4
2008	193	25	1.226	1	786	4
2009	281	19	1.046	2	690	3
2010	603	6	1122	1	477	9
2011	667	6	1.035	1	772	4
2012	741	2	616	3	582	4
	Nokia		Nortel		ZTE	
	Patents	ICT Rank	Patents	ICT Rank	Patents	ICT Rank
2007	543	6	67	61	141	37
2008	366	13	56	67	196	24
2009	352	15	103	41	465	8
2010	406	12	38	92	1040	3
2011	355	13	1	6714	540	9
2012	118	30			122	29

5 On the Determinants of Patent Delays

5.1 Empirical Methodology

In this section we estimate the effect of different patent characteristics on the length of the timespan between patent application and patent granting. We cautiously interpret this effect as correlation rather than causation. We also acknowledge that our findings below might not straightforwardly generalize to other industrial settings.

To accomplish this aim we form a sample of 170,776 ICT patent applications, which covers the period between 1990 and 2012. Our analysis considers the effect of: the type of technology contained in the patent application, the fragmentation in the technological field of application, the patenting intensity in the technological field of application as well as that of the country of origin of a firm, the experience the firm has with the patent application process, and the value of the innovation.

Our dependent variable is the time span between patent application and patent granting expressed in years. We proxy for the technology contained in the patent through dummy variables that capture four ICT macro technological categories, where the omitted category is traditional telecom as per Figure 1. We proxy for fragmentation in the technological field of application with both the number of citations contained in the patent application, and the number of different owners to which the patents cited in the application belong. We proxy for the patenting intensity in the patent class with the total number of patents filed in the IPC class of the patent in the year. We proxy for the patenting intensity of the country of the organization with the total number of patents filed by firms with the legal residence in the country of the organization in the year. We proxy for the experience of the organization with the patenting process with the total number of patents filed by the firm in the year. We proxy for the value of the innovation contained in the patent application with both: the total number of claims contained in the patent application, and the number of citations received by the patent in the years following patent grant. Except for the dependent variable and the dummy variables, we take the logarithm of all the variables in the sample to prevent extreme observations from significantly influencing the results.

To evaluate the effect of the variables described on patent delays we estimate a series of regressions that include both year and country controls. Year controls should capture temporary trends in the global patenting behavior that might be correlated with some of our variables of interest. Country controls should instead account for the specificities of different patent offices (e.g. the level of staffing) that might significantly influence the lag between application and grant. Further, we cluster the standard errors in the estimation by country of application to take into account the possible autocorrelation of the error term between country and across patent applications.

Table 7 contains the descriptive statistics about the patents in the sample. We report the raw values of the variables (i.e. not the logarithms) to give a better sense of the distribution of the data. About 28% of the patents belong to “Traditional Telecom” macro ICT category, 26% to the “Internet Telecom” category, 35% to the “Applications” category, and 11% to the residual category. On average, each patent application contains 23 citations of patents that belong to 4.5 different owners. The IPC technological fields considered in the analysis receive on average 591 patent applications each for all the years included in the sample. By contrast, the countries of origin of the firms included in the sample receive on average 1,283 patent applications each year. The firms to which the patent applications belong make on average 48 patent applications each year. Finally, on average each patent application contains 13 claims of originality and receives 17 citations from other patents after it is granted.

Table 7: Descriptive Statistics

Variable	N	Mean	Min	Max	SD	p25	p50	p75	p95
Appl lag	170776	5.47	0.67	21.27	2.40	3.66	5.15	6.82	9.94
Internet-Telecom	170776	0.26	0	1	0.44	0	0	1	1
Applications-Telecom	170776	0.35	0	1	0.48	0	0	1	1
Other-Telecom	170776	0.11	0	1	0.31	0	0	0	1
Citations Made	170776	23.36	1	4685	43.92	9	15	25	61
Owners of tech. cited	170776	4.59	1	154	4.62	2	3	6	12
N. Class applications	170776	591.04	1	1903	486.38	214	422	887	1747
N. Country applications	170776	1283.18	0	3023	870	399.8452	1407	1927	2748
Firm applications	170776	48.25	0.08	393.83	78.55	2	9	59.5	225
N. Claims	170776	12.69	0	171	8.80	7	11	16	29
Citations received	170776	16.75	0	3041	37.00	2	7	18	62

Table 8 contains the correlations among the variables in the sample. As expected, the variables that are proxies for the same construct are generally positively correlated. For example, the correlation between the citations contained in a patent application and the number of different owners of the technology cited is 0.68, while the correlation between the number of claims and the number of citations received is 0.14. For what concerns the relationship between patent delays and the independent variables, the highest correlation is the positive 0.23 with the number of applications from the country of origin of the organization filing for the patent belongs.

Table 8: Correlations

		1	2	3	4	5	6	7	8	9	10	11
1	Appl. lag	1										
2	Internet Telecom	0.06	1									
3	Applications – Telecom	-0.10	-0.44	1								
4	Other - Telecom	-0.02	-0.21	-0.26	1							
5	Citations Made	0.08	0.03	-0.01	0.00	1						
6	Owner of tech. cited	0.08	0.05	-0.07	0.02	0.68	1					
7	N. Class applications	0.10	0.68	-0.25	-0.23	0.04	0.10	1				
8	N. Country applications	0.23	0.05	0.01	-0.03	0.10	0.10	0.10	1			
9	Firm applications	0.04	0.08	-0.17	-0.02	-0.04	-0.01	0.18	-0.02	1		

10	N. Claims	0.04	0.09	-0.09	0.00	0.13	0.16	0.13	0.04	0.04	1	
11	Citations received	0.16	0.08	-0.06	-0.01	0.28	0.24	0.06	0.16	0.01	0.14	1

5.2 RESULTS

Table 9 contains the results from regression analysis. Except for the dummy variables capturing the macro technological categories, we first test the effect of each independent variable in isolation and then in a full model that includes the rest of the independent variables of the analysis.

Model 1, we regress patent delays on the type of technology contained in the patent application on patent delays. As one can see, relative to patents in the “Traditional Telecom” macro category, patents in the “Applications” category take about half a year less to be granted (-0.463; p<0.01), patents in the residual category “Other” take about 38 days less than patent applications in Traditional Telecom (-0.104; p<0.05), while the difference between “Traditional Telecom” patents and “Internet Telecom” patents is not significant. Model 2 through Model 8 separately estimate the effect of our independent variables on patent delays. Model 2 tests the effect of the number of citations contained in the patent application (0.066; p<0.01), while Model 3 tests the effect of the number of different owners of the technology cited (0.277; p<0.01). As expected, both variables are significant and positively related with the lag between application and grant. Model 4 tests the effect of the total number of applications in the year in the IPC technology class of the patent application. The effect is positive and significant (0.115, p<0.01). Model 5 tests the effect of the number of applications from the country of the organization filing for the patent in the year. The effect is not significant. Model 6 tests the effect of the number of patent applications from the firm filing for the patent in the year. The effect is not significant. Model 7 and Model 8 test the effect of the number of patent claims and the number of forward citations received by the patent from later patent applications. Both effects are statistically insignificant. Finally, Model 9 tests all the independent variables together. The main difference in the results is that coefficients for the “Other” dummy and the number of citations contained in patents become insignificant while value, as measured by the number of patent claims, has a negative effect in the full model on the patent lag (-0.030; p<0.05).

The results indicate that patent applications filed in applications category has consistently lower time to grant, compared to the other three categories, as Internet related telecom and other categories do not have a statistically significant difference in terms of time to grant compared to traditional telecom. It also seems that every other claim in a patent application decreases the time to grant by 11 days. Although significant only at 10% confidence level, the total number of applications in a technology class also seems to increase patent delays, after accounting for country and year differences. More interestingly, we interpret the consistently positive and significant variable for owner of technology cited as evidence that fragmentation of technology classes increases patent delays. Though we are cautious of the fact that our second operationalization of fragmentation, i.e. the number of citations made in the patent application, is negative and insignificant.

Table 9: Regressions on the lag between patent application and grant

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Internet Telecom	0.082								0.034
	(0.063)								(0.045)
Applications-Telecom	-0.463**								-0.476**
	(0.085)								(0.106)
Other-Telecom	-0.104*								-0.110
	(0.048)								(0.070)
Citations Made		0.066**							-0.097
		(0.025)							(0.073)
Owner of tech. cited			0.277**						0.396**
			(0.010)						(0.049)
N. Class applications				0.115**					0.053+
				(0.022)					(0.027)
N. Country applications					0.147				0.158
					(0.142)				(0.147)
Firm applications						-0.004			-0.047
						(0.040)			(0.043)
N. Claims							0.009		-0.030*
							(0.026)		(0.014)
Citation Received								0.010	-0.049
								(0.040)	(0.051)
Intercept	4.450**	4.168**	3.957**	3.706**	4.119**	4.356**	4.328**	4.335**	3.830**
	(0.048)	(0.072)	(0.013)	(0.126)	(0.228)	(0.029)	(0.070)	(0.074)	(0.340)
N	170776	170776	170776	170776	170776	170776	170776	170776	170776
adj. R-sq	0.204	0.196	0.200	0.197	0.196	0.195	0.195	0.195	0.211

Significant at: ** 0.01 level; * 0.05 level; + 0.1 level

6 CONCLUSIVE REMARKS

This report provides a description of patenting activity in ICT in Europe between 1990 and 2012. We use data on patent filings at the EPO to develop our analysis. While it is a narrow focus, on a specific jurisdiction, for a restricted period of time and on a part of the whole ICT industry, we believe that our findings are interesting and relevant. We find some consistent patterns: 1. Patent filings have increased threefold during the study period and ICT accounts for a larger share of all patent filings, from 15% to over 20%; 2. Patent delays in the ICT industry have increased significantly during the study period, by 2012 it takes an average of 6 years to ICT patents to go from application to grant; 3. The quality of ICT patents relative to the quality of other patents has declined over the years, as measured by the number of citations or by the number of patents without any citation (low quality patents); 4. Two technology classes have emerged as central in the ICT landscape starting from the mid 2000s: H04H - Broadband Communications and H04W – Wireless Communications; these two technology classes also show some different patterns in terms of concentration, citations and other aspects; 5. There is a surge in patenting activity by new players in recent years especially Asian firms. 6. Fragmentation of patent landscape, as measured by the number of citations made by each patent or the number of owners of cited patents, has increased up to the mid 2000s and then declined, the latter effect possibly due to data issues (truncation).

We then look more carefully at the relationship between patent delays and some characteristics of the patent. Patent delays are especially problematic because they make the system more uncertain and create additional frictions and costs. It has been shown that patent delays penalize predominantly small innovative companies. Our results show that patent delays are relatively shorter in the Applications category. Patent delays tend to increase if patents have made lots of citations or cite patents belonging to many different owners. Of the two, it is the latter dimension that has most of the explanatory power in the regressions. This suggests that fragmentation of the patent landscape increases patent delays. Finally, more valuable patents, i.e. with more claims, tend to have shorter delays, which is consistent with previous findings.

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