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## Patent Trolls and Technology Diffusion

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# Patent Trolls and Technology Diffusion

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**Abstract**

Patent assertion entities, sometimes known as 'patent trolls,' do not manufacture goods themselves but profit from licensing agreements that they often enforce via the threat of litigation. This paper explores empirically how litigation by one such patent troll affected the sales of medical imaging technology. It finds evidence that relative to similar products, made by the same firm, but not covered by the patent, imaging software sales declined by one-third. This was not due to a suppression in demand by hospitals but instead is linked to a lack of incremental product innovation during the period of litigation.

**Keywords:** Patents, Hospital IT, Economics of Intellectual Property
**JEL:** K0, O3

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# 1 Introduction

A 'patent-assertion entity', sometimes less-politely known as a 'patent troll,' is a class of patent owners who acquire patents from inventors but who do not intend to provide end products or services themselves.[1] Instead, they demand royalties as a price for authorizing the work of others, and these demands are often reinforced by the threat of litigation. Their role in the economy is disputed. There is a long tradition of market-makers in patents who facilitate the commercialization of inventions. However, new evidence suggests that lawsuits involving patent assertion entities do not lead to a simple transfer of stock market value. Instead, the gains in stock market value enjoyed by the patent assertion entity are far smaller than the loss of stock market value experienced by the defendant (Bessen et al., 2011). If patent assertion entities are simply intermediaries, it is not clear why there is this destruction of shareholder value.

To explore this, I examine how patent litigation affects technology sales in the empirical setting of healthcare information technology. Digital medical picture archival and communications systems (PACS) allow hospitals to acquire, store, transfer and review large amounts of data and images from diagnostic imaging devices such as ultrasounds and CAT scans. This technology saves healthcare providers money by removing film and physical image storage costs, and improves the quality of care by providing doctors and technicians with instant access to medical images. Miller and Tucker (2011) document that such software can reduce neo-natal mortality.

This setting has some attractive empirical properties for studying the effect of the actions of patent-assertion entities on technology diffusion. First, there is comprehensive data on sales of this technology to hospitals in the US. This contrasts with the opaque nature of

[1] I use the newer term 'patent-assertion entity' as recommended by the Federal Trade Commission in FTC (2011), rather than the older term 'non-practicing entity,' to exclude universities and similar research institutions from the definition.

most sales figures for new technologies. Second, at the end of 2005, Acacia, a large assertion entity with a reputation for litigating around its patent portfolio, acquired two patents that had not been licensed before. Acacia then launched wide-scale litigation against multiple companies who made PACS. Both the large-scale litigation and the unexpectedness of the patent acquisition makes this case typical of lawsuits involving patent assertion entities.

The last feature of this setting which is helpful for identification is that the targets for litigation were large healthcare IT firms that made otherwise similar products that either fell within or outside the scope of the patent, depending on the need for image compression. Generally, it is problematic to find a control group in patent litigation cases because other firms that were not litigated against are by necessity different. However, an unusual feature of the healthcare IT industry is that firms make and sell similar products in a similar way. The only reason that some products were affected by litigation was the type of medical data that they allowed a hospital to process, meaning that there is a potential control group of similar software products which transmitted a different form of data. Further, external research and technological classification by the Healthcare Information and Management Systems Society identifies products that reflect a similar degree of IT sophistication and therefore represent appropriate controls. This means I study the effect of patent litigation on the sales of affected products relative to similar products made by the exact same firms.

My results suggest that there was a large reduction in sales of imaging software products affected by patent litigation relative to other similar products that were produced by the same firms. There was no such significant change in sales of imaging software for firms that were not the target of litigation.

One potential explanation of my result is that this simply reflects a shift in demand away from imaging software. However, there was an increase in solicitations for bids on new contracts for both textual and imaging software by hospitals in this period, suggesting that these results do not reflect suppression of demand.

I then present some evidence about why this chilling of innovation diffusion occurred. Relative to firms that were not sued and products that were not covered by the scope of the patent, there was no incremental product innovation in imaging IT by the affected vendors during the period of litigation: No new variations of existing products or new models were released. An explanation for this lack of innovation is that the vendors did not want to run the risk of being found guilty of 'wilful infringement' in the patent suit and being liable for treble damages. This last result emphasizes that even if patent assertion entities do not prevail in the courtroom, their actions can have significantly negative consequences for incremental innovation while litigation is ongoing. As Trajtenberg (1989) points out, incremental innovation has large welfare consequences and aids the diffusion of technologies.

These results are important because of the growing debate about whether or not the activities of patent assertion entities are neutral for innovation. Theoretical work has showed that the actions of patent-assertion entities may dull incentives for firms contemplating new innovations (Lemley and Shapiro, 2007), since the assertion of intellectual property rights by firms empirically reduces the adoption of new innovations (Bessen and Meurer, 2008; Wen et al., 2010). An opposing view is that patent assertion entities simply act as intermediaries in the process of intellectual property rights assignment and therefore their actions are at worst neutral (Wang, 2010). Those who argue in favor of the activities of patent assertion entities suggest that their process of licensing, by increasing clarity, may spur innovation and the diffusion of technology (McDonough, 2006).

This paper argues that the manner in which patent assertion entities enforce their property rights - lengthy litigation proceedings - may itself harm technology diffusion. Litigation by patents assertion entities may be more drawn out than other forms of patent litigation. This is partially because there is asymmetry in the harm that uncertainty from litigation poses to a firm that manufactures goods verses a firm that does not manufacture goods (Reitzig et al., 2007). This is also partially because the business model of a patent assertion

entity is that given this asymmetry the defendant firms will ultimately settle and license rather than continuing to pay the legal fees, and lengthy litigation is helpful to increase pressure on firms to license. This paper shows that this form of lengthy litigation can have real economic effects due to the lack of incremental innovation in the period when litigation is ongoing.

# 2 Institutional Background and Data

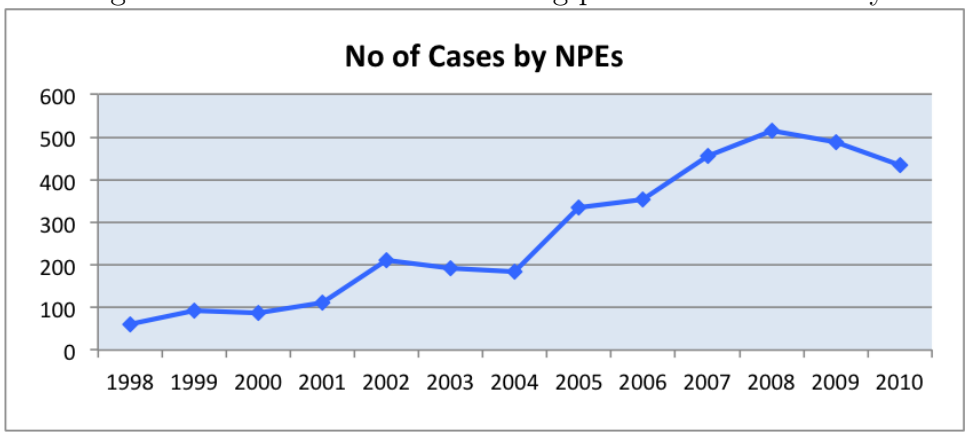
## 2.1 Legal Background

A 'patent-assertion entity' is a patent owner that does not manufacture or use the patented invention. Instead, their focus is on enforcing their right to exclude others from replicating the innovation through the negotiation of licenses and litigation. Though controversial, these actions reflect a perfectly legal practice given the strength of private ownership granted over intellectual property within the US, which gives inventors the right to sell their patents to other firms. Further, it would be problematic to limit such behavior on the ground that they do not produce a physical product, because any such restraints would limit the patenting activities of universities and potentially penalize undercapitalized inventors.

Patent-assertion entities have been involved in an increasingly large proportion of litigation over patents. One explanation for this increase is the broadening of patents to cover software where there are often large interdependencies in software development, meaning that there are many potential licensees (Jaffe and Lerner, 2004). Figure 1 documents this trend. This ability to litigate extensively reflects the fact that often the costs of litigation fall more heavily on the accused infringer, and that patent-assertion entities are not vulnerable to typical patent defense litigation techniques such as counter-claims or patent misuse, because they do not actually manufacture anything.

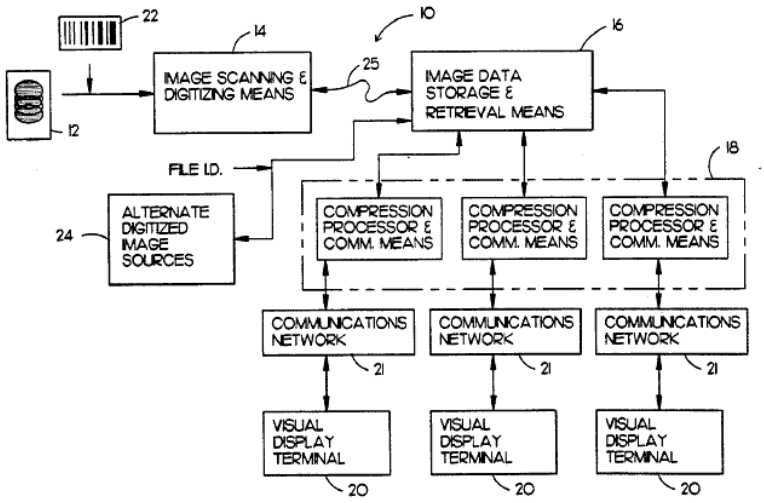
I study the actions of a patent-assertion entity in the field of healthcare software. In November 2005, Acacia, a large patent holding company with a reputation for litigating

Figure 1: Growth of cases involving patent-assertion entity




*Source: PatentFreedom.com*

Figure 2: Diagram for illustrating purpose and application of Patent US 5,321,520



around its patent portfolio, announced the purchase of two patents. These were: United States Patent No. 5,321,520, (June 14, 1994) for 'Automated High Definition/Resolution Image Storage, Retrieval and Transmission System' and United States Patent 5,416,602 (May 16, 1995), for 'Medical Image System with Progressive Resolution.' Acacia is a publicly traded company which does nothing but acquire and license patents. It has a history of extensive litigation over many different fields including adult-content filters, online-advertising techniques, and smartphones. Acacia is the seventh largest patent-assertion entity in terms of its patent holdings, holding 536 patents in 2011.[2] Acacia officially defends its business by saying that its actions promote innovation by helping small inventors and companies outsource the difficult and costly business of licensing their patents.

These patents were originally filed by Jorge Inga, a surgeon specializing in the treatment of herniated discs in Tampa, Florida, and Thomas V. Saliga, an engineer also from Tampa, whose website biography states that he owns over 20 covering surveillance, aircraft, and telecommunications systems. These two inventors fit precisely the description of the 'small inventor' whom Acacia says that they are particularly able to help by outsourcing the licensing process. It appears, however, that neither inventor has retired on the basis of the legal proceedings.[3] Table 1 summarizes these patents and Figure 2 is a snapshot of the technology that was included in both of the patent filings. A fuller description of both of their claims are supplied in Tables A-2 and A-3 in the appendix.

Acacia's patent acquisition was widely publicized, and both hospitals and vendors were warned that litigation and enforcement were about to begin. To start litigation to defend its patents, Acacia set up a subsidiary named 'Hospital Systems Corporation.' Their subsequent press release made clear that they viewed these patents as covering technologies that

> ...enable multiple, remote users to simultaneously access image data from remote

[2]Patent Freedom, 2011

[3]Thomas V. Saliga is head of 'Electronic Design Associates,' a new product development company in Tampa. Jorge Inga, who graduated with an MD 41 years ago, continues to practice in Tampa.

> display terminals over common phone and data networks, such as the Internet. PACS are commonly used by hospitals to acquire, store, archive and transmit patient image data for remote access by their physicians, at their homes, offices or within the hospital at the point of care.

The broad scope of the patent claimed by Acacia fits in with the findings of Fischer and Henkel (2011), who find evidence that patent assertion entities' patents receive relatively higher numbers of citations on average.[4]

In September 2007, Hospital Systems Corporation, the newly-formed subsidiary of Acacia, launched a lawsuit in the Eastern District of Texas against GE Healthcare, Fujifilm Medical Systems, Siemens Medical Solutions, Philips Electronics and McKesson Corp (Case No. 2:07-CV-00389-TJW).[5] The main point of complaint was that 'Each defendant manufactures, provides, sells or distributes infringing Picture Archiving and Communication Systems.' The complaint sought an injunction against the infringing companies, treble monetary damages, fees, costs and expenses. The Eastern District of Texas was chosen both because it has a reputation of favoring plaintiffs, and because its judges have expertise in patent suits; it is the venue of choice for litigation by patent-assertion entities. This evidence of 'forum shopping' suggests that this particular plaintiff was an 'excessive royalty extortionist' (Pohlmann and Opitz, 2010). The creation of a newly-formed subsidiary with a name evocative of the industry, the choice of venue and the scope and scale of the firms targeted in litigation resembles other lawsuits launched by Acacia in this period.

Table 2 summarizes the healthcare imaging companies that were sued and the dates that they were included in the court case. It also includes details on the number of legal representatives that they called upon to represent them, to give an idea of the scale of the

[4]Though this was questioned by Lerner (2006), who speculated that citations could be endogenous to the publicity surrounding litigation.

[5]The one step that the 'The American Invents Act of 2011' took to curb the actions of patent assertion entities was to prevent the 'joining' of cases in this manner. This may potentially increase the costs of patent assertion entities when embarking on such litigation.

Table 1: The two disputed patents

| **Name** | **Number** | **Abstract** |
|---|---|---|
| Automated high definition/resolution image storage, retrieval and transmission system (Inga and Saliga, 1994) | 5,321,520 | An automated high definition/resolution image storage, retrieval and transmission system for use with medical X-ray film or other documents to provide simultaneous automated access to a common database by a plurality of remote subscribers upon request, the automated high definition/resolution image storage, retrieval and transmission system comprising an image scanning and digitizing subsystem to scan and digitize visual image information from an image film or the like; an image data storage and retrieval subsystem to receive and store the digitized information and to selectively provide the digitized information upon request from a remote site, a telecommunication subsystem to selectively transmit the requested digitized information from the image data storage and retrieval subsystem to the requesting remote visual display terminal for conversion to a visual image at the remote site to visually display the requested information from the image data storage and retrieval subsystem. |
| Medical image system with progressive resolution (Inga and Saliga, 1995) | 5,416,602 | A storage, retrieval, and transmission system is configured to provide fast, efficient telecommunication access to digitized images (e.g., medical diagnostic X-ray images) to multiple requesting subscribers. Image data are downloaded, via the telephone lines, to a remote display terminal as a plurality of portions of a compressed digital image representation. Data from a first transmitted portion is used to construct a displayable image at the terminal. Data from subsequently transmitted portions are combined with the displayable image data to provide an image with an improved resolution. |

Table 2: Healthcare imaging companies involved in the lawsuit

| Defendant | Date Named | Date Terminated | No. Legal Representatives |
|---|---|---|---|
| General Electric Healthcare | 9/7/2007 | 11/19/2009 | 10 |
| Fujifilm Medical Systems | 9/7/2007 | 7/1/2009 | 6 |
| Siemens Medical Solutions | 9/7/2007 | 6/25/2008 | 6 |
| Philips Electronics | 9/7/2007 | 12/09/2008 | 6 |
| Mckesson Information Solutions | 9/7/2007 | 3/27/2009 | 4 |
| Sectra North America | 11/21/2008 | 7/1/2009 | 3 |
| Agfa Corporation | 11/21/2008 | 1/13/2010 | 2 |
| Novarad Corporation | 11/21/2008 | 12/30/2009 | 4 |
| Merge Healthcare | 11/21/2008 | 12/30/2009 | 4 |
| Infinitt North America | 11/21/2008 | 2/6/2009 | 1 (co-rep) |
| Emageon Inc | 11/21/2008 | 6/19/2009 | 1 (co-rep) |
| Intelerad Medical Systems | 11/21/2008 | 1/13/2010 | 2 |
| UltraRad Corporation | 11/21/2008 | 1/15/2010 | 1 |
| Viztek Inc | 11/21/2008 | 2/27/2009 | 1 |

legal proceedings. Table 3 follows the progress of the lawsuit. This progress was largely echoed by public statements made by Acacia on its websites. These public statements are documented in Table A-1 in the appendix. Table 3 shows that all initial defendants ultimately withdrew and signed licensing agreements with Acacia. As detailed in Table 3, at the end of 2008, nine additional imaging software vendors were added to the lawsuit. These were smaller companies who have sold on average 842 imaging software components to hospitals. My data ends in 2008, so I exclude these vendors from the analysis.

### 2.2 Data

I use data provided by the HIMSS Analytics Database (2011 release). This is a marketing database for professionals who sell healthcare IT and related products to hospitals and healthcare providers. For the majority of hospitals in the US, it details what healthcare IT systems these hospitals have purchased and when they purchased them. The data covers 4,829 hospitals.[6]

[6]Lemley and Shapiro (2007) suggest that patent litigation can lead to fewer new inventions. This can be measured by the number of new patents that cited these existing patents and seeing whether the number of citations was lower after the launch of the lawsuits. Figure A-1, in the appendix, records the number of

Table 3: Timeline of case 2:07-CV-389-TJW

| Date | Event |
|---|---|
| 9/07/2007 | Original Complaint with Jury Demand filed |
| 9/27/2007-10/9/2007 | Motion for extension of time to file by General Electric, Fujifilm, Siemens and Philips |
| 11/05/2007 | Motion to change venue by Fujifilm |
| 11/05/2007 -11/08/2007 | Counterclaim by GE, Siemens, Philips, Fujifilm |
| 5/16/2008 | Discovery Order |
| 6/25/2008 | Siemens terminated from case |
| 11/21/2008 | Amended complaint. Plaintiff amends complaint to include Sectra, Agfa, NovaRad, Merge Healthcare, Infinitt, Emageon, Intelerad Medical Systems, Ultrarad, and Viztek |
| 12/19/2008 | Philips terminated from case |
| 1/5/2009 | Agfa terminated from case |
| 1/23/2009 | Merge Healthcare terminated from case |
| 3/25/2009 | Mckessen terminated from case |
| 10/01/2009 | Jury selection set for 8/2/2010 |
| 11/16/2009 | GE terminated from case |
| 12/30/2009 | Novarad corporation terminated from case |

Note: There were 232 separate court dockets relating to this case. This timeline is a summary of the most important of these events.

For each class of healthcare IT application, the database categorizes whether or not the hospital has contracted to purchase it, and if so from what vendor and in what year the contract was signed. The fact that the primary data is on the 'contract date' has proved a challenge for empirical studies focusing on the effects of installed healthcare IT, but for this particular study it is ideal, since I am interested in the actual purchase of technology rather than its implementation date.

As described by Jha et al. (2009), the healthcare IT system purchased by a hospital is incredibly complex. It consists of different software components that facilitate the transition from paper to electronic transmission for that particular form of patient data or health provider action. It is the cross-variation in whether the patent applied to different types of medical data that I exploit in this data.

The components that deal with remote access to imaging include Ultrasound, Mammography, Magnetic Resonance Imaging (MRI), Radiography, Fluoroscopy, Computed Tomography (CT), Computed Radiography (CR), Angiography, and Orthopedic images. The only software I exclude from this category is the underlying radiology information system (RIS) which is usually focused on patient tracking, scheduling and reporting because an RIS could be used to host images as well as transfer textual data.

I then use applications that do not involve the transfer of medical images, only textual data, as controls.[7] The applications in this category are software modules for 'Physician Documentation', 'Clinical Data Repository', 'Clinical Decision Support', 'Order Entry', 'Computerized Practitioner Order Entry', and 'Physician Portal'. These components are not covered by either of the disputed patents. As shown in Figure 2, the patents cover tech-

patent citations over time for each of these patents. It is clear that these two patents did not receive enough citations to make analysis precise. Further, the number of citations is small enough that it is difficult to disentangle the decrease in patent citations from the natural decrease in citations observed by Mehta et al. (2010).

[7]There were no patent licensing lawsuits in this period for this category of software application I could find in searchable court dockets. There wer separate licensing lawsuits concerning operating room scheduling software but these are not part of the software applications in the analysis.

niques for the compression and distribution of patient image data across a communications network, not the compression and transfer of textual patient data.

It is important to establish the extent to which these different IT components are appropriate controls for each other. They are all inputs into patient care used by the same facility designed to make patient care paperless, but of course there may be differences in sophistication and therefore potential technology sales. Luckily, the non-profit Healthcare Information and Management Systems Society (HIMSS) has devoted time and effort to developing a taxonomy of different levels of healthcare IT complexity and sophistication. This is part of their effort to develop an Electronic Medical Records Adoption model to allow hospitals to track their progress towards creating a paperless patient record environment. The image-based technologies that I study satisfy the stage 3 criterion of 'medical image access from picture archive and communication systems (PACS).' The textual-data technologies I use as controls are also stage 3 technologies ('Clinical documentation installed' and 'First level of clinical decision support' and 'Error checking with order entry'). A clinical data repository is a stage 2 technology when stand-alone and stage 3 when integrated, which is why I include it. The results are robust to its inclusion or exclusion.

To investigate the extent to which this comparability holds in the data, I compare the characteristics of hospitals that purchased imaging and data products in the 4-years prior to the litigation period in Table A-4 in the appendix. As might be expected given the use of imaging in obstetrics, the hospitals that had more births were more likely to purchase imaging software. Also, hospitals that had more doctors were also more likely to purchase such software. I therefore show that my results hold for hospitals that have low and high numbers of births and doctors in later robustness checks. However, in general the profiles of hospitals that purchased imaging and data products is not startlingly different, which validates the HIMSS contention that these are products that are bought by hospitals who are in a similar stage in their IT adoption process.

I include only observations of vendors that made *both* software that allowed access to textual and image patient data. This means that I exclude sales by Fujifilm from the analysis since they only made imaging software.[8]

The five defendants had made an average of 4,755 sales of different software components to hospitals. The 163 software firms that were not targeted had made an average of 138 sales of software components to hospitals. The five defendants are responsible for just over half of all software sales in imaging software. This of course leads to worries that these vendors are competing in very different markets. Table A-5 shows a comparison in terms of the kind of hospitals that purchased from the sued vendors and the kind of vendors who purchased from the smaller vendors that were not sued in the period prior to litigation. There appears to be fewer differences in the characteristics of the hospitals that purchased from the sued and non-sued vendors than might be expected. The most significant difference between sued and non-sued customers is the number of outpatient visits and the number of doctors, which is one of the reasons why in the robustness checks I check that the results hold for both large and small hospitals.

Figure 3 compares sales of imaging and textual software units by vendors that were sued and vendors that were not sued. It suggests that there was a large drop in imaging software sales by those vendors who were targeted by the lawsuit relative to textual software sales. There was no such pattern for vendors who were not sued. Figure 4 presents similar analysis but where the outcome is whether there were *any* sales of that category of product to a hospital. Even when controlling for distortions introduced by hospitals purchasing multiple units of related software, hospitals purchased fewer imaging data products relative to textual data products from the vendors that were sued after litigation commenced.

[8]Fujifilm also exhibited a similar decrease in sales after litigation commenced.

Figure 3: Changes over time in imaging software sales relative to non-imaging software sales for vendors targeted by litigation and vendors not targeted by litigation.

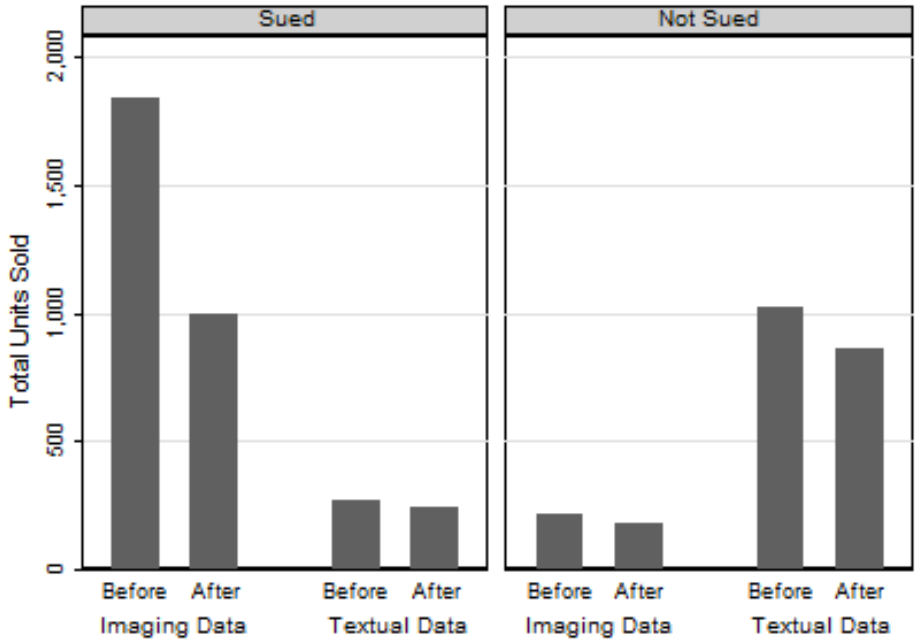
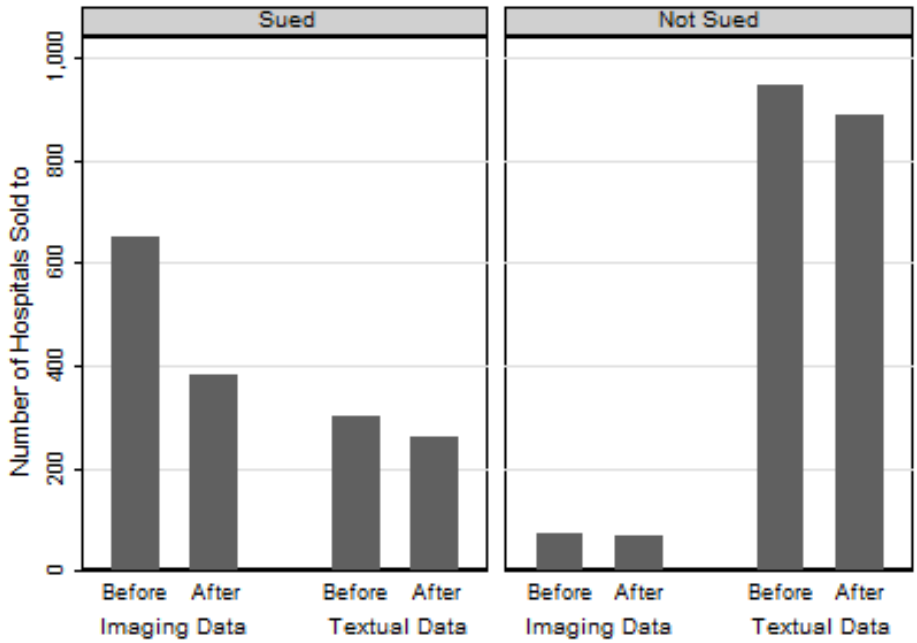



Figure 4: Changes over time in imaging software sales relative to non-imaging software sales for vendors targeted by litigation and vendors not targeted by litigation.



## 3 Empirical Analysis

Though this graphical analysis is suggestive that there was a negative effect on the sales of imaging software by the vendors who were targeted for litigation by Acacia, such aggregate analysis does not control for other confounding time-varying factors. To better address this possibility, I turn to a regression framework and look at sales to individual hospitals which allows me to control for time variation in the characteristics of potential clients. This helps rule out alternative explanations that are driven by changes in customer needs, such as changes in the number of inpatients compared to outpatients or medical staffing.

I convert the healthcare IT sales data into a panel dataset that records for each hospital from 2005-2008 what technologies the hospital contracted to purchase each year. I check robustness to a longer pre-period in subsequent analysis. The main dataset focuses on sales by vendors that were part of the initial lawsuit launched by Acacia. I also construct an identical dataset for sales by vendors that were not involved in litigation, which I use in further robustness analysis. The unit of observation in the estimation is for a particular software application for a particular year at a particular hospital. Each hospital-year-software component observation is augmented by the characteristics of the hospital from the yearly survey of the American Hospital Association (AHA).

This gives a four-year panel for 2005-2008. In the first two years there was no litigation. The second two-year period covers the period when litigation had commenced. The empirical analysis concludes before 2009 because of the potential for confounds introduced by a major shift in government policy in 2009 towards giving hospitals incentives for purchasing various forms of healthcare IT - the HITECH (Health Information Technology for Economic and Clinical Health) Act. Fortuitously, for this study the size and scope of the incentives offered by the HITECH act was not anticipated by the industry as it was part of the hastily put together measures that formed the American Recovery and Reinvestment Act of 2009.

Table 4: Summary statistics for sales by vendors involved in litigation

| | Mean | Std Dev | Min | Max | Observations |
|---|---|---|---|---|---|
| Technology Sale (Vendor involved in Litigation) | 0.03 | 0.17 | 0 | 1 | 214179 |
| Imaging Software | 0.73 | 0.44 | 0 | 1 | 214179 |
| Staffed Beds | 0.14 | 0.16 | 0 | 2 | 214179 |
| Inpatient Days (000,000) | 0.03 | 0.05 | 0 | 1 | 214179 |
| Medicare Inpatient Days (000,000) | 0.02 | 0.02 | 0 | 0 | 214179 |
| Medicaid Inpatient Days (000,000) | 0.01 | 0.01 | 0 | 0 | 214179 |
| Births (000) | 0.70 | 1.19 | 0 | 19 | 214179 |
| Total Operations (000,000) | 0.00 | 0.01 | 0 | 0 | 214179 |
| Total Outpatient Visits (000) | 0.11 | 0.17 | 0 | 3 | 214179 |
| No. Doctors (000) | 0.01 | 0.07 | 0 | 2 | 214179 |

Each observation is a hospital-technology-year.

Table 4 summarizes the data I use in the regressions. Vendors sell a software unit to around 3 percent of potential clients each year. 73 percent of observations in the data are for imaging software, reflecting the fact there are more imaging data components in the HIMSS Analytics data than textual data components.

To understand how the patent litigation affected new technology sales, I model sales to each hospital. I treat a technology sale as irreversible and non-repeatable and exclude observations after the year a hospital purchased the technology: This means that the specification is equivalent to a proportional-hazards Cox style model of diffusion (Allison, 1982). For each potential customer $i$, therefore, I observe whether a sale of software application $j$ was made in year $t$:

$$Sale_{ijt} = \beta_1 Postlitigation_t \times ImagingSoftware_j + \beta_2 Postlitigation_t + \beta_3 ImagingSoftware_j + \alpha_1 X_{it} + \delta_t + \gamma_j + \epsilon_{ijt} \quad (1)$$

$X_{it}$ is a vector of hospital time-varying characteristics that include changes in the patient

mix and staffing levels that might affect demand for software. $\delta_t$ is a vector of year dummies. $\gamma_j$ is a vector of controls for the different software applications to capture differences in how likely a hospital is to purchase the software. $Postlitigation_t$ is an indicator variable for whether the year was 2007 or later, the year that litigation commenced. $ImagingSoftware_j$ is an indicator variable for whether this was software that was used to transmit image data and therefore covered by the disputed patents.

The key variable of interest is $Postlitigation_t \times ImagingSoftware_j$, which captures whether there was any change in vendors' propensity to sell imaging software to hospitals after the litigation commenced, relative to software designed for textual data. I use a linear probability model and estimate the model with ordinary least squares to facilitate interpretation of the interaction terms. I show robustness to a non-linear specification subsequently. Table 5 presents the initial analysis for sales by affected vendors. I build up incrementally to the final specification by adding in different layers of fixed effects and controls across Columns (1)-(3). The direction and significance of the key results remain relatively consistent, however, in all columns. In all cases there is a drop in sales after litigation of imaging software commences as captured by the negative coefficient for $Postlitigation_t \times ImagingSoftware_j$. The magnitudes of the estimates suggests roughly a drop of one third of sales after litigation commenced.

The controls in Column (3) are often insignificant but consistent with previous studies such as Miller and Tucker (2011). Generally the likelihood of a hospital purchasing a system increases with the size of the hospital, though there are some exceptions such as inpatient days and outpatient visits. However, these negative estimate are driven largely by the multi-collinearity with measures such as 'staffed beds'. The number of births positively predicts whether or not the hospital purchases health IT, reflecting the use of software in Maternal-Fetal medicine.

Table 5: Sales of imaging software fell relatively for sued vendors after litigation commenced

| | Affected Vendor | | | | | Not Affected Vendor |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | No Controls | Fixed Effects | Full Controls | Double-Cluster | TimeTrend | Full Controls |
| PostLitigation × ImagingSoftware | -0.019*** | -0.011*** | -0.020*** | -0.020*** | -0.026*** | -0.004 |
| | (0.003) | (0.003) | (0.003) | (0.004) | (0.003) | (0.003) |
| ImagingSoftware | 0.028*** | | | | | |
| | (0.002) | | | | | |
| PostLitigation | 0.001 | | | | | |
| | (0.002) | | | | | |
| Imaging linear time trend | | | | | 0.005*** | |
| | | | | | (0.000) | |
| Linear time trend | | | | | -0.000 | |
| | | | | | (0.000) | |
| Staffed Beds | | | 0.114*** | 0.114*** | 0.051** | -0.042*** |
| | | | (0.043) | (0.042) | (0.023) | (0.016) |
| Inpatient Days (000,000) | | | -0.393*** | -0.393*** | -0.197** | 0.086 |
| | | | (0.144) | (0.146) | (0.082) | (0.060) |
| Medicare Inpatient Days (000,000) | | | 0.572*** | 0.572*** | 0.423*** | 0.121 |
| | | | (0.162) | (0.169) | (0.096) | (0.089) |
| Medicaid Inpatient Days (000,000) | | | -0.305** | -0.305** | -0.109 | 0.082 |
| | | | (0.144) | (0.138) | (0.091) | (0.090) |
| Births (000) | | | 0.004*** | 0.004*** | 0.003*** | -0.001 |
| | | | (0.002) | (0.002) | (0.001) | (0.001) |
| Total Operations (000,000) | | | -0.015 | -0.015 | 0.435* | 0.281 |
| | | | (0.291) | (0.281) | (0.229) | (0.241) |
| Total Outpatient Visits (000) | | | -0.022** | -0.022** | -0.004 | 0.001 |
| | | | (0.009) | (0.009) | (0.006) | (0.005) |
| No. Doctors (000) | | | 0.009 | 0.009 | -0.003 | 0.003 |
| | | | (0.024) | (0.023) | (0.016) | (0.012) |
| Constant | 0.017*** | | | | | |
| | (0.001) | | | | | |
| Application Controls | No | Yes | Yes | Yes | Yes | Yes |
| Year Controls | No | Yes | Yes | Yes | Yes | Yes |
| Observations | 213712 | 213712 | 213712 | 213712 | 544220 | 213712 |

OLS Estimates for linear probability model. Dependent variable is whether or not there is a successful sale of that type of software to a hospital that year. An observation is hospital-technology pair. The sample is all hospitals that have not yet bought that technology. Robust standard errors clustered at hospital level in Columns (1)-(3) and (5). Robust standard errors clustered both n at hospital and application level in Column (4). * $p < 0.10$, ** $p < 0.05$,*** $p < 0.01$

Column (4) presents a specification where I 'double-cluster' the standard errors by both application and hospital following the methodology proposed by Cameron et al. (2011). This helps address concerns that the choice to make an observation a hospital-technology pair is not biasing downwards significantly the size of the standard errors and consequently inflating the level of significance. There appears to be a small increase in size of the standard error as expected, but this has only a small effect on the significance of the result ($t$=6.27 vs $t$=5.15).

One concern is that the short time span of the data means that I fail to capture long-term trends (such as declining sales of imaging software) in the healthcare IT software business that might provide alternative explanations for my results. Column (5) reports the results that include additional observations from 2000-2004. It also adds a linear time trend for both data products and imaging software products in order. This time trend suggests instead that software sales for imaging products were generally increasing year-on-year.

The results in Columns (1)-(5) of Table 5 could potentially simply reflect a downward trend in sales of imaging software for external reasons, such as hospitals not purchasing diagnostic imaging equipment in the wake of a downturn in the economy. To examine whether this is the case, I then turned to look at the software vendors who were not sued by Acacia. Table A-6 in the appendix reports summary statistics for this data. Column (6) of Table 5 reports the identical empirical specification of Equation (1) for this group. There was no significant downward trend in the sales of imaging software for these vendors, suggesting that there was not a large global drop in imaging software sales. This is of course not an entirely 'clean' control group. It is likely the vendors were aware of the ongoing litigation and aware that they could potentially be targets. They also (as is clear in Figure 3) sold fewer imaging software units relative to their data software unit sales initially which leads to less precise estimates in general. However, one would expect that the effect of litigation would be more pronounced for the group of vendors that were being sued - something I check in the next section.

Table 6: 'Diff-in-Diff-in-Diff': Robustness checks

| | All | | Big Hospitals | Small Hospitals | High Births | Low Births |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | OLS | Probit | OLS | | | |
| PostLitigation × ImagingSoftware × Targeted Vendor | -0.019*** | -0.220** | -0.016** | -0.020*** | -0.024*** | -0.012** |
| | (0.005) | (0.090) | (0.007) | (0.006) | (0.008) | (0.006) |
| PostLitigation × ImagingSoftware | -0.002 | -0.070 | -0.005 | -0.000 | -0.003 | -0.002 |
| | (0.003) | (0.069) | (0.005) | (0.004) | (0.005) | (0.004) |
| ImagingSoftware × Targeted Vendor | 0.088*** | 1.506*** | 0.095*** | 0.081*** | 0.099*** | 0.075*** |
| | (0.003) | (0.059) | (0.005) | (0.004) | (0.005) | (0.004) |
| PostLitigation × Targeted Vendor | 0.001 | 0.016 | -0.004 | 0.005 | -0.001 | 0.003 |
| | (0.004) | (0.052) | (0.006) | (0.005) | (0.006) | (0.005) |
| Targeted Vendor | -0.048*** | -0.628*** | -0.050*** | -0.046*** | -0.043*** | -0.053*** |
| | (0.003) | (0.036) | (0.004) | (0.003) | (0.004) | (0.003) |
| Staffed Beds | 0.036 | 0.672** | 0.017 | 0.055 | 0.006 | 0.070 |
| | (0.023) | (0.333) | (0.029) | (0.040) | (0.025) | (0.057) |
| Inpatient Days (000,000) | -0.153** | -3.527** | -0.095 | -0.172 | 0.027 | -0.309* |
| | (0.075) | (1.436) | (0.096) | (0.129) | (0.094) | (0.174) |
| Medicare Inpatient Days (000,000) | 0.347*** | 6.264*** | 0.311*** | 0.418** | 0.190 | 0.518*** |
| | (0.096) | (1.696) | (0.106) | (0.213) | (0.129) | (0.181) |
| Medicaid Inpatient Days (000,000) | -0.112 | -0.964 | -0.121 | -0.175 | -0.233** | -0.038 |
| | (0.083) | (1.752) | (0.090) | (0.194) | (0.117) | (0.130) |
| Births (000) | 0.002** | 0.033*** | 0.001 | 0.003* | 0.002* | 0.006 |
| | (0.001) | (0.012) | (0.001) | (0.001) | (0.001) | (0.010) |
| Total Operations (000,000) | 0.133 | 2.146 | 0.027 | 0.114 | -0.292 | 0.521 |
| | (0.198) | (2.719) | (0.213) | (0.389) | (0.193) | (0.435) |
| Total Outpatient Visits (000) | -0.010* | -0.152* | -0.014** | 0.001 | -0.017*** | 0.030 |
| | (0.005) | (0.092) | (0.006) | (0.014) | (0.006) | (0.020) |
| No. Doctors (000) | 0.006 | 0.085 | 0.019 | -0.150** | 0.016 | -0.037 |
| | (0.016) | (0.183) | (0.018) | (0.061) | (0.019) | (0.026) |
| Application Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 427424 | 427424 | 198946 | 228478 | 213800 | 213624 |

Dependent variable is whether or not there is a successful sale of that type of software to a hospital that year. An observation is hospital-technology pair. The sample is all hospitals that have not yet purchased that technology. Ordinary Least Squared Estimates in Columns (1) and (3)-(4). Probit estimates in Column (2). Robust standard errors clustered at hospital level. * $p < 0.10$, ** $p < 0.05$,*** $p < 0.01$

Table 6 reports the results from an analysis that pools both sued and non-sued vendors into a single dataset. This difference-in-difference-in-difference verifies the significance of the difference observed between Columns (4) and (5) of Table 5 for the coefficient $Postlitigation_t \times ImagingSoftware_j$. The estimate for $Postlitigation_t \times ImagingSoftware_j \times AffectedVendor_k$ is, as expected, negative and significant, suggesting that there was a relative decrease in sales by affected vendors of litigated products after litigation commenced. Again, the non-sued vendors are not a clean control group as they would have been aware of the risk of litigation by Acacia, but it makes sense to expect a larger effect associated with litigation for the vendors that were sued.

The rest of Table 6 is devoted to further robustness checks. Column (2) checks robustness to a probit specification. The results are also robust to the correction for interactions suggested by Ai and Norton (2003). Column (3) and (4) compare results for small and large hospitals, defined as being either those with a below-median or above-median number of doctors.[9] This is an important robustness check as larger hospitals were more likely to purchase software from the larger vendors before litigation commenced. The findings are in a similar direction for both types of hospitals but the economic size of the effect is smaller for small hospitals, simply because they are far less likely to purchase this kind of software.

Column (5) and (6) stratify by the number of births that occurred at the hospitals. As shown in Table A-4, this appeared to be one of the major differences in hospitals that bought imaging products relative to data products. However, there is a decline for hospitals that have below and above median number of births suggesting that it was not a shift in obstetric-driven demand that is driving our results.

### 3.1 Does this drop in sales reflect a drop in demand?

The drop in sales observed could be driven by a fall in hospital demand for reasons unrelated to their observable characteristics. This could occur either because they themselves feared

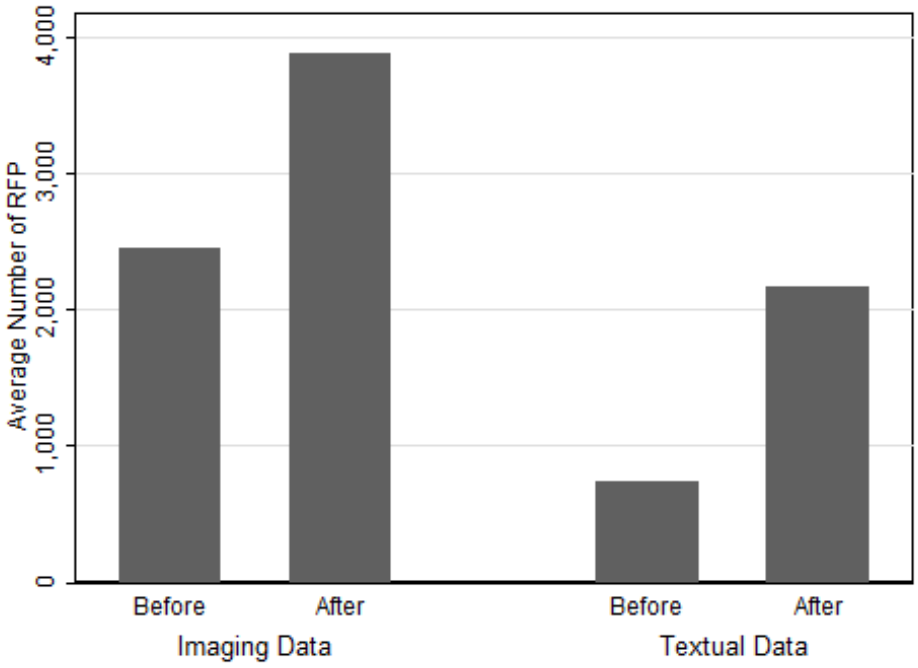
[9]The results also hold when I do a median split by revenues.

being sued by Acacia or because of other reasons such as general satiation in demand for imaging software from the larger vendors.

There is anecdotal evidence that a hospital-driven explanation could be the case. Patent lawyers warned hospitals that they themselves could be in danger after Acacia's acquisition of the patents. For example, Cahr and Kalina (2006) stated explicitly 'Hospitals and other providers should not assume that because they hold an important (and often not-for-profit) place in the culture, that Acacia will hesitate to sue.' They also went through the appropriate protective actions that a hospital should take when approached by Acacia, of which one component was retaining IP counsel.

However, there is little empirical evidence that there was a slowdown in hospital demand. In fact, the reverse may be the case. Figure 5 displays the number of requests for proposals (RFP) by hospitals for different healthcare IT data components before and after litigation commenced. An RFP is issued as the first part of the procurement process, where an invitation is presented for suppliers to submit a proposal on a specific software solution. This data on the issuance of requests for proposals is from the same HIMSS Analytics Database that provides the main data on technology sales used in this paper. For both textual and imaging data products there appears to have been an increase in the number of RFPs. In 2005, across all healthcare applications, 95.70% of requests for proposals led to the installation of a software system according to the HIMSS database. Though not all hospitals made public their RFPs in the HIMSS database, this evidence suggests there was not satiation in the demand for imaging software by hospitals and that instead the decline in sales I observe was driven by the supply side.

Figure 5: No evidence of slowdown in hospital demand



## 4 Mechanism

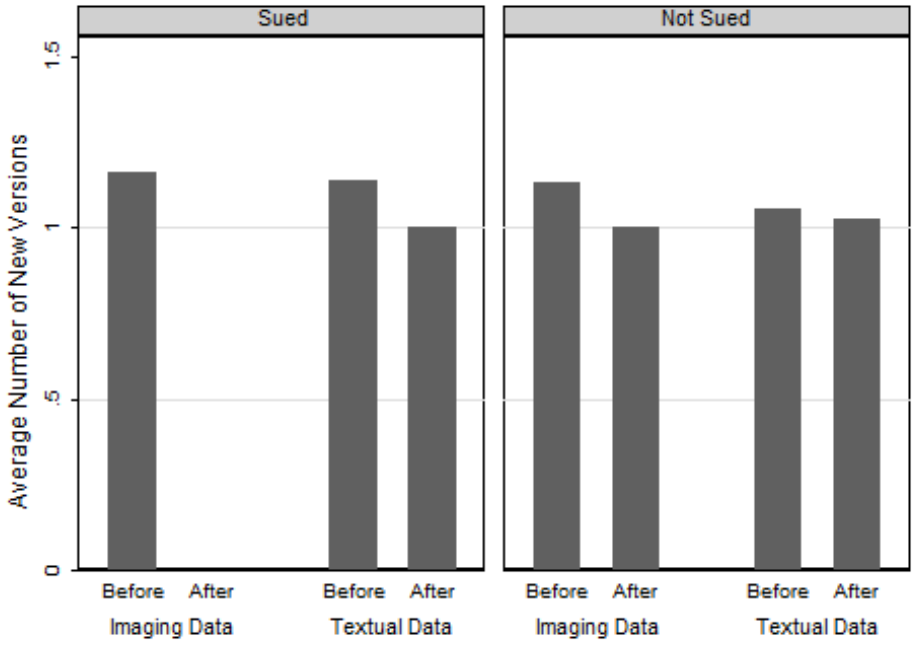
A possible explanation for this supply-side shift is that vendors themselves did less to sell products. Figure 6 displays analysis which investigates whether this is the case. It plots the number of new product releases before and after litigation for the vendors that were sued relative to vendors that were not sued. This data is based on whether there is a new version of the software for that vendor mentioned in product description field in the HIMSS Analytics database. It is clear that there was a complete collapse in the number of new incremental product releases and upgrades during the period of litigation.

An explanation for this is that the court system imposes treble penalties if a firm is found guilty of 'wilful infringement'. The issue of wilfulness 'rests on a determination of the infringer's state of mind,' Mahurkar v. C.R. Bard, Inc., 79 F.3d 1572, 1579 (Fed.Cir.1996), and 'includes elements of intent, reasonableness, and belief'. Among the grounds for a wilfulness finding are '[t]he extent to which the infringer disregarded the property rights of the patentee, the deliberateness of the tortious acts, or other manifestations of unethical or injurious commercial conduct.' Hoechst Celanese Corp. v. BP Chems. Ltd., 78 F.3d 1575, 1583 (Fed.Cir.) (1996). The issue is of course that if a company is being sued it cannot claim ignorance, making any attempts to bring new products to market potential evidence of wilfulness. A firm that proceeds with the launch of new products that would fall under the scope of a disputed patent could be found guilty of the kind of 'objective recklessness' that is used as a criterion to determine wilful infringement.[10]

One explanation for the drop in sales is therefore that because the sued firms were not innovating and engaged in the sales cycle surrounding new products they did not fulfil the latent demand for imaging software apparent in Figure 5. Though the complete absence of new releases of imaging software for any of the sued vendors is compelling, it means that I

[10]Confidential interviews of people who have involved in patent dispute cases confirm that indeed lawyers tell their clients to stop releasing new products.

Figure 6: Evidence of reduction in incremental innovation




cannot explore whether after litigation, sued vendors who had a new product release were less likely to experience a sales drop.

However, the data suggests that after litigation commenced, on average, software vendor that were not sued sold 48 percent more units of an application that year if they had a new product release. Of course this is not proof of causality - new product releases are attended by increased marketing efforts. Further, the release of new products is related to unobserved aspects of technology vendor expertise and commercial confidence. However, it is suggestive that in this industry the product launch cycle (with attendant unobserved marketing efforts) is associated with an increase in sales and that this might offer a partial explanation for why sales dropped so severely during the period of litigation for vendors that were sued. The lack of incremental innovation also has separate welfare implications (Trajtenberg, 1989).

# 5 Conclusion

Patents are intended to give patent-holders enforceable rights over their intellectual property and to enable the sharing of information without the risk of appropriation. Protection is given to small inventors to ensure they can profit from their invention even if they lack the resources to manufacture it. This means that there is a role for patent intermediaries that broker agreements with large firms who infringe on the patent of a small inventor. Patent-assertion entities themselves emphasize their role as intermediaries and the efficiency benefits this could bring. For example, Intellectual Ventures, after being accused of being a patent troll by Blumberg (2011), responded on its website that 'Our ultimate value proposition is simple: we provide an efficient way for patent holders to get paid for the inventions they own, and in turn, for technology companies to gain easy access to the invention rights they need now or may need as they enter new markets.' However, the actions of these patent intermediaries or patent-assertion entities have been criticized, especially as part of their role as intermediaries is to buttress their licensing demands by aggressive and drawn-out litigation.

This paper explores empirically whether such litigation by patent-assertion entities hampers the diffusion of innovations. It studies this in the field of healthcare information technology in light of recent litigation over medical imaging software patents. Empirical analysis suggests that there was a large reduction in sales of imaging software products relative to other similar products that were produced by the same sued firms but did not fall under the scope of the disputed patent. There was no such significant change in sales of imaging software for firms that were not the target of litigation. Further, there was an increase in sales proposal requests for both textual and imaging software by hospitals in this period, suggesting that these results do not reflect a suppression of demand.

Instead, it appears the drop in sales was linked to a drop in incremental product in-

novation. No new variations of existing products or new models of imaging software were released by the affected vendors during the period of litigation. An explanation for this lack of innovation is that the vendors did not want to run the risk of being found guilty of 'wilful infringement' in the patent suit and being liable for treble damages. Therefore, one explanation of the slow-down in sales is that the product release and attendant sales cycle was halted as a result of litigation. This emphasizes that even if patent assertion entities do not prevail in the courtroom, their actions can have significantly negative consequences for incremental innovation while litigation is ongoing.

It is of course an open question about the extent to which this chilling of technology sales observed during the process of litigation is particular to technology cases that involve patent assertion entities or would apply more generally to other patent litigation. There are, however, reasons to think that such spillovers from litigation on technology sales may be more acute in cases involving patent assertion entities. First, patent assertion entities have both the flexibility to allow them to choose legal venues which makes litigation and the threat of being found guilty of wilful infringement a credible risk. Second, the patent assertion entity business model means that there are fewer costs to them of prolonging litigation since they are not vulnerable to counter-claims or increased risk over a manufacturing process, producing asymmetry in the negative effects of litigation.

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Figure A-1: Patent citations over time

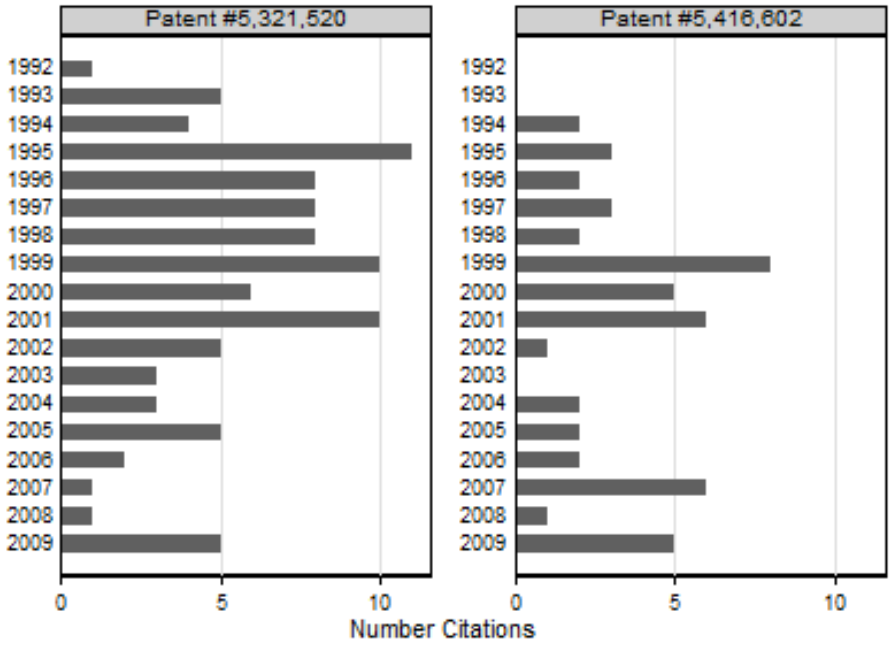

Table A-1: Timeline of public statements by Acacia

| Date | Event |
|---|---|
| June 26, 2008 | HSC reaches a licensing agreement with Siemens Medical Solutions USA Inc. |
| January 22, 2009 | HSC reaches a licensing agreement with Merge Healthcare, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| February 2, 2009 | HSC reaches a licensing agreement with Infinitt North America. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| February 3, 2009 | HSC reaches a licensing agreement with Viztek, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| February 18, 2009 | HSC reaches a licensing agreement with UltraRAD. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| March 11, 2009 | HSC reaches a licensing agreement with Mckesson. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| June 5, 2009 | HSC reaches a licensing agreement with Sectra |
| March 31, 2009 | HSC reaches a licensing agreement with Aware. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| June 5, 2009 | HSC reaches a licensing agreement with Sectra |
| June 15, 2009 | HSC reaches a licensing agreement with Amicas, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas concerning the subsidiary Emageon, Inc. |
| June 29, 2009 | HSC reaches licensing agreement with Fujifilm. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| July 16, 2009 | HSC reaches a licensing agreement with AGFA Healthcare Corp. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| October 15, 2009 | HSC reaches a licensing agreement with Sage Software. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| November 3, 2009 | HSC reaches a licensing agreement with General Electric Co. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| November 9, 2009 | HSC reaches a licensing agreement with Ramsoft, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| December 22, 2009 | HSC reaches a licensing agreement with Aspyra, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| December 24, 2009 | HSC reaches a licensing agreement with NovaRad Corporation. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| December 31, 2009 | HSC reaches a licensing agreement with Stryker Corporation. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| January 15, 2010 | HSC announces it is winding down its lawsuit over two patents covering a system for storing and accessing medical images, dropping Intelerad Medical Systems Inc. and Merge Healthcare Corp. from the suit and seeking to dismiss remaining defendant UltraRad Corp. |
| April 7, 2010 | HSC reaches a licensing agreement with software provider Aware Inc., which becomes the latest defendant to settle a suit brought by Acacia Research Corp. |
| May 20, 2010 | HSC reaches a licensing agreement with DR Systems, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| June 3, 2010 | HSC reaches a licensing agreement with ScImage, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| July 23, 2010 | HSC reaches a licensing agreement with Intuitive Imaging Informatics, LLC. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| September 2, 2010 | HSC reaches a licensing agreement with eRad, Inc. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |
| September, 2010 | HSC reaches a licensing agreement with Cerner Corporation. This agreement resolves the parties' dispute that was pending in the District Court for the Eastern District of Texas. |

## Table A-2: Claims of US 5,321,520 patent

1. A medical image storage, retrieval and transmission system providing simultaneous automated access to an image database by a plurality of remote subscribers upon request over a communications network, said system comprising

   image digitizing means forming a first digitized representation of said image, first data compression means generating from said first digitized representation a low-loss second digitized representation of said image, image data storage and retrieval means comprising means to receive and store said second digitized representation and to selectively provide said second digitized representation to data channel compression means compressing said second digitized representation to form a third digitized representation, and telecommunication means including means to selectively transmit said requested third digitized representation to a requesting remote visual display terminal, said telecommunication means initially telecommunicating a first portion of said third digital representation, said remote terminal including means to convert said first portion of said third representation to a visual image having an initial resolution less than a resolution limit of said requesting terminal, said telecommuncation means subsequently telecommunicating a second portion of said third digital representation, said second portion usable with said first portion to form an image having a resolution intermediate said initial resolution and said resolution limit.

2. A system of claim 1 wherein said first data compression means includes logic means to generate a run-length compressed digitized image data signal as said second representation.

3. A system of claim 1 wherein said first data compression means is operatively coupled to an external data storage drive to store said second representation.

4. A system of claim 1 wherein said image data storage and retrieval means comprises a data modem coupled to said image scanning and digitizing means, a write drive operatively coupled to said data modem to receive and to store said second digitized representation, and a plurality of data retrieval and transmission channels, each said channel comprising an image data reader means operatively coupled to said telecommunication means to selectively receive said second digitized representation of said image for transmission to a said requesting remote visual display terminal.

5. A system of claim 4, wherein a said image data reader means is operatively coupled to an external data write drive configured to receive a storage medium and to store compressed digital image data thereon.

6. A system of claim 4 wherein said telecommunication means comprises a control computer operatively coupled to said image data storage and retrieval means to selectively control data flow between said image data storage and retrieval means and said remote visual display terminal and a plurality of data compression channels coupled to said control computer, wherein each said data compression channel comprises a data memory including means to decompress said low-loss second representation of said image data received from said data retrieval and transmission channel and a compression means including logic means to compress and decompress second representation of said image data to form said third digitized representation of said image for transmission over said communication network to a said requesting remote visual display terminal.

7. A system of claim 1 wherein said first portion of said third representation of said image comprises a plurality of super pixels, and said second portion of said third representation comprises data representative of exact gray levels of a first subset of said super pixels and wherein a third portion of said third representation comprises similar data for a third subset of said super pixels.

8. A system of claim 1 wherein said remote terminal further includes means to select a region of a said image and said telecommunication means includes means to transmit a third portion of said third digitized representation, said third portion specific to said selected region, thereby providing an expanded visual display of said selected region, said expanded visual display containing more pixels than were included in said selected region.

9. A system of claim 1 wherein said remote visual display terminal further includes logic means to enhance an edge contrast of a displayed image.

10. A system of claim 1 wherein said remote visual display terminal further includes logic means to enhance gray level contrast by means of gray level region expansion.

11. A system of claim 1 wherein said remote visual display terminal further includes logic means for differential gray level tracking and gray level enhancement.

12. A system of claim 1 wherein individual patient information corresponding to said image is read by an optical character reader for compression and transmission with a said corresponding second digital representation to said image data storage and retrieval means.

## Table A-3: Claims of US 5,416,602 patent

1. A method of acquiring, storing, retrieving and displaying a medical diagnostic image comprising the steps of a) acquiring said image having a first resolution, and translating said image to a predetermined digital format, b) storing said digitized image in a computer memory at a first location, c) requesting said image from a user-operated terminal having a predetermined resolution limit and located at a second location, d) creating from said digitized image, at said first location, by means of a first algorithm, a patterned and compressed representation thereof, e) transmitting from said first location to said terminal a first portion of said stored patterned representation, f) reconstructing, at said terminal, by means of a second algorithm, from said first portion of said patterned representation, a first displayable representation of said diagnostic image, said first displayable representation having a second resolution no greater than said first resolution, g) displaying said displayable representation at said terminal, h) transmitting from said first location to said terminal an additional portion of said patterned representation, i) reconstructing, at said terminal, by means of a third algorithm, from said additional portion of said patterned representation, an improved displayable representation of said image, said improved displayable representation having a third resolution greater than said second resolution, j) repeating steps g), h) and i), thereby progressively increasing the resolution of said displayed representation until said displayed resolution attains the less of said first resolution of said image or said predetermined resolution limit of said terminal.

2. A method of claim 1 including an additional step of

   k) enhancing, by means of a fourth algorithm, said displayed representation.

3. A method of claim 2 wherein said fourth algorithm comprises enhancing an edge contrast of said displayed representation.

4. A method of claim 2 wherein said fourth algorithm comprises enhancing a gray level contrast by means of gray level region expansion.

5. A method of claim 2 wherein said fourth algorithm comprises differential gray level tracking and gray level enhancement.

6. A method of claim 1 further comprising an additional step after step g) of defining a sub-image of said visual representation by means of a user-operated computer-interactive device operatively connected to said terminal, and wherein said subsequent reconstructions in step j) are directed at reconstruction only of said sub-image.

7. A method of claim 1 wherein said step of acquiring said image and forming a digitized representation thereof further includes a step of compressing said image by means of a run length compression algorithm.

8. A method of claim 1 wherein said first algorithm comprises a hexagonal pattern classification.

9. A method of claim 1 wherein said predetermined digital format formed in step a) comprises a compressed digital image, and wherein said first algorithm re-expands said compressed digital image before forming said patterned and compressed representation therefrom.

10. A method of claim 1 wherein said step of acquiring said image comprises scanning a diagnostic film.

11. A method of claim 1 wherein said step of acquiring said image comprises digitizing a video signal.

12. A method of claim 1 wherein step a) further comprises acquiring, with said diagnostic image, retrieval data uniquely associating said image with a patient, and step b) further comprises storing said retrieval data in said computer memory.

13. A medical diagnostic image system comprising,

    computer means storing a digital representation of said diagnostic image having a first resolution, remote terminal means having a predetermined resolution limit, telecommunication means linking said computer means and said remote terminal means, said telecommunication means comprising means for creating from said digitized image, by means of a first algorithm, a patterned and compressed representation thereof, means for transmitting from said computer to said terminal a plurality of portions of said stored patterned representation, means for reconstructing at said terminal, by means of a second algorithm, from a first portion of said plurality of portions, a first displayable representation of said diagnostic image, said first displayable representation having a second resolution no greater than said first resolution, and means for reconstructing, at said terminal, by means of a third algorithm, from a second portion of said plurality of portions of said patterned representation, and said first displayable representation of said diagnostic image, a second displayable representation having a third resolution greater than said second resolution but no greater than the smaller of said first resolution and said predetermined resolution limit, and means for displaying said representation at said terminal means.

14. A system of claim 13 further comprising means to enhance the gray scale of said image and means

    to transmit from said computer to said terminal means a first data block usable to reconstruct said image without said enhancement, and to transmit from said computer to said terminal means an said incremental block usable to reconstruct said image with said enhanced gray scale.

15. A system of claim 14 wherein said means to enhance the gray scale of said image includes logic means to enhance an edge contrast of said image.

16. A system of claim 14 wherein said means to enhance the gray scale of said image includes logic means to enhance gray level contrast by means of gray level region expansion.

Table A-4: Comparison of characteristics between hospitals who bought imaging products and hospitals who bought data products

| | Mean: Data Product | Mean: Imaging Product | Mean Diff | T-stat |
|---|---|---|---|---|
| Staffed Beds | 0.25 | 0.27 | -0.01 | -1.93 |
| Inpatient Days (000,000) | 0.06 | 0.07 | -0.00 | -1.38 |
| Medicare Inpatient Days (000,000) | 0.03 | 0.03 | -0.00 | -0.24 |
| Medicaid Inpatient Days (000,000) | 0.01 | 0.01 | -0.00 | -0.65 |
| Births (000) | 1.27 | 1.49 | -0.21 | -3.59 |
| Total Operations (000,000) | 0.01 | 0.01 | -0.00 | -1.86 |
| Total Outpatient Visits (000) | 0.18 | 0.20 | -0.01 | -1.68 |
| No. Doctors (000) | 0.02 | 0.03 | -0.01 | -3.19 |
| Observations | 5136 | | | |

Table A-5: Comparison of characteristics between hospitals who bought from vendors that were sued and hospitals that bought from vendors that were not sued

| | Mean: Not-Sued | Mean: Sued | Mean Diff | T-stat |
|---|---|---|---|---|
| Staffed Beds | 0.29 | 0.27 | 0.02 | 1.51 |
| Inpatient Days (000,000) | 0.08 | 0.07 | 0.01 | 2.37 |
| Medicare Inpatient Days (000,000) | 0.03 | 0.03 | -0.00 | -0.78 |
| Medicaid Inpatient Days (000,000) | 0.01 | 0.01 | 0.00 | 0.27 |
| Births (000) | 1.57 | 1.49 | 0.09 | 0.77 |
| Total Operations (000,000) | 0.01 | 0.01 | 0.00 | 1.62 |
| Total Outpatient Visits (000) | 0.16 | 0.20 | -0.03 | -2.25 |
| No. Doctors (000) | 0.02 | 0.03 | -0.01 | -2.28 |
| Observations | 4414 | | | |

Table A-6: Summary statistics for vendors that were not sued

| | Mean | Std. Dev. | Min | Max | Observations |
|---|---|---|---|---|---|
| Technology Sale (Vendor not involved in Litigation) | 0.02 | 0.15 | 0 | 1 | 214179 |
| Imaging Software | 0.73 | 0.44 | 0 | 1 | 214179 |
| Staffed Beds | 0.14 | 0.16 | 0 | 2 | 214179 |
| Inpatient Days (000,000) | 0.03 | 0.05 | 0 | 1 | 214179 |
| Medicare Inpatient Days (000,000) | 0.02 | 0.02 | 0 | 0 | 214179 |
| Medicaid Inpatient Days (000,000) | 0.01 | 0.01 | 0 | 0 | 214179 |
| Births (000) | 0.70 | 1.19 | 0 | 19 | 214179 |
| Total Operations (000,000) | 0.00 | 0.01 | 0 | 0 | 214179 |
| Total Outpatient Visits (000) | 0.11 | 0.17 | 0 | 3 | 214179 |
| No. Doctors (000) | 0.01 | 0.07 | 0 | 2 | 214179 |

Each observation is a hospital-technology-year.