# INNOVATION UNDER THREAT? AN ASSESSMENT OF THE EVIDENCE FOR PATENT HOLDUP AND ROYALTY STACKING IN SEP-INTENSIVE, IT INDUSTRIES

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## I. INTRODUCTION: AN INFLUENTIAL THEORY PREDICTS MARKET FAILURE

Most electronic devices we use such as smartphones, laptop computers, televisions or audio systems rely on technological standards that make them interoperable. Technology standards enable the owner of a Samsung Galaxy to call a friend subscribed to a different network who uses an iPhone, switch to WiFi while at home, or make a video recording that can be edited on a laptop and then viewed on a TV or tablet. A myriad of firms design apps that enable the owner of that smartphone to order a cab, read her favorite magazine or apply for a home mortgage. Yet Patent Holdup Theory, an influential body of thought among legal academics and antitrust authorities around the world, predicts market failure in precisely these SEP-intensive, information technology ("IT") industries. Indeed, many authors argue that innovation in IT is under threat. As one seminal paper puts it: "…I submit that this holdup problem is very real today, and that both patent and antitrust policymakers should regard holdup as a problem of

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first order significance in the years ahead."[2]

According to Patent Holdup Theory the holders of standard essential patents ask for "excessive royalties" for the use of their technologies after manufacturers make standard-specific, sunk investments. Opportunistic patent owners are therefore "holding up" manufacturers, charging royalties that only allow them to cover their short-run costs. The predictions of the theory are straightforward: because there is no incentive to continue investing once capital equipment wears out, innovation ceases and the industry stagnates or even collapses.

Royalty stacking is claimed to be patent holdup repeated multiple times. At the same time, it is also claimed to be an application of the Cournot complements theory — the idea that when two separate upstream input monopolies collude and price as a single monopoly they charge less than when each sets prices independently. Patent holdup theorists substitute SEP patent holders for Cournot's upstream monopolists, and then note that there may be dozens, or hundreds of such patent holders, each independently charging a royalty. Lemley and Shapiro (2007: 2014) provide a mathematical expression to operationalize the Cournot complements problem caused by multiple patent owners:

> [...] if marginal costs are constant and the downstream firm faces linear demand, the output level if N essential patents are owned by N separate firms is equal to the output level if all N patents were owned by a single firm multiplied by the factor 2/(N+1).

Figure 1 shows the implications of Lemley and Shapiro's expression. As the graph shows, in a competitive industry with no royalties, output would be 100. If only one patent holder charges a profit-maximizing royalty rate however, she reduces equilibrium output by half relative to marginal cost pricing — even a single patent holder acting as a monopolist would significantly worsen the industry's performance. With a second patent holder, the cumulative royalty rises and output falls further to one-third relative to no royalties. By the time the number of patent holders reaches 9, output is ten percent of the quantity with no royalties. And if the number of patent holders is 99, then output would be 99 percent lower. In short, it does not take a large number of patent owners to devastate an industry, a result that holds regardless of the shape of the demand curve.

## II. A THEORY IN SEARCH OF EVIDENCE

We have shown elsewhere that patent holdup and royalty stacking cannot happen together; they are mutually exclusive economic mechanisms. We have also shown that, claims by patent holdup theorists to the contrary, patent holdup is not a straightforward variant of the transactions cost theory of holdup in mainstream economics.[3] We will not, therefore pursue those issues here.

Nevertheless, the mechanics of both patent holdup and royalty stacking independently predict market failure, and thus call for government intervention in markets to prevent that

[2] Shapiro (2001: 125). Also see Farrell et. al. (2007), Lemley (2007), Lemley and Shapiro (2007), Shapiro (2007), Scott Morton and Shapiro (2015).
[3] See Galetovic and Haber (2016).

failure. Neither mechanism permits effects at the margin, such that an industry can be saved by exogenous technological change or falling manufacturing costs; if surplus increases for whatever reason, then patent owners will raise the royalty rate to extract it. Hence, the literature makes dire predictions about the future of innovation. As Shapiro (2001: 1260) puts it:

> The holdup problem is worst in industries where hundreds if not thousands of patents, some already issued, others pending, can potentially read on a given product. In these industries, the danger that a manufacturer will step on a land mine is all too real. The result will be that some companies avoid the mine field altogether, that is, refrain from introducing certain products for fear of holdup.

Farrell et. al (2007: 647) concur: "…surprise hold-up may be largely a transfer, but anticipation of hold-up encourages a range of inefficient forms of self-protection, such as postponing or minimizing investment, or ensuring that standards use only antique technology." Lemley and Shapiro (2007a: 2012) reach a similar conclusion:

> In the long run, if products are expected to be subject to some degree of holdup, the firm may not find it worth incurring the costs necessary to develop, manufacture, and sell the product. Assertions based on the shut-down condition that royalty stacking is somehow a minor problem or that royalty stacking cannot stifle innovation or hinder the market penetration of products that have been developed are simply unfounded.

Scott Morton and Shapiro (2016: 124) have recently applied this framework to suggest that patent holdup and royalty stacking threaten the "Internet of Things":

> …the "Internet of Things" is a new and growing area where royalty stacking and patent holdup appear to be very real dangers.… Failure to prevent patent holdup relating to tomorrow's information technology and communications standards is likely to cause significant social welfare loss in the years ahead.

Patent holdup theorists should have tested these claims about patent holdup, royalty stacking, and collapsing rates of innovation directly. Doing so would have been straightforward: economists measure differential rates of innovation by comparing differential rates of change of quality-adjusted prices across industries and within industries over time; and thus researchers should have asked: "Within an affected product line, has the number of SEPs and SEP holders increased over time, and were those increases followed by increasing quality adjusted prices, relative to product lines not affected by patent holdup or royalty stacking?" Similar tests might have focused on the relationship of the number of SEP and SEP holders to output, industry structure or rates of new firm entry in affected product lines. One would think, for example, that if patent holdup or royalty stacking were causing market failure in an industry, then incumbent firms would cease to invest and new firms would not enter the industry.

Instead of testing the observable implications of patent holdup or royalty stacking against equilibrium economic outcomes, the proponents of Patent Holdup Theory focused on anecdotes about litigation involving SEPS or claims by reluctant licensees that they were asked to pay royalties they deemed excessive.[4] To the degree that they focused on quantitative data,

[4] One recent line of argument is that while evidence of patent holdup is difficult to obtain, there is evidence for the general, Transactions Cost Theory of holdup; see, for example, Contreras (2016), citing Carl Shapiro. These authors

they presented evidence about assumptions of the theory, rather than the outcomes predicted by the theory. For example, Contreras (2015: 2) cites the large and increasing number of patents in IT industries as evidence of royalty stacking:

> It is well known that modern computing, telecommunications, and consumer electronics devices are covered by multitudes of patents. In 2011, patent aggregator RPX estimated that an average smartphone is covered by at least 250,000 different patents, up from only 70,000 in 2000. To the extent that the multiple owners of patents covering a single standard or device charge royalties to the manufacturer, the cumulative effect of those royalty demands can be appreciable. This phenomenon is often called royalty "stacking."

The number of patents reading on a product is not, however, evidence that royalty stacking is occurring. If that would be the case, any industry that uses many inputs produced by different suppliers — from motorcycles to ski parkas — would be a victim of the Cournot complements problem; it would be a wonder that anything is produced at all. Thus, demonstrating that there are large numbers of SEP holders in a product line is only a first step in demonstrating that royalty stacking is hindering innovation. As a second step, a researcher must show that those SEP holders have market power and independently charge a per-unit royalty.[5] As a third and crucial step, it must be shown that, as the number of SEP holders has increased over time, the equilibrium price of the final good has increased as well, while output has fallen. Indeed, according to Lemley and Shapiro's formal expression, if royalty stacking is taking place, a researcher should observe that once there are 10 or more SEP holders each independently setting a per-unit royalty output should almost completely collapse.

Other authors have cited as evidence of royalty stacking the allegedly excessive cumulative royalties demanded by patent holders. For example, in 2007 Mark Lemley famously stated that the cost of paying patent royalties might exceed the price of final products in the wireless phone industry:

> Time and time again, we have seen this sort of royalty-stacking problem arise. One great example is 3G telecom in Europe. The standard-setting organization (SSO) put out a call for essential patents, asking which they must license to make the 3G wireless protocol work and the price at which the patent owners would license their rights. 3G telecom received affirmative responses totaling over 6,000 essential patents and the cumulative royalty rate turned out to be 130%. This is not a formula for a successful product.

Beyond the fact that looking at opening-bids is a notoriously inaccurate way of measuring the market price of anything, a 130 percent cumulative rate should have brought the industry to a grinding halt at its inception — an observable outcome. Given that more than 1.4 billion 3G and 4G phones were sold worldwide in 2015, and that the prices of those devices have fallen like

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ignore that: transactions-cost holdup, unlike the theory of patent holdup, is not a theory about market failure. On the contrary, transactions-cost holdup is mostly a theory that explains how contractual or structural adaptation successfully prevents holdup from becoming a problem in the first place.

[5] Spulber (2016) showed that the Cournot complement problem emerges only if input monopolists charge per unit, linear prices. With two-part tariffs, for example, it is no longer an equilibrium and the complements problem disappears.

stones since 2007, this outcome obviously did not obtain.

To our knowledge, the closest any paper has come to providing any evidence that fragmented patent ownership has had an effect on innovation is Cockburn, Macgarvie and Muller (2010), which looked at a sample of German firms. Nevertheless, this study found that the firm in the sample with the highest royalty burden spent only 2.12 percent of its sales on patent licenses. The average amount spent on patent licenses across all firms was only 0.054 percent of sales. These royalty rates are one or two orders of magnitude smaller than the royalty rates predicted by the theory. Thus, rather than being evidence consistent with the hypothesis that royalty stacking slows innovation, they are evidence showing that these German firms are not affected by royalty stacking.

Many authors have pointed out that there is scant evidence of patent holdup or royalty stacking. In 2008 Denicolo et al concluded (p. 600) that: "Taking all of the evidence together, we find the proof of prevalent, recurring patent holdup, and royalty stacking in high-tech industries to be extremely weak."

The same year, Gerardin, Layne-Farrar and Padilla (2008) surveyed the literature on royalty stacking. After an exhaustive study of the theory and evidence they found that there was a possible but limited royalty stacking effect in the software industry, a possible effect in the semiconductor industry that appeared to be mitigated by cross-licensing, no measurable effect in the mobile telecom industry and no systematic evidence in the biomedical industry.

Noel and Shankerman (2013: 484) reached a similar conclusion regarding the software industry. They note: "Despite widespread concern about patent thickets, the econometric evidence on their effects is quite limited."

Layne-Farrar (2014) also reviewed the empirical literature on patent holdup and royalty stacking and concluded:

> Certainly the theories have been developed, but the empirical support is still lacking. Despite the 15 years proponents of the theories have had to amass evidence, the empirical studies conducted thus far have not shown that holdup or royalty stacking is a common problem in practice.

Similarly, a comprehensive review of 164 papers on patent thickets (which includes, as a special case, royalty stacking) by Egan and Teece (2015) concluded that:

> It would be nice to conclude this paper by answering the two big questions in the literature: Do patent thickets exist? And do patent thickets cause economic inefficiencies? But, despite carefully reading and analyzing the 164 papers that make up our sample, what we can say is limited. [...] there is simply no evidence that this is the happening even in areas like software.

Finally, Hall, Helmers, and Graevanitz (2015: 23) recently summarized the state of the literature about the effect of patent thickets as follows:

> The theoretical analysis of patent thickets (Shapiro, 2001) and the qualitative evidence provided by the FTC in a number of reports (FTC, 2003; 2011) suggest that thickets impose significant costs on some firms. The subsequent literature has focused on the measurement of thickets (e.g. Graevenitz et. al. 2011;

Ziedonis, 2004) and has linked thickets to changes in firms' IP strategies in a number of dimensions. There is still a lack of evidence on the effect of patent thickets as well as their welfare implications at the aggregate level.

In summary, almost 15 years after Carl Shapiro (2001) argued in an influential paper that patent holdup is "a problem of first order significance," no systematic evidence has been produced that supports the contention that SEP-intensive, IT industries are under threat.

## III. EVIDENCE OF THRIVING, NOT DYING, INDUSTRIES

As we have already mentioned, there is a straightforward way to measure the differential rate of innovation in SEP-intensive industries; look at differential rates of change in quality adjusted prices in SEP-intensive and non-SEP-intensive product lines. In fact, there is a broad and deep literature on the economics of productivity growth, whose key insight is that there is a one-to-one relationship between differential rates of innovation and differential rates of changes in quality-adjusted prices.[6] That is, if technological progress is 10 percent faster in good A relative to good B, the quality-adjusted price of good A falls 10 percent faster than the quality-adjusted price of good B.

Research that we carried out with Ross Levine (Galetovic, Haber and Levine 2015) therefore takes this approach to assessing the empirical implications of patent holdup and royalty stacking. The main findings of Galetovic, Haber and Levine (2015) are summarized in Figure 2, which graphs an index of quality adjusted prices for a broad range of SEP-intensive and products between 1997 and 2013 relative to the rest of the economy. Rates of technological progress in SEP-intensive industries (phone equipment, video equipment, audio equipment, televisions and laptop computers) were very fast relative to technological progress in the overall economy and almost any other industry. For example, the overall rate of innovation in phone equipment (which includes such low tech items as fax machines and landline phones, as well as wireless phones) was 10 percent per annum faster than the economy-wide average. The rate of innovation in portable and laptop computers was faster still, 31 percent per annum faster than the economy-wide average. The figure also shows that these fast differential rates of innovation in SEP-intensive products have not slowed over time.

Galetovic, Haber and Levine (2015) also exploited the U.S. Supreme Court's decision in *eBay Inc. v. MercExchange LLC*, which made it relatively more difficult for SEP owners to obtain injunctions against infringers. One argument made in the SEP holdup literature is that SEP owners extracted excessive royalties by threatening licensees with an injunction. If the manufacture of products that were highly reliant on SEPs were being held up prior to eBay, after eBay we should see faster decreases in the quality-adjusted prices of those products, relative to the quality-adjusted prices of products that that are non-SEP-reliant. Nevertheless, no matter how they treated the data, Galetovic, Haber and Levine could not reject the null hypothesis that there was no patent holdup or royalty stacking in SEP-reliant industries.

Galetovic and Gupta (2016) assess the hypothesis that royalty stacking has occurred in a canonical patent holdup industry – mobile wireless. Figure 3 is adapted from their paper. The

[6] See, for example, Flamm (2010), Griliches and Jorgenson (1967), Jorgenson (2004), Jorgenson and Wessner (2004 and 2007), and Nordhaus (2007).

right axis shows that the number of firms that declared SEPs to ETSI (a consortium of standard setting organizations formed to develop 3G technology) increases from 2 to 128 between 1994 and 2013. On the left axis, Figure 3 shows the average annual wholesale price of phones and tablets by technological generation (2G, 2.5G, 3G, 3.5G, 4G). Note that the introductory price of every generation is lower than previous generation — even though each generation delivers better products. Note also that, within each generation, prices fell between 10 and 20 percent per annum. The behavior of prices is inconsistent with royalty stacking: as the number of SEPs grew from 2 to 128, prices should have increased.

The rapid fall of prices is a sign of a thriving industry. As Mallinson (2016) reports, "[...] at around 7.5 billion subscriber connections by June 2015, basic cellular telephony has already achieved extraordinary, worldwide penetration, given the estimated global adult population of 5.0 billion." Indeed, during the last ten years fast technological progress has reshaped the industry. According to Malinson (2016):

> Successive generations of mobile technology have continued to massively increase performance. For example, end-user data rates have increased well over 1,000-fold since 1991. With the first commercial services of GPRS in 2000, this 2G GSM technology initially provided users with data speeds of up to 56 kilobits per second. By around 2005 in most developed nations, 3G UMTS with WCDMA provided users up to 384 kbps. Technology enhancements to WCDMA with HSDPA and HSPA+ then provided ever-increasing speeds from megabits per second to tens of megabits per second. Today, 4G Long-Term-Evolution ("LTE") networks are providing users in excess of 100,000 kbps (100 Mbps).

Indeed, faster speeds have

> [...] transformed the purpose of cellular communications. What, until the latter part of the last decade, was primarily a means of voice and simple text communication is now overwhelmingly used for the high-bandwidth data that smartphones both consume and generate. Usage includes viewing web pages, downloading video, uploading photographs and video, on-line gaming, immediate dissemination of such content through social media platforms, audio and video streaming including video conferencing.

## IV. CONCLUSION

For many years Patent Holdup Theory has influenced antitrust thinking and action in SEP-intensive industries the world over. Yet while the theory predicts market failure or industry stagnation at best, SEP-intensive industries have thrived and consumers have benefitted from better products at lower prices. It should not be surprising, therefore, that proponents of the theories have failed to produce evidence that patent hold up and royalty stacking systematically affect the performance of SEP-intensive industries. Thriving industries are inconsistent with both patent holdup and royalty stacking and show that Patent Holdup Theory is rejected by the data. It is a failed theory and should be abandoned as guide of antitrust policy.

**Figure 1**
**Royalty stacking and output**

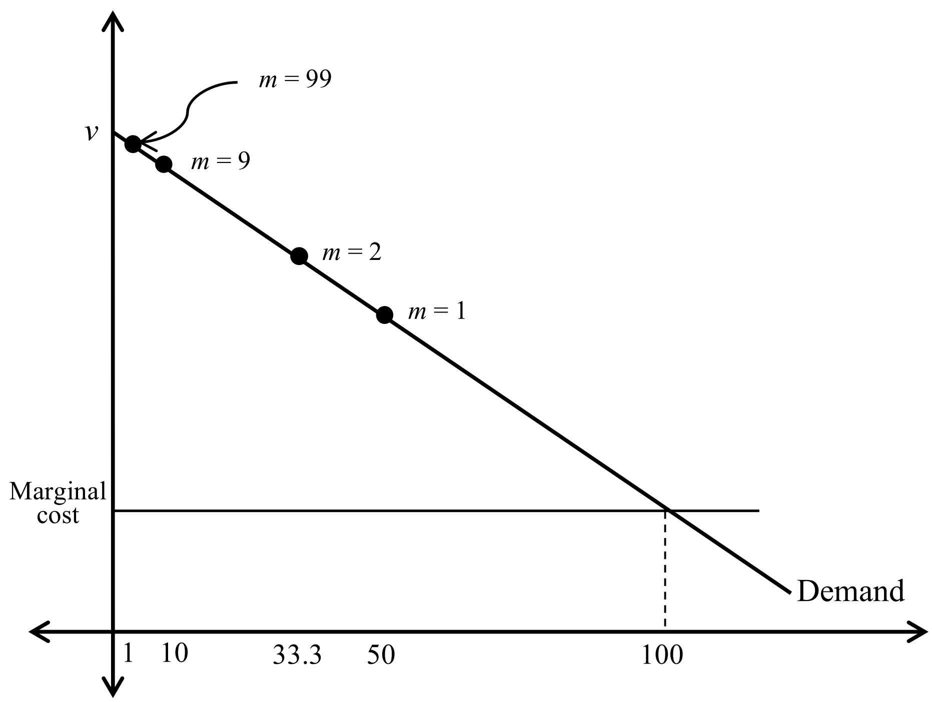


**Figure 2**
**Quality-Adjusted Relative Prices of SEP-Intensive Consumer Products**
**(rest of the economy = 100)**

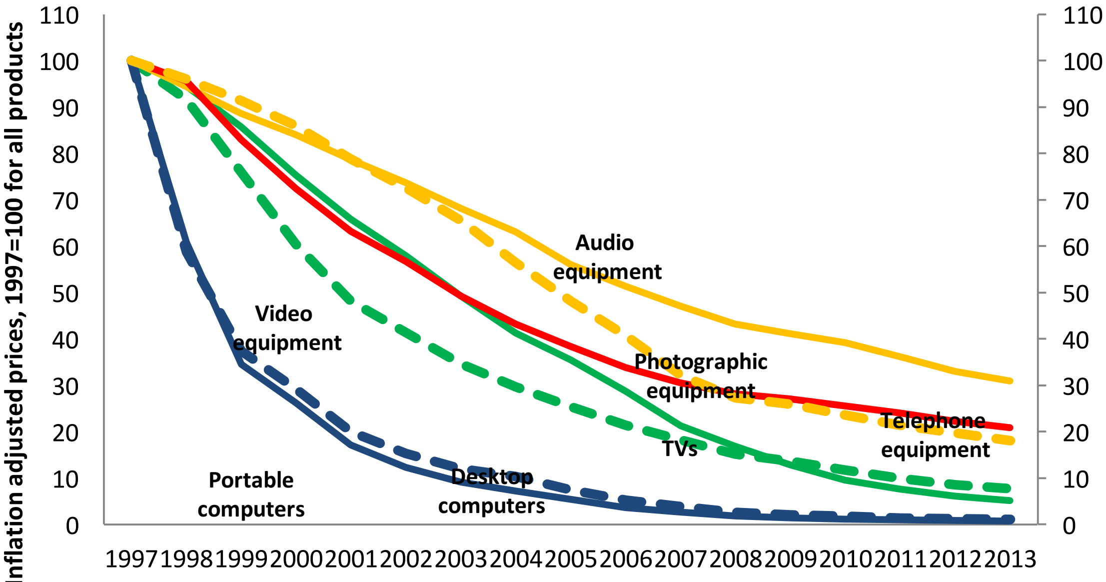
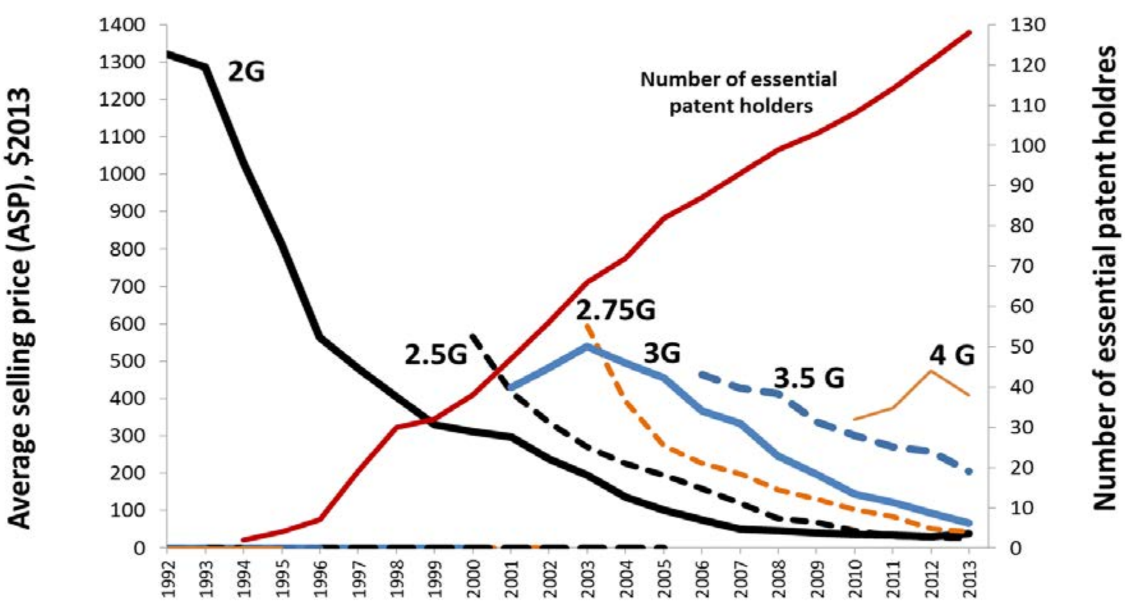



**Figure 3**
**Average selling price of devices and number of SEP holders**



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