Empirical Analysis of Technical Contributions to IEEE 802 Standards

Ongoing Technical Engagement and R&D for IEEE 802 Standards Development After IEEE's Patent Policy Updates

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I Introduction

Companies and individuals that participate in technical standard setting can help to drive the future of technology development. New and innovative technical solutions, such as emerging technologies associated with the so-called "Internet of Things" (IoT), will heavily rely on technical standards to facilitate communications between myriad devices and objects, affecting all sorts of different industries beyond traditional technology and telecommunication businesses, such as automotive, buildings and construction, energy metering, traffic management and medical instruments. Technical standards can specify a common language for technologies to communicate and interact, and to ensure the compatibility between complex technology systems. The success of a standard can depend on the scope of its installed base; the more standard adopters, the more successful the technology using the standard. Consequently, standards development organizations (SDOs) may pursue wide market acceptance and adoption.

SDOs recognize that technical standards often incorporate technologies that are subject to patents owned by participants in the development of a particular standard. Without an effective approach to facilitate use of such "standard essential patents" (SEPs) by the market, standards developers could use their patents to foreclose competitors and otherwise limit the standard's widespread adoption in the market. To address this issue (and associated competition law concerns), SDOs often adopt patent policies requiring their members to agree to license their SEPs. One common approach is to require promises that SEPs will, upon request, be licensed to third parties on "fair, reasonable and non-discriminatory" (FRAND) terms.

In recent years, a number of courts have been called upon to resolve disputes about how to apply the FRAND promise in a particular situation. Some commentators, including competition agencies, have called upon SDOs to further clarify their patent policies so as to provide more information and predictability as to how they should be interpreted. A number of SDOs have accepted this advice and provided various clarifications, and there have been different conclusions by various commentators as to the positive or negative effects of such clarifications.

IPlytics has previously reviewed empirical evidence associated with one prominent SDO – the Institute of Electrical and Electronics Engineers (IEEE) – to evaluate any such effects from the policy clarifications on the SDOs activity, membership and overall success.[1] The data showed that:

[1] *See* IPlytics, *Empirical Study on Patenting and Standardization Activities at IEEE* (March 2017), *available at* https://www.iplytics.com/wp-content/uploads/2018/01/IPlytics_2017_Patenting-and-standardization-activities-at-IEEE.pdf; IPlytics, *IEEE's Empirical Record of Success and Innovation Following Patent Policy Updates* (April 2018), *available at* https://www.iplytics.com/wp-content/uploads/2018/04/IPlytics_Report-on-IEEE-activities_2018.pdf.

- More standards documents were completed and published in 2017 than in any other year in the IEEE's history;
- More new standardization projects were launched at IEEE in 2016 and 2017 than ever before in the organization's history;
- IEEE's membership has grown considerably since 2015, and it remains the world's largest standardization organization;
- Contributions to technical working groups at IEEE, and in particular in the 802.11 working group, have been at historically high levels since the IEEE patent policy was updated; and
- The largest technology contributors at IEEE continue to declare their patents subject to the IEEE's patent policy.

In this paper, we continue our evaluation of the IEEE's empirical record following the SDO's 2015 patent policy updates. In particular, this paper further evaluates data on technical contributions submitted to IEEE's 802 working groups, to determine how such contributions are, or are not, in-line with historical contributions prior to 2015. We focus on technical contributions as a reflection of participants' commitment and investment in standards development, and their willingness to contribute their technologies to standardization. Standards contributions also may reflect a company's R&D investments in developing standards, and ongoing engagement with the development process. In other words, the analysis seeks to evaluate empirically whether the 2015 IEEE patent policy updates influenced companies' willingness to contribute technologies, and to make associated R&D investments, in support of ongoing development of IEEE 802 standards.

Our findings are that:

- The number of technical contributions submitted in IEEE 802 working groups has continued to increase since the IEEE patent policy updates, and was in 2018 at the highest level in IEEE's history;

- The level of technical contributions submitted to leading IEEE 802.11 standards projects initiated after 2015 parallels, and to some extent exceeds, the level of contributions submitted to leading IEEE 802.11 standards projects prior to 2015.

- The increase of technical contributions in patent-heavy IEEE 802 working groups closely parallels the increase in technical contributions for IEEE 802 standards where no patent declarations were

filed, suggesting that patent policy considerations have not been a significant factor in companies' decisions about whether to invest in and submit technologies to IEEE 802 working groups;

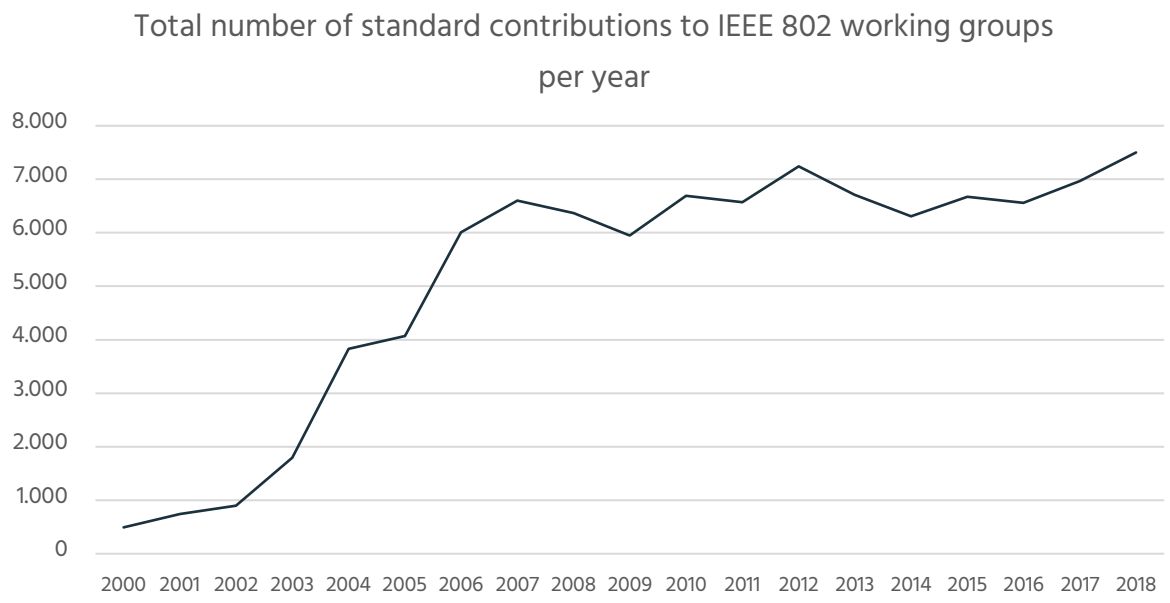
- The increase in technical contributions to IEEE 802 working groups beyond 2015 does not appear to be biased by external factors (*e.g.*, changes in the commercial value of a standard).

In short, in this third installment of our analysis of the empirical record since the IEEE patent policy updates, we once again conclude that the IEEE has continued to prosper in its development of technical standards, and that companies are in fact expanding their technical engagement with, investments in, and support for IEEE's standards development processes.

II Descriptive analysis on standards contribution trends

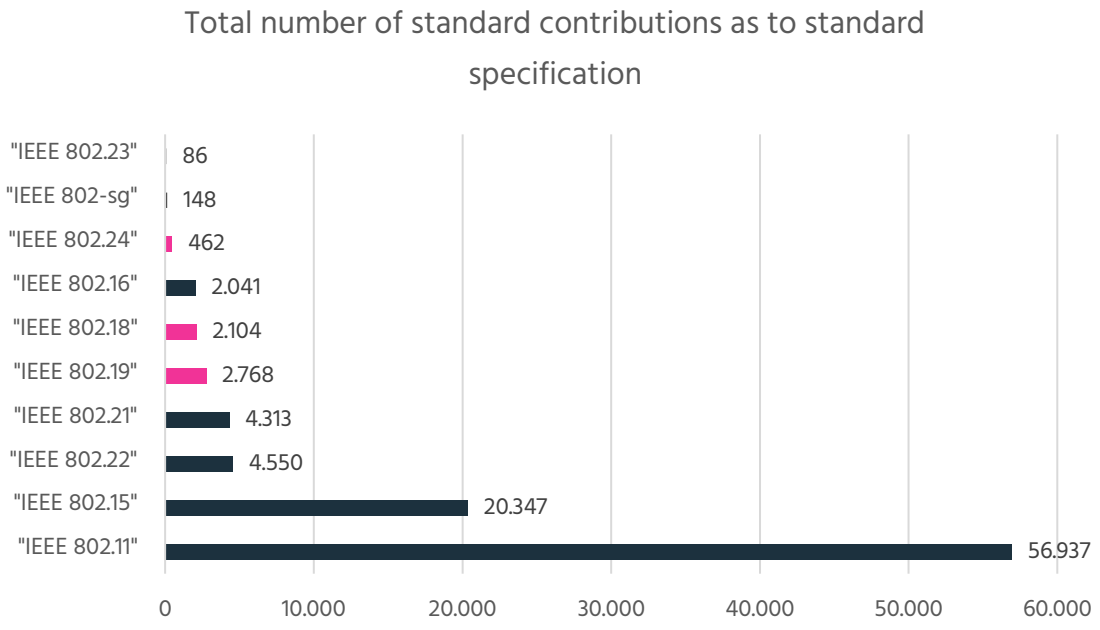
To conduct our study, we harvested data from the IEEE's Mentor database. The database collects and makes public information regarding technical contributions to IEEE working groups, such as the standards document identification number, the relevant working group, the date of submission, and the authors of the contribution with name and company affiliation. Figure 1 illustrates the total number of contributions submitted to IEEE 802 working groups since 2000. The numbers for 2018 cover data collected though the entirety of 2018. As can be seen, there has been a significant uptick in contributions to IEEE since the patent policy updates, from roughly 6,000 contributions in 2014 to almost 8,000 contributions in 2018 – an increase of about 30%.

Figure 1: Total number of standard contributions to IEEE 802 working groups per year



We can also consider whether IEEE participants' willingness to contribute their technologies has varied as between patent-heavy standards as compared to standards where SEPs do not seem to be implicated. Below, Figure 2 breaks down contributions to different 802 standard standards, highlighting 802 standards where at least one patent has been declared essential colored in dark blue and standards not subject to SEP declarations colored in pink.

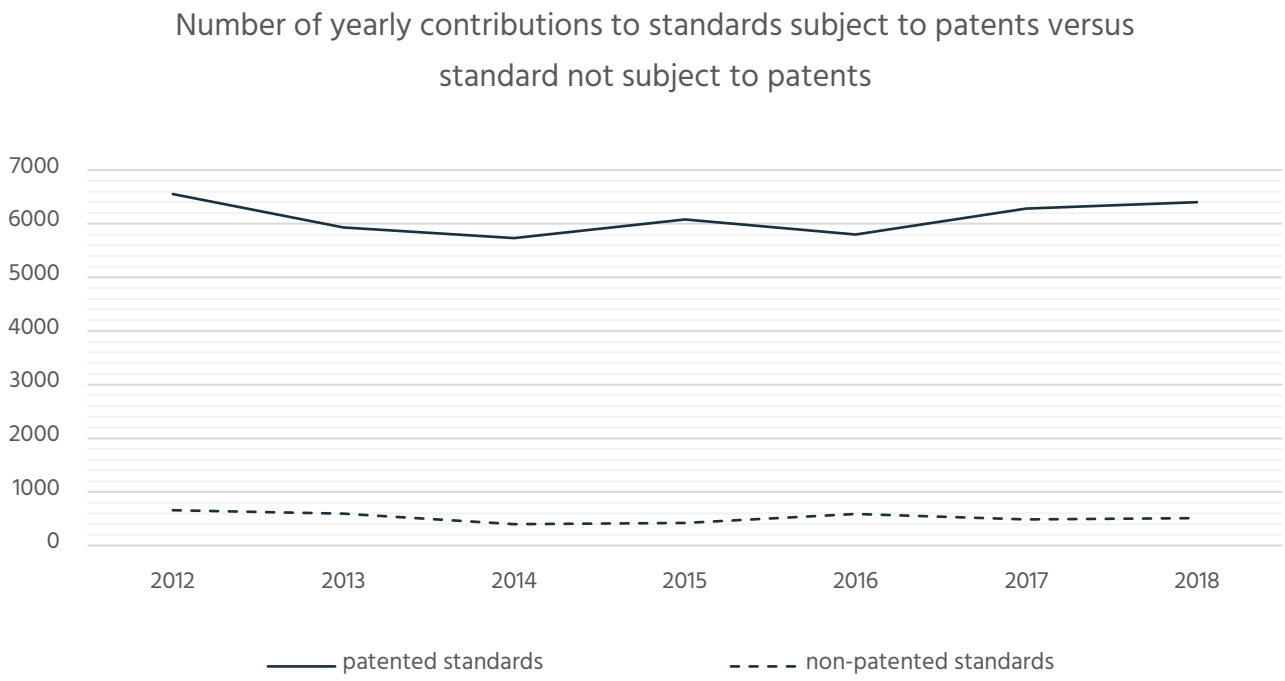
Figure 2: Total number of standard contributions as to standard specification



We might expect that if the IEEE patent policy update had any effect on its members' behavior to contribute to the standards development, that these effects only accrue for those standards subject to SEPs.

To identify such potential effects, we therefore split the dataset into contributions submitted to standards subject to SEPs, and standards not subject to SEP declarations. Figure 3 shows the number of technical contributions submitted between 2012 and 2018 for each group. Technical contributions made for standards subject to SEP declarations increased from 2016-18, after the patent policy update, whereas technical contributions to standards not subject to SEP declarations remained relatively constant after 2015. Again, it would seem that the IEEE patent policy updates had no negative effect on participants' willingness to submit their technologies (whether patented or non-patented) to IEEE.

Figure 3: Marginal number of yearly contributions as to standard



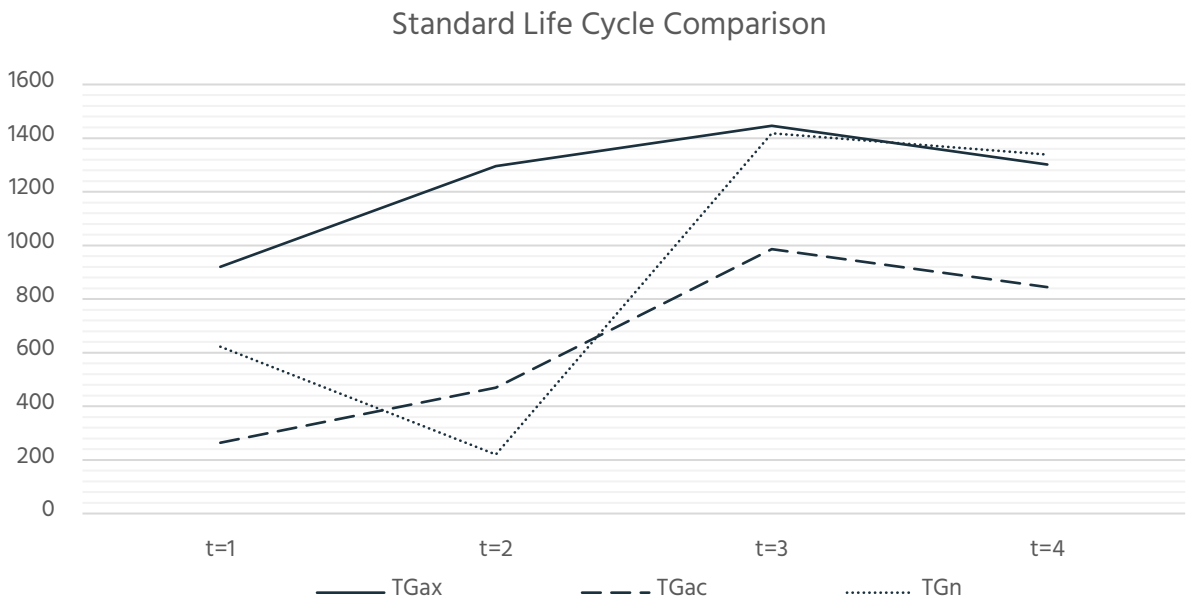
Using calendar years as in figure 3, however, does not consider the actual life cycle of the standard development. For example, a new Project Authorization Requests (PAR) at IEEE may lead to a flurry of activity while that project is in process, and then a drop off after the project moves closer to completion. To ensure that our conclusions about the increase in technical contributions is not simply the product of such development life cycle factors, we compared our findings with historical development life cycles for one key standard, 802.11.

Specifically, we compare three project life cycles for the three most recent commercially significant versions of the 802.11 standard: 802.11n (first technical contributions submitted in 2003), 802.11ac (first technical

contributions submitted in 2008), and 802.11ax (first technical contributions submitted in 2015). All three standards are subject to significant numbers of declarations regarding SEPs, and the working groups each have a comparable size and similar members. If technical participation and contributions to IEEE had been negatively affected by the IEEE's policy updates, then we might anticipate that 802.11ax would have lower contribution levels at similar stages of the technical development process.

In fact, however, the empirical evidence leads us to the opposite conclusion. As Figure 4 illustrates, the number of standards contributions submitted after the technical process was first initiated were much higher in year 1 and year 2 for 802.11ax (*i.e.*, in 2015 and 2016) than IEEE experienced with the pre-2015 802.11ac and 802.11n projects. It was only in year 3 and year 4 that technical contributions in 802.11ac and 802.11n began to equal the pace of contributions to the 802.11ax project, and the cumulative number of technical contributions to 802.11ac and 802.11n lagged well behind the contributions to 802.11ax over the first four years of the projects.

Figure 4: Number of yearly contributions comparing the life time of a standard (t-1 refers to the first year after the submission of the first contribution; t-2 to the second year; etc.; the numbers on the y axis refer to the number of technical contributions submitted)



In short, the empirical record regarding 802.11ax's development process does not indicate any problematic dynamics in companies' willingness to submit their technologies to IEEE following the IEEE's patent policy updates. If anything, standards participants demonstrated an even greater willingness to submit their technologies to IEEE subsequent to approval of the IEEE policy updates.

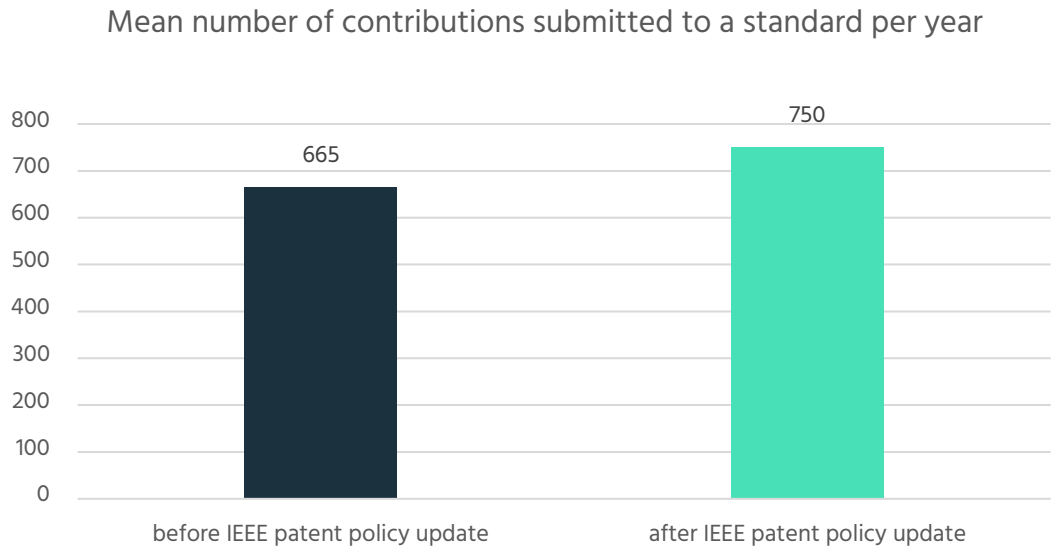
III Statistical evaluation of IEEE contribution trends before and after the patent policy update

To further test our analysis above, and to seek to exclude additional factors that could potentially account for the uptick in technical contributions to the IEEE after enactment of the patent policy updates, we now further apply our dataset of IEEE standards contributions to statistical testing – specifically, we apply a t-test comparison.

T-testing is an analysis framework used to determine the difference between two sample means from two normally distributed populations with unknown variances. Analysts commonly use a t-test with two samples, testing the difference between the samples. A t-test looks at the t-statistic, the t-distribution and degrees of freedom to determine the probability of difference between populations; the test statistic in the test is the t-statistic. In other words, our t-test can help us to determine the level of confidence we might have that the modest differences between the level of technical contribution before and after the IEEE policy updates is more than just a chance occurrence.

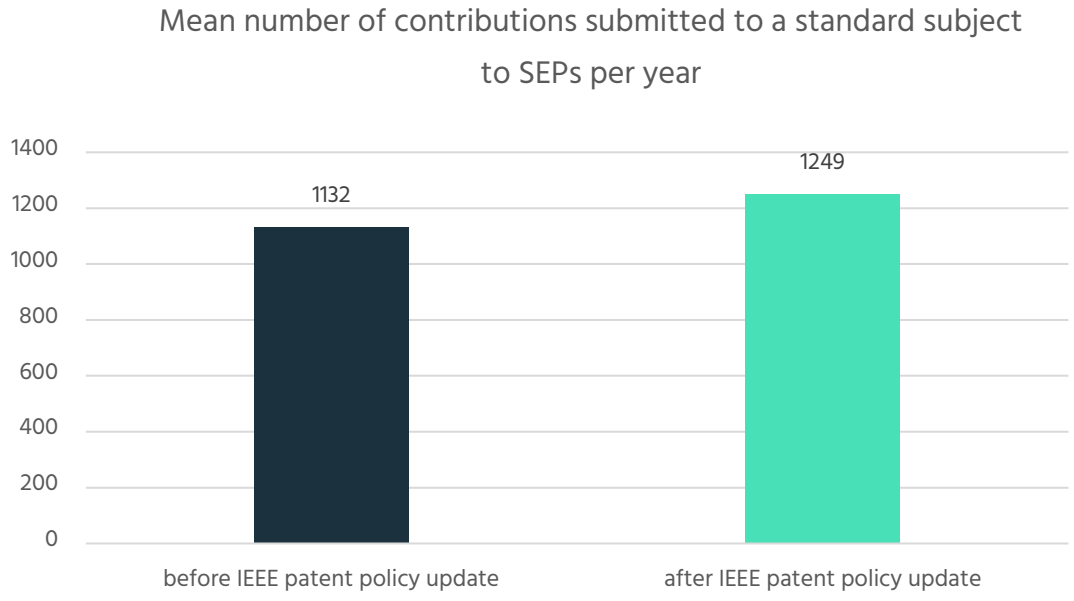
In our analysis we compare the average number of contributions per year and standard before and after the IEEE patent policy update for the years 2011-2014 and for the years 2015-2018. In a first step we run comparisons for all IEEE standards (figure 5). The data set is structured by totaling the number of technical contributions for each year and each standard. Years up until 2014 are marked as “before IEEE patent policy update”, years from 2015 are marked as “after IEEE patent policy update”. For each year-per-standard combination, on average we measure 665 technical contributions before the patent policy was updated, and 750 contributions after the patent policy was updated. The results show no negative effect to the level of IEEE standards contributions after the patent policy update, but rather a modest positive uptick in technical contributions.

Figure 5: T-test statistic of all IEEE standards contributions as to periods before and after the patent policy update



In a second step we run comparisons only for contributions submitted to IEEE standards that are subject to patents (figure 6). The mean values show on average 1,132 technical contributions per standard before the patent policy update, and 1,249 technical contributions per standards after the patent policy update. The results again show no negative effect to the level of IEEE standards contributions after the patent policy update, but again a modest positive uptick in technical contributions.

Figure 6: T-test statistic of contributions to IEEE standards subject to SEPs as to periods before and after the patent policy update



In short, our analysis indicates that it is unlikely these consistent (if slightly increased) results in the number of technical contributions during development processes at IEEE before and after the IEEE patent policy updates would have occurred due to mere chance.

IV Statistical regression of IEEE contribution trends before and after the patent policy update

The results presented in Figures 1-2 show that technical contributions to IEEE have only increased since the IEEE's patent policy update, even though we split the sample into tranches of standards subject to declared SEPs and tranches of contributions to standards not subject to declared SEPs. While the t-test analysis allows not only to compare mean values but also to measure significance of its differences, t-tests do not control for external effects that may have influenced the mean values. For example, one might imagine that external events such as any increasing commercial value of the IEEE 802 standard may have led to increasing interest in the IEEE's 802 projects and associated technical contributions. Such an effect could overlap any effect that may arise from the 2015 patent policy update.

To determine whether the possible increasing commercial interest around IEEE 802 standards might explain the observed increase in technical contributions to IEEE, we proceed to a difference-in-difference regression model that endeavors to control for such external effects.[2] First, we posit that if the patent policy update had an effect on companies' willingness to contribute their technologies, we would expect to see that reflected in behaviors relating to standards where SEPs are involved, but would not expect to see behavioral effects in connection with standards that are not subject to SEPs. As noted above, that has not been the case, but rather, the level of technical contributions submitted to each type of standard has been increasing at a similar rate.

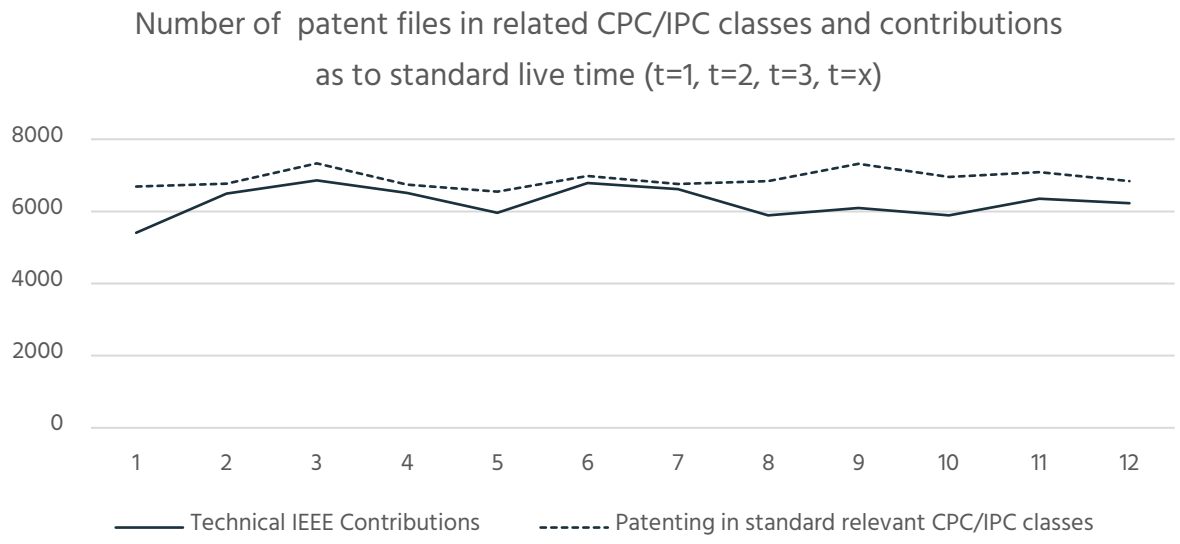
Second, we consider whether increased commercial interest around wireless standards might be reflected in the number of overall patent filings (whether SEP or non-SEP) in technical areas associated with the areas of development relevant to IEEE's 802 standards. To define these technical areas, we considered all patents filed in the CPC/IPC classes that also include declared SEPs for IEEE's 802 standards. This consideration of overall patenting volume in associated patent classes is our "control variable"; if we observe substantial increases or decreases in patenting in these classes, such heightened or diminished activity can suggest

[2] The difference-in-differences methodology is a statistical technique used in quantitative research that attempts to mimic an experimental research design using observational study data, by analyzing the differential effect of a treatment on a "treatment group" versus a "control group" in a natural experiment. The treatment group in our analysis are IEEE standards subject to patents. In other words, IEEE standards for which at least one patent or blanket statement has been declared. The control group are standards where no patent or blanket statement has been submitted. The natural experiment is the time when the IEEE patent policy update was set in force (2015-2018).

increasing or decreasing commercial interests in these technology areas, or other external issues such as technology chocks or variances due to the technology life cycle of a standard.

Figure 7 shows that overall patenting volumes in the relevant CPC/IPC classes has been closely correlated with variances in technical contributions to IEEE. However, and contrary to suggestions that the increase in technical contributions to IEEE is due to external issues such as increases in commercial interest, the increase in technical contributions to IEEE since the patent policy updates has been *more pronounced* than the increase in overall patenting. In other words, increases in technical engagement at IEEE have outpaced increases in overall market engagement with the underlying technologies. Figure 7 illustrates the varying rates of technical submissions to IEEE as compared to the rates of overall patenting.

Figure 7: Number of technical contributions as compared to patent filings in associated technical areas over the standard's life time (in this graph, 802.11 is treated as one project with different versions).



Evaluating this data using a regression model allows us to determine whether overall interest in these technology areas, as measured by overall patent filings, might explain the uptick in technical contributions to the IEEE. The difference-in-difference regression model integrates the overall patent filing variable in the equation to predict the influence on the level of standard contribution. Further it looks at effects for standards subject to SEPs, as well as for periods after the policy update to isolate a possible IP policy update effect from the general commercial interest in IEEE standards. The regression results indicate a significant positive correlation of standard contributions and overall patent filings as illustrated in figure 7. This supports that our "control variable" captures the effect of a general commercial interest in the standard. Further the regression result shows a significant positive correlation for standards subject to SEPs, independent from the time period. However, periods after the patent policy update do to not show any correlating effect for standards subject to SEPs and for standards not subject to SEPs. The regression model separates the correlation of contributions submitted after 2015 from other possibly overlapping influence

on the rate of contributions. The results confirm, while the regression model captures meaningful correlations, the patent policy update in 2015 had no significant effect on the level of contributions.

A table presenting the regression is attached as Annex 1. The difference-in-difference regression results confirms no significant influence on the magnitude of standard contributions submitted to IEEE standards after 2015, and that technical contributions to IEEE actually outpaced overall interest in these technology areas.

Based on our analysis and review, the close correlation between behaviors by IEEE participants regarding standards subject to SEP declarations and those that are not subject to SEP declarations strongly suggests that patent considerations relating the patent policy updates did not impair companies' choices to submit their technologies to IEEE for inclusion in IEEE standards. Moreover, it does not appear that overall increases in the importance of these technology areas could be responsible for the increased technical engagement and contribution to IEEE's 802 working groups.

V Conclusions

Technical contributions submitted at the IEEE 802 standards working groups may serve as a helpful indicator of IEEE participants' willingness to support IEEE's development efforts, invest in related R&D, and contribute their technologies to IEEE's standards development activities. According to the empirical evidence the IEEE patent policy updates have not diminished technical support and engagement at IEEE, and if anything companies have increased their support for IEEE's development efforts since the updates were finalized.

About IPlytics

IPlytics is an IP-Intelligence company specializing in analyzing the relation of patents and standards. IPlytics Platform links over 90 million patents to 2,5 million standards documents, 1,5 million standards contributions, 1 million records on meeting minutes as well as 300,000 declared or pooled SEPs. IPlytics Platform is a widely-used tool to analyze patent ownership, patent value and a patent's likelihood of essentiality for standards.

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IPlytics thanks Intel Corporation for providing financial support to enable the research behind the data described in this research paper, but notes that we have retained full independence in preparing and publishing our findings and analysis.

Annex 1 – Regression Data (Difference-in-Difference Regression Results)

DV= IEEE Contributions	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Periods after the policy update	23.00639	218.5077	0.11	0.916	-409.2849	455.2977
Standards subject to SEPs	356.3795	164.8151	2.16***	0.032	30.3126	682.4465
Periods after the policy update * Standards subject to SEPs	-135.91	293.2475	-0.46	0.644	-716.0651	444.2451
Patents in standard relevant CPC/IPC	1.968662	0.1848443	10.65***	0.001	1.60297	2.334354
_cons	75.52156	112.8375	0.67	0.504	-147.7139	298.757
Number of observations	135					
F(4, 130)	44.3					
Prob > F	0					
R-squared	0.5768					
Adj R-squared	0.5638					
Root MSE	748.47					

Note: ***, **,and * imply significance at the 99%, 95%, and 90% levels of confidence, respectively.