

# INNOVATIVE OR INDEFENSIBLE?

## AN EMPIRICAL ASSESSMENT OF PATENTING WITHIN STANDARD SETTING

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29 September 2008

### Abstract

Much has been written—especially in recent years—regarding the perceived problem of “over patenting” within cooperative standard setting. Because standards are thought to frequently convey market power to those firms whose patented technologies are included in the standard, the concern is that “strategic” patenting, driven not by innovation but by rent seeking, will enable some firms to license their patents in an anticompetitive fashion. In particular, concerns have been raised over patenting that takes place *after* the first versions of a standard are published, as these patents may be opportunistic and aimed at the unwarranted acquisition or enhancement of market power. While this is a reasonable concern, another possibility may be likely as well: that at least some portion of ex post patenting is driven by genuine innovation. The question then becomes, which is more prevalent? To test the opportunistic patenting theory, I empirically assess the patenting that occurs within a standard setting organization. On the basis of this analysis, I reject the hypothesis that *all* patenting that takes place after a standard has been published must be opportunistic. Some may be, but an assessment of the available data suggests that much is not. This analysis is necessarily preliminary, but on the basis of the empirical assessments developed here, I conclude that ex post patenting is most likely a mixed bag of truly (albeit incremental) innovative contributions along with some highly skeptical ones. The bottom line, then, is that any policy prescriptions should proceed with much caution so that the good is not eliminated with the bad.

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## 1. INTRODUCTION

Much has been written—especially in recent years—regarding the perceived problem of “over patenting” within cooperative standard setting. Because standards are thought to frequently convey market power to those firms whose patented technologies are included in the standard, the concern is that “strategic” patenting, driven not by innovation but by rent seeking, will enable some firms to license their intellectual property (IP) in an anticompetitive fashion. Along these lines, theories of IP “anti-commons”, “patent thickets”, and “royalty stacking” have been proposed in the academic literature, along with policy ideas aimed at reducing such problems (Shapiro, 2001; Mueller, 2002; Lemley & Shapiro, 2007). A good deal of the attention has focused on the sheer rise in patent numbers. With more and more patents being declared as “essential” for the implementation of any given standard, what are the potential detrimental effects on the standardization process? How could the commercialization of the standard be affected? And what are the implications for the overall innovative climate within standard setting contexts?

While a number of scholars have recognized a link between standards and innovation when considering the overall benefits of standardization, the story here is traditionally one of research and development in anticipation of a standard (e.g., Farrell & Saloner, 1985). That is, the chance to increase the end market size through cooperative standardization efforts can provide enhanced incentives to innovate, meaning higher expenditures on R&D which of course can be accompanied by patenting.

Increased patenting that takes place *during* standardization, however, and especially patenting that takes place *after* the first versions of a standard are published, has been viewed quite differently. Here the presumption often seems to be that patenting that occurs “ex post”—after the path that the standard will take is chosen—is opportunistic and aimed at the unwarranted acquisition or enhancement of market power. The logic behind this presumption is that once a standard is defined, the key pioneering innovations have already taken place and thus any

additional patenting is likely aimed at shifting rents and staking a larger (unjustified) claim of the standard's IP licensing revenues.

A number of scholars have espoused such concerns in the academic literature. For example, in their empirical analysis of the 3G mobile telecom standard UMTS (for Universal Mobile Telecommunications System), Bekkers and West (2006) caution that “A key form of standards-related strategic patenting is when a firm deduces the direction that a standardization effort is proceeding [in] and then attempts to create patents to read on that standard.” Likewise, Hunt, Simojoki, and Takalo (2007) posit that “... firms may anticipate the outcome of the standard-setting process and apply for patents that would be infringed by users conforming to the standard.” And Dewatripont and Legros (2007) use such strategic patenting as one of the motivations for their theoretical assessment of patent “padding” within a standard.

It seems safe to conclude that firms sometimes do engage in opportunistic patenting, particularly when the commercial stakes are high, as they often are in standards contexts. But another possibility exists in tandem: that at least some portion of ex post patenting is driven by genuine innovation. This follows from the incremental nature of the standardization process. Once the path of a new standard is chosen, a great deal of work may still remain to define the precise implementation details of the standard. For example, at the time the technology for the UMTS mobile telecoms standard was selected, the document specifying a crucial component of that standard was only 30 pages long, but by the time the standard was ready for commercial implementation the page count had increased to over 13,000.<sup>1</sup> This suggests that a great deal of additional work was necessary to move from the theoretical concept of the chosen technology to the reality of putting that technology to work in the field. This interpretation is corroborated in an industry analyst report, which although focused on mobile telecom notes that the difficulties in moving from concept to implementation are felt in all industries involving complex products and cooperative standard setting: “Implementation IPR ... actually makes up the vast

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<sup>1</sup> Technical Specifications for TS 25.xxx.

majority of all IPR filed in any technical standard. ... In many ways it is just as important ... just as a window is of no use unless it can be effectively placed in the space that has been designed for it.”<sup>2</sup>

Considering, then, the process of standardization, participating firms can have strong incentives to solve specific technical problems related to the optimal implementation of the standard in order to move the standard to commercialization as quickly as possible and in the best fashion possible in order to increase end consumer acceptance and maximize overall profits. As a result, the period of time just after a standard’s initial publication, when the general technology path has been chosen, could be a highly innovative one for standard participants. Under the strategic patenting view, though, a burst in patenting activity here might suggest opportunistic patenting (meant to add rights to an already defined standard), when in fact the activity reflected (at least in part) genuine innovations aimed at solving crucial, albeit relatively incremental, details of the soon-to-be-commercialized standard.

A second possibility for ex post innovation lies in market structure. Consider an early generation of a standard dominated by a relatively small set of firms. If that standard achieves commercial success, other firms (outside the standard organization) with closely related operations or skill sets could have incentives to innovate in the space in order to join the standard and share in the rents. In this case the existing standard demonstrates commercial success and a perception of supra-competitive pricing for the oligopoly of incumbents suggests profits to be made for new entrants. This is how markets are supposed to work: high profits lure entry and competition. Outside firms cannot join an existing standard, however, without a valuable contribution to offer; incumbents will not relinquish their positions easily and must see something in exchange. Innovating and then offering those innovations for consideration in the next generation of the standard therefore can provide outside firms with an entrée into the evolution of an existing standard.

The above reasoning raises the possibility that ex post patenting within cooperative standard setting can reflect both innovative efforts as well as

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<sup>2</sup> Nomura International plc, “Equipment Matters, IPR: The Master Craftsman” at 14.

opportunistic motives. If so, late patenting need not represent purely strategic, and potentially anticompetitive, maneuvers by SSO participants. This insight offers a new perspective on the IP rights debate. While we cannot disregard potential problems associated with opportunistic patenting and patent proliferation within standards, knowing that cooperative standard setting can also spur legitimate innovation throughout the standardization process provides a mitigating effect to the concerns over strategic patenting. This paper represents a first attempt at measuring whether and to what extent mid-standard patenting reflects incremental innovations or purely opportunistic motives.

To address the question of opportunistic patenting within standard setting organizations, this paper offers an empirical assessment of the patenting that occurs within an SSO. Under the most cynical view of rent-seeking behavior, all (or the vast majority of) patenting that occurs after the initial version of a standard has been published is opportunistic. Because it offers an easy starting point for analysis on this question, the null hypothesis here is that *none* of the ex post patenting is innovative. The trick then lies in determining what is and what is not “innovative”.

Taking the 3G mobile telecom standard as the test case,<sup>3</sup> I consider three basic indicators of innovation. First and foremost is R&D expenditures. If we see no increase in R&D expenditures in response to key standardization milestones but we do see increased patent filings (appropriately taking account of time lags), we can reasonably conclude that patent filings and R&D expenditures are not positively correlated, consistent with the null hypothesis of no innovation in ex post patenting. If, on the other hand, we find that patenting is positively correlated with R&D expenditures even after a standard is published, then we could reject the null hypothesis and conclude instead that at least some of the patenting that takes place ex post represents innovation and not opportunism.

The second measure of innovation relies on proxies developed in the IP literature (Trajtenberg, 1990). In particular, a number of patent variables, including the number

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<sup>3</sup> As explained in greater detail in Section 2.A, we select this standard because of the relative richness of the data available. The ETSI website posts all declared patents for its standards, along with the patent holder and the project the patent is declared for. In addition, the technical specifications submitted for the standard are made public as well.

of claims per patent and the number of forward citations a patent receives, are evaluated. These measures provide reasonable proxies for the value of patents and can thus be used for the purpose of weeding out innovative patents from “standard padding”.

Finally, for the third measure I consider the technical specifications that SSO members submit for consideration by technical working groups. These contributions are useful in identifying genuine innovative efforts as they are typically technical suggestions for modifying and improving a standard. As such, these contributions do not represent IP rights, but instead are made within the technical working groups largely comprised of engineers and other technical specialists. Firms with purely opportunistic motives are unlikely to make the investments necessary to create contributions of this sort as they do not play a role in increased rents.

Section 2 presents the quantitative analysis. The section begins with a definition of the dataset, which includes patents declared as potentially “essential” for the implementation of the 3G mobile standard being developed under the oversight of the European Telecommunications Standards Institute (ETSI). I categorize these patent declarations according to the phase of standardization at the time of filing: early development, after the technology path has been frozen, or during commercialization. Using these categorizations, I measure the extent of ex post patenting. The section then turns to an assessment of the innovativeness of the ex post patents. As an initial test, I track the patent declarations against the proxy measures of patent value; only those patents that emerge as valuable on the basis on these proxy measures can be considered indicative of innovation. Next, I consider the correlation between patent declarations and technical specification filings. As a final and more rigorous test, I present regression analysis of patent filings against R&D expenditures and an indicator variable for whether the patent was filed ex post or not, among other controls. Section 3 offers conclusions.

Given the complexity of standard setting and patenting, it is only through empirical investigation that we can separate the genuine concerns from the not-so-problematic. I find that ex post patent filings likely fall into the grey area and cannot

be dismissed as mere rent seeking. Certainly patent filings that come later in a standard's development tend to be less valuable than patent filings that come earlier. This is to be expected, as the earliest phases of standard setting require the big picture, with pioneering innovations. Nevertheless, a considerable number of ex post patents do appear to be valuable on the basis of reasonable measures. Seen in the context of how standards are developed, this finding should not be surprising: moving from the forest of the general technology path to the trees of specific implementation is bound to raise a whole host of unresolved technological problems. Many of these problems will require new thinking, new R&D, and as a result, new patent filings. I therefore conclude that some significant portion of the ex post patenting within ETSI has in fact been beneficial and not opportunistic.

Assuming ETSI's UMTS standard is representative of complex standardization in general, the broader lesson is that caution should be exercised when considering policies aimed at "late" patents, from either competition agencies or from standard setting bodies. It is too optimistic to consider every ex post patent as providing some valuable incremental contribution. But it is too pessimistic to assume that simply because the patent was filed after the technology path was frozen that the patent must be of no value. The findings here suggest that reality lies in between.

## **2. SEPARATING INNOVATIVE FROM STRATEGIC PATENTING**

As explained, determining whether the patents filed after a standard's general path has been frozen have any merit as innovative or whether they are merely tools for rent extraction is an empirical matter. Both theories sound (and likely are) plausible, so the question must be answered by examining the data. This paper takes the first steps in that direction.

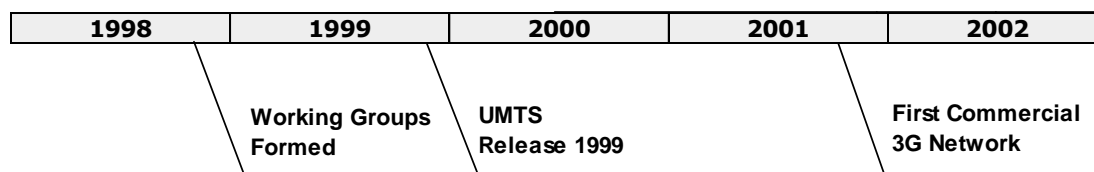
The dataset contains patents declared as potentially essential for the 3G mobile telecom standard referred to as UMTS (also known as WCDMA). To this data are added measures meant to capture the value of the patented technology, in order to separate the defensible patenting of genuine innovations from the patenting intended

only to extort additional licensing revenues. These measures are evaluated over time, in relation to key milestones in standardization, to determine whether ex post patents tend to hold little or no value.

### A. The Data

In order to test whether or not patenting that comes after a standard is defined is purely opportunistic or not, we first need data on patents declared to a standard. I consider patents declared as potentially essential to the European 3G mobile telecom standard under ETSI, UMTS.<sup>4</sup> The figure below identifies key standardization dates for UMTS.

**Figure 1: UMTS Timeline**



The first UMTS working groups were created in December 1998. These groups evaluated several different overarching technologies that could have formed the basis for the 3G standard.<sup>5</sup> One of these technology paths was voted as the standard in December 1999, when UMTS Release 1999 took place. This is the date that referred to as the “freeze” date for the path of the standard. At this point, the general technology path for the 3G standard was in essence frozen—the other broad technologies that had been competing were taken off the table. From December 1999 to late 2001 the working groups then filled in the many details required to flesh out the standard within the chosen technology path. It was not until enough of these details were settled that the firms hoping to implement the standard—handset makers, network equipment makers, network operators, etc.—began their commercialization efforts in earnest and were able to introduce the first commercial network based on UMTS in late 2001.

<sup>4</sup> I collected the patent data in January, 2008, considering only US and European patents. ETSI is an organizational partner and founding member of 3rd Generation Partnership Project (3GPP).

<sup>5</sup> The International Telecommunications Union approved the following 5 radio interfaces for mobile telecom: cdma-2000, W-CDMA, TD-CDMA, TDMA-EDGE and DECT (Goldstein & Kearsy, 2004).



The UMTS standard is a good candidate for an investigation into strategic patenting for a number of reasons. First, ETSI is a very large SSO with member firms from across the globe.<sup>6</sup> Second, the UMTS standard involves a great many patents—most likely in the neighborhood of 1500 – 2000, although a perfectly accurate count is difficult to attain.<sup>7</sup> Third, ETSI appears to do a reasonably good job of listing on its website all patents declared as potentially essential so the data is publicly available. Fourth, ETSI members do a reasonably good job of declaring specific IP, as opposed to making vague blanket declarations pertaining to “any relevant patents” a firm might hold that might be deemed to read on the standard. Other large SSOs, such as the Institute for Electronics and Electrical Engineers (IEEE), tend to have far more blanket declarations than specific ones, rendering empirical analysis infeasible.

The final dataset contains 1247 US patents and 341 EPO patents,<sup>8</sup> declared by 31 different entities. Some of the entities included in the count are subsidiaries of others; these were merged together. Another entity (ETRI) is a non-profit, government sponsored research institute. Given that the hypothesis involves rent-seeking behavior on the part of the patent holder, this non-profit is deleted. After these steps, the final sample has 27 for-profit firms holding UMTS patents, 25 of which have at least one US patent.<sup>9</sup> For each firm in the sample, company data is added, specifically, each firm’s yearly R&D expenditures as well as total company patent filings.

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<sup>6</sup>ETSI has close to 700 member firms from about 60 different countries. Membership list available at <http://www.etsi.org/WebSite/AboutETSI/structure/members.aspx>.

<sup>7</sup> The ETSI dataset includes a great many duplicates, both exact duplicates and jurisdictional “duplicates” filed with multiple patent offices as a means of ensuring protection in different geographic regions. Purely duplicate patents are removed as well as jurisdictional duplicates, keeping as the first choice US patents. Patents that had the same title and company name but that were declared to different jurisdictions are considered equivalent. US patents are favored since the US Patent and Trademark Office (USPTO) maintains an extensive, publicly available database that makes analysis easier. If there was no US patent, we gave second priority to EPO patents. Should a patent have been declared only to an EU member nation, we found the corresponding EPO patent whenever possible.

<sup>8</sup> Note that this number includes all patents for which we were able to find an application year. Our USPTO database contains all the patents granted up to the end of 2005, while our EPO database runs till September 2006. For consistency, we limited our patent specific analysis to patents declared before 2005 regardless of jurisdiction. Also note that only 968 of the 1252 US patents and/or application were granted prior to 2005. Thus the patent specific analyses are based on this subsample.

<sup>9</sup> Two firms, Telia AB and Axalto, have only EPO patents.

## 1. R&D Statistics

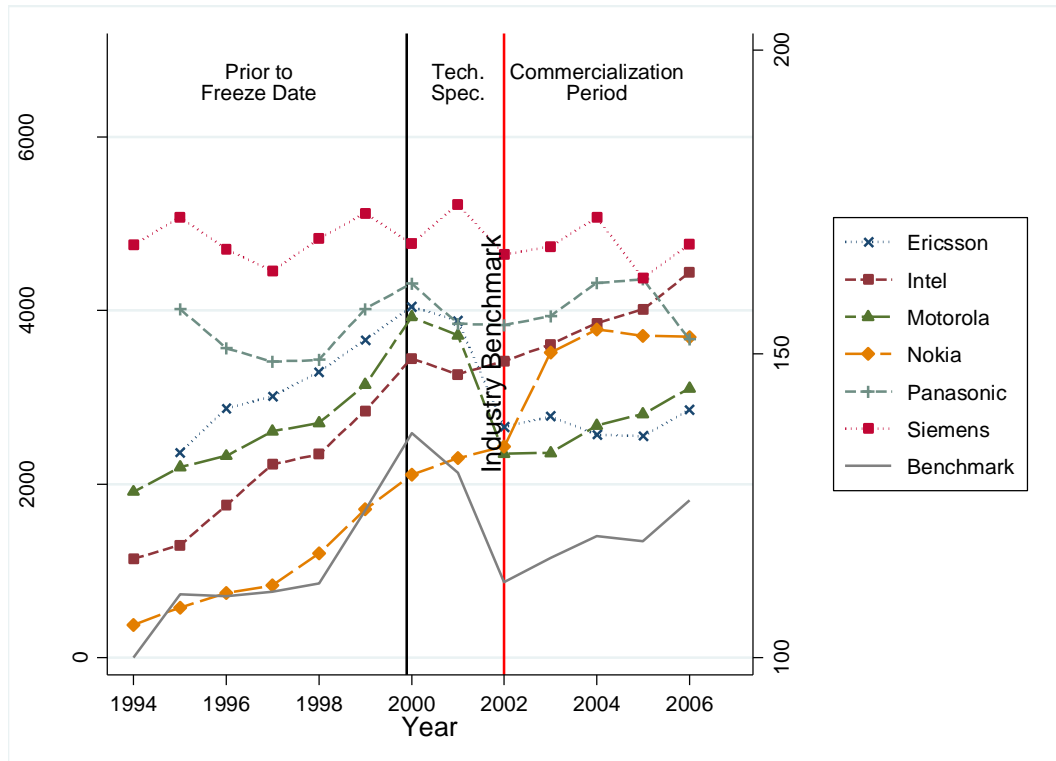
The next three charts, Figures 2 – 4, show how the R&D expenditures of the 21 ETSI member firms with the highest yearly R&D expenditures change over time.<sup>10</sup> As an important caveat note that all of the firms report aggregate R&D expenditures; they do not break spending out into technology fields or product lines. As a result, the R&D figures for firms with widely diversified operations, such as Panasonic and Intel among others, will include R&D on many projects wholly unrelated to UMTS. Each of the three charts, split according to the distribution of overall R&D expenditures, includes an industry benchmark<sup>11</sup> as a fixed comparison point across charts. Observe that the industry benchmark peaks at the UMTS standard freeze date, bottoms out at the date of the first commercial network, and then rises again during the commercialization phase.

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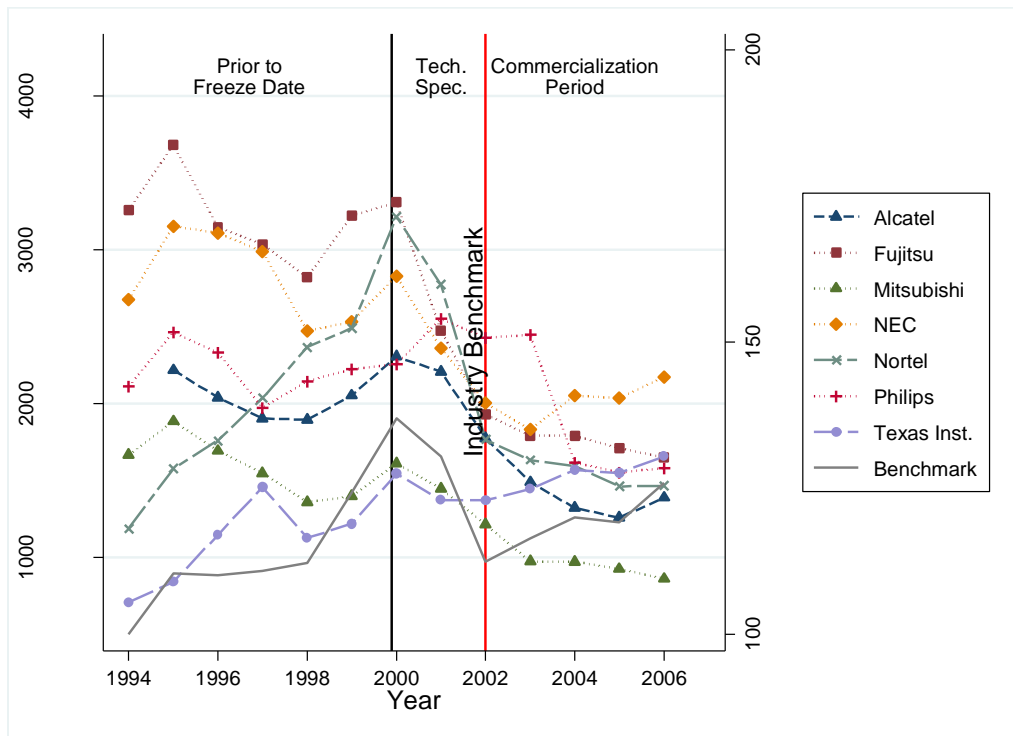
<sup>10</sup> We plot the 21 firms that rank highest when looking at the maximum R&D expenditures over the 1994-2006 time period. Note that for some of the firms we were unable to get R&D numbers for some of the earlier years.

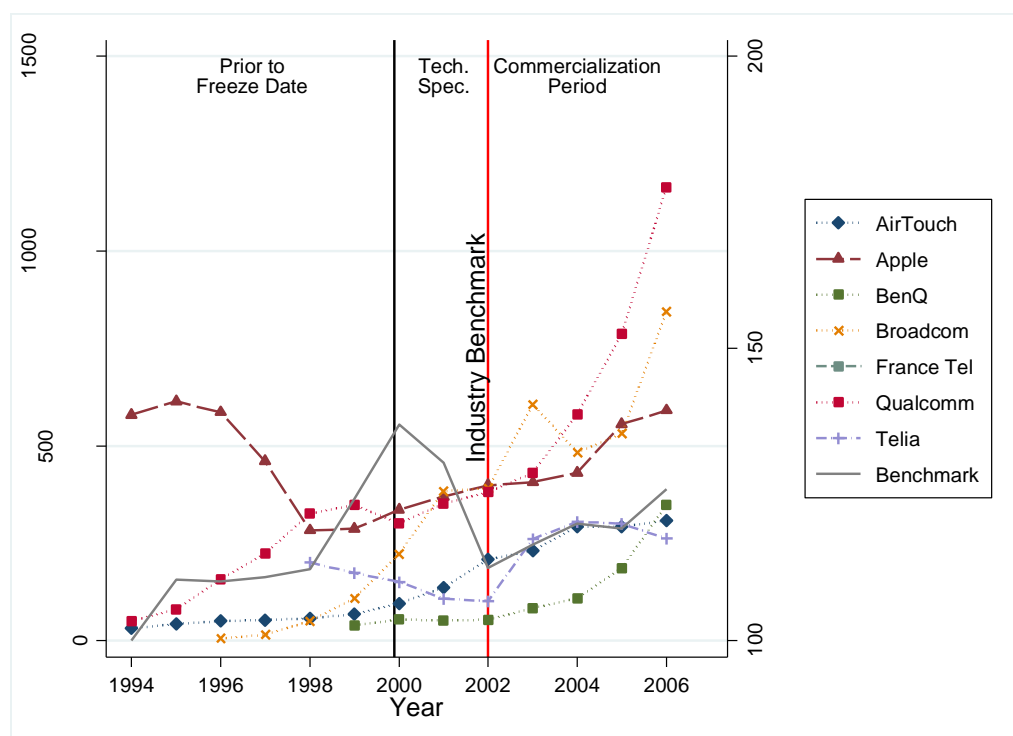
<sup>11</sup> We calculate the benchmark by looking at the change in average inflation adjusted R&D expenditures from a given year to our benchmark year, 1994, for all the firms in our sample. In particular, since we don't have data for all the firms over the entire time period, we calculated the relative change by assuming that a given firm had R&D expenditures similar to the year prior. (For ex. France Telecom had R&D expenditures of \$737 million in 1998; we assumed the same for 1997. We however made no assumptions for years before 1997.) We did this to ensure that we used the same firms in our year to year calculation which were then benchmarked against 1994.

**Figure 2: Inflation Adjusted R&D Expenditures (Top Third)**



**Figure 3: Inflation Adjusted R&D Expenditures (Middle Third)**



**Figure 4: Inflation Adjusted R&D Expenditures (Bottom Third)**

It is clear from the three charts that no one trend describes R&D spending for all of the involved firms. The firms in the top and bottom thirds of R&D spending have tended to increase their R&D from year to year. For example, Qualcomm was a small start up in 1994 and has increased its R&D spending dramatically over the decade graphed. Nokia and Intel, both on the first chart, also show tremendous growth in R&D expenditures over the period. In contrast, the R&D spending for most of the firms in the middle tier on spending (Figure 3) trends downward. Overall, for 7 of the 25 firms for which we have sufficient data, average R&D spending is not statistically different for the period before versus after commercialization. Of the remaining 18 firms, 9 have a statistically higher average R&D spend for the period prior to commercialization, while 9 have a lower average before. Overall it appears that roughly one third of the firms spent more on R&D after commercialization, another third spent about the same and the final third spent less.

In assessing the innovative content of patents filed after the UMTS standard was frozen, below I consider the relationship between R&D spending and patenting.

## 2. Measures to Identify Innovation

The key to the analysis is being able to distinguish between innovative and strategic patenting. Measures of innovation are therefore critical to the efforts. Relying on the literature, I collect and calculate a number of proxies for patent value or innovative content. Among these are the subsequent citations that the UMTS declared patents have received thus far.<sup>12</sup> As established by the literature (Trajtenberg, 1990; Harhoff et al., 1999), an accepted method for objectively quantifying a patent's value involves calculating the number of times that patent is cited by later patents (called forward cites).<sup>13</sup>

When filing a patent in the United States, inventors and assignees typically provide the patent examiner with a list of “prior art” (referred to as backward citations). Prior art is the foundation of earlier innovations that influenced the invention seeking a patent. It can be comprised of earlier patents, academic articles or papers, trade press, or textbooks. In addition to the prior art supplied by the patent filer, patent examiners search through patent office records to determine whether other patents bear on the patent application. Prior art in the form of patents are carefully considered as they define the breadth of the current patents' claims and can affect patent validity examinations and patent litigation outcomes (Jaffe and Trajtenberg, 1999; Hall et al., 2005). A patent that is subsequently cited by several later patents is therefore taken as an influential or valuable patent. Thus, future citations for a patent provide a tangible, objective, and readily available indication of a patent's value.

In addition to relying on forward and backward citations directly, additional patent value measures are based on citations.<sup>14</sup> For example, the “generality” measure assesses the extent to which the patented invention is employed across a wide array of technologies or is instead useful only in a narrow band of applications (e.g., Trajtenberg et al., 1997). The generality measure captures the breadth of technology classes among forward citations—those future patents influenced by the

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<sup>12</sup> Note that we only collected US patent filings and subsequent citations.

<sup>13</sup> This measure is not without controversy. Nonetheless, the critics of these measures have offered no other concrete, objective, and replicable measures to replace citations.

<sup>14</sup> Note that we only use US patents here. It is our experience that citation based calculations on EPO patents have little meaning since prior cites for EPO patents are determined primarily by the patent examiner.

patent. More general patents tend to be more valuable and can generate higher licensing revenues since the technology is applicable for a larger number of fields. Trajtenberg et al. observe that the generality measure “presumably capture[s] important determinants of the *social* returns to innovation” (Trajtenberg et al., 1997).

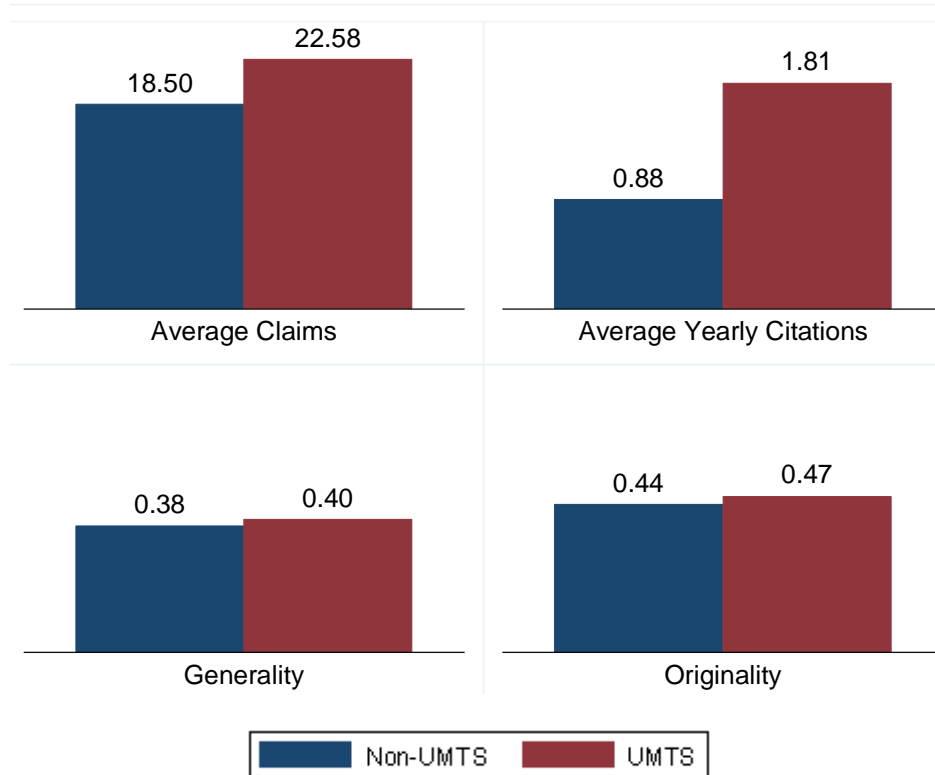
“Originality” is an analogous measure that looks to backward citations, measuring the breadth of technology fields the patent draws from in its prior art (e.g., Harhoff, et al., 1999; Jaffe and Lerner, 2001). When a patent’s prior art falls into a relatively large number of classes, it signals that the patent drew from a broad range of technologies, rather than a narrow field. Thus, it is considered to be more original, and less likely to be an incremental improvement.

As yet another value measure, this one unrelated to citations, I consider the total number of claims made within a patent. Claims define a patent’s scope—the more claims, the broader the patent rights are on average (Lanjouw et. al. 1999).

Those few studies with empirical analysis of patenting within standard setting clearly demonstrate that patents named to a standard tend to have significantly higher observable patent value as compared to patents outside of standard setting (Lerner et al., 2003; Rysman and Simcoe, 2008). The dataset employed here provides further confirmation of this point. Figure 5 below compares the US patents within the dataset with the rest of the US patents granted in the same year and belonging to the same technological class as the UMTS patents.<sup>15</sup> All four of the patent value proxies are considered: number of claims per patent, forward citations received per year, generality, and originality. This comparison is offered as descriptive of the dataset, and as a confirmation that the data used here comports with earlier studies.

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<sup>15</sup> We refer to each grant year/technology class as a patent cohort.

**Figure 5: Comparing UMTS with same Cohort, non-UMTS Patents<sup>16</sup>**

As the figure shows, patents declared to the UMTS standard have higher values for each of the value measures, although the differences in generality and originality are small. For average claims, yearly citations and originality, the differences between UMTS and non-UMTS patents are statistically significant at the 1% level; the difference in the generality score is statistically significant at the 5% level. I therefore conclude that, at least for the US patents, our dataset conforms to the findings in the literature, with higher value measures within the standard as compared to patents outside of the standard.

As one final measure for innovation, this one not specifically related to patent filing, consider the count of distinct technical contributions made by the 27 firms to working groups within the SSO. Technical contributions are useful in identifying genuine innovative efforts as they are typically documents describing specific

<sup>16</sup> Non-self forward citations are usually counted using the organization number assigned to each firm by the USPTO. Large companies tend to have different organization numbers for each of their subsidiaries. Therefore the non-self forward citation count for such patents tends to be higher than what it should be. For patents assigned to firms that have at least one UMTS patent however, we generated our own organization number so as to account for subsidiaries. For all other firms we use the USPTO assigned organization number. All analyses that follow use our own organization number for UMTS firms.

technical suggestions for modifying and improving a standard made by a firm's representative to the members of the SSO working group. As such, these contributions do not represent IP rights but instead are made within the technical working groups largely comprised of engineers and other technical specialists. Firms with purely opportunistic motives are unlikely to make the time investments necessary to create contributions of this sort as they do not play a role in increased rents. Technical contributions therefore offer a statistic measuring incremental innovative activity within a standard that is fairly insulated from strategic concerns. I collected technical contributions made to those groups that worked on at least one specification that applied to key components of the UMTS standard.<sup>17</sup>

The UMTS working groups held their first meetings in mid-December 1998 so the data includes yearly contribution counts from 1999 onward for the 27 firms in the dataset.<sup>18</sup> The technical contribution counts as an additional check on the innovative content of declared patents. If patent filings and contributions are positively correlated, more technical contributions indicate more innovative patents.

The following charts show the number of technical contributions over time for all of the firms that made at least 100 contributions in at least one year in our timeframe (1999-2006).<sup>19</sup> As the scales on Figures 6 – 8 demonstrate, contributions per firm range from zero to the many thousands in any given year.

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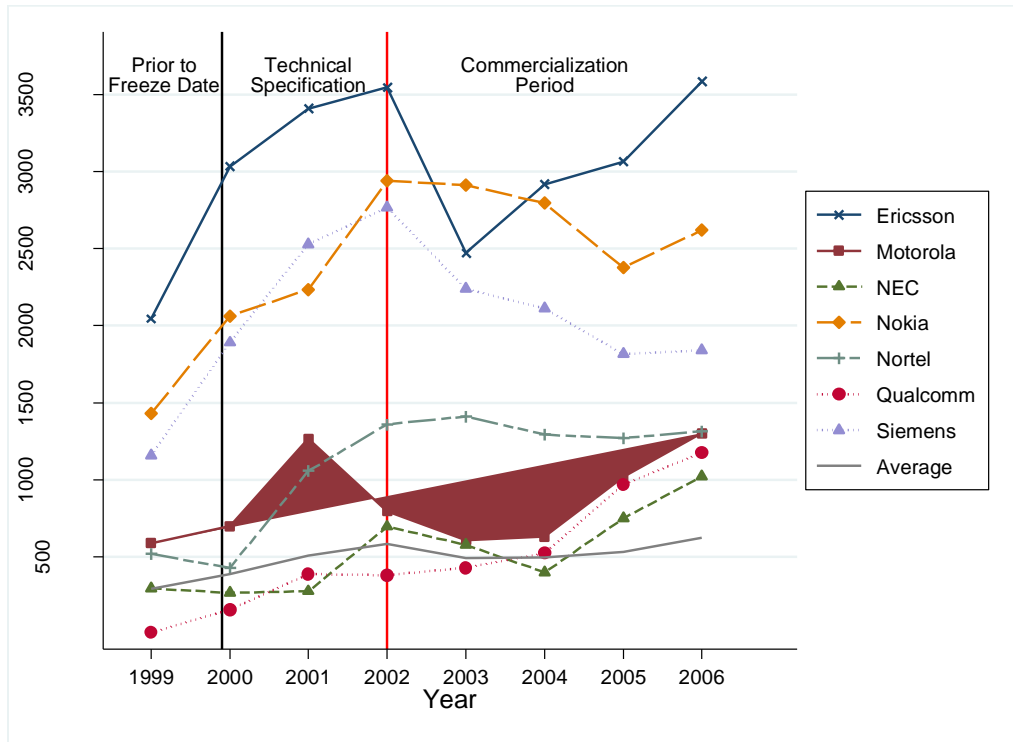
<sup>17</sup> UTRAN contributions are considered, which include all working groups under the following technical specification groups (TSG): CN, CT(active), RAN(active), SA(active), and T.

<sup>18</sup> <http://www.umtsworld.com/umts/history.htm>.

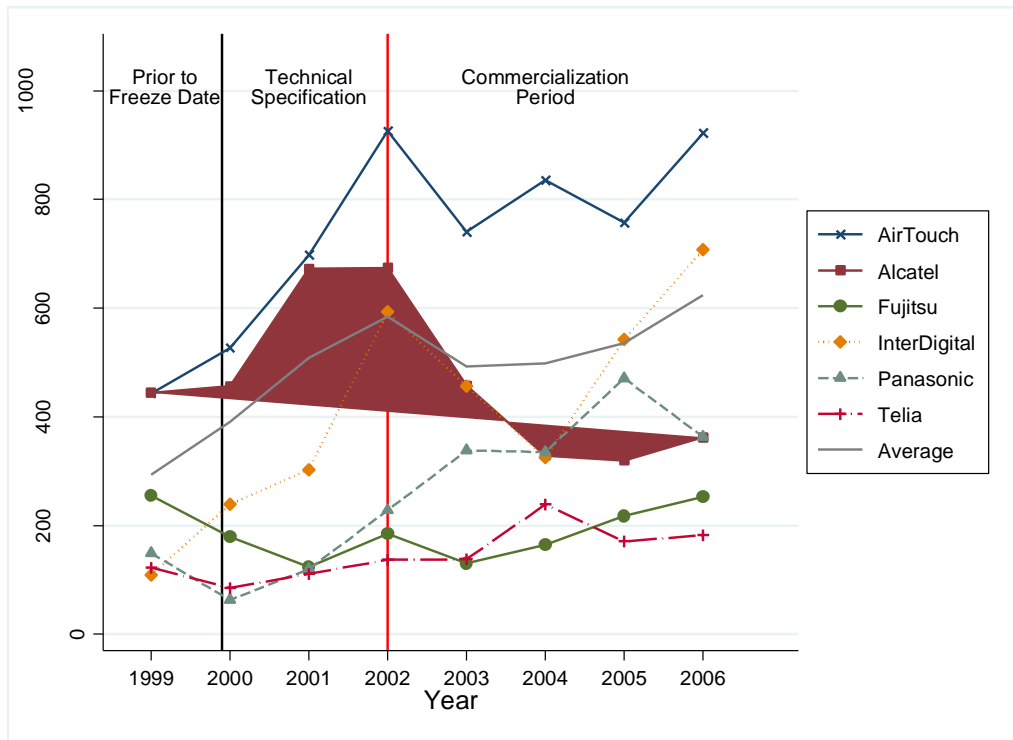
<sup>19</sup> For visual purposes we group the firms based on the maximum number of technical contributions they made for any given year in our dataset. We exclude any firms whose maximum yearly contribution is less than 100. Note that AirTouch Communication is now part of Vodafone.

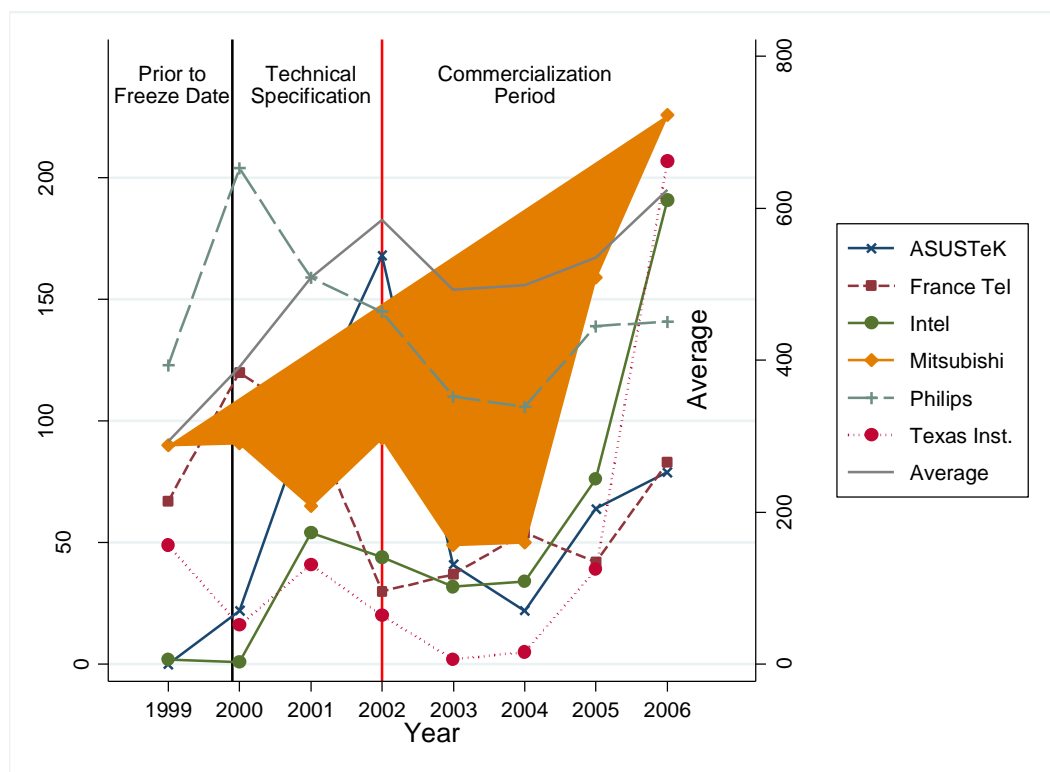


**Figure 6: Total Contributions to 3GPP Working Groups (Top Third)**



**Figure 7: Total Contributions to 3GPP Working Groups (Middle Third)**



**Figure 8: Total Contributions to 3GPP Working Groups (Bottom Third)**

The charts reveal that most firms either continued to make roughly the same number of contributions to the working groups over time or increased their contributions after the standard was frozen.<sup>20</sup> Similarly during the commercialization of 3G, most firms tend to hold the line on the number of contributions made to working groups. Although there is variation from year to year, no firm's contributions significantly decreased over time.<sup>21</sup> Furthermore for 15 of the 21 firms with 100-plus contributions,<sup>22</sup> the average number of technical contributions made to the working groups before commercialization was no different than after commercialization. I conclude from these statistics that work on the UMTS standard did not end with the adoption of a particular technology path. To the contrary, it

<sup>20</sup> Note that at the end of 2004 ETSI approved release 6 of the UMTS standard, which may explain the uptick in contributions in 2005 and 2006. Release 7 is due sometime in Q2 of 2008.

<sup>21</sup> We ran regressions of the number of contributions on the year and got positive slope for 20 out of the 28 firms, with one value being significantly different from zero. In the other 8 cases we got a negative slope which was not significant from zero.

<sup>22</sup> 5 of the remaining firms have a higher post commercialization average, while only France Telecom contributed less on average after commercialization.

appears that a great many details remained to be resolved, leading firms to continue contributing to the standard in non-trivial ways.

### **B. The Extent of Ex Post Patenting**

Before launching into an assessment of the innovative merits (or lack thereof) of ex post patenting, consider first how prevalent ex post patenting is in practice. Table 1 presents counts of patents filed before and after the UMTS standard was frozen.

**Table 1: US and EPO UMTS Patents by Firm**

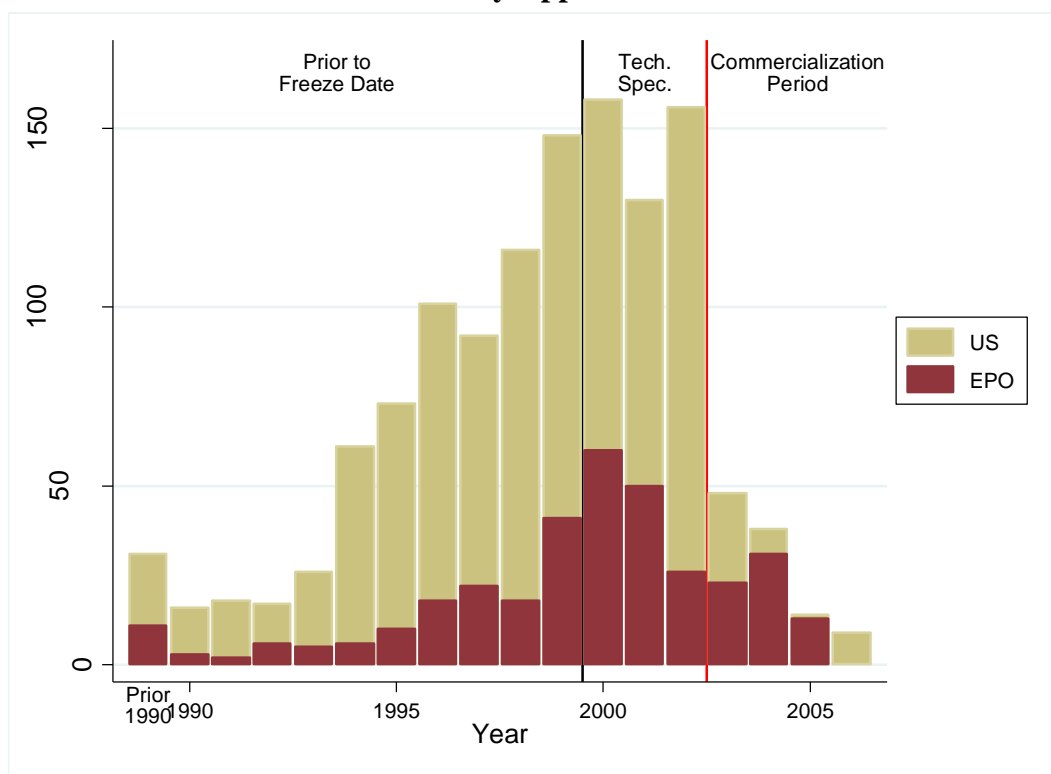
<b>Number of Firms</b>	<b>Aggregate Patents Filed Before Standardization</b>	<b>Aggregate Patents Filed After Standardization</b>
10	51	0
8	348	94
6	245	493
3	1	39
27	839 (53%)	749 (47%)

Over one third of the firms in the dataset, 10 of 27, have no ex post patents at all. Another eight filed the majority of their patents ex ante, with only 21% of this group's patents filed ex post (94 of their 442 total patents). The next group down, 6 firms, instead filed the majority of their patents ex post (493 out of 738), but nonetheless filed 33% (245 out of 738) ex ante. Only 3 firms filed next to none of their UMTS patents before the standard was frozen. Two firms in this last group, AsUSTEK (a late comer into the handset market) and Axalto (the recently spun off subsidiary of a large oilfield services corporation), filed all of their UMTS patents (29 and 2 respectively) after standardization. The data presented in Table 1 demonstrates that while ex post patenting clearly occurs in a non-trivial way (at 47% of all patents declared), most of the firms in the dataset did in fact file the bulk of their declared patents before the standard's technology path was settled.

To more precisely define the extent of ex post patenting, Figure 9 below shows the distribution of US and EPO UMTS patents by application year. Of the 1247 US patents/applications, 56% (697) were applied for before the standard was frozen. Similarly, 42% (142) of the 341 EPO patents have an application year of 1999 or

before. Both the US and EPO distributions peak around the time when the standard was frozen. Nonetheless, the chart shows that patenting activity continued well after the UMTS standard was frozen and has continued into the commercialization period. The vast majority of these ex post UMTS patents, however, were applied for before the commercialization period. In particular, 35% (441) US UMTS patents were applied for during the technical specification period while 40% (136) EPO patents have application year 2000-2002. Thus around 91% of the US patents and around 82% of the EPO patents were filed prior to the commercialization period.

**Figure 9: US and EPO UMTS Patents by Application Year**



### C. Are Ex Post Patents Innovative or Indefensible?

Under the null hypothesis of pure rent-seeking patenting, the patents filed after the standard was frozen, during the commercialization period, should be of less-than-average value. In terms of our proxy measures, this means that ex post patents should

have fewer than expected claims and earn less than average citations over time.<sup>23</sup> If a sizeable portion of the patents filed after the standard freeze date either meet expectations or are of above-average value, then this evidence would indicate that at least some of the ex post patents reflect genuine innovation. First define expectations in terms of the earliest patents. Next define expectations in terms of average patents granted at the same time and in the same technology class, but not included in the UMTS standard.

After making these simple comparisons, the paper turns to regression analysis that considers the strategic patenting question in a more systematic fashion. In particular, I regress the number of annual patent filings against R&D expenditures, an indicator variable for whether the filing was made ex post or not, and a host of other control variables.

### **1. Comparing US UMTS Patents Pre and Post 2000**

In order to determine whether all patents applied for after 1999 are opportunistic, or whether some might be considered innovative, I first analyze their values relative to the rest of the UMTS patents. Table 2 presents this comparison for claims per patent and average originality. Neither of these two value proxies changes over time, so the comparisons are based on overall averages. The comparisons rely on US patents only, as the dataset does not include claims or prior art citations for EPO patents.

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<sup>23</sup> Averages are calculated for all patents in the same grant year and USPTO technology class (i.e., overall) and all patents declared to the SSO (i.e., within standard).

**Table 2: US UMTS Patent Pre and Post Standardization<sup>24</sup>**

<b>Application Year</b>	<b># of Patents</b>	<b>Average App. Year</b>	<b>Average Claims</b>	<b>Average Originality</b>
1999 and earlier	670	1996	23.45	0.464
2000 and later	298	2001	20.60	0.477
Difference	372	5	2.85	-0.013
Test Statistic	n/a	n/a	2.16*	-0.81

*Notes: Significant at 5% level denoted by \*, significance at 1% denoted by \*\*.*

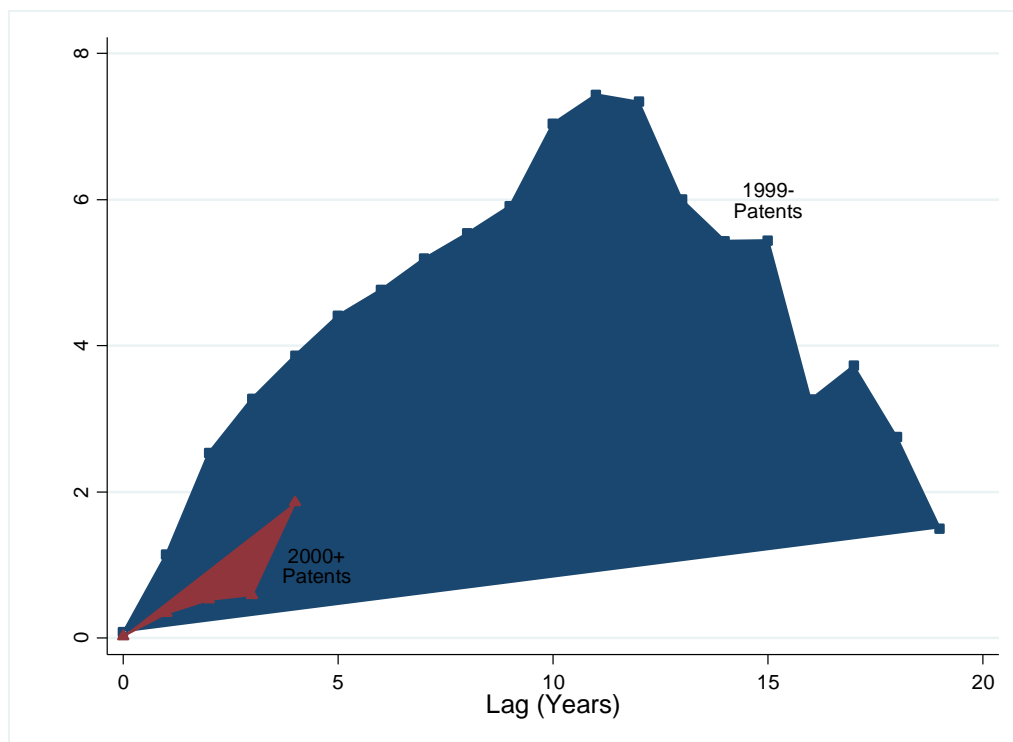
Patents with an application year of 1999 or earlier make on average about 3 more claims than the patents applied for after 1999 (the 2000+ patents). The difference is statistically significant. Originality, however, is in fact slightly higher for the post-freeze patents, although the difference is not statistically different from zero.

We cannot compare forward citation measures in the same fashion since these measures do change over time. As Hall et al. (2001) show in their analysis of USPTO patents, “the citation process is indeed a lengthy one”; they continue, observing that “if we have citation data truncated at 5 years after the initial application, we are seeing about 33% of the “lifetime” (actually, of the first 35 years) citation total for an average C&C [Computers and Communications] patent”. Hall et al. also show that for patents applied for in 1990, the number of forward cites is highest 5 - 7 years after the application year (Hall et. al., 2001). With far fewer years to garner citations, the 2000+ patents are bound to have fewer citations than the pre-1999 patents. Nevertheless, we can compare the citations received in the first few years after the grant date, which is presented in Figure 10 below. The pre-1999 patents received the highest number of cites from patents applied for 12 years after their filing date. The 2000+ patents have, thus far, received their highest cites in the most recent year of data. While, we cannot rule out a different citation pattern for the ex post patents, one which could eventually rival the pre-1999 patents in aggregate citations, the chart

<sup>24</sup> We do not present a comparison of generality scores since such comparison would be meaningless due to the way generality is calculated

illustrates that the 2000+ patents are off to a far slower start than the pre-1999 patents..

**Figure 10: Distribution of Average Yearly Non-Self Forward Citation Lags Pre/Post Standardization**



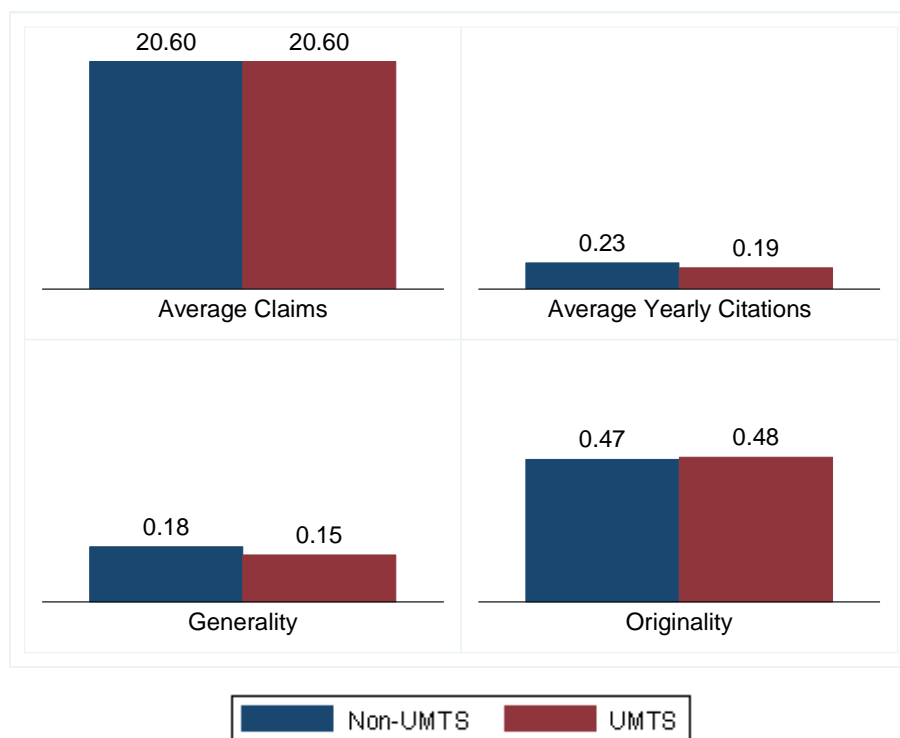
Taking the comparisons altogether we obtain a mixed view. As discussed earlier, the fact that the earliest patents declared to the standard have more claims per patent and more forward citations (thus far) does not automatically imply that the patents that come later are not valuable. But even if late patents are not as valuable as the ex ante ones, these comparisons do not rule out that ex post patents have made a valuable *incremental* contribution to UMTS. The next section therefore makes a more reasonable comparison, given the question posed here, with contemporaneous patents.

## 2. Comparing 2000+ Patents to Non-Standard Patents in the Same Cohort

Given the inconclusive nature of the comparisons above, consider next a group of “peers” as a benchmark for the 2000+ patents. Here the 2000+ patents declared to

UMTS are compared against the group of patents that have the same grant year and US technology class,<sup>25</sup> but which were not declared to the standard. Figure 11 below presents the results.

**Figure 11: Comparing UMTS with same Cohort, non-UMTS Patents**



The figure compares UMTS 2000+ patents to non-UMTS 2000+ patents on the four value proxies—per patent claims, number of forward citations, generality, and originality. All of the differences are slight and none is statistically significant. Thus while the UMTS patents are not valued at a premium compared to similar patents not declared to the standard, as is the case for UMTS patents overall, neither are they any less valuable. I take from this result that ex post patent filings are of average value. They are not below average as predicted by the purely opportunistic hypothesis.

<sup>25</sup> We also compared the UMTS patents with the group of patents that were in the same class and had the same application year. The results were qualitatively identical.



### 3. Comparing Patent Filing with Technical Submissions

For the final simple comparison, consider the relationship between technical submissions to an SSO working group and patent filings. Technical submissions are just what their name implies: assessments, proposals, or discussions of particular technical issues that arise within a working group in relation to the development of a standard. The submissions are typically written by engineers for engineers and as such they carry no property right claims. They may cover a firm's proprietary technology, making the firm's case for that technology's inclusion in the standard, or they might compare the workings of two or more options currently under consideration by the working group, or they may simply raise technical concerns in an effort to open discussion.

Given that technical submissions can be time consuming to prepare (time that the engineer could have devoted to other productive endeavors), that they must pass muster among other technical specialists, and that they carry no property rights, it seems likely that purely opportunistic patenting would not be associated with technical submissions. On this premise, we calculate the correlation between the timing of a technical submission and the timing of patent filings. Firms may, however, be reluctant to reveal any proprietary information in a submission that has not already been (or that soon will be) covered by property rights, which suggests lagging patent filing dates.

I consider three correlations. First is a contemporaneous comparison of technical submissions and patent filings within a given year. That correlation is 0.37 and is statistically significant. Next, I consider patents filed the year prior to a technical submission, which yields a higher positive correlation of 0.49, which is also statistically significant. Finally, I consider patents filed two years prior to a technical submission, which yields an even higher positive correlation of 0.55, which is again statistically significant.<sup>26</sup> I find that these correlations support the overall picture that has emerged from the analysis thus far: a reasonable portion of the ex post patents

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<sup>26</sup> Note that the sample size falls as the lags on patent filing increase.

appear to have innovative content. I turn next to the patent mining question, tested in rigorous regression analysis.

#### 4. Regression Analysis

The analyses in the prior sections look at each of our variables separately. In order to see interactions among the variables, I consider regression analysis. In particular, the number of UMTS patents filed for in a given year by a given firm is the dependent variable. The independent variables are annual, inflation adjusted R&D expenditure, the total number of US patents the given firm applied for in the given year, year dummies, a post standardization dummy that takes value of 1 when the year variable is greater than 1999, and an interaction variable between R&D expenditure and the post standardization dummy. I considered lagging R&D on the theory that it tends to take time to move from research findings to submitted patent filings. That is, the research for any given patent typically occurs well before the application date of that patent. I find, however, that the correlation between the total number of applied patents and R&D expenditures is roughly the same regardless of whether R&D is lagged by one year (correlation of 0.70), two years (0.70), or is contemporaneous (0.69). Given that corporate R&D programs tend to be fairly consistent over time, this finding makes sense.

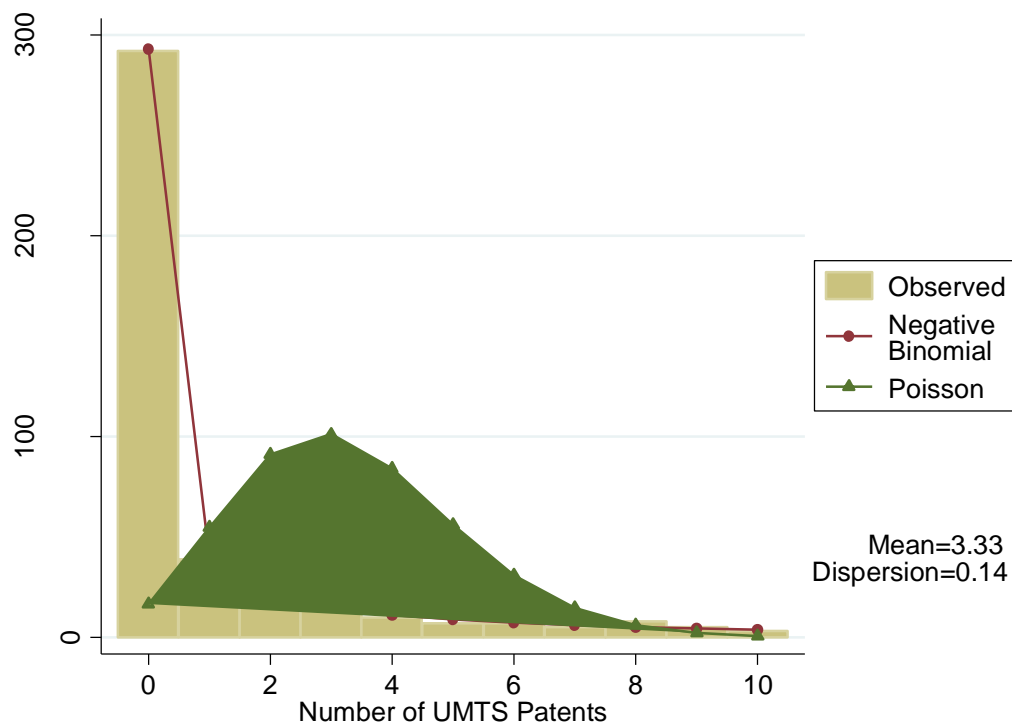
Since the data are at the firm level measured over time, I treat the dataset as a panel. In addition, because the dependent variable is a count variable which by definition must be non-negative (that is, some firms have no patents at all while others have many), I follow standard practice in the literature and employ Poisson and Negative Binomial regression models.<sup>27</sup> The chart below, Figure 12, shows the distribution of our dependent variable (number of UMTS patents by firm-application year) along with best fitted Poisson and Negative Binomial distributions. The Negative Binomial distribution is clearly a better fit for the data.<sup>28</sup> I therefore present the results from this regression model.

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<sup>27</sup> For a classical paper on this topic see Hausman, Jerry, Bronwyn H. Hall, and Zvi Griliches, (1984),

<sup>28</sup> Note that we truncated the x-axis for display purposes.

**Figure 12: Fitting Poisson and Negative Binomial Distributions to the Observed Counts of UMTS Patents by Firm/Year**



The hypothesis being tested in the regression is one flavor of the ex-post opportunistic patenting theory: that the firms patenting in the post-2000 period, after the standard is frozen, have increased their patent propensity in relation to the early period, reflecting “patent mining”. In other words, I test whether these firms are filing for more patents per dollar of R&D expenditure than they did before the standard was set, as an indication of rent seeking within an established standard. This test thus provides yet another view of the ex post rent seeking theory.

For this test, the estimated coefficient on the interaction between R&D expenditures and patent filings is the key parameter. The R&D variable captures the well established positive relationship between investments and patenting (R&D as an innovation input, patents as an innovation output). The dummy variable for post-2000 captures any increase in patent filing that takes place after the freeze date. The interaction between the two variables then captures any incremental patenting per R&D dollar that might occur in the post-2000 period. If the interaction coefficient is

positive and significant, then we can conclude that firms increased their patent filing for a given dollar of R&D investment. While such a pattern might reflect some newfound productivity in R&D, it is far more likely to reflect purely opportunistic patent mining. If, on the other hand, the interaction coefficient estimate is negative or not statistically different from zero, then we can conclude that firms' R&D patent propensities have not increased with patent mining and that the same relationship between R&D investments and patent filing exists after the standard freeze date as before it. This latter case would be consistent with the other evidence presented above that suggests at least some of the ex post patenting is reflective of innovation. Table 3 presents the regression results.

**Table 3: Negative Binomial Regression Estimates, Dependent Variable is Annual UMTS Patent Filings<sup>29</sup>**

<b>Independent Variables:</b>	<b>Coefficient</b>	<b>P-Value</b>
Inflation Adjusted R&D (\$M)	0.000213*	0.04
Total # of Applied US Patents	0.000577**	0.00
Post Standardization Dummy	1.36527*	0.05
Interaction R&D/Standardization Dummy	0.000024	0.76
Year 1994	0.806308	0.26
Year 1995	0.641318	0.37
Year 1996	0.94449	0.18
Year 1997	1.012887	0.15
Year 1998	1.232287	0.08
Year 1999	1.63293*	0.02
Year 2001	-0.76513**	0.01
Year 2002	-0.94814**	0.00
Year 2003	-1.14029**	0.00
Year 2004	-1.3435**	0.00
Year 2005	-1.73652**	0.00
Year 2006	-2.89275**	0.00
Constant	-1.03909	0.13

Notes: \*\* Denotes significance at the 1% level or better; \* denotes significance at the 5% level.

As expected, the more R&D investments made, the higher the number of patent filings. The total number of applied US patents, in the second row, captures a firm's propensity to patent in general, and it is also positive and significant. The post standardization dummy is positive and significant as well. The key variable, the interaction term, is slightly positive but not statistically significant from zero at the 5% level.<sup>30</sup> I therefore conclude that this test corroborates our earlier measures: firms

<sup>29</sup> The results in this table are for the fixed effect model (assuming random effects yields similar results). We also ran a variety of robustness checks. In particular we ran models excluding the year dummies and other models using permutations of the other explanatory variable. In all models our variable of interest, the interaction between R&D and standardization was not significant.

<sup>30</sup> With lagged R&D the estimated coefficient on the interaction term was also not statistically different from zero.

are not increasing their rate of patenting after standardization in an effort to patent mine.

### 3. CONCLUSIONS

I have focused in this paper on the issue of opportunistic, and potentially anticompetitive, patenting within standard setting. Some have voiced concern that SSO members filing patents after a standard's technology path has been chosen have strategic rent seeking as their primary motivation. A closer look at how standards evolve over time, however, raises another possibility—incremental innovation. I have therefore attempted the first steps toward detangling these two possibilities with an empirical assessment of patenting that occurs after a standard has been published.

In particular, I have examined the relationship between ex post patent filing and R&D expenditures along with measures meant to proxy patent value and thus indicate innovation. I find that while ex post patents are less valuable/innovative than ex ante patents declared to the UMTS standard, the null hypothesis that ex post patents are purely strategic and have no value can nonetheless be rejected. Instead, the results here suggest that sizable portion of the ex post patents are at least incrementally innovative and therefore contribute value to the standard. We cannot determine, on the basis of the results here, how many ex post patents are valuable, or which ones are truly innovative, but we can reasonably conclude that innovation does indeed continue as the standard develops and moves through commercialization.

In addition to the realities of standard development, which occurs slowly over time, I also find this result conforms well to an understanding of how many firms license their patents. In particular, firms frequently license their patents on a portfolio basis, as opposed to individually, especially within standard setting contexts. If a relatively small portion of a firm's patents were applied for after standardization then one cannot argue that the firm's patent *portfolio* as it relates to the standard is opportunistic. To the extent that firms license their patents on a portfolio basis, they have less of an incentive to apply for valueless patents—either ex ante or ex post. Since these firms negotiate their royalty rates based on the strength of their entire

portfolio, “padding” the portfolio with trivial ex post patents offers no incremental revenues but does cost the firm in patent filing expenses. As Table 1 showed, most of the firms with patents declared as potentially essential to UMTS filed at least some portion of their patents pre-standardization.

Unless there is reason to believe UMTS is a special case, which is unfortunately difficult to determine empirically given the lack of data available at other SSOs, then the findings presented here suggest that ex post patent filing should not automatically be considered strategic rent seeking. Certainly I do not mean to imply that all ex post patenting is valuable and driven entirely by innovation. That would be taking the other extreme view. Rather, I believe the truth lies somewhere in the middle. Some late patenting activity is likely to be opportunistic, meant to extort additional licensing rents from the standard, especially among firms that license on an individual patent basis. But at least some significant portion of late patenting, enough to lead to a rejection of purely strategic patenting in the statistical analysis, is valuable and makes an innovative contribution to the standard.

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